NASA

Aeronautical Engineering
A Continuing Bibliography with Indexes

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NASA SP-7037(220)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 220)

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 November 1987 in

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

Scientific and Technical Information Division 1987
National Aeronautics and Space Administration
Washington, DC

This supplement is available from the National Technical Information Service (NTIS), Springfield, Virginia 22161, price code A08.

INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 596 reports, journal articles and other documents originally announced in November 1987 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

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

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

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

An annual cummulative index will be published.

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

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Category 11	**Chemistry and Materials** Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; propellants and fuels; and materials processing.	**780**

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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 792

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 793

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 796

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 798

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

NASA SPONSORED

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ACCESSION NUMBER → **N87-10039*#** National Aeronautics and Space Administration. ← CORPORATE SOURCE
Langley Research Center, Hampton, Va.

TITLE → **WIND-TUNNEL INVESTIGATION OF THE FLIGHT CHARACTERISTICS OF A CANARD GENERAL-AVIATION AIRPLANE CONFIGURATION**

PUBLICATION DATE

AUTHOR → D. R. SATRAN Oct. 1986 60 p ← AVAILABILITY SOURCE

REPORT NUMBERS → (NASA-TP-2623; L-15929; NAS 1.60:2623) Avail: NTIS HC

PRICE CODE → A04/MF A01 CSCL 01A ← COSATI CODE

A 0.36-scale model of a canard general-aviation airplane with a single pusher propeller and winglets was tested in the Langley 30- by 60-Foot Wind Tunnel to determine the static and dynamic stability and control and free-flight behavior of the configuration. Model variables made testing of the model possible with the canard in high and low positions, with increased winglet area, with outboard wing leading-edge droop, with fuselage-mounted vertical fin and rudder, with enlarged rudders, with dual deflecting rudders, and with ailerons mounted closer to the wing tips. The basic model exhibited generally good longitudinal and lateral stability and control characteristics. The removal of an outboard leading-edge droop degraded roll damping and produced lightly damped roll (wing rock) oscillations. In general, the model exhibited very stable dihedral effect but weak directional stability. Rudder and aileron control power were sufficiently adequate for control of most flight conditions, but appeared to be relatively weak for maneuvering compared with those of more conventionally configured models.
Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

ACCESSION NUMBER → **A87-11487*** National Aeronautics and Space Administration.
Ames Research Center, Moffett Field, Calif.

COMPUTATION OF TURBULENT SUPERSONIC FLOWS AROUND POINTED BODIES HAVING CROSSFLOW SEPARATION ← TITLE

AUTHORS → D. DEGANI and L. B. SCHIFF (NASA, Ames Research Center, Moffett Field, CA) ← AUTHOR'S AFFILIATION

JOURNAL TITLE → Journal of Computational Physics (ISSN 0021-9991), vol. 66, Sept. 1986, p. 173-196. refs

The numerical method developed by Schiff and Sturek (1980) on the basis of the thin-layer parabolized Navier-Stokes equations of Schiff and Steger (1980) is extended to the case of turbulent supersonic flows on pointed bodies at high angles of attack. The governing equations, the numerical scheme, and modifications to the algebraic eddy-viscosity turbulence model are described; and results for three cones and one ogive-cylinder body (obtained using grids of 50 nonuniformly spaced points in the radial direction between the body and the outer boundary) are presented graphically and compared with published experimental data. The grids employed are found to provide sufficient spatial resolution of the leeward-side vortices; when combined with the modified turbulence model, they are shown to permit accurate treatment of flows with large regions of crossflow separation. T.K.

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 220)

DECEMBER 1987

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AERONAUTICS (GENERAL)

A87-47250
DESIGNING INTERIORS FOR REAL PEOPLE
PAUL SILLERS Interavia (ISSN 0020-5168), vol. 42, July 1987, p. 751-753.

The distinction between industrial designers and engineers is not always clearly understood; in the context of aircraft interiors, a good example is seen in the design of passenger seats. While the engineer is primarily concerned with weight reduction, safety factors, and production-cost reduction, the industrial designer considers anthropometry, dynamic passenger posture adjustment, and aesthetics. The two former considerations fall under the purview of ergonomics, which studies human relationships with working environments and is therefore relevant to every aspect of aircraft interior design, from cabin lighting and seat design to the location of passenger service units. O.C.

A87-47777
OBJECTIVES OF MAINTENANCE - AIRWORTHINESS
J. W. SAULL (Civil Aviation Authority, Airworthiness Div., Redhill, England) Aerospace (UK) (ISSN 0305-0831), vol. 14, July-Aug. 1987, p. 41-47.

Maintenance activities constitute the major portion of 'continuing airworthiness' considerations for both fixed wing and rotary wing aircraft, especially in the large transport category. An account is presently given of the British regulatory system concerned with maintenance requirements and procedures. The control and implementation of mandatory inspections and modifications is the most important aspect of ensuring that post-certification type design standards are met. The legal liability problem is making its own imprint on all aspects of aircraft maintenance work, as well as design engineering; it is therefore vital that all legal requirements be met in full, including the appropriate history records. O.C.

A87-48154
YEARBOOK 1986 II; DGLR, ANNUAL MEETING, MUNICH, WEST GERMANY, OCT. 8-10, 1986, REPORTS [JAHRBUCH 1986 II; DGLR, JAHRESTAGUNG, MUNICH, WEST GERMANY, OCT. 8-10, 1986, VORTRAEGE]
Meeting sponsored by DGLR. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, 566 p. In German and English. For individual items see A87-48155 to A87-48167.

Recent advances in aerospace technology in the FRG are examined in reviews and reports. Topics discussed include spacecraft propulsion and control; spacecraft and payloads; aircraft systems, performance, and propulsion; AI tools, sensors, and diagnosis; man-machine interfaces; and experimental aerodynamics and thermodynamics. Consideration is given to materials and structures, the history of air and space flight, and the optimization of seaplanes. T.K.

A87-48158
AIRCRAFT TECHNOLOGY OF THE 1990S IN TRANSPORT-AIRCRAFT PROJECTS AT MBB [FLUGZEUG-TECHNOLOGIE DER 90ER JAHRE IN VERKEHRFLUGZEUG-PROJEKTEN VON MBB]
MUNICH MESSERSCHMITT-BOELKOW-BLOHM GMBH, IN: Yearbook 1986 II; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 513-552. In German.
(DGLR PAPER 86-108; MBB-UT-021-86)

Advanced designs, materials, and avionics being developed at MBB for future transport aircraft are presented in diagrams, drawings, graphs, and photographs and characterized. The cost factors driving the R&D efforts are discussed, and it is shown that fuel-consumption savings produced by such technologies as propfan engines, laminar wings, and high-aspect-ratio wings must be weighed against their high development and manufacturing costs, especially for smaller short-haul aircraft. Consideration is given to various propfan concepts and their implementation problems, advanced aerodynamics, and the increasing use of CFRP structures. It is pointed out that the main effect of avionics improvements will be increased operating safety, rather than lower operating costs. T.K.

A87-48167
EUROPEAN V/STOL: FROM THE PIONEERS TO PRODUCTION - AND THE FUTURE
C. H. HANSFORD (British Aerospace PLC, Military Aircraft Div., Weybridge, England) (European Pioneers Day, 11th, Garmisch-Partenkirchen, West Germany, Sept. 24, 25, 1986) IN: Yearbook 1986 II; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 812-836.

The history of V/STOL R&D efforts in Western Europe since 1950 is reviewed and illustrated with extensive photographs and drawings. Topics examined include military V/STOL needs, the early experimental prototypes, the Short SC.1, the SNECMA Coleoptere, the Hawker P.1127, the Dassault Balzac/Mirage IIIV, the EWR VJ.101C, the Do 31, the VFW-Fokker VAK 191B, the application of the lessons learned in early programs to the current Harrier series, and plans for advanced STOVL aircraft. T.K.

A87-48638
AIAA LIGHTER-THAN-AIR TECHNOLOGY CONFERENCE, 7TH, MONTEREY, CA, AUG. 17-19, 1987, TECHNICAL PAPERS
Conference sponsored by AIAA. New York, American Institute of Aeronautics and Astronautics, 1987, 112 p. For individual items see A87-48639 to A87-48651.

The present conference on LTA advancements discusses a U.S. eastern seaboard airship transport system, a hybrid airship RPV for entomological research, design considerations for a Martian balloon rover, LTA developments in Britain, the design and dynamics of large crane airships, and a simulation of the emergency descent of a tethered aerostat after breakaway. Also discussed are a heat-transfer model for a hot helium airship, the nonlinear dynamic simulation of a moored aerostat, preflight and postflight test models compared to measured Skyship 500 control responses, and the potential flow over bodies-of-revolution in unsteady motion. O.C.

A87-48642#
UK LIGHTER-THAN-AIR ACTIVITY - A REVIEW
A. W. L. NAYLER (Royal Aeronautical Society, London, England) IN: AIAA Lighter-Than-Air Technology Conference, 7th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 21-31. refs
(AIAA PAPER 87-2307)

The present evaluation of airship technology development in Britain notes that one British manufacturer is marketing two nonrigid airship sizes (Skyship 500 and 600) that are fully certified for passenger carriage, while a second manufacturer has obtained financing for detailed design and initial construction work. About 60 hot-air airships have been sold for export by an additional two British manufacturers, which have also developed helium-filled airships. Attention is given to fly-by-light controls and the use of solar arrays as a basis for electrical propulsion. O.C.

A87-48686
COMPOSITES FOR GENERAL AVIATION AIRCRAFT; PROCEEDINGS OF THE GENERAL AVIATION AIRCRAFT MEETING AND EXPOSITION, WICHITA, KS, APR. 28-30, 1987
Meeting and Exposition sponsored by SAE. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-717), 1987, 37 p. For individual items see A87-48687 to A87-48691.
(SAE SP-717)

The present conference discusses the certification of bonded primary structure composite airframes for general aviation aircraft, the composite implementation of a lightweight and low cost air-to-air missile control surface, and the state-of-the-art development status of general aviation aircraft structures technologies. Also discussed are the roles that may be played by alternative types of woven reinforcements in advanced composite materials, and the determination of resin-matrix composites' fiber volumes by means of density measurements. O.C.

A87-48689
STRUCTURES TECHNOLOGY OF MODERN GENERAL AVIATION AIRCRAFT
WOLFGANG UHSE and EBERHARD ROSTAN (Dornier GmbH, Friedrichshafen, West Germany) IN: Composites for general aviation aircraft; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987 . Warrendale, PA, Society of Automotive Engineers, Inc., 1987, p. 13-20.
(SAE PAPER 871025)

A comparative study is presented for the application of advanced composites and contemporary metallic structure-processing methods in European private and commuter aircraft, such as the Do 228, whose manufacturer has undertaken two programs for composite fuselage and laminar-flow wing control surface development. Attention is given to a tooling and production method conceived for the manufacture of integrally stiffened CFRP shells, as well as to the manufacture of cabin interiors. Advanced superplastically formed aluminum alloy substructures are used in shallow wing and stabilizer sections. O.C.

A87-48771
SELECTED PROBLEMS IN THE DECISION MAKING PROCESS FOR FUTURE SMALL TRANSPORT/UTILITY AIRCRAFT
JOHANNES SPINTZYK and GERHARD BEHRENDT (Dornier GmbH, Friedrichshafen, West Germany) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 12 p. refs
(SAE PAPER 871-045)

An aircraft company undertaking a new aircraft development program faces complex problems such as financial risks, prediction of future market development, implementation of advanced technologies, economics/prices, and production cost. In the present paper, the regional aircraft market is discussed with emphasis placed on return on investment and modern cost-saving production methods. It is noted that allowance must be made for certain unforeseeables such as oil crises, natural catastrophes, and the influence of terrorism. K.K.

A87-48908#
THE COMING-OF-AGE OF THE PUBLIC TRANSPORT HELICOPTER
JOHN DENT (Civil Aviation Authority, London, England) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 12 p.

Research being done to improve public transport helicopter safety is reviewed. Ditching performance, helicopter health monitoring, crashworthiness, human factors in accidents, safety monitoring, and operational aspects of safety are discussed. Future trends in the area of public helicopter transport are briefly addressed. C.D.

A87-48933#
THE FAMILIES OF MILITARY HELICOPTERS - A FASHION, A NEED OR A CONVENIENCE?
EMIDIO VALENTE and ANTONIO GIOVANNINI (Agusta S.p.A., Milan, Italy) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 19 p.

The family concept of military helicopters is considered with particular reference to two European programs: the Italian A-129 and the British-Italian EH-101. It is noted that this concept starts from precise military requirements with the aim of achieving better operational capabilities together with a substantial reduction in costs with respect to acquisition, maintenance, operation, and personnel. It is argued that, in this sense, this concept is not a transient fashion but a need which must be translated in such a way that it has a positive impact on the civil market. It is concluded that, if widely applied, this concept will result in substantial benefits for European interests from both the military and the industrial points of view. B.J.

A87-48934#
MODERN TECHNOLOGIES FOR FUTURE LIGHT HELICOPTERS
HUBERT FROMMLET and CLAUS SCHICK (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 13 p.

The paper describes the development of advanced helicopter subsystems at MBB, the objective of which is to improve the efficiency and comfort and to minimize the life cycle costs of future helicopters. Improvements in rotor system technology have been achieved through the use of advanced blade airfoils and blade planforms, as well as through the use of bearingless rotors with reduced weight and an increased component life. Vibrational levels have been reduced by a new rotor isolation system combined with a flat two-stage main transmission. Weight and manufacturing costs have been reduced through the use of composite fuselage structures and a special cockpit design. Finally, new display systems have been found to enhance safety through reduced pilot workloads. B.J.

A87-48939#
HELICOPTER CONDITION MONITORING IN UK MILITARY SERVICE TODAY
R. K. PINHEY and D. MORGAN (Royal Navy, London, England) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 8 p.

Current techniques and their equipment and limitations for monitoring the condition of helicopters are discussed. Oil analysis programs for transmission systems, engine health monitoring, and vibrational analysis including tracking and balancing of main rotors are examined, stressing environmental problems and operational restrictions. The problems of data analysis and collection for scattered military units are discussed. The outstanding needs for condition monitoring are indicated and explained. C.D.

A87-48940#
OPERATIONAL EXPERIENCE WITH THE ADVANCED TRANSMISSION HEALTH MONITORING TECHNIQUES ON THE WESTLAND 30 HELICOPTER
M. E. COLLIER-MARSH and D. G. ASTRIDGE (Westland Helicopters, Ltd., Yeovil, England) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 17 p.

Experience with various health monitoring techniques both in commercial operations and in development aircraft programs is reviewed. Particular attention is given to oil analysis, magnetic plug examination, the TEDECO quantitative debris monitor, a vibration monitoring system, and in situ inspection in connection with the Westland 30 helicopter. The health monitoring completed to date has been effective in removing two gearboxes from aircraft prior to the defect becoming an airworthiness problem. K.K.

A87-48941#
HELICOPTER ROTOR HEAD CONDITION MONITORING
I. C. CHEESEMAN and R. TALBOT (Stewart Hughes, Ltd., Southampton, England) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 20 p. Research supported by the Ministry of Defence (Procurement Executive).

Condition monitoring of rotor heads on helicopters has traditionally depended on manual acquisition of data and subsequent analysis. This paper describes an automatic system which provides accurate track, lag, and blade-velocity information on every rotor revolution. Interpretation of blade-motion and fuselage-mounted-accelerometer data simultaneously for both steady and varying-rotor-speed tests leads to powerful diagnostic techniques. Interpretation of such data is illustrated. An example of the use of the tracker for more detailed blade-motion experiments in which the first three flap-bending blade modes are determined is included. The real variation with time is illustrated from a continuous two minute recording. A technology demonstration unit for use by helicopter manufacturers and operators is described. Author

A87-48942#
REPORT OF THE WORKING GROUP ON HELICOPTER HEALTH MONITORING
European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 90 p. refs

The Working Group reviewed the current state-of-the-art and considered the proposed airworthiness requirements for future helicopters, seeking to define the health monitoring (HM) improvements which would be needed to realize the intended safety objectives. The main conclusions were that HM is particularly relevant to the transmission, rotor systems, flight control systems, and engines; and that current technology can provide airworthiness and reliability benefits. Areas in which research or application development is required are addressed; and details of the time scale for the R&D activity are considered. B.J.

A87-48943#
THE INTEGRATION OF HEALTH MONITORING TECHNIQUES FOR HELICOPTER GEARBOXES
M. J. D. BROUGHAM (Ministry of Defence (Procurement Executive), London, England) and P. GADD (Royal Navy, Fleetlands, England) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 21 p. refs

The joint use of several health monitoring techniques to provide comprehensive coverage of possible failure modes in a typical transmission gearbox is discussed. The relative value of conventional status parameters such as oil level, pressure, and temperature is assessed together with that of newer techniques such as wear debris and vibration analysis. The development of the Anglo-Italian EH 101 Health and Usage Monitoring System is used to illustrate the process of sensor location and the validation of processor algorithms. It is concluded that the health monitoring system for a new gearbox should be considered from the design stage and fully integrated into the development program; it will improve airworthiness and reduce maintenance costs so long as the data produced by the system are handled and interpreted correctly. K.K.

A87-48944#
MANAGING HELICOPTER DYNAMIC COMPONENTS
K. PIPE (Stewart Hughes, Ltd., Southampton, England) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 18 p.

The constraints to be observed in the design of an on-condition maintenance system for helicopter machinery are detailed. A low-cost data-base solution is presented which is an extension of a system (the Prototype Information Management System) which has already been successfully demonstrated to the RAF for fixed wing aeroengine management. It is noted that the ability to provide a remote terminal to maintain the essential monitoring functions while the helicopter is on detachment or deployed away from the maintenance base is essential for a system designed to support a helicopter. K.K.

A87-49156
AIAA FLIGHT SIMULATION TECHNOLOGIES CONFERENCE, MONTEREY, CA, AUG. 17-19, 1987, TECHNICAL PAPERS
Conference sponsored by AIAA. New York, American Institute of Aeronautics and Astronautics, 1987, 167 p. For individual items see A87-49157 to A87-49176.

Papers are presented on such topics as simulation in ADA, multiaircraft simulation, part-task simulation techniques, the effect of time delay and simulation mode on closed-loop pilot-vehicle performance, temporal fidelity in aircraft simulation visual systems, and the response of airline pilots to flight simulator motion. Consideration is also given to the flight simulation of multiple aircraft and helicopters using a single high-performance computer; the development of a real-time blade element aeroelastic rotor motion; simulation in support of advanced cockpit performance; and a flight simulator evaluation of the approach path parameters for MLS curved aproaches. B.J.

A87-49198
SOCIETY OF FLIGHT TEST ENGINEERS, ANNUAL SYMPOSIUM, 17TH, WASHINGTON, DC, AUG. 10-14, 1986, PROCEEDINGS
Symposium sponsored by the Society of Flight Test Engineers. Lancaster, CA, Society of Flight Test Engineers, 1986, 176 p. For individual items see A87-49199 to A87-49214.

Consideration is given to the management of the USAF operational test and evaluation flight-test programs, F14-A inlet icing, the satisfaction of flight-test data requirements of flight training simulators, the use of flight-test techniques in aircraft accident investigations, a report on Shuttle Mission STS 51-A, and the STOL/Maneuver Technology Demonstrator Test Program. Other topics discussed include flight simulator fidelity in a total G-force environment, the test and development of holographic HUD systems, NLR contributions to the flutter certification of aircraft with external stores, full envelope aerodynamic modeling of the Harrier aircraft, the effects of inlet temperature on the generalized performance parameters of the T56 engine, and the development of an air-to-surface automated maneuvering attack system on the AFTI/F-16. B.J.

A87-49208
THE E-3 JOINT TEST FORCE - A UNIQUE TEST ORGANIZATION
BRUCE J. GASPER (USAF, AWACS Field Test Div., Seattle, WA) IN: Society of Flight Test Engineers, Annual Symposium, 17th, Washington, DC, Aug. 10-14, 1986, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1986, p. 4.3-1 to 4.3-6.

The E-3 Joint Test Force was created to oversee the Airborne Warning and Control System test program at the contractor's facility in Seattle, WA. The test force has remained on-site long after the initial AWACS development test and evaluation was completed in order to support AWACS enhancement programs and to support other tests requiring the JTF's specially modified JE-3C AWACS aircraft. The JTF member organizations and personnel change as the mission changes. Throughout the program evolution, the people

of the JTF have met all past challenges and they look forward to meeting the challenges of the future. Author

A87-49627
DESIGNING FOR LOW COST FABRICATION; PROCEEDINGS OF THE WORKSHOP, LOUGHBOROUGH UNIVERSITY OF TECHNOLOGY, ENGLAND, APR. 16, 17, 1986
London, Royal Aeronautical Society, 1987, 233 p. For individual items see A87-49628 to A87-49637.

The present conference discusses approaches to cost engineering, the improvement of cost effectiveness in fabrication of aerospace structures with conventional materials, the importance of research to aerospace parameters and concepts, airframe cost engineering methods, carbon fiber-reinforced composite applications to airframes, the application of composites to propulsion systems, and design criteria for low cost structures fabrication. Also discussed are low cost missile structure fabrication, the use of plastics for the fabrication of a launch-tube saddle, low cost composite rotor blade manufacture, novel manufacturing techniques for aircraft, kevlar manufacturing for weapons systems, novel airframe bonding techniques, and low cost aluminum and titanium alloy manufacture using superplastic forming and diffusion bonding. O.C.

A87-49635
NOVEL MANUFACTURING TECHNIQUES FOR AIRCRAFT
G. W. HUGHES (British Aerospace, PLC, London, England) IN: Designing for low cost fabrication; Proceedings of the Workshop, Loughborough, England, Apr. 16, 17, 1986 . London, Royal Aeronautical Society, 1987, p. 160-173.

The typical route for the manufacture of an aircraft structure in conventional materials is for raw material to be processed either by machining or sheet metal fabrication through a number of levels of subassembly to the assembly of major components from fuselage, wings, etc., to the final assembly of the aircraft. All these areas are being developed to minimize the cost of manufacture, e.g., flexible manufacturing systems have been introduced in both the machining areas and in sheet metal fabrication. In the subassembly areas progress has been made through the use of robotics and automated assembly techniques. This paper will cover improvements in the subassembly area using the novel technqiues of Super Plastic Forming and Diffusion Bonding of titanium and aluminum alloys, but will concentrate on the impact of the introduction of Carbon Fiber Composite (CFC) in all areas from detail manufacture through to assembly. Author

A87-49636
NOVEL JOINTING TECHNIQUES FOR AIRCRAFT
P. R. GILBERT, R. W. LEWIS, and S. J. PALMER (3M United Kingdom, PLC, Adhesives, Coatings and Sealants Div., Swansea, Wales) IN: Designing for low cost fabrication; Proceedings of the Workshop, Loughborough, England, Apr. 16, 17, 1986 . London, Royal Aeronautical Society, 1987, p. 189-197.

In recent years, the thrust of aircraft structural adhesive development efforts has been toward long-term durability and high strength retention under severe environmental conditions; this has led to a film adhesive which, while cured at 120 C, will operate continuously at 150 C when in service. Further development of elastomerically modified structural adhesives has led to significant mechanical property improvements, such as improved resistance to mechanical and thermal shock, without loss of lap shear strength, at both room and elevated temperatures. Attention is presently given to state-of-the-art applications to fuel tank bonding, titanium/composite bonding, composite aircraft engine sound-suppressant panel bonding, and expandable fillers for aircraft interiors. O.C.

A87-49638
INTERNATIONAL HELICOPTER FORUM, 16TH, BUECKEBURG, WEST GERMANY, JUNE 11, 12, 1986 AND INTERNATIONAL AEROSPACE EXHIBITION, HANOVER, WEST GERMANY, JUNE 6-15, 1986, REPORTS [INTERNATIONALES HUBSCHRAUBER-FORUM, 16TH, BUECKEBURG, WEST GERMANY, JUNE 11, 12, 1986 AND INTERNATIONALE LUFTFAHRT-AUSSTELLUNG, HANOVER, WEST GERMANY, JUNE 6-15, 1986, VORTRAEGE]
Bueckeburg, West Germany, Helicopter Center, 1986, 232 p. In German and English. For individual items see A87-49639 to A87-49646.

Various papers on helicopter research are presented. The topics addressed include: new developments in West European military and civilian helicopters, bus systems, navigation, night fighting equipment in helicopters, helicopter survival capability, new engine developments for helicopters in Western Europe and the U.S., new developments in dynamic helicopter components, and helicopter logistics. C.D.

A87-49639#
NEW DEVELOPMENTS IN MILITARY AND CIVIL HELICOPTERS IN WESTERN EUROPE [NEUENTWICKLUNGEN MILITAERISCHER UND ZIVILER H UBSCHRAUBER IN WESTEUROPA]
F. VON DOBLHOFF IN: International Helicopter Forum, 16th, Bueckeburg, West Germany, June 11, 12, 1986 and International Aerospace Exhibition, Hanover, West Germany, June 6-15, 1986, Reports . Bueckeburg, West Germany, Helicopter Center, 1986, 10 p. In German.

The historical development of the helicopter is briefly reviewed, and the latest developments in Western European civil and military helicopters are discussed. The combat helicopters Agusta A-129 and Westland Lynx III, the Italian-British EH-101 project, the French HAP and HAC and the German PAH-II combat helicopters, and the European NH-90 transport helicopter are examined. The importance of multinational cooperation in new helicopter development is stressed. C.D.

A87-49643#
HELICOPTER SURVIVABILITY [UEBERLEBENSFAEHIGKEIT VON HUBSCHRAUBERN]
SIEGFRIED WAGNER (Muenchen, Universitaet der Bundeswehr, Munich, West Germany) IN: International Helicopter Forum, 16th, Bueckeburg, West Germany, June 11, 12, 1986 and International Aerospace Exhibition, Hanover, West Germany, June 6-15, 1986, Reports . Bueckeburg, West Germany, Helicopter Center, 1986, 35 p. In German. refs

The studies and measures that must be taken to increase helicopter survivability are examined. The missions that combat helicopters typically undertake and the most important threats that they face are reviewed, and the problems of analyzing mission threats and combat flight data are considered. Measures that can be taken to reduce the vulnerability of helicopters, including crashworthy designs, are addressed. C.D.

A87-49645#
NEW DEVELOPMENTS IN DYNAMIC HELICOPTER COMPONENTS [NEUENTWICKLUNG DYNAMISCHER HUBSCHRAUBERKOMPONENTEN]
G. REICHERT (Braunschweig, Technische Universitaet, Brunswick, West Germany) IN: International Helicopter Forum, 16th, Bueckeburg, West Germany, June 11, 12, 1986 and International Aerospace Exhibition, Hanover, West Germany, June 6-15, 1986, Reports . Bueckeburg, West Germany, Helicopter Center, 1986, 22 p. In German.

Examples are used here to show how new design elements and new materials are influencing helicopter rotor development. The uses of fiber-reinforced composite structures in complete dynamic systems are examined. Developmental tendencies in new helicopter configurations are briefly addressed. C.D.

A87-49646#
HELICOPTER LOGISTICS
ALEC MERVYN CUNDICK (Westland Helicopters, Ltd., Customers Support Div., Yeovil, England) IN: International Helicopter Forum, 16th, Bueckeburg, West Germany, June 11, 12, 1986 and International Aerospace Exhibition, Hanover, West Germany, June 6-15, 1986, Reports . Bueckeburg, West Germany, Helicopter Center, 1986, 19 p.

The manufacturer's contribution to cost-effective support of helicopters for their execution of operational tasks is discussed. The logistics task and its uniqueness for the helicopter is defined, and the business/market scenario in which it is to be executed and the constraints and problems thus imposed on logistic support are examined. The tools that are available to ensure that cost-effective logistic support is achieved in future collaborative projects are considered. C.D.

A87-50372#
TIME TO REINVENT THE GENERAL AVIATION AIRCRAFT
ROBERT F. STENGEL (Princeton University, NJ) Aerospace America (ISSN 0740-722X), vol. 25, Aug. 1987, p. 24-27.

Revival of the U.S. general aviation aircraft market is presently suggested to require radical redesign efforts aimed at the incorporation of modern equipment in all systems. The primary reasons for the decline in production numbers within this category are high production and certification costs, together with high manufacturer liability. Attention is presently given to the benefits obtainable through aggressive application of microprocessor-based technologies to private aircraft design, automated manufacture, and operation, in conjunction with state-of-the-art materials and propulsion systems. O.C.

A87-50373*# National Aeronautics and Space Administration, Washington, D.C.
REKINDLED VISION OF HYPERSONIC TRAVEL
RAYMOND S. COLLADAY (NASA, Washington, DC) Aerospace America (ISSN 0740-722X), vol. 25, Aug. 1987, p. 30, 31, 34.

NASA has joined with the DOD to conduct the National Aerospace Plane (NASP) program, whose experimental test vehicle will be designated the X-30. NASP will study the X-30's takeoff from a runway under its own power, acceleration to high Mach number on the basis of airbreathing propulsion, emergence into LEO, reentry into the earth atmosphere, and descent to a powered horizontal landing. NASP will thereby generate technology base data for three distinct types of aircraft: upper-atmosphere hypersonic-cruise aircraft, LEO space transports, and military transatmospheric vehicles. The current concept-validation phase of NASP focuses on airbreathing propulsion, lightweight/high-strength heat-resistant materials, and compuational fluid dynamics. O.C.

A87-50437#
NONLINEAR GUIDANCE ALGORITHM FOR AIRCRAT PURSUIT-EVASION AND TARGET INTERCEPTION
M. D. ARDEMA (Santa Clara University, CA), N. RAJAN, and L. YANG (Sterling Software, Palo Alto, CA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 316-327. refs
(AIAA PAPER 87-2316)

The algorithm developed by Ardema and Rajan (1987) for real-time, near-optimal, three-dimensional guidance of high-performance aircraft in pursuit-evasion and target-interception missions is further developed in this paper in three ways. First, example calculations of slow subsystem extremals are performed in feedback form for a contemporary high-performance aircraft. Second, details are given of the transformation between the relative reference frame, in which onboard measurements are made, and the inertial frame, in which slow subsystem extremals are stored. Third, the nonlinear guidance law is developed to an algorithmic form suitable for digital-computer implementation. All three of these developments are necessary for the eventual implementation of the algorithm. Author

A87-50525*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A PILOTED SIMULATOR EVALUATION OF A GROUND-BASED 4D DESCENT ADVISOR ALGORITHM
STEVEN M. GREEN, THOMAS J. DAVIS, and HEINZ ERZBERGER (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1173-1180.
(AIAA PAPER 87-2522)

A ground-based, four-dimensional (4D) descent-advisor algorithm is under development at NASA Ames Research Center. The algorithm combines detailed aerodynamic, propulsive, and atmospheric models with an efficient numerical integration scheme to generate 4D descent advisories. This paper investigates the ability of the 4D descent advisor algorithm to provide adequate control of arrival time for aircraft not equipped with on-board 4D guidance systems. A piloted simulation was conducted to determine the precision with which the descent advisor could predict the 4D trajectories of typical straight-in descents flown by airline pilots under different wind conditions. The effects of errors in the estimation of wind and initial aircraft weight were also studied. A description of the descent advisor as well as the results of the simulation studies are presented. Author

N87-26855# Aeronautical Systems Div., Wright-Patterson AFB, Ohio.
A COMPARISON OF AIR FORCE VERSUS FEDERAL AVIATION ADMINISTRATION AIRFRAME STRUCTURAL QUALIFICATION CRITERIA: MIL-A-87221 (USAF) VERSUS FAR PARTS 23 AND 25 Final Report, 15 Aug. 1984 - 15 Aug. 1986
PATRICK J. LONG and JAMES E. ELLIS Aug. 1986 38 p
(AD-A180922; ASD-TR-86-5018) Avail: NTIS HC A03/MF A01 CSCL 01B

Air Force acquisitions of off-the-shelf commercially developed aircraft for use in cargo, tanker, transport, and trainer roles have made it essential that the capability be developed within Aeronautical Systems Division acquisition organizations to evaluate commercially developed aircraft designs for adequacy in meeting Air Force requirements. Development of this capability to evaluate commercial aircraft designs has been complicated by a lack of understanding of the differences in the design approaches embodied in Air Force and Federal Aviation Administration airframe qualification procedures. This report is intended to provide an insight into Federal Aviation Regulation Parts 23 and 25, the FAA regulations which govern airplane qualification and certification, including airframe structures. This report is intended primarily for use by ASD engineers familiar with Air Force regulations and specifications governing aircraft structural design, particularly MIL-A-87221(USAF). GRA

N87-27596*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
JOINT UNIVERSITY PROGRAM FOR AIR TRANSPORTATION RESEARCH, 1985
FREDERICK R. MORRELL, comp. Jul. 1987 100 p Conference held in Atlantic City, N.J., 30 Jan. 1986
(NASA-CP-2453; NAS 1.55:2453; NAS) Avail: NTIS HC A05/MF A01 CSCL 01B

Air transportation research being carried on at the Massachusetts Institute of Technology, Princeton University, and Ohio University is discussed. Global Positioning System experiments, Loran-C monitoring, inertial navigation, the optimization of aircraft trajectories through severe microbursts, fault tolerant flight control systems, and expert systems for air traffic control are among the topics covered.

N87-27609*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SOME INNOVATIONS AND ACCOMPLISHMENTS OF AMES RESEARCH CENTER SINCE ITS INCEPTION
May 1987 38 p Original contains color illustrations
(NASA-TM-88348; A-86375; NAS 1.15:88348) Avail: NTIS HC A03/MF A01 CSCL 01B

The innovations and accomplishments of Ames Research Center from 1940 through 1966 are summarized and illustrated. It should be noted that a number of accomplishments were begun at the NASA Dryden Flight Research Facility before that facility became part of the Ames Research Center. Such accomplishments include the first supersonic flight, the first hypersonic flight, the lunar landing research vehicle, and the first digital fly-by-wire aircraft. Author

N87-27610# Michigan State Univ., East Lansing.
CORROSION MAINTENANCE AND EXPERIMENTAL DESIGN Final Report, 1 Apr. 1984 - 31 Mar. 1986
ROBERT SUMMITT 30 Jan. 1987 82 p
(Contract F33615-84-C-5066)
(AD-A181926; AFWAL-TR-86-4074) Avail: NTIS HC A05/MF A01 CSCL 11F

The objective of this program was to provide external assessments, analyses, experimental design, liaison, and direction in support of logistics-oriented technology research and development programs sponsored by AFWAL Materials Laboratory and the Air Force logistics Command. The purpose was to provide Air Force program management maximum visibility of the overall direction of efforts in: (1) evaluation of corrosion inhibitor effectiveness for aircraft rinsing, (2) improvements to AFLC's Maintenance Data Collection System (MDCS), (3) improvements to base level corrosion severity indices, and (4) adapting corrosion prediction to an airworthiness model. GRA

N87-27611# Naval Postgraduate School, Monterey, Calif.
THE EFFECTS OF FLIGHT HOURS AND SORTIES ON FAILURE RATES M.S. Thesis
STEVEN J. PHILLIPS Mar. 1987 139 p
(AD-A182084) Avail: NTIS HC A07/MF A01 CSCL 01B

This thesis focuses on the modeling of F-14A component failure rates. Current methodology employs the Exponential distribution to model component failures and the associated Poisson distribution to determine expected demand. Three other failure rate distributions are explored as alternatives: a Weibull flight hour model, a Geometric sortie-dependent model, and a Mixed sortie-flight hour model. The expected number of component failures is calculated for each model and a comparison is made between the current model and these alternatives. The specific results pertain to aircraft of this type but the concepts employed can be applied to other aircraft as well. The Geometric model provided a better fit for components which were not operated continuously, and the Weibull performed better when the components were operated continuously. Overall, the Exponential was the least effective model for the nine components studied. GRA

N87-27612# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
CHINA AERODYNAMICS RESEARCH SOCIETY
10 Apr. 1987 242 p Transl. into ENGLISH of Kongquidonglixue Xuebao (China), v. 4, no. 1, 1986 p 1-127
(AD-A182577; FTD-ID(RS)T-0853-86) Avail: NTIS HC A11/MF A01 CSCL 01A

Following are the partial contents of a report by the China Aerodynamics Researxh Society: Airfoil Design at Sonic Velocity; Passive Control of Shock Waves on Transonic Airfoils; Computer-Aided Asymptotic Expansions of Solution for Incompressible Potential Flow in Slender Two-Dimensional Nozzle; Numerical Modeling of Combustor Recirculation Flowfield; Multiple Laminar Flows of a Viscous, Incompressible Fluid Through a Curved Tube; An Improvement to the Numerical Method for Calculations of Aircraft Configuration Longitudinal Aerodynamic Characteristics; Numerical Calculation of Swirling Flow in Combustor; Calculation of Transonic Viscous Flows Over an Arbitrary Airfoil; A Review of Aerodynamic Characteristics for Several Recovery Schemes of Reentry Vehicles; A Primary Investigation of Drag Reduction and Mechanism for a Blunt Body of Revolution with Slanted Base. GRA

02

AERODYNAMICS

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

A87-47087#
A METHOD FOR CALCULATING AXISYMMETRIC AFTERBODY FLOWS
A. J. PEACE (Aircraft Research Association, Ltd., Bedford, England) Journal of Propulsion and Power (ISSN 0748-4658), vol. 3, July-Aug. 1987, p. 357-364. Research supported by the Ministry of Defence (Procurement Executive). refs

A numerical method for calculating the flow around axisymmetric afterbodies with single or coaxial jets is presented. The solution technique used is based on the modification of an Euler method to include a representation of viscous effects on the afterbody surface and in the wake region. The development of the afterbody boundary layer and its continuation into the wake is predicted by an integral boundary-layer method used in inverse mode. The boundary-layer equations can thus be integrated through a region of separated flow. Jet entrainment due to turbulent mixing is modeled empirically. Results from the method and their comparison with experimental data are presented. The agreement obtained demonstrates that the method can be used in a civil or military design environment. Author

A87-47153
A WAKE SOURCE MODEL FOR AIRFOILS WITH SEPARATED FLOW
G. V. PARKINSON and W. YEUNG (British Columbia, University, Vancouver, Canada) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 179, June 1987, p. 41-57. NSERC-supported research. refs

In an extension of an earlier potential-flow theory using conformal mapping and source singularities in the wake region to simulate two-dimensional bluff-body flow, new mapping sequences and additional boundary conditions are presented for the application of the method to lifting airfoils fitted with upper-surface spoilers or lower-surface split flaps of arbitrary size, location, and erection angle. The only empirical input is the base pressure coefficient. Calculations are presented of pressure distribution and lift for several cases of a Joukowsky airfoil fitted with a spoiler or a split flap, and these results are compared with experimental data from wind tunnel tests. Good agreement is found. Author

A87-47161
TRIPLE-DECK SOLUTIONS FOR SUPERSONIC FLOWS PAST FLARED CYLINDERS
PH. GITTLER and A. KLUWICK (Wien, Technische Universitaet, Vienna, Austria) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 179, June 1987, p. 469-487. refs
(Contract FFWF-P-5557)

Using the method of matched asymptotic expansions, the interaction between axisymmetric laminar boundary layers and supersonic external flows is investigated in the limit of large Reynolds numbers. Numerical solutions to the interaction equations are presented for flare angles alpha that are moderately large. If alpha is greater than 0 the boundary layer separates upstream of the corner and the formation of a plateau structure similar to the two-dimensional case is observed. In contrast to the case of planar flow, however, separation can occur also if alpha is less than 0,

owing to the axisymmetric effect of overexpansion and recompression. The separation point then is located downstream of the corner and, most remarkably, a hysteresis phenomenon is observed. Author

A87-47446
NONSYMMETRIC TRANSONIC FLOW OVER AN AIRFOIL [NESIMETRICHNE TRANSZVUKOVE OBTIKANNIA PROFILIU]
S. K. ASLANOV (Odesskii Gosudarstvennyi Universitet, Odessa, Ukrainian SSR) Akademiia Nauk Ukrains'koi RSR, Dopovidi, Seriia A - Fiziko-Matematichni ta Tekhnichni Nauki (ISSN 0002-3531), March 1987, p. 25-28. In Ukrainian. refs

The problem of sonic flow over a plate at a small angle of attack is solved as a problem with singular perturbations using the Tricomi approximation. By extending the theory to the full Chaplygin equation, it is determined that the order of smallness is maintained for the first coefficient of the regular part of the solution. For the correct asymptotic form in terms of the vanishing angle of attack, the solution obtained here is different from that for the reduced statement of the Guderley problem. V.L.

A87-47658
THEORY OF SMALL DISTURBANCES FOR FLAT, NEAR-SONIC FLOW THROUGH A VIBRATING CASCADE [THEORIE KLEINER STOERUNGEN FUER EBENE, SCHALLNAHE STROEMUNG DURCH SCHWINGENDE SCHAUFELGITTER]
F. KOLLER and A. KLUWICK (Wien, Technische Universitaet, Vienna, Austria) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, West Germany, Apr. 1-4, 1986) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 67, no. 5, 1987, p. T 296-T 298. In German. refs

An improved method for calculating flow disturbances is presented which can be used to determine the structure of the flow field starting from near-sonic, unsteady nozzle flow and near-sonic, steady cascade flow. An analytical method of characteristics is used to obtain nonlinear, unsteady effects for nearly one-dimensional flows and temporally unchanging geometry in a relatively simple fashion. Any combination of the profile thickness, reduced frequency, and vibrational amplitude can be determined for a given laminar flow, and the result will also hold valid for unsteady flow. C.D.

A87-47660
NUMERICAL SOLUTION OF THREE-DIMENSIONAL TRANSONIC FLOWS PAST AN OSCILLATING THIN BODY
K. KOZEL and M. VAVRINCOVA (Ceske Vysoke Uceni Technicke, Prague, Czechoslovakia) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, West Germany, Apr. 1-4, 1986) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 67, no. 5, 1987, p. T 300-T 302.

This paper addresses the numerical solution of three-dimensional unsteady transonic flows past an oscillating thin body in a tunnel. The governing equation is the unsteady small disturbance potential equation. Using the conservative form of the governing equation, a weak solution of the boundary value problem and an appropriate finite difference approximation are defined. The solution is presented in the form of the Mach number distributions along the upper and lower body surfaces. C.D.

A87-47664
TRANSONIC SUPERSONIC FLOWS [TRANSSONISCHE UEBERSCHALLSTROEMUNGEN]
F. OBERMEIER (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, West Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, West Germany, Apr. 1-4, 1986) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 67, no. 5, 1987, p. T 314, T 315. In German.

An attempt is made to overcome the fact that the solutions of two-dimensional, conventional, nonlinear supersonic flows become singular. A valid solution is found for transonic supersonic flows around slender bodies in a general flow field. The method of fitted asymptotic developments is used to demonstrate a relationship of these solutions to those of conventional supersonic flows, and a 'composite' solution valid for both conventional and transonic supersonic flows is derived from these solutions. The solutions are used to calculate the pressure distributions along the profile around which flow occurs and the corresponding drag coefficients. The results are compared with those from the 'Reverse-Flow Theorem' of Schnerr and Zierep (1985). C.D.

A87-47665
PRESSURE WAVES - BOUNDARY LAYER INTERACTION [DRUCKWELLEN - GRENZSCHICHT-WECHSELWIRKUNG]
H. REISTER (DFVLR, Aerodynamische Versuchsanstalt, Goettingen, West Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, West Germany, Apr. 1-4, 1986) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 67, no. 5, 1987, p. T 322, T 323. In German. refs

The interaction between upflow pressure waves generated by flow around a flat plate and the boundary layer of the plate is simulated. A Runge-Kutta finite volume method is used to solve the compressible Navier-Stokes equations. It is found that the waves steepen to a sawtooth pressure shock and are simultaneously damped. Regions of unsteady backflow form in the boundary layer when a critical amplitude is surpassed. C.D.

A87-47673
EXPERIMENTAL DETERMINATION OF POSITION OF VORTEX CORE AT HIGHER ANGLE OF ATTACK IN TRANSONIC-SUPERSONIC FLOW
A. NASTASE and G. BOZINIS (Aachen, Rheinisch-Westfaelische Technische Hochschule, West Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, West Germany, Apr. 1-4, 1986) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 67, no. 5, 1987, p. T 375-T 378. refs

The core positions of leading edge vortices have been experimentally obtained by interpreting oil pictures on the upper side of three wing models: a wedged delta wing fitted with a fuselage, a double-wedged wing, and a wedged delta wing. It is found that the vortex core angle increases when the angle of attack decreases and the Mach number increases as shown in several previous studies. The angle decreases under the influence of the fuselage. The vortex shape in the forward part is not influenced by convex surface modifications at the rear part of the wing. C.D.

A87-47674
THEORETICAL PREDICTION OF AERODYNAMIC CHARACTERISTICS ON WINGS IN TRANSONIC-SUPERSONIC FLOW AT HIGHER ANGLE OF ATTACK AND ITS AGREEMENT WITH EXPERIMENTAL RESULTS
A. NASTASE and A. SCHEICH (Aachen, Rheinisch-Westfaelische Technische Hochschule, West Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, West Germany, Apr. 1-4, 1986) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 67, no. 5, 1987, p. T 378-T 381. refs

A method for predicting the lift and pitching moment coefficients for thick, lifting delta wings alone or fitted with fuselages with arbitrarary camber, twist, and thickness distributions is reported. The method involves solving the fully linearized hyperbolic boundary value problem for axial disturbance velocities of thin and thick-symmetrical wing components. Good agreement exists between the method's predictions and experimental results. The method is general and very rapid, and can therefore be useful in aircraft design. C.D.

A87-47747
QUASI-TRANSONIC FLOW PAST DELTA WINGS
GILBERTO SCHLEINIGER (Rensselaer Polytechnic Institute, Troy, NY) Quarterly of Applied Mathematics (ISSN 0033-569X), vol. 45, July 1987, p. 265-277. refs
(Contract AF-AFOSR-82-0155)

Results obtained by Fraenkel and Watson (1964) indicate that linearized supersonic theory for flows past delta wings must be corrected for the cases of wing sweepback angles close to the Mach angle. This paper presents results of calculations based on a local transonic expansion valid near the leading edge. It is concluded that the numerical results obtained support the statements of Fraenkel and Watson regarding the drag correction due to the nonlinear character of the flow near the leading edge.
B.J.

A87-47850
SOME MATHEMATICAL PROBLEMS IN THE THEORY OF TRANSONIC FLOW [ZU EINIGE MATHEMATISCHEN PROBLEMEN IN DER THEORIE DER TRANSONISCHEN STROEMUNG]
K. KOZEL and J. POLASEK (Ceske Vysoke Uceni Technicke, Prague, Czechoslovakia) Mathematical Methods in the Applied Sciences (ISSN 0170-4214), vol. 9, no. 2, 1987, p. 177-197. In German. refs

This paper deals with a definition of a weak solution of steady plane transonic flows past a thin profile, with the properties of the solution across a shock wave, and with a derivation of a conservative difference scheme suitable for numerical solution of the abovementioned problem by a finite difference method. The paper presents several examples of numerical solutions of transonic flows past a profile, through a plane cascade, and some three-dimensional results. The numerical results are compared with experimental ones or with numerical ones by other authors.
Author

A87-47853
DEVELOPMENT EFFICIENT ALGORITHMS FOR THE SOLUTIONS OF FULL POTENTIAL AND EULER EQUATIONS ON VECTOR COMPUTERS
R. K. JAIN, N. KROLL, and R. RADESPIEL (DFVLR, Institut fuer Entwurfs-Aerodynamik Brunswick, West Germany) IN: The efficient use of vector computers with emphasis on computational fluid dynamics; Proceedings of the Workshop, Karlsruhe, West Germany, Mar. 13-15, 1985 . Brunswick, West Germany, Friedr. Vieweg und Sohn, 1986, p. 35-46. refs

For the efficient use of vector computers, three problems in the area of computational aerodynamics are dealt with. These are: 3-D full potential equation, body-fitted grid generation for wing-body configurations and 3-D Euler equations. Special features of each of these problems are emphasized. Various techniques to overcome the bottlenecks appearing therein are described.
Author

A87-47855
SIMULATING 3D EULER FLOWS ON A CYBER 205 VECTOR COMPUTER
P. J. KOPPENOL (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: The efficient use of vector computers with emphasis on computational fluid dynamics; Proceedings of the Workshop, Karlsruhe, West Germany, Mar. 13-15, 1985 . Brunswick, West Germany, Friedr. Vieweg und Sohn, 1986, p. 71-92. refs

A computational method for solving the three-dimensional Euler equations is studied. The method is based upon an upwind flux-difference splitting scheme by Osher (1981), exhibiting an implicit mechanism for numerical viscosity, in connection with an explicit time-marching finite-volume technique. The computer program is developed to run efficiently on both a scalar computer and the Cyber 205 vector computer. Demands made by the necessity of vectorizability of the code, on algorithm, data-structuring, and the code itself, are discussed. Also, the large data sets involved in three-dimensional calculations appear to impose severe claims on central-memory size, I/O devices and line connections. The method is tested for a transonic and supersonic quasi-two-dimensional channel flow. The Euler model is found to give an accurate simulation of aerodynamic phenomena in the channel.
Author

A87-47856
VECTOR ALGORITHM FOR LARGE-MEMORY CYBER 205 SIMULATIONS OF EULER FLOWS
ARTHUR RIZZI (Flygtekniska Forsoksanstalten, Bromma, Sweden) and J. P. THERRE (Lausanne, Ecole Polytechnique Federale, Switzerland) IN: The efficient use of vector computers with emphasis on computational fluid dynamics; Proceedings of the Workshop, Karlsruhe, West Germany, Mar. 13-15, 1985 . Brunswick, West Germany, Friedr. Vieweg und Sohn, 1986, p. 93-116.

The paper reviews a finite-volume method for the large-scale numerical simulation of fluid flow and discusses the vector coding and execution of the procedure on the CYBER 205. With the proper structure given to the data by the grid transformation each coordinate direction can be differenced throughout the entire grid in one vector operation. Boundary conditions must be interleaved which tends to inhibit the concurrency of the overall scheme, but a strategy of no data motion together with only inner-loop vectorization is judged to be the best compromise. The computed example of transonic vortex flow separating from the sharp leading edge of a delta wing demonstrates the processing performance of the procedure. Vectors over 40,000 elements long are obtained, and a rate of over 125 megaflops, sustained over the entire computation, is achieved when the entire data set is resident in real memory. Attempts to use secondary memory, either explicitly or with virtual management, greatly degrades the performance.
Author

A87-47859
ON VECTORIZATION OF A 2D NAVIER-STOKES SOLVER
Y. LECOINTE and J. PIQUET (Ecole Nationale Superieure de Mecanique, Nantes, France) IN: The efficient use of vector computers with emphasis on computational fluid dynamics; Proceedings of the Workshop, Karlsruhe, West Germany, Mar. 13-15, 1985 . Brunswick, West Germany, Friedr. Vieweg und Sohn, 1986, p. 154-173. refs
(Contract DRET-83-473)

This paper is devoted to the implementation of several vectorization techniques for the resolution of 2D Navier-Stokes problem. The original version of the code was running on classical scalar computers and the main part of this work is the adaptation of the algorithms used for vectorization. In the first part, the equations to be solved are presented; the numerical methods (higher order finite differences) and the algorithms are presented in the second part. The adaptation for vectorization is also detailed. In the third part, the results concerning the speed-up obtained by the vectorization and by the optimization of the different versions of the codes are presented; finally, some comparisons between a scalar versus a vectorial computer are done.
Author

A87-48120* New York Univ., New York.
ASPECTS OF SUPERCRITICAL WING THEORY
P. R. GARABEDIAN (New York University, New York) Applied Numerical Mathematics (ISSN 0168-9274), vol. 3, May 1987, p. 49-57. refs
(Contract NSF DMS-83-20430; NSG-1579; NAG2-345)

Concepts and techniques that have proved successful in the computational theory of shockless airfoils are examined. Shockless airfoils have been used in the design of supercritical wings for fuel-efficient aircraft. In transonic aerodynamics, it is has been found that test data agree well with the best results obtained from CFD. This is particularly true for two-dimensional flow, where accurate experiments are difficult to perform and numerical calculations are relatively easy. However, it is important to choose reasonable models in setting up the computations. Particular attention is given to the formulation of the relevant differential equations in ways that have been found to be satisfactory in practice.
B.J.

A87-48339
NUMERICAL SIMULATION OF CONFINED UNSTEADY AERODYNAMICAL FLOWS
A. FREY, C. HALL, and T. PORSCHING (Pittsburgh, University, PA) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 24, July 1987, p. 1233-1250. MIT-supported research. refs
(Contract AF-AFOSR-84-0131)

The paper presents a system of algorithms, known collectively as ALGAE, which are capable of numerically simulating the dynamical behavior of the pressure, temperature, and velocity fields of a two-dimensional compressible fluid. A finite difference algorithm is proposed which uses a convex combination of an upwind difference and a centered difference approximation of the convective terms in the momentum equations; judicious choice of the weight provides a means of simulating sustained unsteady behavior. The proposed methods are valid for a wide range of time scales, and are applied to the simulation of wind-tunnel acoustics, flow over a ramp, and flow past aircraft cavities. B.J.

A87-48718#
A STUDY OF THE LEADING EDGE VORTEX AND TIP VORTEX ON PROP-FAN BLADES
C. M. VACZY (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) and D. C. MCCORMICK (United Technologies Research Center, East Hartford, CT) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 109, July 1987, p. 325-331. refs
(ASME PAPER 87-GT-234)

An oil flow visualization study was conducted on the blades of a counterrotating prop-fan model, the CRP-X1. A kink in the oil streaks was interpreted as an indication of the leading edge vortex reattachment line. The leading edge vortex was found to be on the lower surface for cases with negative leading edge loading and on the upper surface for cases with positive leading edge loading. For most cases, the leading edge vortex merged with a tip vortex. The results presented here represent the first systematic study of this phenomenon. Author

A87-48719*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EULER ANALYSIS OF THE THREE-DIMENSIONAL FLOW FIELD OF A HIGH-SPEED PROPELLER - BOUNDARY CONDITION EFFECTS
M. NALLASAMY (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH), B. J. CLARK, and J. F. GROENEWEG (NASA, Lewis Research Center, Cleveland, OH) ASME, Transactions, Journal of Turbomachinery (ISSN)889-504X), vol. 109, July 1987, p. 332-339. Previously announced in STAR as N87-16798. refs
(ASME PAPER 87-GT-253)

The results of an investigation of the effects of far field boundary conditions on the solution of the three dimensional Euler equations governing the flow field of a high speed single rotation propeller are presented. The results show that the solutions obtained with the nonreflecting boundary conditions are in good agreement with experimental data. The specification of nonreflecting boundary conditions is effective in reducing the dependence of the solution on the location of the far field boundary. Details of the flow field within the blade passage and the tip vortex are presented. The dependence of the computed power coefficient on the blade passage and the tip vortex are presented. The dependence of the computed power coefficient on the blade setting angle is examined. Author

A87-48723#
SOME EXPERIMENTS WITH A SUPERSONIC AXIAL COMPRESSOR STAGE
A. J. WENNERSTROM (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 109, July 1987, p. 388-397. refs

Ten supersonic axial compressor stage variants were designed and tested in 1970-1974; the variants encompassed two rotor configurations, three rotor tip clearances, boundary layer control measures by means of vortex generators on both the rotor and outer casing, and slots in the stator vanes. The tenth variant achieved over 91 percent of design flow at design speed, yielding a stage pressure ratio of 3.03, with an isentropic efficiency of 0.75. While design tools available in 1987 would allow the original performance goals to be met or exceeded, the efficiency targets typical of current programs are much higher than those conceived in 1970. O.C.

A87-48724#
SUPERCRITICAL CASCADE FLOW ANALYSIS WITH SHOCK - BOUNDARY LAYER INTERACTION AND SHOCK-FREE REDESIGN
P. NIEDERDRENK, H. SOBIECZKY (DFVLR, Institut fuer theoretische Stroemungsmechanik, Goettingen, West Germany), and G. S. DULIKRAVICH (Pennsylvania State University, University Park) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 109, July 1987, p. 413-419. refs

This paper describes improvements made in a user-oriented analysis code for steady two-dimensional transonic flows in turbomachinery cascades. The full potential equation is solved by a finite area technique, using a C-type grid and an analytical wake model. Solution adaptive grid clustering refines the inviscid computationally captured shock. The boundary layer is computed by an integral method except in the shock region, where the analytical interaction model of Bohning and Zierep smoothes out the pressure distribution on the airfoil surface. The code is applied in its analysis and design modes to an experimentally tested cascade of airfoils. Author

A87-48725#
UNSTEADY AERODYNAMIC INTERACTIONS IN A MULTISTAGE COMPRESSOR
V. R. CAPECE and S. FLEETER (Purdue University, West Lafayette, IN) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 109, July 1987, p. 420-428. USAF-supported research. refs
(ASME PAPER 87-GT-171)

The fundamental flow physics of multistage blade row interactions is experimentally investigated, with unique data obtained which quantify the unsteady harmonic aerodynamic interaction phenomena. In particular, a series of experiments is performed in a three-stage axial flow research compressor over a range of operating and geometric conditions at high reduced frequency values. The multistage unsteady interaction effects of the following on each of the three vane rows are investigated: (1) the steady vane aerodynamic loading, (2) the waveform of the aerodynamic forcing function to each vane row, including both the chordwise and traverse gust components. Author

A87-48757* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
WIND-TUNNEL INVESTIGATION OF A GENERAL AVIATION AIRPLANE EQUIPPED WITH A HIGH ASPECT-RATIO, NATURAL LAMINAR-FLOW WING
DANIEL G. MURRI, FRANK L. JORDAN, JR. (NASA, Langley Research Center, Hampton, VA), RANDY NELSON (Cessna Aircraft Co., Wichita, KS), and PATRICK J. DAVIS (PRC Kentron, Inc., Hampton, VA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 21 p. refs
(SAE PAPER 871019)

A wind tunnel investigation has been conducted to evaluate the aerodynamic performance, stability, and control characteristics

of a full-scale general aviation aircraft equipped with an advanced natural laminar flow wing. Force and moment data were measured over wide angle-of-attack and sideslip ranges and at Reynolds numbers from 1.4 million to 2.4 million based on the mean aerodynamic chord. Additional measurements determined the condition of the wing boundary layer and the wing stalling characteristics. The results showed that large regions of natural laminar flow existed on the wing which would significantly enhance the cruise performance of the configuration. Artificially tripping the boundary layer did not significantly affect the lift, stability, and control characteristics. Leading-edge modifications were effective in improving the stall resistance of the configuration, and resulted in only minor penalties in calculated cruise performance. C.D.

A87-48770
FLIGHT TEST INVESTIGATIONS OF A WING DESIGNED FOR NATURAL LAMINAR FLOW
JACK BEFUS, E. RANDEL NELSON, DAVID R. ELLIS, and JOE LATAS (Cessna Aircraft Co, Wichita, KS) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987 8 p. (SAE PAPER 871-044)

Full-scale flight tests of a wing designed for natural laminar low (NLF) have provided insights into the aerodynamics of the NLF(1)-0414F airfoil used, and into the effects of transition location on airfoil lift, drag, pitching moment and overall aircraft performance. Results of these tests help answer questions pertaining to the development of aircraft using NLF airfoils such as the one tested. These data also provide comparisons of predictions based on computational and wind tunnel test methods. Instrumentation methods used to gather data during these tests include flush-mounted airfoil pressure orifices, hot-film anemometers, and a wing-mounted integrating wake rake. Author

A87-48923*# College of William and Mary, Williamsburg, Va.
APPLICATION OF A LIFTING SURFACE THEORY FOR A HELICOPTER IN FORWARD FLIGHT
HARRY L. RUNYAN (College of William and Mary, Williamsburg, VA) and HSIANG TAI (NASA, Langley Research Center, Hampton, VA) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 19 p. refs

A lifting-surface theory has been developed for a helicopter rotor in forward flight for compressible and incompressible flow. The method utilizes the concept of the linearized acceleration potential and makes use of the doublet lattice procedure. Calculations demonstrating the application of the method are given in terms of the lift distribution on a single rotor, a two-bladed rotor, and a rotor with swept-forward and swept-back tips. In addition, the lift on a rotor which is vibrating in a pitching mode at 4/rev is given. Compressibility effects and interference effects for a two-bladed rotor are discussed. Author

A87-48924*# California Univ., Los Angeles.
FINITE-TIME ARBITRARY-MOTION UNSTEADY CASCADE AIRFOIL THEORY FOR HELICOPTER ROTORS IN HOVER
M. A. H. DINYAVARI and P. P. FRIEDMANN (California, University, Los Angeles) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 33 p. refs
(Contract NAG2-209)

A complete and detailed derivation of finite-time arbitrary-motion cascade theory is presented for both Laplace and frequency domains. This theory includes the effect of returning wakes for both single- and multibladed rotors. The generalized cascade lift-deficiency function (CLDF) is shown to be consistent with the generalized Theodorsen lift-deficiency function when the wake spacing approaches infinity or when the reduced frequency tends to infinity. This function predicts correct zero-reduced-frequency limit. Accurate and efficient numerical procedures are presented for the evaluation of the CLDF. Numerical examples comparing the CLDF with Loewy's lift deficiency function in frequency domain are presented. Accurate Pade approximants of the CLDF are constructed using a Bode-plot approach which allows for complex poles. Author

A87-48925#
THE AERODYNAMIC CALCULATION OF COUNTER ROTATING COAXIAL ROTORS
H. ZIMMER (Dornier GmbH, Friedrichshafen, West Germany) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 32 p. refs

For the calculation of the loading, vibrations, and instability of counterrotating coaxial helicopter rotors and propellers, the knowledge of the aerodynamic forces on each blade element at every time step is essential. For the aerodynamic calculation of these interfering rotors, a method was developed which, on one hand, should be inexpensive in computer time and, on the other hand, should represent the complicated flowfield as realistically as possible. The method should apply in hovering and forward flight with uniform and nonuniform inflow. The method is built up in such a way that besides the relatively lightly loaded helicopter rotors, heavily loaded single rotating and counterrotating propellers can also be calculated. Because of the inherent aerodynamic advantages, the coaxial arrangement is becoming more and more important in this field. Author

A87-48926#
ANALYSIS OF THE WAKE DYNAMICS OF A TYPICAL TILT-ROTOR CONFIGURATION IN TRANSITION FLIGHT
DAVID R. CLARK (Analytical Methods, Inc., Redmond, WA) and MICHAEL A. MCVEIGH (Bell-Boeing, Philadelphia, PA) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 36 p. Research supported by Bell-Boeing. refs

The paper presents the results of an analytical study of the wake dynamics of a tilt-rotor wind tunnel model in transition flight. As a prelude to the analysis of the tilt-rotor configuration and in order to build confidence in the computer program it was used in a study of a simple tilt-propeller/wing combination tested by NASA. Correlation of calculated forces and moments throughout the transition speed range was excellent. Based upon the success of the preliminary study, a panel model of an early wind tunnel model of the V-22 tilt-rotor aircraft was developed. The characteristics of this configuration were explored for a wide range of conditions in the helicopter mode, from hover into forward flight, and the interaction between rotor and wing wakes investigated in detail. The paper presents examples of this interaction, and discusses the effect of rotor-induced changes in wing loading as a function of air speed at representative flight conditions. Author

A87-48927#
A FREE WAKE ANALYSIS FOR HOVERING ROTORS AND ADVANCING PROPELLERS
D. FAVIER, M. NSI MBA, C. BARBI, and C. MARESCA (Aix-Marseille II, Universite, Marseille, France) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 23 p. DRET-supported research. refs

From new experimental results obtained on either hovering rotors or propellers in axial flight, an attempt in improving and checking a free wake analysis model is made. In both flight cases the wake is divided into near and far regions which are empirically prescribed according to synthesized laws of contraction and convection obtained in each region. For hovering rotors, the free wake model is checked by comparisons with data obtained either on the circulation distribution measured along the blade or on the tip vortex path and the induced velocity field measured in the wake. For the propeller in axial flight, particular attention is given to the dependence of the prescribed wake geometry on the upstream conditions (operating parameter, collective pitch angle). As functions of these parameters, the synthesized empirical laws are derived for the prescribed wake geometry in axial flight. Author

A87-48928#
A PRESCRIBED WAKE MODEL FOR HELICOPTER ROTOR BEHAVIOUR
H. AZZAM and P. TAYLOR (Southampton, University, England) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 15 p. Research supported by the Ministry of Defence (Procurement Executive). refs

The development of an efficient prescribed wake model which describes the rotor behavior adequately at any flight speed is reported. In the model, the wake is allowed to contract and deflect, the strength of the tip vortex is related to the blade dynamic response, and the three-dimensional effects and blade-vortex interaction are accounted for simply. The model is validated by comparing results with a set of experimental data collected from various sources. The model is found to adequately predict the flapping angles (including the lateral one), induced power, blade loadings, and the instantaneous induced velocities below the rotor. B.J.

A87-48930#
INFLUENCE OF REAR END SPOILER ON AERODYNAMIC CHARACTERISTICS AND WAKE STRUCTURE OF A HELICOPTER FUSELAGE
J. AMTSBERG and S. R. AHMED (DFVLR, Brunswick, West Germany) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 14 p.

Experimental studies on a 1:7 scale model helicopter fuselage with cowl and spoiler were performed in the open test section of the DFVLR low-speed wind tunnel. The objective was to investigate the effect of a spoiler located at the start of the rear end upsweep on vortex formation, aerodynamic characteristics, and pressure distribution on the fuselage. Parameters varied were spoiler span, angle of incidence, and yaw. A full-span spoiler situated at the start of the rear end upsweep was found to inhibit the formation of longitudinal vortices; for strong yaw, these vortices reappear but have superposed axes, producing a more favorable flow field in the tail rotor plane. B.J.

A87-48931#
THE EFFECT OF PITCH RATE ON THE DYNAMIC STALL OF A NACA 23012 AIRFOIL
LUP. Y. SETO and RODERICK A. MCD. GALBRAITH (Glasgow, University, Scotland) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 17 p. refs
(Contract MOD-2048/026-XR/STR)

The paper presents the results of dynamic stall tests on a NACA 23012 airfoil when subjected to constant pitch rates about the quarter chord. The tests were performed over a reduced frequency range of K between 0.00007 and 0.04 and at corresponding Reynolds and Mach numbers of 1.5 x 10 to the 6th and 0.11, respectively. The analysis of the data and comparison with other work indicated a possible Mach-number dependency of the leading-edge suction's influence on stall type and a constancy of the time taken for the stall vortex to develop and pass the trailing edge. Author

A87-48955*# California Univ., Los Angeles.
FINITE STATE MODELLING OF UNSTEADY AERODYNAMICS AND ITS APPLICATION TO A ROTOR DYNAMIC PROBLEM
P. P. FRIEDMANN and C. VENKATESAN (California, University, Los Angeles) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 27 p. refs
(Contract NAG2-209)

The paper presents a method for formulating finite state unsteady aerodynamic models in the time domain from frequency domain unsteady aerodynamics. The method is based on recognizing that the lift deficiency function represents an aerodynamic transfer function and utilizes the Bode plot technique, used in control systems engineering, to construct approximation to the lift deficiency function. Indicial response functions for both fixed wing and rotary wing applications are obtained, using these finite state unsteady aerodynamic models. It is shown that the rotary wing indicial response function is oscillatory and thus it is fundamentally different when compared to the fixed wing indicial response function which is nonoscillatory. Certain aspects of the finite state aerodynamic model are demonstrated by applying it to the flapping dynamics of an articulated helicopter rotor blade. The influence of unsteady aerodynamics on the damping characteristics of the rotor is examined. The same problem is also treated by using a different unsteady aerodynamic model, namely dynamic inflow. Based on a comparison of the results obtained with these two unsteady aerodynamic models, useful conclusions are drawn regarding some fundamental features of these theories. Author

A87-48970#
INVESTIGATIONS OF BLADE-VORTICES IN THE ROTOR-DOWNSTREAM
B. JUNKER (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 12 p.

Rotor-blade vortices in helicopter downwash were investigated by a simple measurement technique in the DNW wind tunnel using the closed 8 x 6 m test section. Data on vortex diameter, trace, and location with respect to the fuselage and especially the tail-rotor were obtained. It is concluded that these test results provide a better understanding of the rotor downwash structure and are of use in the preparation of hot-wire measurements at selected points. B.J.

A87-49051
AIAA APPLIED AERODYNAMICS CONFERENCE, 5TH, MONTEREY, CA, AUG. 17-19, 1987, TECHNICAL PAPERS
Conference sponsored by AIAA. New York, American Institute of Aeronautics and Astronautics, 1987, 646 p. For individual items see A87-49052 to A87-49114.

The present conference discusses aircraft flow field computation by means of a multigrid Euler method, the influence of Re number on forebody side forces for tangent-ogive bodies, boundary layer separation and the vortex structures around an inclined body-of-revolution, ultrahigh bypass installation design for transport aircraft, aerodynamic parameters for a pitching airfoil, EA-6B high lift wing modifications, a new computational capability for ramjet projectiles, and the aerodynamic analysis of a complex configuration using a full potential code. Also discussed are fighter aircraft vortex-fin interaction, trailing vortex rollup computations using the point vortex method, finned multibody aerodynamic interference at transonic Mach numbers, winglets on low aspect ratio wings, an aerodynamic design method for hypersonic vehicles, pseudo-Re number trends, an airfoil designed for a high-altitude long-endurance RPV, and the aerodynamics of a winged-cone concept. O.C.

A87-49052#
COMPUTATION OF AIRCRAFT FLOW FIELDS BY A MULTIGRID EULER METHOD
G. VOLPE, M. J. SICLARI (Grumman Corporate Research Center, Bethpage, NY), and A. JAMESON (Princeton University, NJ) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1-13. refs
(AIAA PAPER 87-2268)

An algorithm for computing transonic flow fields about fighter-type aircraft is described in the paper. The compressible Euler equations are solved numerically using a vertex-based, finite volume multigrid scheme. The space around the aircraft is discretized with a single-block H-O mesh which is generated by the union of separate O-meshes around successive cross sections of the aircraft. The discretized equations are integrated via a five-stage Runga-Kutta scheme, and a variety of techniques - local time-step maximization, residual smoothing and enthalpy damping - are used along with a multigrid scheme to accelerate convergence to the steady state. The algorithm has proved to be very efficient in practice, and several examples at transonic and supersonic free stream conditions are presented. Author

A87-49053*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EULER AND NAVIER-STOKES SOLUTIONS FOR THE LEESIDE FLOW OVER DELTA WINGS AT SUPERSONIC SPEEDS
S. N. MCMILLIN, J. L. THOMAS (NASA, Langley Research Center, Hampton, VA), and E. M. MURMAN (MIT, Cambridge, MA) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 14-33. refs
(Contract N00014-86-K-0288)
(AIAA PAPER 87-2270)

Distinctly different types of leeside flowfields over highly swept sharp leading edge delta wings in supersonic flow were numerically simulated using Euler and Navier-Stokes solvers. The Euler code was seen to be adequate only in predicting primary flow structures (leading edge vortex and cross flow shock) whereas the Navier-Stokes code was capable of predicting secondary flow structures (i.e., secondary vortex). A comparison of laminar and turbulent Navier-Stokes solutions indicated that the turbulent boundary layer model is more accurate in predicting the effect of the boundary layer model on the flowfield. Also, the Navier-Stokes code indicated detailed flow structures not observed in the qualitative experimental data available (i.e., vapor screen photographs) indicating a need for quantitative flow field data. Author

A87-49054#
EULER ANALYSIS OF THE AFWAL 65-DEG DELTA WING
JAMES R. SIRBAUGH (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 34-53.
(AIAA PAPER 87-2272)

The 'International Vortex Flow Experiment on Euler Code Validation' program experimental data has been compared to Euler code predictions for a range of Mach numbers and angles-of-attack. The geometry used in this study is a generic, 65-deg swept leading edge delta wing with both round and sharp leading edges. Comparisons of experimental and predicted coefficients of lift, drag, pitching moment and pressure are presented at Mach numbers of 0.4, 0.85 and 1.2 for angles of attack from 0 to 25 deg. The comparison of force and moment data is in good agreement for all cases, except for subsonic pitching moment coefficient. Pressure coefficients are in excellent agreement in attached flow regions and in poor agreement in separated flow regions. The effect of vortex breakdown on lift and drag has been accurately predicted using the Euler equations at a free stream Mach number of 0.85. An examination of a predicted complex shock structure interacting with the vortex breakdown structure is presented. Author

A87-49055#
TRANSONIC FLOW SOLUTIONS ON A BLUNT, BODY-WING-CANARD CONFIGURATION USING THE EULER EQUATIONS
LAWRENCE E. LIJEWSKI (USAF, Armament Laboratory, Eglin AFB, FL) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 54-62. refs
(AIAA PAPER 87-2273)

The purpose of this investigation is to validate a recently developed Euler code for multifinned bodies with low aspect ratio surfaces and examine the aerodynamic effect of these fin surfaces on the configuration. Pressure distribution, local Mach number, and force and moment calculations are compared to wind tunnel data for cruciform, wing-canard body of revolution at angles of attack up to 12 degrees. Near sonic conditions at Machs 0.95 and 1.05 are successfully predicted and presented for body, wing, and canard surfaces. Effects of the wings and canards are examined by comparing body-wing-canard calculations with body-wing and body alone predictions. An elliptic grid generator and explicit upwind Euler solver were used on a CRAY-XMP to obtain results presented. The paper illustrates the inviscid code's capability to predict aerodynamic characteristics on a geometrically complex configurations at near sonic conditions and low to moderate angles of attack. Author

A87-49056*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INFLUENCE OF REYNOLDS NUMBER ON FOREBODY SIDE FORCES FOR 3.5-DIAMETER TANGENT-OGIVE BODIES
ROBERT M. HALL (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 63-73. refs
(AIAA PAPER 87-2274)

Vortex asymmetries can arise on aircraft and missile forebodies at high angles of attack and have proven difficult to simulate in the wind tunnel because of a large array of parameters that can influence the test results. One of the most important of these parameters is Reynolds number. The current report compares, for tangent-ogive forebodies with fineness ratios of 3.5, flow patterns from oil-flow photographs to features in pressure distributions. The pressure data base is then used to illustrate the development of the sectional side force coefficient along both the tangent-ogive nose and an attached cylindrical afterbody for Reynolds numbers of 0.2, 0.8 and 3.8 million, based on maximum diameter, and angles of attack of 40, 50 and 60 deg. General commments concerning the effects of Reynolds number are presented, as well as an analysis of the effects of Reynolds number on the sectional side force coefficient near and at the apex of the pointed body. All data presented are for freestream Mach numbers on the order of 0.25. Author

A87-49057#
HIGH ANGLE OF ATTACK SUBSONIC NON-LINEAR VORTEX FLOW CALCULATIONS
J. ROM, D. ALMOSNINO, and R. GORDON (Technion-Israel Institute of Technology, Haifa, Israel) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 74-82. refs
(AIAA PAPER 87-2275)

The application of the Nonlinear Vortex Lattice Method (NLVLM) to various configurations which are of practical interest are presented. The aerodynamic characteristic of bodies of elliptical cross section and of lifting bodies which are cone-derived waverider are presented at subsonic speeds. Results for close coupled canard configurations are also presented, to illustrate the interaction between the rolled up vortices shed from the leading and trailing edges of the canard on the main wing flow, at moderate to high angles of attack. The effects of the various parameters which are required by the NLVLM are discussed and the limits of their values which give reasonable results are presented. Author

A87-49058#
BOUNDARY LAYER SEPARATION AND THE VORTEX STRUCTURES AROUND AN INCLINED BODY OF REVOLUTION
KENNETH C. WARD and JOSEPH KATZ (Purdue University, West Lafayette, IN) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 83-93. refs
(Contract NSF MEA-84-04413)
(AIAA PAPER 87-2276)

The results of laser-induced fluorescence flow visualizations for the three-dimensional wake structures in the lee of a sharp-tipped, 3.5-slenderness ratio tangent ogive nose are presented, with attention to the effects of incidence angle and Re number on the axial development of the wake structures as well as the points of boundary layer separation and reattachment. As a vortex lifts off from the model surface, the attachment line separating the primary vortices develops into a region of attachment located below the separating structure. The axial distance over which these phenomena occur is directly affected by both incidence

angle and Re number; at the highest Re number, traces of asymmetry can be observed very close to the model tip. O.C.

A87-49059*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A STRAKE DESIGN METHOD FOR SUPERSONIC SPEEDS AND LOW LIFT
JAMES L. PITTMAN and DARYL L. BONHAUS (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 94-104. refs
(AIAA PAPER 87-2638)

A method is presented for the design of a strake for a forebody typical of supersonic aircraft at typical cruise (low lift) conditions, in order to ensure attached flow on the strake upper surface. The method systematically varies strake camber and thickness until an attached flow surface pressure distribution is achieved. Surface pressures are computed by the full potential flow solver, NCOREL. The high-alpha flowfield of the strake is also investigated experimentally and computationally; a large vortex is noted on the strake leeside, together with a pair of vortices on the forebody upper centerline. The effect of sideslip on the high-alpha flowfield is also discussed. O.C.

A87-49060#
THE CONTROL OF VORTICAL FLOW ON A DELTA WING AT HIGH ANGLES OF ATTACK
N. J. WOOD, L. ROBERTS (Stanford University, CA), and K. T. LEE IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 105-112. refs
(AIAA PAPER 87-2278)

An experiment has been performed to examine the feasibility of control of the vortical flow over a rounded leading-edged delta wing by tangential leading-edge blowing. Initial results indicated the ability of the device to provide direct control of the vortical flow at angles of attack beyond the point of unblown maximum normal force. Further analysis of the experimental data clearly shows that the blowing affects only the lift due to the presence of the vortex, the so-called nonlinear lift contribution. Further analysis has shown the importance of the relative contributions of the vortex strength and position and the loads induced by the blowing as a function of angle of attack. Information regarding the effect of movement of the point of crossflow separation on the strength and location of the primary vortex has been deduced from experimental results. Author

A87-49062*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ANALYSIS OF INDUCED VELOCITIES IN THE WAKE OF A HOVERING HELICOPTER ROTOR
JEFFREY S. LIGHT and FORT F. FELKER (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 124-130. refs
(AIAA PAPER 87-2283)

A simple analytical method has been developed to predict the induced velocities at the tip vortex in the wake of a hovering helicopter rotor. The wake model in the analysis includes the blade bound vortex as well as a tip vortex and vortex sheet trailed from each blade. Standard, prescribed wake models were used to describe the geometry of the tip vortex and the vortex sheet. Curved vortex elements were used to model the tip vortices and the vortex sheets. The analysis was used to study the contribution from each wake component to the axial-induced velocity of the tip vortex. Results show a highly variable induced velocity at the tip vortex both before and after the first blade passage. However, the prescribed tip vortex models require a constant axial velocity of the tip vortex. This inconsistency between the prescribed axial velocity of the tip vortex and the velocity that the wake geometry induces on the tip vortex points to a limitation of the current prescribed tip vortex geometry models. Author

A87-49066#
COMPARISON OF EULER AND NAVIER-STOKES SOLUTIONS FOR VORTEX FLOW OVER A DELTA WING
ARTHUR RIZZI (Forsvarsdepartementet, Flygtekniska Forsoksanstalten, Bromma; Kungliga Tekniska Hogskolan, Stockhol, BERNARD MULLER (Forsvardepartementet, Flygtekniska Forsoksanstalten, Bromma, Sweden), and CHARLES J. PURCELL (ETA Systems, Inc., St. Paul, MN) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1987, p. 154-163. Research supported by the Styrelsen for Teknisk Utveckling, Navy, and NSF. refs
(AIAA PAPER 87-2347)

A numerical method has been developed to solve the Navier-Stokes equations for laminar compressible flow around delta wings. A large-scale Navier-Stokes solution on a mesh of 129 x 49 x 65 points for transonic flow at freestream Mach of 0.85, alpha of 10 deg, and freestream Re of 2.38 million, around a 65-deg delta wing with round leading edge, is presented and compared with a correspondingly large-scale Euler solution. The viscous results reveal the presence of primary, secondary, and even tertiary vortices. The starting location of the primary vortex is seen to be quite different in the two solutions. In the viscous solution it starts at the wing apex, but in the Euler results it starts about one-quarter chord downstream. The secondary separations are also different, due to the up-lifting of the boundary layer in the viscous results, but to a cross-flow shock in the Euler computation. Comparison with experiment shows that the interaction between the primary and secondary vortices in the Navier-Stokes computation is obtained correctly, and that these results are a more realistic simulation than the one given by the Euler equations. Author

A87-49067#
STEADY THREE-DIMENSIONAL FLUID PARTICLE SEPARATION FROM ARBITRARY SMOOTH SURFACE AND FORMATION OF FREE VORTEX LAYERS
J. Z. WU, J. W. GU (Chinese Aeronautical Establishment, Beijing, People's Republic of China), and J. M. WU (Tennessee, University, Tullahoma) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 164-174. refs
(AIAA PAPER 87-2348)

After noting the differences between the boundary layer separation and fluid particle separation methods, a systematic study is made of the latter through the reexamination of steady, three-dimensional incompressible Navier-Stokes flow over curved surfaces that leads to an unambiguous definition of separation stream surfaces and streamlines; on the basis of this, various local separation behaviors are deduced. It is found that in both the cases of open and closed separation, the separation line is a skin-friction line segment between successive critical points rather than an envelope or asymptotic line related to neighboring skin friction lines. These analyses are combined with three-dimensional vorticity production from a curved surface to examine the initial formation of skin friction layers, through the substitution of normal and shear stresses on the surface. O.C.

A87-49069#
END PLATE GAP EFFECTS ON A HALF WING MODEL AT LOW REYNOLDS NUMBERS
JAMES F. MARCHMAN, III (Virginia Polytechnic Institute and State University, Blacksburg) and SUBRAHMANYAM KUPPA IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 186-195. refs
(AIAA PAPER 87-2350)

Wind tunnel tests were conducted at low Reynolds numbers for different gap sizes, including a sealed gap. Results from the

experiments showed that even very small gaps produce substantial changes in zero-lift angle of attack and the change in this parameter was reduced as Reynolds number increased. Sealed gap test results did not show such a behavior. Flow visualization of the flow through the gap showed a significant flow through the gap even at very low Reynolds number and small gap size. Tests with sealed gap resulted in zero-lift angle-of-attack data equal to that found in conventional, single-strut mounted, three-dimensional wing tests, and predicted by theory. Results from vortex panel method indicated an effect of reduced aspect ratio with increase in end plate gap size. Author

A87-49070#
LOW REYNOLDS NUMBER AIRFOIL PERFORMANCE SUBJECTED TO WAKE INTERFERENCE FROM AN UPSTREAM AIRFOIL
W. D. MICHELSEN and T. J. MUELLER (Notre Dame, University, IN) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 196-206. Research supported by the University of Notre Dame. refs
(Contract N00014-83-K-0239)
(AIAA PAPER 87-2351)

Performance measurements of an airfoil in a two-dimensional canard/wing configuration at low Reynolds numbers have been obtained. Wind tunnel studies were conducted with a 152 mm chord Wortmann FX63-137 airfoil mounted on a three-component strain gage force balance. A 100 mm chord airfoil was located upstream and was traversed across the test section to provide an interfering wake. The experiments were conducted at a Reynolds number of 150,000 based on the downstream airfoil chord. Configurations consisted of a streamwise separation distance of 4.5 chord lengths, cross-stream offset positions ranging from -0.75 to 0.75 chord lengths, and relative angles of attack of 0, 2.5, and 5.0 degrees. Performance data are presented as a function of upstream airfoil offset. The measurements showed that maximum influence occurred when the wake center impinged near the leading edge of the downstream airfoil. All aerodynamic coefficients were reduced due to the velocity deficit in the wake. However, outside the wake, the lift was reduced by the upstream airfoil's downwash, and the drag was increased by the higher flow velocity induced by the wake blockage. Author

A87-49071#
AERODYNAMIC PARAMETERS FOR A PITCHING AIRFOIL
W. D. SIURU, JR. (Colorado, University, Colorado Springs), J. M. WALKER (USAF, Frank J. Seiler Research Laboratory, Colorado Springs, CO), and D. CHOU (New Mexico, University, Albuquerque) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 207-214.
(AIAA PAPER 87-2352)

The key aerodynamic parameters of lift, pressure, and moment coefficient, were determined for a rapidly-pitching airfoil. The investigation was based on extensive wind tunnel data obtained for a NACA 0015 airfoil pitched at rates from 115 to 1380 deg/second to a maximum angle of attack of 60 deg. Reynolds numbers based on the airfoil chord ranged from 25,000 and 200,000. The lift, drag, and moment were determined by integrating the pressure coefficients obtained from 18 pressure transducers embedded in the airfoil. Instantaneous, maximum, and average values for each of the aerodynamic parameters were determined. The results were found to correlate well with the similarity parameter alpha(+). While the average lift, drag, and moment coefficients are substantially higher than for the same airfoil under steady state conditions, the increase is never as substantial as for the peak values. The investigation showed that it is possible to achieve almost the same average lift coefficient by only pitching the airfoil up to the angle of attack for maximum lift. Author

A87-49073#
BUFFETING PREDICTION FOR TRANSPORT AIRCRAFT APPLICATIONS BASED ON UNSTEADY PRESSURE MEASUREMENTS
B. BENOIT and I. LEGRAIN (ONERA, Chatillon-sous-Bagneux, France) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 225-235. refs
(AIAA PAPER 87-2356)

Aircraft dynamic response computations based on the measurement of a scaled static deformation wind tunnel model's unsteady pressure field are under development for a buffet onset prediction method. Attention is given to the results thus obtained for an RA 16SC1 airfoil and a rectangular wing, in order to analyze unsteady separated flows. While organized separated flow fluctuations were observed at transonic speeds, this type of flow does not appear to be relevant to buffet onset in the case of transport aircraft. O.C.

A87-49074#
CALCULATION OF UNSTEADY TRANSONIC FLOW WITH LARGE LONGITUDINAL DISTURBANCE ABOUT AIRFOILS
HAISONG ANG (Nanjing Aeronautical Institute, People's Republic of China) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 236-240. refs
(AIAA PAPER 87-2357)

The present, computationally efficient method for the calculation of steady and unsteady transonic flows around airfoils gives attention to large longitudinal disturbances and such viscous effects as shock wave/boundary layer interactions. The method is shown to yield results superior to those of the transonic small disturbance method for the same amount of computational time. Computed results for NACA 0012 and NLR 7301 airfoil profiles are compared with experimental data. O.C.

A87-49081#
NUMERICAL SIMULATION OF COMPRESSIBLE VISCOUS FLOWS AROUND PRACTICAL AIRCRAFT CONFIGURATIONS
S. TAKANASHI, K. FUJII (National Aerospace Laboratory, Tokyo, Japan), S. OBAYASHI (Tokyo, University, Japan), and K. MATSUSHIMA (Fujitsu, Ltd., Tokyo, Japan) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 312-317, 319-321. refs
(AIAA PAPER 87-2410)

A parametric simulation of compressible viscous flow fields is carried out for an advanced transonic transport configuration under development. A single grid system for the computation is constructed by the sequential use of analytical transformations. The Reynolds-averaged Navier-Stokes equations in a thin-layer form are solved on a supercomputer, FACOM VP 400, using the LU-ADI factorization technique. Some of the computed results are presented which show good agreement with the wind tunnel test data. Author

A87-49086*# Kansas Univ. Center for Research, Inc., Lawrence.
VSAERO ANALYSIS OF STRUCTURALLY DECOUPLED TIP PLANFORMS FOR A SEMISPAN WING
DANIEL M. MARTIN (University of Kansas Center for Research, Inc., Lawrence) and ROBERT H. STROUB (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 356-366. refs
(AIAA PAPER 87-2416)

A numerical analysis has been conducted with the three-dimensional panel code VSAERO for two interacting lifting surfaces that are separated in the spanwise direction by a narrow gap, with the angle of attack of the outboard section being set

independently of the inboard section, as in the 'free tip' rotor blade system proposed for helicopters. Computed values of tip surface lift and pitching moment coefficients are correlated with experimental data to determine the most suitable method for modeling the gap region between the surfaces. It is shown that the induced drag of the tip surface is reduced for negative incidence angles relative to the inboard section. O.C.

A87-49087#
APPLICATION OF A FOURIER PANEL METHOD TO 3-D SPOILER CALCULATIONS
T. H. LE, J. RYAN, and Y. MORCHOISNE (ONERA, Chatillon-sous-Bagneux, France) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 367-370. refs
(AIAA PAPER 87-2417)

A three-dimensional inviscid flow model is presently extended in order to compute the flow around a spoiler-wing configuration, where this flow features the presence of both thick and thin bodies and constant-pressure bubbles around the spoiler. The broad wake is modeled with a fixed set of potential jump surfaces bounding a quasi-equipressure zone with a streamwise linear doublet distribution that is determined in order to minimize local kinetic energies. The results obtained exhibit good agreement with experimental data, and indicate the obtainability of reasonably good accuracy in predictions of the spoiler's wing pressure effects. O.C.

A87-49088#
AERODYNAMIC ANALYSIS OF A COMPLEX CONFIGURATION USING A FULL POTENTIAL CODE
GREGORY E. SMITH, KENNETH B. WALKLEY (Dynamic Engineering, Inc., Newport News, VA), and JAMES R. SNYDER (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 371-380. refs
(Contract AF TASK 013026)
(AIAA PAPER 87-2418)

A detailed comparison between supersonic full potential calculations and experimental surface pressures and force and moment coefficients for the F-111/TACT configuration at Mach numbers of 1.6 and 2.1 has been performed. The agreement between the predicted and measured surface pressure distributions, the lift curve slope and the lift-to-drag ratio was good to excellent. The zero-lift pitching moment for both Mach numbers examined was underpredicted. The drag polar for Mach 1.6 was in good agreement with experiment. For Mach 2.1 the drag was underpredicted by about forty counts but the shape of the polar was in good agreement with experiment. The disagreement between the predicted and measured zero-lift pitching moments and drag levels was attributed to the use of actual geometry rather than the distorted configuration required for incorporation of the wind tunnel sting. Author

A87-49089*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPUTATIONAL STUDY OF WIND-TUNNEL WALL EFFECTS ON FLOW FIELD AROUND DELTA WINGS
NEAL T. FRINK (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 381-391. refs
(AIAA PAPER 87-2420)

This paper addresses wind-tunnel wall effects on delta-wing flow fields using the Free Vortex Sheet (FVS) theory in support of planned subsonic wind-tunnel tests. The configurations include several sizes of a 65-deg delta wing in the NASA Langley Research Center Low-Turbulence Pressure Tunnel (LTPT), and an aspect ratio 1 delta wing in the Delft University low-speed tunnel. Standard upflow correction methodology is extended to account for angle-of-attack and nonplanar effects. Blockage and streamline curvature corrections are not applied in the present investigation. Resulting corrections to the 65-deg delta flow field were good for model-to-tunnel span ratios up to 0.5 and angles of attack up to 30-deg, both for linear attached flow and nonlinear vortex flow. For the aspect ratio 1 delta wing, corrections to the vortex flow field for the effect of the averaged upflow angle were satisfactory but streamline curvature effects were larger. Author

A87-49090*# Wichita State Univ., Kans.
VORTEX-FIN INTERACTION ON A FIGHTER AIRCRAFT
WILLIAM H. WENTZ, JR. (Wichita State University, KS) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 392-399. Navy-sponsored research.
(Contract NAG2-371)
(AIAA PAPER 87-2474)

Water tunnel tests have been conducted to study the flow associated with fin buffet for twin-fin fighter aircraft using 1/48th scale F/A-18 models. Flow visualization made use of colored dyes to determine vortex patterns, and surface hot-film anemometry was used to study the turbulent energy and the frequencies present in the flow. Configurations tested include the full aircraft, aircraft without fins, aircraft without leading-edge-extensions, and aircraft without wings. Test Reynolds number ranged from 4300 to 12,800, with corresponding Mach numbers less than 10 to the -6th. The flow studies show that the LEX vortices burst just forward of the fins at about 25-deg angle-of-attack. Hot film anemometer signals show that fin surface turbulence increases with angle of attack, and that dominant frequencies appear in the flow when bursting occurs. The dominant frequencies correspond to a Strouhal number of about 0.7 for all speeds tested, and for all angles of attack for which vortex bursting was present. Author

A87-49091*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INVESTIGATION OF THE VORTEX FLAP CONCEPT ON A 75-DEG SWEEP DELTA WING AT SUPERSONIC SPEEDS
PETER F. COVELL, RICHARD M. WOOD, and DAVID S. MILLER (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 400-406. refs
(AIAA PAPER 87-2475)

An experimental investigation of the aerodynamic performance of vortex flaps on a 75-deg sweep delta wing has been conducted in the NASA Langley Unitary Plan Wind Tunnel at Mach numbers from 1.7 to 2.8. The sharp leading edge vortex flaps consisted of the outboard 30 percent of the local wing semispan. Flap deflections of 0, 5, 10, and 15 deg were investigated, for both a wing-alone and a wing-body configuration. The flaps were effective in reducing the drag across the lift-coefficient range. Integration of the upper surface pressure distributions showed that the suction pressures induced by the vortex on the flap were responsible for the drag reductions. At some lift conditions, the minimum drag condition permitted hinge line separation or vortex migration inboard of the hinge line. This result is in contrast to subsonic results, where optimum conditions call for no hinge line separation. The magnitude of the drag reduction due to flap deflection generally decreased as Mach number increased. The effect of a cylindrical forebody on the drag reduction due to flap deflection was minimal. Author

A87-49092*# Kansas Univ., Lawrence.
THREE-DIMENSIONAL INCOMPRESSIBLE NAVIER-STOKES SIMULATIONS OF SLENDER-WING VORTICES
CHUNG-HAO HSU (Kansas University, Lawrence), PETER-MICHAEL HARTWICH (Vigyan Research Associates, Inc., Hampton, VA), and C. H. LIU (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1987, p. 407-415. refs
(Contract NAG1-455; NAS1-17919)
(AIAA PAPER 87-2476)
The application of an implicit flux-difference splitting scheme to leading-edge vortex flows is described. The numerical scheme combines approximate factorization in crossflow planes with a symmetric planar Gauss-Seidel relaxation in the remaining spatial direction. Second-order spatial accuracy is achieved by applying TVD-like upwind discretization to the inviscid fluxes and central differencing to the viscous shear fluxes. Good agreement between computed results and experimental data has been obtained for three different low-aspect-ratio wings. Author

A87-49093*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FLOW VISUALIZATION MODEL OF THE LEESIDE FLOWS OVER CONICALLY CAMBERED DELTA WINGS AT SUPERSONIC SPEEDS
RICHARD M. WOOD and PETER F. COVELL (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 416-424. refs
(AIAA PAPER 87-2477)
Surface pressure, flow visualization, and force-and-moment data have been obtained for four, variously conically-cambered delta wing models in a range of flow conditions, with a view to leeside flow mechanisms. The influences exerted by Mach number, angle-of-attack, and camber are determined. An analysis of photographic data leads to the analysis of 12 distinctive leeside flow types, which are further categorizable into two groups respectively possessing either one or two dominant features in the leeside flow field: in the former, either the leading edge or hinge line are the originators of the dominant feature; in the latter, both the leading edge and hinge line are generators. O.C.

A87-49094#
VORTEX BREAKDOWN INDUCED BY AN ADVERSE PRESSURE GRADIENT - EXPERIMENTAL AND NUMERICAL APPROACHES
D. PAGAN and R. BENAY (ONERA, Chatillon-sous-Bagneux, France) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 425-435. refs
(AIAA PAPER 87-2478)
The present experimental and theoretical study of isolated vortex breakdown in incompressible air flwos emphasizes adverse pressure gradient effects, first giving attention to the gradient on delta wing-generated vortices, and then documenting the detailed breakdown of a vortex by means of three-dimensional LDV and laser-sheet visualizations. The proposed numerical modeling of the phenomenon solves the axisymmetric Navier-Stokes equation for a laminar flow. The magnitude of the pressure rise between the inflow and exit sections plays a major role. O.C.

A87-49095#
TRAILING VORTEX ROLLUP COMPUTATIONS USING THE POINT VORTEX METHOD
SHAHID SIDDIQI (Aviation Advanced Technology Applications, Orlando, FL) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 436-446. refs
(AIAA PAPER 87-2479)
This paper surveys the problem of computing the vortex wake rollup of behind large aspect ratio wings using the Point Vortex Method (PVM), first used in 1931 and stil popular today. The vortex sheet is studied as an inviscid and incompressible flow from the Lagrangian viewpoint. The PVM becomes an initial value problem consisting of a set of ordinary differential equations. The computational problems of the PVM are discussed, and its utility is compared to both panel and cloud-in-cell methods. A vorticity redistribution modification of the PVM is described, this gives better rollup results, while also improving computational efficiency. Computational results are compared to available flight and experimental measurements, and possible reasons for differences are given. Author

A87-49096#
A STUDY OF FINNED, MULTI-BODY AERODYNAMIC INTERFERENCE AT TRANSONIC MACH NUMBERS
CHARLES J. COTTRELL and LAWRENCE E. LIJEWSKI (USAF, Armament Laboratory, Eglin AFB, FL) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 447-455. refs
(AIAA PAPER 87-2480)
A wind tunnel experiment involving single, double, and triple combinations of mutually interfering, generic, finned aircraft stores has been conducted. Each combination of stores was tested at Mach numbers from 0.60 to 1.20 and at angles of attack from 0 to 20 deg for the single store and from 0 to 10 deg for the double- and triple-store configurations. Extensive body and fin pressure and flow visualization data were obtained at each store location. The data indicate that finned, multibody interference (measured on the body) in the transonic region seems to be greatest at Mach numbers near 1, and subsides as the freestream Mach number increases or decreases from sonic conditions. Although somewhat dependent on fin orientation, the inboard fins seem to experience greater multibody interference at freestream Mach = 0.60, than at Mach numbers closer to 1. An Euler solution for the double store configuration (x fin orientation) at freestream Mach = 0.95, 0-deg angle-of-attack was generated and compared with these data. The generally good correlation indicates an Euler flow solver can yield accurate predictions of the location and magnitude of multibody interference on both the body and the fins, provided the viscous effects associated with these configurations remain small. Author

A87-49097*# West Virginia Univ., Morgantown.
WINGLETS ON LOW ASPECT RATIO WINGS
JOHN M. KUHLMAN and PAUL LIAW (West Virginia, University, Morgantown) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 456-469. refs
(Contract NAG1-625)
(AIAA PAPER 87-2482)
The drag reduction potentially available from the use of winglets at the tips of low aspect ratio (1.75-2.67) wings with pronounced (45-60 deg) leading edge sweep is assessed numerically for the case of a cruise design point at Mach of 0.8 and a lift coefficient of 0.3. Both wing-winglet and wing-alone design geometries are derived from a linear-theory, minimum induced drag design methodology. Relative performance is evaluated with a nonlinear extended small disturbance potential flow analysis code. Predicted lift coefficient/pressure drag coefficient increases at equal lift for the wing-winglet configurations over the wing-alone planform are

of the order of 14.6-15.8, when boundary layer interaction is included. O.C.

A87-49099#
DFVLR-F5 TEST WING EXPERIMENT FOR COMPUTATIONAL AERODYNAMICS
H. SOBIECZKY, G. HEFER, and S. TUSCHE (DFVLR, Goettingen, West Germany) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 479-487. refs
(AIAA PAPER 87-2485)

In the present investigation of a test wing configuration for aerodynamic computer codes' development, a mathematically explicit half-wing wind tunnel model was designed and built. A set of detailed static pressure distributions has been obtained for wing surfaces and wind tunnel walls; the measurement of inlert and exit flow parameters completely defined the aerodynamic boundary value problem of this channel flow. Additional data on viscous flow structure is obtained with acenaphtene visualization. O.C.

A87-49102#
ON WAVERIDER SHAPES APPLIED TO AERO-SPACE PLANE FOREBODY CONFIGURATIONS
MAURICE L. RASMUSSEN (Oklahoma, University, Norman) and DANIEL R. STEVENS (General Dynamics Corp., Fort Worth, TX) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 506-515. refs
(AIAA PAPER 87-2550)

This paper sets forth a systematic scheme for the aerodynamic design of hypersonic lifting-body configurations. The theory utilizes the approximate formulas available for waveriders constructed from axisymmetric hypersonic flow past cones. The configurations are appropriate for the design of generic aerospace planes, because they provide not only lift, but also favorable conditions for the inlets of scramjet propulsion units. The analytical nature of the analysis and the simple formulas involved allow for a large variety of systematic variations of flight conditions and body shapes. A number of examples are presented for freestream Mach number = 10. Author

A87-49103*# Texas A&M Univ., College Station.
INVISCID TRANSONIC WING DESIGN USING INVERSE METHODS IN CURVILINEAR COORDINATES
THOMAS A. GALLY and LELAND A. CARLSON (Texas A & M University, College Station) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 516-526. refs
(Contract NAG1-619)
(AIAA PAPER 87-2551)

An inverse wing design method has been developed around an existing transonic wing analysis code. The original analysis code, TAWFIVE, has as its core the numerical potential flow solver, FLO30, developed by Jameson and Caughey. Features of the analysis code include a finite-volume formulation; wing and fuselage fitted, curvilinear grid mesh; and a viscous boundary layer correction that also accounts for viscous wake thickness and curvature. The development of the inverse methods as an extension of previous methods existing for design in Cartesian coordinates is presented. Results are shown for inviscid wing design cases in super-critical flow regimes. The test cases selected also demonstrate the versatility of the design method in designing an entire wing or discontinuous sections of a wing. Author

A87-49104*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A HYBRID ALGORITHM FOR TRANSONIC AIRFOIL AND WING DESIGN
RICHARD L. CAMPBELL and LEIGH A. SMITH (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 527-538. refs
(AIAA PAPER 87-2552)

The present method for the design of transonic airfoils and wings employs a predictor/corrector approach in which an analysis code calculates the flowfield for an initial geometry, then modifies it on the basis of the difference between calculated and target pressures. This allows the design method to be straightforwardly coupled with any existing analysis code, as presently undertaken with several two- and three-dimensional potential flow codes. The results obtained indicate that the method is robust and accurate, even in the cases of airfoils with strongly supercritical flow and shocks. The design codes are noted to require computational resources typical of current pure-inverse methods. O.C.

A87-49106#
COMPARISONS AMONG MEASURED AND COMPUTED BOUNDARY-LAYER PROPERTIES ON A TRANSPORT WING
F. W. SPAID (McDonnell Douglas Corp., Saint Louis, MO) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 546-554. refs
(AIAA PAPER 87-2555)

The upper-surface boundary layer on a transport wing model was extensively surveyed at a subsonic and a transonic test condition. The present study consists of comparisons among these data and predictions from a variety of computational methods. The computed predictions are in reasonable agreement with the experimental data in the outboard regions where three-dimensional effects are moderate and adverse pressure gradients are not severe. In the more highly loaded mid-semispan region near the trailing edge, displacement-thickness growth was significantly underpredicted, except when unrealistically severe adverse pressure gradients associated with inviscid calculations were used to perform boundary-layer calculations. Author

A87-49107#
COMPRESSIBLE, VISCOUS, MULTI-FOIL ANALYSIS AND DESIGN ON A MICRO-COMPUTER
ALAN HARRIS (Micro Scientific, Beds, England) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 555-563. refs
(AIAA PAPER 87-2556)

The present microcomputer code generates accurate solutions for the compressible viscous flow about multifoil sections, efficiently yielding a drag polar that consists of eight points in only 6 min. The program also constitutes a design tool for compressible viscous flow, which has been used to demonstrate the feasibility of a 26-percent thick flapped airfoil at freestream Mach numbers of about 0.6 and Re of about 15 million. This airfoil section has no difficulty in maintaining attached flow down to negative values of lift. O.C.

A87-49109#
NUMERICAL COMPUTATIONS AND MEASUREMENTS OF TRANSONIC FLOW IN A SLOTTED-WALL WIND TUNNEL
NADA AGRELL, BJORN PETTERSSON (Flygtekniska Forsoksanstalten, Bromma, Sweden), and YNGVE C-J. SEDIN (Saab-Scania AB, Linkoping, Sweden) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 572-577. refs
(AIAA PAPER 87-2610)

Numerical simulation of transonic flow around a simple wingbody combination in a rectangular test section, provided by

four slots on each wall, has been carried out. Comparisons between the computational results and the recently available experimental data have been performed. The experimental data include wall pressure- and total force measurements on the model. The basically inviscid numerical method treats the flow through each individual slot and couples this to the flow in the test section. The inviscid theoretical slot flow model is qualitatively corrected for viscous slot flow losses and viscous wall boundary layers. The slot flow equations consist of basically two equations, one mass-flux equation and one pressure equation imposing the constant plenum pressure. The interior test-section flow in the wind tunnel is described by the nonlinear small perturbation potential equation. The test model is blocking 0.5 percent of the wind tunnel cross section area which is 0.5 x 0.5 sq m. Numerical and experimental results are shown for two Mach numbers at two angles of attack. Considering the rather small test model producing small disturbances at the walls the computed wall pressure distributions agree quite well with the measurements. Author

A87-49112#
COMPUTATION OF TRANSONIC AERODYNAMICALLY COMPENSATING PITOT TUBE
SHIJUN LUO (Northwestern Polytechnical University, Xian, People's Republic of China) and YUN BAO IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 596-600. refs
(AIAA PAPER 87-2613)

The transonic flows around an aerodynamically compensating pitot tube mounted in front of fuselage with nose inlet working at various mass flow rates are computed by using the transonic small transverse perturbation equation. The boundary condition and the solution on the body are treated according to the slender body theory. The successive line over relaxation of the difference equation is accelerated by an artificial time damping term. The computational results agree well with the wind tunnel and flight test data. Author

A87-49114*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ON THE NONLINEAR AERODYNAMIC AND STABILITY CHARACTERISTICS OF A GENERIC CHINE-FOREBODY SLENDER-WING FIGHTER CONFIGURATION
GARY E. ERICKSON (NASA, Ames Research Center, Moffett Field, CA) and JAY M. BRANDON (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 607-641. refs
(AIAA PAPER 87-2617)

An exploratory investigation was conducted of the nonlinear aerodynamic and stability characteristics of a tailless generic fighter configuration featuring a chine-shaped forebody coupled to a slender cropped delta wing in the NASA Langley Research Center's 12-Foot Low-Speed Wind Tunnel. Forebody and wing vortex flow mechanisms were identified through off-body flow visualizations to explain the trends in the longitudinal and lateral-directional characteristics at extreme attitudes (angles of attack and sideslip). The interactins of the vortical motions with centerline and wing-mounted vertical tail surfaces were studied and the flow phenomena were correlated with the configuration forces and moments. Single degree-of-freedom, free-to-roll tests were used to study the wing rock susceptibility of the generic fighter model. Modifications to the nose region of the chine forebody were examined and fluid mechanisms were established to account for their ineffectiveness in modulating the highly interactive forebody and wing vortex systems. Author

A87-49297
IMPLEMENTATION OF KUTTA CONDITION FOR A FINITE ELEMENT FORMULATION OF EULER EQUATIONS
H. U. AKAY and A. ECER (Purdue University, Indianapolis, IN) IN: Innovative numerical methods in engineering; Proceedings of the Fourth International Symposium, Atlanta, GA, Mar. 24-28, 1986 . Berlin and New York, Springer-Verlag, 1986, p. 291-296. refs
(Contract F49620-83-K-0034)

A finite element method for solving compressible Euler equations using a Clebsch transformation of the velocity vector, proposed in an earlier study (Akay and Ecer, 1982), is extended to the analysis of transonic flows at high angles of attack in which the streamline of discontinuity can no loger be treated as horizontal. A procedure which adaptively moves the grid lines to fit this streamline is described. Results obtained for transonic flow around an airfoil are presented to demonstrate the method. V.L.

A87-49496* Vigyan Research Associates, Inc., Hampton, Va.
VORTICAL FLOW MANAGEMENT TECHNIQUES
DHANVADA M. RAO (Vigyam Research Associates, Inc., Hampton, VA) and JAMES F. CAMPBELL (NASA, Langley Research Center, Hampton, VA) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 24, no. 3, 1987, p. 173-224. USAF-supported research. refs

The aerodynamic performance and controllability of advanced, highly maneuverable supersonic aircraft can be enhanced by means of 'vortex management', which refers to the purposeful manipulation and reordering of stable and concentrated vortical structures due to flow separations from highly swept leading edges and slender forebodies at moderate-to-high angles-of-attack. Attention is presently given to a variety of results obtained in the course of experiments on generic research models at NASA Langley, clarifying their underlying aerodynamics and evaluating their performance-improvement potential. The vortex-management concepts discussed encompass aerodynamic compartmentation of highly swept leading edges, vortex lift augmentation and modulation, and forebody vortex manipulation. O.C.

A87-49604#
A NEW ANALYTICAL APPROACH TO VORTEX BREAKDOWN INVESTIGATION
S. G. BRYCE IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 257-265. Research supported by British Aerospace, PLC. refs
(AIAA PAPER 87-2495)

A simple inviscid incompressible model for the crossflow past a delta wing was developed for use in an investigation of vortex breakdown. The well-known leading edge vortices were reduced to two point vortex-sink combinations, and the governing complex potential for this representation was determined. Imposition of a Kutta condition at the leading edges revealed the existence of a critical ratio of sink-to-vortex strength at which the flow altered dramatically. On the basis of the crossflow representation, the model was extended into three dimensions by a space marching method. It was found that the sink-to-vortex strength ratio remained a dominant control parameter and that the numerical calculation failed as the critical ratio was approached. It is considered that this behavior may indicate the role of entrainment in the vortex breakdown phenomenon. Author

A87-49605#
ANALYTIC PREDICTION OF SLENDER WING ROCK
L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 266-271. refs
(AIAA PAPER 87-2496)

Wing rock of slender delta wings is controlled by two vortical flow phenomena; asymmetric vortex shedding from the wing leading edges, and breakdown of these leading edge vortices. The asymmetric vortex shedding provides the mechanism driving the wing rock motion, and the vortex breakdown or burst provides the

mechanism limiting the amplitude of the wing rock. Simple analytic means are presented by which the maximum wing rock amplitude measured experimentally can be predicted. Author

A87-49606#
MEASUREMENT AND PREDICTION OF FREE FLIGHT WING-INDUCED VORTEX VELOCITY FIELDS
RUSSELL M. CUMMINGS and DORAL R. SANDLIN (California Polytechnic State University, San Luis Obispo) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 272-278. refs
(AIAA PAPER 87-2497)

An experimental method was developed to measure the wing-induced vortex velocity field of a free flight aircraft. Radio-controlled airplane models were flown through a field of small particles and measurements of the particle velocities were made using various photographic techniques. A theoretical model of the motion of the particles was developed and used to determine the vortex strength and velocity field induced by the aircraft. The experimental method is considered for application to full-scale aircraft or for comparisons and analysis of various wing-tip vortex alleviation devices. Author

A87-49608*# Royal Aircraft Establishment, Farnborough (England).
VALIDATION OF AERODYNAMIC PARAMETERS AT HIGH ANGLES OF ATTACK FOR RAE HIGH INCIDENCE RESEARCH MODELS
A. JEAN ROSS, GERALDINE F. EDWARDS (Royal Aircraft Establishment, Aerodynamics Dept., Farnborough, England), VLADISLAV KLEIN (Joint Institute for Advancement of Flight Sciences, Hampton, VA), and JAMES G. BATTERSON (NASA, Langley Research Center, Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 296-304. refs
(AIAA PAPER 87-2558)

Two series of free-flight tests have been conducted for combat aircraft configuration research models in order to investigate flight behavior near departure conditions as well as to obtain response data from which aerodynamic characteristics can be derived. The structure of the mathematical model and values for the mathematical derivatives have been obtained through an analysis of the first series, using stepwise regression. The results thus obtained are the bases of the design of active control laws. Flight test results for a novel configuration are compared with predicted responses. O.C.

A87-49626*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NAVIER-STOKES COMPUTATIONS OF PROLATE SPHEROIDS AT ANGLE OF ATTACK
V. N. VATSA, J. L. THOMAS (NASA, Langley Research Center, Hampton, VA), and B. W. WEDAN (Vigyan Research Associates, Inc., Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 488-506. refs
(AIAA PAPER 87-2627)

Three-dimensional viscous flow calculations are made for a 6:1 prolate spheroid at conditions for which detailed experimental data are available. The computations are made with two finite-volume algorithms for the compressible Navier-Stokes equations, one using central differencing for the convective and pressure terms and the other using an upwind-biased flux-difference-splitting approach. The effects of grid density and artificial dissipation on the accuracy of the numerical results are included. Generally good agreement of the computations with the experimental results is obtained over a range of Reynolds numbers and angles-of-attack, up to 30 deg, although the results at lower Reynolds numbers are sensitive to the assumed transition location. Author

A87-49649*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NUMERICAL SIMULATIONS OF UNSTEADY, VISCOUS, TRANSONIC FLOW OVER ISOLATED AND CASCADED AIRFOILS USING A DEFORMING GRID
DENNIS L. HUFF (NASA, Lewis Research Center, Cleveland, OH) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 16 p. Previously announced in STAR as N87-24435. refs
(AIAA PAPER 87-1316)

A compressible, unsteady, full Navier-Stokes, finite difference code was developed for modeling transonic flow through two-dimensional, oscillating cascades. The procedure introduces a deforming grid technique to capture the motion of the airfoils. Results using a deforming grid are presented for both isolated and cascaded airfoils. The load histories and unsteady pressure distributions are predicted for the NASA 64A010 isolated airfoil and compared with existing experimental data. Results show that the deforming grid technique can be used to successfully predict the unsteady flow properties around an oscillating airfoil. The deforming grid technique was extended for modeling unsteady flow in a cascade. The use of a deforming grid simplifies the specification of boundary conditions. Unsteady flow solutions similar to the isolated airfoil predictions are found for a NACA 0012 cascade with zero interblade phase angle and zero stagger. Experimental data for these cases are not available for code validation, but computational results are presented to show sample predictions from the code. Applications of the code to typical turbomachinery flow conditions will be presented in future work. Author

A87-49978#
COMPARISON OF THREE EXPERIMENTAL METHODS FOR TRANSONIC TURBINE CASCADES
XUEZHEN YANG (Gas Turbine Establishment, People's Republic of China) Journal of Aerospace Power, vol. 2, April 1987, p. 105-108, 184. In Chinese, with abstract in English. refs

Three typical transonic turbine cascades have been designed and tested with the aid of three diffrent methods: two-dimensional cascade wind tunnel test, wind tunnel test with sector of annular cascade, and hydraulic analogy. The results of these three methods are compared under the condition of geometry similarity. They are also compared with numerical solutions of the Finite Area Time-Marching calculation. The strong and weak points and reliability of these methods are evaluated. Author

A87-49980#
INVESTIGATION OF SUPERSONIC MULTIPLE CIRCULAR ARC (MCA) AIRFOIL CASCADE OF AXIAL-FLOW COMPRESSOR
GECHENG ZHA and RUQUN YAN (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power, vol. 2, April 1987, p. 113-116, 184, 185. In Chinese, with abstract in English.

A computational method-of-characteristics for the initial-value line in a rotational supersonic cascade flow field with detached shock waves is presented. With the solution of complete Euler flow equations by the shock-fitting method, a cascaade supersonic inlet flow field containing detached waves is computed. The calculated detached shock waves before the cascade and the pressure distribution in the supersonic region are satisfactory. From the calculated results of the flow field, the relation between the Mach number and the unique incidence, which meets the design requirements, can also be obtained. In this investigation, the loss-computational method of the supersonic cascade is also presented, which correlates the computation of supersonic flow field with the wake method of subsonic profile. This method can determine the shock loss and the subsonic profile loss separately. Agreement between the calculated and the measured total loss is quite good. Author

A87-49989#
EXPERIMENTAL INVESTIGATION ON FLOW PERFORMANCE OF TANDEM BLADE CASCADES WITH DOUBLE CIRCULAR ARC PROFILES
BIAONAN ZHUANG, GUOCHUAN WU, and BINGHENG GUO (Nanjing Aeronautical Institute, People's Republic of China) Journal of Aerospace Power, vol. 2, April 1987, p. 159-161, 189. In Chinese, with abstract in English. refs

Wind tunnel experiments have been made with 24 types of tandem-blade cascades with different geometrical parameters. Under the conditions that the inlet Mach number is 0.3 and the Reynolds number is 270,000, the main flow characteristics of tandem cascades have been obtained, and the operation ranges of main geometrical parameters under optimum conditions have been found. Author

A87-49991#
COMPUTER-AIDED EXPERIMENTAL INVESTIGATION OF AXIAL-FLOW COMPRESSORS
NIANGUO ZHU and MAOZHANG CHEN (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power, vol. 2, April 1987, p. 165, 166, 190. In Chinese, with abstract in English. refs

An approach has been developed to evaluate some important aerodynamic parameters of axial-flow compressors, such as air-flow angle, blockage factor and loss coefficient, at umeasurable surfaces. It can be used for two cases of measurement of multistage, axial-flow compressors. In order to verify this approach, several examples have been calculated, and the results show that this approach provides reliable data for further performance improvement. Author

A87-50187*# Case Western Reserve Univ., Cleveland, Ohio.
METHOD FOR THE DETERMINATION OF THE THREE DIMENSIONAL AERODYNAMIC FIELD OF A ROTOR-STATOR COMBINATION IN COMPRESSIBLE FLOW
SRIDHAR M. RAMACHANDRA (Case Case Western Reserve University, Cleveland, OH), LAWRENCE J. BOBER (NASA, Lewis Research Center, Cleveland, OH), and SURESH KHANDELWAL (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 32 p. Previously announced in STAR as N87-23625. refs
(AIAA PAPER 87-1742)

Using the lifting surface theory and the acceleration potential method for the flow field of an axial turbocompressor stage, a recursive and a direct method are presented that make use of the eigenfunction solutions of the isolated rotor and stator to solve for the rotor-stator interaction problem. The net pressure distribution on the rotor and stator blades is represented by modified Birnbaum series, whose coefficients are determined using a matrix procedure and satisfying the boundary conditions on the surface of the blades. The relation between the matrix operators of the recursive and the direct methods is also shown. Expressions have been given for the blade circulation, the axial and tangential forces on the blade, the rotor power required, and the induced upwash velocity of the stage. Author

A87-50338#
OPTIMIZATION OF WING TIP STORE MODELING
ALFRED GERHARD STRIZ and SUNG KUK JANG (Oklahoma, University, Norman) Journal of Aircraft (ISSN 0021-8669), vol. 24, Aug. 1987, p. 516, 517. Abridged.
(Contract AF-AFOSR-83-0184)

In present three-dimensional flutter investigations of aircraft with external stores, the stores are often approximated by flat plates to reduce the cost and complexity of the analyses. In this Synoptic, the doublet lattice and kernel function methods are utilized to investigate the validity of this flat-plate approximation in comparison to store models of other geometries for an F-5 wing with tip-mounted launcher/store combination. Various cross sections are found that show improved results with only a moderate increase in model complexity and thus computer cost. Author

A87-50339*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AERODYNAMIC CHARACTERISTICS OF BIPLANES WITH WINGLETS
PETER D. GALL (NASA, Langley Research Center, Hampton, VA) and HUBERT C. SMITH (Pennsylvania State University, University Park) Journal of Aircraft (ISSN 0021-8669), vol. 24, Aug. 1987, p. 518-522. Previously cited in issue 07, p. 842, Accession no. A85-19631. refs

A87-50341*# Sterling Software, Palo Alto, Calif.
NUMERICAL SIMULATION OF TRANSONIC SEPARATED FLOWS OVER LOW-ASPECT-RATIO WINGS
UNVER KAYNAK (Sterling Software, Palo Alto, CA), TERRY L. HOLST, REESE L. SORENSON (NASA, Ames Research Center, Moffett Field, CA), and BRIAN J. CANTWELL (Stanford University, CA) Journal of Aircraft (ISSN 0021-8669), vol. 24, Aug. 1987, p. 531-539. Previously cited in issue 08, p. 986, Accession no. A86-22704. refs
(Contract NCA2-0R-745-309)

A87-50342*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
APPLICATION OF THE TRANAIR FULL-POTENTIAL CODE TO THE F-16A
L. L. ERICKSON, M. D. MADSON, and A. C. WOO (NASA, Ames Research Center, Moffett Field, CA) (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 1, p. 313-323) Journal of Aircraft (ISSN 0021-8669), vol. 24, Aug. 1987, p. 540-545. Previously cited in issue 24, p. 3530, Accession no. A86-49009. refs
(Contract NAS2-11851)

A87-50343#
CALCULATION OF FLOW OVER MULTIELEMENT AIRFOILS AT HIGH LIFT
TUNCER CEBECI (California State University, Long Beach), K. C. CHANG, R. W. CLARK, and N. D. HALSEY (Douglas Aircraft Co., Long Beach, CA) (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 1, p. 335-342) Journal of Aircraft (ISSN 0021-8669), vol. 24, Aug. 1987, p. 546-551. Previously cited in issue 24, p. 3530, Accession no. A86-49011. refs
(Contract NSF MEA-81-8565)

A87-50345*# Massachusetts Inst. of Tech., Cambridge.
LOW REYNOLDS NUMBER TESTS OF NACA 64-210, NACA 0012, AND WORTMANN FX67-K170 AIRFOILS IN RAIN
R. JOHN HANSMAN, JR. and ANTHONY P. CRAIG (MIT, Cambridge, MA) Journal of Aircraft (ISSN 0021-8669), vol. 24, Aug. 1987, p. 559-566. Previously cited in issue 08, p. 1035, Accession no. A87-22518. refs
(Contract NAG1-568)

A87-50346#
LOW REYNOLDS NUMBER EFFECTS ON SUBSONIC COMPRESSIBILITY CORRECTIONS
AJAY P. KOTHARI and JOHN D. ANDERSON, JR. (Maryland, University, College Park) Journal of Aircraft (ISSN 0021-8669), vol. 24, Aug. 1987, p. 567, 568. refs
(Contract N00014-85-K-0246)

A numerical experiment is conducted whose results demonstrate the considerable extent to which the highly viscous effects associated with low Reynolds number flows influence subsonic compressibility corrections. The Kothari and Anderson (1985) compressible Navier-Stokes code is used to calculate the flow over a Wortmann FX 63-137 airfoil at freestream Mach numbers of 0.5, 0.4, and 0.3. The highly viscous effects yield a relatively constant center-of-lift up to Mach 0.5. O.C.

A87-50347*# Iowa State Univ. of Science and Technology, Ames.
APPLICATION OF A PANEL CODE TO UNSTEADY WING-PROPELLER INTERFERENCE
A. A. RANGWALLA and L. N. WILSON (Iowa State University of Science Technology, Ames) Journal of Aircraft (ISSN 0021-8669), vol. 24, Aug. 1987, p. 568-571. Research supported by the Iowa State University of Science and Technology and NASA. refs

Attention is given to the predictions of unsteady, incompressible, potential flow, on the basis of an extension of Maskew's (1982) low-order paneling method. This approach, which is a nonlinear one in that the small-perturbation approximation is not made, is able to arrive at solutions for such general problems as that of the interference between a two-bladed propeller and a wing. Due to the geometry and flow field in question, a wake-snipping procedure is introduced. O.C.

N87-26858*# Kansas Univ. Center for Research, Inc., Lawrence. Flight Research Lab.
AN EXPERIMENTAL INVESTIGATION OF DYNAMIC GROUND EFFECT Semiannual Status Report, 19 Sep. 1985 - 15 Mar. 1986
PAI HUNG LEE, C. EDWARD LAN, and VINCENT U. MUIRHEAD 1 Apr. 1986 61 p
(Contract NAG1-616)
(NASA-CR-180305; NAS 1.26:180305; CRINC-FRL-717-1) Avail: NTIS HC A04/MF A01 CSCL 01A

Experimental studies were conducted to determine the longitudinal force and moment aerodynamic coefficients for a 1/48 scale model of an F-106 aircraft and a 0.01 scale model of an XB-70-1 aircraft. The two airplanes and one 60 degree delta wing model were designed and fabricated to satisfy the specific test conditions of the Kansas University wind tunnel with a 3 by 4.3 test section. Results of the tests are given Author

N87-26860*# Kansas Univ. Center for Research, Inc., Lawrence.
CALCULATION OF AERODYNAMIC CHARACTERISTICS AT HIGH ANGLES OF ATTACK FOR AIRPLANE CONFIGURATIONS Semiannual Status Report, 1 Aug. 1986 - 31 Jan. 1987
C. EDWARD LAN and J. B. TSENG 24 Feb. 1987 25 p
(Contract NAG1-635)
(NASA-CR-180678; NAS 1.26:180678) Avail: NTIS HC A02/MF A01 CSCL 01A

The primary objective is to determine how an airplane configuration should be modeled to predict both longitudinal and lateral aerodynamic characteristics at high angles of attack. A generic fighter model, an F-16 and an F-18 configuration with leading edge flap deflection and an F-106B configuration were investigated. Furthermore, the F-16XL and X-29 configurations were examined. Some calculated results are given. Author

N87-26862*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
NON-LINEAR UNSTEADY WING THEORY, PART 1. QUASI TWO-DIMENSIONAL BEHAVIOR: AIRFOILS AND SLENDER WINGS Progress Report
J. E. MCCUNE Jun. 1987 41 p
(Contract NAG1-658)
(NASA-CR-181008; NAS 1.26:181008) Avail: NTIS HC A03/MF A01 CSCL 01A

The initial phases of a study of the large-amplitude unsteady aerodynamics of wings in severe maneuver are reported. The research centers on vortex flows, their initiation at wing surfaces, their subsequent convection, and interaction dynamically with wings and control surfaces. The focus is on 2D and quasi-2D aspects of the problem and features the development of an exact nonlinear unsteady airfoil theory as well as an approach to the crossflow problem for slender wing applications including leading-edge separation. The effective use of interactive on-line computing in quantifying and visualizing the nonsteady effects of severe maneuver is demonstrated. Interactive computational work is now possible, in which a maneuver can be initiated and its effects observed and analyzed immediately. Author

N87-26864*# General Dynamics Corp., Fort Worth, Tex.
A STUDY OF THE EFFECTS OF REYNOLDS NUMBER AND MACH NUMBER ON CONSTANT PRESSURE COEFFICIENT JUMP FOR SHOCK-INDUCED TRAILING-EDGE SEPARATION Final Report
ATLEE M. CUNNINGHAM, JR. and GREGORY S. SPRAGLE Washington NASA Aug. 1987 81 p
(Contract NAS1-17955)
(NASA-CR-4090; NAS 1.26:4090) Avail: NTIS HC A05/MF A01 CSCL 01A

The influence of Mach and Reynolds numbers as well as airfoil and planform geometry on the phenomenon of constant shock jump pressure coefficient for conditions of shock induced trailing edge separation (SITES) was studied. It was demonstrated that the phenomenon does exist for a wide variety of two and three dimensional flow cases and that the influence of free stream Mach number was not significant. The influence of Reynolds number was found to be important but was not strong. Airfoil and planform geometric characteristics were found to be very important where the pressure coefficient jump was shown to vary with the sum of: (1) airfoil curvature at the upper surface crest, and (2) camber surface slope at the trailing edge. It was also determined that the onset of SITES could be defined as a function of airfoil geometric parameters and Mach number normal to the leading edge. This onset prediction was shown to predict the angle of onset to within + or - 1 deg accuracy or better for about 90% of the cases studied. Author

N87-26865*# Kansas Univ. Center for Research, Inc., Lawrence.
AN INVESTIGATION OF TIP PLANFORM INFLUENCE ON THE AERODYNAMIC LOAD CHARACTERISTICS OF SEMISPAN, UPSWEPT WING AND WING-TIP
JOHANNES M. VANAKEN Dec. 1986 86 p Previously announced as N86-29766
(Contract NCC2-112)
(NASA-CR-177428; NAS 1.26:177428) Avail: NTIS HC A05/MF A01 CSCL 01A

A semi-span wing, equipped with an interchangeable tip, which was varied in planform and size was examined. Total wing aerodynamic loading was obtained from the wind tunnel scale system. The wing tip was mounted on a separate six-component strain gauge balance, which provided the aerodynamic loads on the tip. The tests were accomplished in the NASA Ames 7X10-Foot Wind Tunnel at a Mach number of 0.178. The aerodynamic load characteristics of the wing and of the tip were presented with the tip at several incidence angles relative to the wing inboard section. Author

N87-26866# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.
AERODYNAMIC/DYNAMIC INTERACTION Annual Technical Report
DEAN T. MOOK and ALI H. NAYFEH 30 Apr. 1987 80 p
(Contract AF-AFOSR-0158-85)
(AD-A180621; AFOSR-87-0670TR) Avail: NTIS HC A05/MF A01 CSCL 20D

Simulations of wingrock with an additional degree of freedom have been completed and a new technique to simulate the unsteady wake behind an airfoil was developed. An analytical model of the subsonic wingrock phenomenon for a slender wing has been completed and a numerical simulation of the interference between the leading and trailing wings of an X-29 model have been developed further. GRA

N87-26867# Aeronautical Research Labs., Melbourne (Australia).
THE EFFECT OF ROTOR WAKE GEOMETRY VARIATION ON HOVER INDUCED POWER ESTIMATION FOR A UH-1H IROQUOIS HELICOPTER
K. R. REDDY Oct. 1986 25 p
(AD-A180787; ARL-AERO-TM-384) Avail: NTIS HC A02/MF A01 CSCL 01A

In a simple prescribed rotor wake model for hover developed at ARL, generalized model rotor experimental data are used to position the tip vortices. Parametric studies are conducted to explore the sensitivity of calculated induced power with the positioning of these vortices. Calculated induced power, obtained directly by extrapolating model data to the full-scale case of a UH-1H Iroquois helicopter, is compared with flight data, and the required repositioning of the vortices to match flight data is given. GRA

N87-26869# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
ACTA AERONAUTICA ET ASTRONAUTICA SINICA (SELECTED ARTICLES)
18 May 1987 34 p Transl. into ENGLISH from Hangkong Xuebao (China), v. 7, no. 2, Apr. 1986 p 205-216
(AD-A181204; FTD-ID(RS)T-0117-86) Avail: NTIS HC A03/MF A01 CSCL 20D

Translated articles from Chinese periodicals are presented. Some topics covered are: Calculations of Steady and Unsteady TranTransonic Flows Over Airfoils by Monotone Switch; and Applications of Dual Hologram Interferometry to Density Field Determination in Wind Tunnels. GRA

N87-26871# Grumman Aerospace Corp., Bethpage, N.Y. Aerosciences Directorate.
AN INVESTIGATION OF TURBULENCE MECHANISMS IN V/STOL UPWASH FLOW FIELDS Final Report
BARRY L. GILBERT Mar. 1987 72 p
(Contract F49620-85-C-0111)
(AD-A181265; RE-730; AFOSR-87-0603TR) Avail: NTIS HC A04/MF A01 CSCL 01A

Results are presented of an experimental investigation of the abnormally high turbulent mixing layer growth rate characteristics found in the upwash regions of V/STOL flows in ground effect. Three dimensional experimental studies were conducted in a radial wall jet facility. Measurements included velocity components, second - third - fourth moments, and integral and microscale lengths. The upwash formed by the collision of radial wall jets contains the essential characteristics of a radial upwash while decoupling the problem caused by the impinging jets on the ground plane and the recirculation zone. GRA

N87-26872# Nielsen Engineering and Research, Inc., Mountain View, Calif.
A STUDY OF SUPERMANEUVER AERODYNAMICS Final Report, 1 Aug. 1986 - 31 Jan. 1987
DAVID NIXON and MOHAMMAD FARSHCHI 13 Feb. 1987 10 p
(Contract F49620-86-C-0071)
(AD-A181490; NEAR-TR-375; AFOSR-87-0626TR) Avail: NTIS HC A02/MF A01 CSCL 01A

An innovative method of examining fluid flow phenomena is described and preliminary results are given. The technique uses a subproblem formulation which examines only those portions of the flow which are of interest. The particular flow examined is that of a stalled airfoil and the objective of the technique is to develop ways of controlling the stall. Both conventional and nonconventional means of stall control have been examined and it is concluded that the subproblem technique is a viable approach for the study of fluid flow phenomena. GRA

N87-26874*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SUBSONIC LONGITUDINAL AND LATERAL-DIRECTIONAL CHARACTERISTICS OF A FORWARD-SWEPT-WING FIGHTER CONFIGURATION AT ANGLES OF ATTACK UP TO 47 DEG
MICHAEL J. MANN, JARRETT K. HUFFMAN, and CHARLES H. FOX, JR. Sep. 1987 103 p
(NASA-TP-2727; L-16206; NAS 1.60:2727) Avail: NTIS HC A06/MF A01 CSCL 01A

Subsonic lateral-direction and longitudinal characteristics of a forward-swept-wing fighter configuration were examined in wind-tunnel tests at Mach numbers of 0.2 and 0.5 for angles of attack from -7 to 47 deg. and over a sidelslip range of +/- 15 deg. The effects of a canard, strakes, vertical tail, and leading- and trailing-edge flaps are examined. The canard and strakes both reduce asymmetric moments and side forces at zero sideslip for angles of attack up to about 30 deg. The canard has a small influence on lateral-directional stability; however, strakes produce a substantial reduction in lateral stability for angles of attack greater than about 20 deg. The vertical tail improves directional stability for angles of attack up to 30 deg. Deflection of the leading-edge flap to 20 deg. at high angles of attack on the strake and canard configurations degrades lateral and directional stability. Deflection of the trailing-edge flap to 20 deg. on the canard configuration generally increases lateral and directional stability at high angles of attack. Leading- and trailing-edge flaps on the wing-body and canard configurations are effective for increased lift only for angles of attack up to about 40 deg. The leading-edge flap remains effective on the strake configuration over the entire angle-of-attack range tested. Author

N87-26875*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AERODYNAMIC CHARACTERISTICS OF THE MODIFIED 40- BY 80-FOOT WIND TUNNEL AS MEASURED IN A 1/50TH-SCALE MODEL
BRIAN E. SMITH and TIM NAUMOWICZ Aug. 1987 56 p
(NASA-TM-88336; A-86329; NAS 1.15:88336) Avail: NTIS HC A04/MF A01 CSCL 01A

The aerodynamic characteristics of the 40- by 80-Foot Wind Tunnel at Ames Research Center were measured by using a 1/50th-scale facility. The model was configured to closely simulate the features of the full-scale facility when it became operational in 1986. The items measured include the aerodynamic effects due to changes in the total-pressure-loss characteristics of the intake and exhaust openings of the air-exchange system, total-pressure distributions in the flow field at locations around the wind tunnel circuit, the locations of the maximum total-pressure contours, and the aerodynamic changes caused by the installation of the acoustic barrier in the southwest corner of the wind tunnel. The model tests reveal the changes in the aerodynamic performance of the 1986 version of the 40- by 80-Foot Wind Tunnel compared with the performance of the 1982 configuration. Author

N87-26877*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
OPERATIONAL PERFORMANCE OF VAPOR-SCREEN SYSTEMS FOR IN-FLIGHT VISUALIZATION OF LEADING-EDGE VORTICES ON THE F-106B AIRCRAFT
JOHN E. LAMAR, PHILIP W. BROWN, ROBERT A. BRUCE, JOSEPH D. PRIDE, JR., RONALD H. SMITH, and THOMAS D. JOHNSON, JR. (PRC Kentron, Inc., Hampton, Va.) Sep. 1987 84 p
(NASA-TM-4004; L-16306; NAS 1.15:4004) Avail: NTIS HC A05/MF A01 CSCL 01A

A flight research program was undertaken at the NASA Langley Research Center to apply the vapor-screen technique, widely used in wind tunnels, to an aircraft. The purpose was to obtain qualitative and quantitative information about near-field vortex flows above the wings of fighter aircraft and ascertain the effects of Reynolds and Mach numbers over the angle-of-attack range. The hardware for the systems required for flight application of the vapor-screen

technique was successfully developed and integrated. Details of each system, its operational performance on the F-106B aircraft, and pertinent aircraft and environmental data collected are presented. Author

N87-26878*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
WIND-TUNNEL EVALUATION OF AN ADVANCED MAIN-ROTOR BLADE DESIGN FOR A UTILITY-CLASS HELICOPTER
WILLIAM T. YEAGER, JR., WAYNE R. MANTAY, MATTHEW L. WILBUR, ROBERT G. CRAMER, JR., and JEFFREY D. SINGLETON Sep. 1987 40 p Prepared in cooperation with Army Aviation Research and Development Command, Hampton, Va.
(Contract DA PROJ. 1L1-62209-AH-76B)
(NASA-TM-89129; L-16260; NAS 1.15:89129; AVSCOM-TM-87-B-8) Avail: NTIS HC A03/MF A01 CSCL 01A

An investigation was conducted in the Langley Transonic Dynamics Tunnel to evaluate differences between an existing utility-class main-rotor blade and an advanced-design main-rotor blade. The two rotor blade designs were compared with regard to rotor performance oscillatory pitch-link loads, and 4-per-rev vertical fixed-system loads. Tests were conducted in hover and over a range of simulated full-scale gross weights and density altitude conditions at advance ratios from 0.15 to 0.40. Results indicate that the advanced blade design offers performance improvements over the baseline blade in both hover and forward flight. Pitch-link oscillatory loads for the baseline rotor were more sensitive to the test conditions than those of the advanced rotor. The 4-per-rev vertical fixed-system load produced by the advanced blade was larger than that produced by the baseline blade at all test conditions. Author

N87-26881# Leicester Univ. (England). Dept. of Engineering.
THE AERODYNAMICS OF PARACHUTES
D. J. COCKRELL and A. D. YOUNG, ed. Jul. 1987 81 p Sponsored by AGARD, Neuilly-sur-Seine, France
(AGARD-AG-295; ISBN-92-835-0422-4) Avail: NTIS HC A05/MF A01

This AGARD report discusses the principal aerodynamic characteristics of parachutes and the factors which affect them. It is anticipated that its main readers will be recent engineering graduates entering research establishments, parachute companies or related industries so some appreciation of basic mechanics, the principles of computing and elementary fluid dynamics on the part of the reader has been assumed. Its contents include Steady-State and Unsteady Aerodynamics, Parachute Deployment and Inflation, Experimental Investigations, Methods of analysis, Extraterrestrial Parachute Applications, and some suggestions for future research. Author

N87-26882# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction Scientifique de la Resistance des Structures.
COMPUTATION OF GENERALIZED AERODYNAMIC FORCES OVER AN ENTIRE AIRCRAFT, TAKING INTO ACCOUNT THE SUBSONIC INTERACTIONS BY MEANS OF THE VELOCITY POTENTIAL METHOD [CALCUL DES FORCES AERODYNAMIQUES GENERALISEES SUR UN AVION COMPLET EN TENANT COMPTE DES INTERACTIONS EN SUBSONIQUE PAR LA METHODE DU POTENTIEL DE VITESSE]
J. P. GRISVAL Nov. 1986 39 p In FRENCH
(Contract STPA-85-95-004)
(ONERA-RT-26/3064-RY-052-R; ETN-87-90123) Avail: NTIS HC A03/MF A01

A computer program for aerodynamic forces on aircraft is presented. The numerical analysis in the subsonic domain is based on the solution of integral equations relating the velocity potential to the structure modes. Program performance on a CRAY-1 computer is detailed (computation time and memory utilization for each case). ESA

N87-26883*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AN EXPERIMENTAL INVESTIGATION OF AN ADVANCED TURBOPROP INSTALLATION ON A SWEPT WING AT SUBSONIC AND TRANSONIC SPEEDS
JOHN R. CARLSON and ODIS C. PENDERGRAFT, JR. Sep. 1987 242 p
(NASA-TP-2729; L-16043; NAS 1.60:2729) Avail: NTIS HC A11/MF A01 CSCL 01A

An investigation was conducted in the Langley 16-Foot Transonic Tunnel to determine the effects of a turboprop-nacelle installation on the pressure distributions over a swept, supercritical wing. The tests were conducted at Mach numbers from 0.20 to 0.80, at angles of attack from 0 to 5 degrees, nacelle nozzle pressure ratios from 1.0 to 1.6, and at propeller tip speeds from 700 to 800 ft/sec. The results of this study indicate that the turboprop nacelle interference, with and without power, on a swept wing is greater on the inboard wing panel than on the outboard wing panel. The over-the-wing nacelle installation with the propeller upwash on the inboard panel had flow separation problems at a Mach number of 0.80. No severe flow separation problems appear to exist for either propeller rotation direction for the under-the-wing nacelle installation. The local flow disturbances caused by the under-the-wing nacelle installation were in general less severe than for the over-the-wing nacelle installation. Author

N87-27619# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction Scientifique de la Resistance des Structures.
DEVELOPMENT OF A COMPUTING CODE FOR THREE DIMENSIONAL UNSTEADY TRANSONIC SMALL PERTURBATIONS Final Report [DEVELOPPEMENT DU CODE DE CALCUL DES PARTIES PERTURBATIONS TRANSSONIQUES INSTATIONNAIRES EN TRI-DIMENSIONNEL]
P. MULAK Dec. 1986 24 p In FRENCH
(Contract STPA-85-95-004)
(ONERA-RT-27/3064-RY-052-R; ETN-87-90126) Avail: NTIS HC A02/MF A01

A direct fluid-structure coupling computing method is presented as an evolution of an existing two dimensional method based on the ONERA flow computation program to analyze aeronautical profiles. The aeroelasticity computations give the frequency-damping of the profile, diminishing the overalll computation time. It is argued that with the traditional indirect method, only the first harmonics are used to compute the overall lift, while the presented method eliminates the negative aspects of that approximation. ESA

N87-27620*# Texas A&M Univ., College Station. Dept. of Aerospace Engineering.
A DIRECT-INVERSE METHOD FOR TRANSONIC AND SEPARATED FLOWS ABOUT AIRFOILS Final Report
LELAND A. CARLSON May 1986 81 p
(Contract NSG-1174)
(NASA-CR-181233; NAS 1.26:181233) Avail: NTIS HC A05/MF A01 CSCL 01A

A direct-inverse technique called TAMSEP that can be used for the analysis of the flow about airfoils at subsonic and low transonic freestream velocities is presented. The method is based upon the direct-inverse nonconservative full potential inviscid method, a Thwaites laminar boundary layer technique, and the Barnwell turbulent momentum integral scheme. It is formulated using Cartesian coordinates. The method is suitable for predicting the flowfield about airfoils having trailing edge separated flow under high lift conditions. Comparisons with experimental data indicate that the method should be a useful tool for applied aerodynamic analysis. Author

N87-27622*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CALCULATION OF VISCOUS EFFECTS ON TRANSONIC FLOW FOR OSCILLATING AIRFOILS AND COMPARISONS WITH EXPERIMENT
JAMES T. HOWLETT and SAMUEL R. BLAND Sep. 1987 77 p
(NASA-TP-2731; L-16289; NAS 1.60:2731) Avail: NTIS HC A05/MF A01 CSCL 01A

A method is described for calculating unsteady transonic flow with viscous interaction by coupling a steady integral boundary-layer code with an unsteady, transonic, inviscid small-disturbance computer code in a quasi-steady fashion. Explicit coupling of the equations together with viscous -inviscid iterations at each time step yield converged solutions with computer times about double those required to obtain inviscid solutions. The accuracy and range of applicability of the method are investigated by applying it to four AGARD standard airfoils. The first-harmonic components of both the unsteady pressure distributions and the lift and moment coefficients have been calculated. Comparisons with inviscid calcualtions and experimental data are presented. The results demonstrate that accurate solutions for transonic flows with viscous effects can be obtained for flows involving moderate-strength shock waves. Author

N87-27623*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
UNSTEADY HYBRID VORTEX TECHNIQUE FOR TRANSONIC VORTEX FLOWS AND FLUTTER APPLICATION Progress Report, 1 Jan. - 31 Jul. 1987
OSAMA A. KANDIL Aug. 1987 49 p
(Contract NAG1-648)
(NASA-CR-180308; NAS 1.26:180308) Avail: NTIS HC A03/MF A01 CSCL 01A

Papers resulting from work performed from January 1, 1987 to July 31, 1987 are listed. Transonic computational schemes based on Integral Equation Formulation of the full potential equation were presented. Classical and zero-total pressure-loss sets of Euler equations applied to delta wings were examined.

N87-27624*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
TRANSONIC AIRFOIL COMPUTATION USING THE INTEGRAL EQUATION WITH AND WITHOUT EMBEDDED EULER DOMAINS
OSAMA A. KANDIL and HONG HU *In its* Unsteady Hybrid Vortex Technique for Transonic Vortex Flows and Flutter Applications 15 p Aug. 1987 Presented at the 9th International Conference on Boundary Element Methods in Engineering, Stuttgart, West Germany, 31 Aug. - 4 Sep. 1987
Avail: NTIS HC A03/MF A01 CSCL 01A

Two transonic computational schemes which are based on the Integral Equation Formulation of the full potential equation were presented. The first scheme is a Shock Capturing-Shock Fitting (SCSF) scheme which uses the full potential equation throughout with the exception of the shock wave where the Rankine-Hugoniot relations are used to cross and fit the shock. The second scheme is an Integral Equation with Embedded Euler (IEEE) scheme which uses the full potential equation with an embedded region where the Euler equations are used. The two schemes are applied to several transonic airfoil flows and the results were compared with numerous computational results and experimental domains with fine grids. The SCSF-scheme is restricted to flows with weak shock, while the IEEE-scheme can handle strong shocks. Currently, the IEEE scheme is applied to other transonic flows with strong shocks as well as to unsteady pitching oscillations. Author

N87-27625*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
APPLICATIONS OF CLASSICAL AND ZERO-TOTAL-PRESSURE-LOSS SETS OF EULER EQUATIONS TO DELTA WINGS
OSAMA A. KANDIL and ANDREW H. CHUANG *In its* Unsteady Hybrid Vortex Technique for Transonic Vortex Flows and Flutter Applications 29 p Aug. 1987 Presented at the 1st International Conference on Industrial and Applied Mathematics, Le Chesnay, France, 29 Jun. - 3 Jul. 1987
Avail: NTIS HC A03/MF A01 CSCL 01A

Classical and zero-total pressure-loss sets of Euler equations were applied to sharp- and round-edge delta wings. The origin of the total pressure was explained in the classical set. For sharp-edged delta wings, all sets of Euler equations produce the same separated flow solutions. For round-edged delta wings and for coarse grids, the solution depends on the level of dissipation, the accuracy of the surface boundary condition, and the type of Euler equations set. For round-edged delta wings and for fine grids, attached flow solutions are obtained. Also presented were three dimensional flow solutions and asymmetric flow solutions including unsteady flow for sharp-edged delta wings. Euler equations should be restricted to sharp-edged wings for real flow solutions. For roung-edged wings, Navier-Stokes equations must be used. B.G.

N87-27626*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DRAG MEASUREMENTS OF BLUNT STORES TANGENTIALLY MOUNTED ON A FLAT PLATE AT SUPERSONIC SPEEDS
FLOYD J. WILCOX, JR. Sep. 1987 68 p
(NASA-TP-2742; L-16284; NAS 1.60:2742) Avail: NTIS HC A04/MF A01 CSCL 01A

An investigation has been conducted in the Langley Unitary Plan Wind Tunnel to measure the drag of blunt stores (hemispherical noses and afterbodies) tangentially mounted in various arrays on a flat plate at nominal Mach numbers of 1.60, 1.90, 2.16,and 2.86 and at a nominal Reynolds number of 2X10 to the 6th power per foot. The arrays consisted of two and three stores mounted in lateral, tandem, or staggered arrangements. The relative position of the stores in the arrays was varied while the drag of only one store was measured to determine the effect of spacing on the store drag. Store-on-store interference was determined by comparing the drag of a single store with the drag of the store in an array. The results indicate virtually all arrangements and spacings which were tested had favorable store-on-store interference (drag reduction) across the Mach number range. Tabulated data, schlieren photographs, and shadowgraphs are included. Author

N87-27628*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF VARIABLE INLET GUIDE VANES ON THE OPERATING CHARACTERISTICS OF A TILT NACELLE INLET/POWERED FAN MODEL
R. R. WOOLLETT and H. C. PONTONIDES (Grumman Aerospace Corp., Bethpage, N.Y.) Sep. 1987 41 p
(NASA-TM-88983; E-3453; NAS 1.15:88983) Avail: NTIS HC A03/MF A01 CSCL 01A

The effects of a variable inlet guide vane (VIGV) assembly on the operating characteristics of a V/STOL inlet and on the performance of a 20-in. (0.508-m) diameter fan engine were investigated. The data indicate that the VIGVs are effective thrust modulators over a wide range of free-stream velocities, nacelle angles of attack, and fan speeds. The thrust modulation ranges, including choking limits, fan stall limits, and inlet separation boundaries are presented. The presence of the VIGV assembly causes significant losses in inlet angle-of-attack capability and generally increases the blade stress levels at all limit conditions except at high angle of attack and high free-stream velocity. Reducing the fan nozzle exit area limited the positive VIGV actuation range and consequently decreased the range of thrust

modulation at all limit conditions except at both high free-stream velocity and high angle of attack conditions. Author

N87-27631*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
MODELING XV-15 TILT-ROTOR AIRCRAFT DYNAMICS BY FREQUENCY AND TIME-DOMAIN IDENTIFICATION TECHNIQUES
MARK B. TISCHLER and JUERGEN KALETKA (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick, West Germany) Dec. 1986 23 p Prepared in cooperation with Army Aviation Research and Development Command, Moffett Field, Calif.
(NASA-TM-89404; A-86435; NAS 1.15:89404; USAAVSCOM-TR-86-A-3) Avail: NTIS HC A02/MF A01 CSCL 01A

Models of the open-loop hover dynamics of the XV-15 Tilt-Rotor Aircraft are extracted from flight data using two approaches: frequency-domain and time-domain identification. Both approaches are reviewed and the identification results are presented and compared in detail. The extracted models compare favorable, with the differences associated mostly with the inherent weighting of each technique. Step responses are used to show that the predictive capability of the models from both techniques is excellent. Based on the results of this study, the relative strengths and weaknesses of the frequency- and time-domain techniques are summarized, and a proposal for a coordinated parameter identification approach is presented. Author

N87-27633# Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil). Dept. de Engenharia Mecanica Espacial.
COMPARING AN IMPROVED FIRST ORDER PANEL METHOD RESULTS WITH WIND-TUNNEL MEASUREMENTS FOR A COMPLETE AIRPLANE CONFIGURATION
FRANCISCO LEME GALVAO Feb. 1987 14 p Presented at the Boundary Element Technology Congress, BETECH-Rio/87, Brazil, 2-4 Jun. 1987
(INPE-4132-PRE/1043) Avail: NTIS HC A02/MF A01

A numerical computation of pressure distribution over a complete commercial airplane configuration, using an improved first order panel method, is made and results are compared with experimental measurements obtained for the same configuration with a 1/14 model in a wind tunnel. Author

N87-27634# Naval Postgraduate School, Monterey, Calif.
VISCOUS/INVISCID INTERACTION ANALYSIS OF THE AERODYNAMIC PERFORMANCE OF THE NACA 65-213 AIRFOIL M.S. Thesis
PHUTUT H. SUBROTO Mar. 1987 112 p
(AD-A182091) Avail: NTIS HC A06/MF A01 CSCL 20D

Cebeci's viscous/inviscid interaction program was applied to the analysis of steady two-dimensional incompressible flow past a NACA 65-213 airfoil at zero angle of attack at a Reynolds number of 240,000. Predicted boundary layer characteristics were found to be quite sensitive to the choice of boundary layer transition begin and length. Good agreement with the experimental results of Hoheisel et al could be obtained by proper choice of both transition begin and length. GRA

N87-27638# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
EXPERIMENTAL STUDY OF WING-IN-GROUND EFFECTS IN THE AFIT 5-FOOT WIND TUNNEL M.S. Thesis
LAWYN C. EDWARDS Mar. 1987 200 p
(AD-A182570; AFIT/GAE/AA/87M-1) Avail: NTIS HC A09/MF A01 CSCL 01A

The effect of flying close to the Earth's surface on the lift to drag ratio (L/D) was investigated. This was accomplished with the model of a NACA 4415 wing. The model was equipped with a full span adjustable flap and three sets of end and center plates. Ground boards were placed in the tunnel to simulate the Earth's surface. Five different heights of the model above the ground boards were selected to represent in and out of ground effect regimes. Data were collected for forces and pressures on the model and on the board. The graphical representation of results displayed the effects of changing model parameters versus force, moment and pressure coefficients. These conclusions were compared to theory and other literature for correlation. Results were conclusive. The effects of center plates and the variation of plate size were negligible. The presence of the set of end plates was beneficial near the surface but was negligible out of ground effects. The height of the model above the board produced noticeable differences in results. Angle of attack was shown to have a marked influence along with flap angle. Pressure plots also appeared to provide a method of predicting the amount of lift produced. GRA

N87-27641*# Rockwell International Corp., Columbus, Ohio.
LOW SPEED WIND TUNNEL TEST OF A PROPULSIVE WING/CANARD CONCEPT IN THE STOL CONFIGURATION. VOLUME 1: TEST DESCRIPTION AND DISCUSSION OF RESULTS
V. R. STEWART Sep. 1987 96 p
(Contract NAS1-17171)
(NASA-CR-178348; NAS 1.26:178348) Avail: NTIS HC A05/MF A01 CSCL 01A

A propulsive wing/canard model was tested at STOL operating conditions in the NASA Langley Research Center 4 x 7 meter wind tunnel. Longitudinal and lateral/directional aerodynamic characteristics were measured for various flap deflections, angles of attack and sideslip, and blowing coefficients. Testing was conducted for several model heights to determine ground proximity effects on the aerodynamic characteristics. Flow field surveys of local flow angles and velocities were performed behind both the canard and the wing. This is volume 1 of a 2 volume report. The model, instrumentation, and test procedures are described. An analysis of the data is included. Author

N87-27642*# Rockwell International Corp., Columbus, Ohio.
LOW SPEED WIND TUNNEL TEST OF A PROPULSIVE WING/CANARD CONCEPT IN THE STOL CONFIGURATION. VOLUME 2: TEST DATA
V. R. STEWART Sep. 1987 405 p
(Contract NAS1-17171)
(NASA-CR-178349; NAS 1.26:178349) Avail: NTIS HC A18/MF A01 CSCL 01A

A propulsive wind/canard model was tested at STOL operating conditions in the NASA Langley Research Center 4 x 7 meter wind tunnel. Longitudinal and lateral/directional aerodynamic characteristics were measured for various flap deflections, angles of attack and sideslip, and blowing coefficients. Testing was conducted for several model heights to determine ground proximity effects on the aerodynamic characteristics. Flow field surveys of local flow angles and velocities were performed behind both the canard and the wing. This is volume 2 of a 2 volume report. All of the test data in three appendices are presented. Appendix A presented tabulated six component force and moment data, Appendix B presents tabulated wing pressure coefficients, and Appendix C presents the flow field data. Author

N87-27643*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PRESSURE MEASUREMENTS ON A THICK CAMBERED AND TWISTED 58 DEG DELTA WING AT HIGH SUBSONIC SPEEDS
JULIO CHU and JOHN E. LAMAR Sep. 1987 233 p
(NASA-TP-2713; L-16224; NAS 1.60:2713) Avail: NTIS HC A11/MF A01 CSCL 01A

A pressure experiment at high subsonic speeds was conducted by a cambered and twisted thick delta wing at the design condition (Mach number 0.80), as well as at nearby Mach numbers (0.75 and 0.83) and over an angle-of-attack range. Effects of twin vertical tails on the wing pressure measurements were also assessed. Comparisons of detailed theoretical and experimental surface pressures and sectional characteristics for the wing alone are presented. The theoretical codes employed are FLO-57, FLO-28,

PAN AIR, and the Vortex Lattice Method-Suction Analogy. Author

N87-27644*# National Aeronautics and Space Administration, Washington, D.C.
STUDY OF A VARIABLE SWEEP WING IN SUB OR TRANSONIC FLOW
F. MANIE, C. REHBACH, and V. SCHMITT Sep. 1987 28 p Transl. into ENGLISH of conference paper Etude d'une Aile a Fleche Variable en Ecoulement sub ou Transonique presented at the 11th International Council of the Aeronautical Sciences Congress, 1978 Congress held in Lisbon, Portugal, 10-16 Sep. 1978 Original language document was announced in IAA as A81-14391 Transl. by Kanner (Leo) Associates, Redwood City, Calif.
(Contract NASW-4005)
(NASA-TT-20117; NAS 1.77:20117) Avail: NTIS HC A03/MF A01 CSCL 01A

Experiments were performed on models of a variable sweep wing emphasizing in particular flow separation and appearance of vortex structures at low speeds and the formation of shock waves at transonic speeds. The results of these tests have been compared with those of calculations made by available procedures such as a panel method for unseparated flows and an unsteady method based on a volume discretization of the vortex vector for separated flows. Transonic flows were calculated using relaxation methods based on the perturbation theory and on the full potential equation. Author

03

AIR TRANSPORTATION AND SAFETY

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

A87-48639#
A PROGRAM FOR DEVELOPMENT OF AN AIRSHIP TRANSPORT SYSTEM
NORMAN J. MAYER IN: AIAA Lighter-Than-Air Technology Conference, 7th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1-10.
(AIAA PAPER 87-2303)

The paper describes the formulation and initial execution of a program to provide an improved air transport system from major metropolitan centers to Atlantic City, New Jersey through the use of airships capable of taking-off and landing from waterfront facilities near city centers. The program was based on the use of a subscale approach to develop the necessary techniques and equipment to be followed by full scale implementation. Author

A87-48644#
EMERGENCY DESCENT SIMULATION OF AN AEROSTAT AFTER BREAKAWAY
J. A. KRAUSMAN and A. J. EULER (Westinghouse Defense and Electronics Systems Co., Baltimore, MD) IN: AIAA Lighter-Than-Air Technology Conference, 7th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 45-50.
(AIAA PAPER 87-2440)

A tethered aerostat that becomes detached from its mooring system creates numerous potential problems that range from personnel and air traffic safety to compromising payload security. A reliable method to quickly bring the derelict aerostat to the ground is necessary. A computer program has been developed at DESCO to simulate events following an aerostat breakaway. Different cases are presented with parametric variations of aerostat size, lift, altitude, helium vent area, heat transfer, and tether length attached to the aerostat. Depending on the nature of the failure, the results show that the aerostat either rises quickly and ruptures at high internal pressure, rises to a neutrally buoyant float altitude and remains there for a period of time, or rises without reaching burst altitude and then descends to the ground. Author

A87-48648#
NONLINEAR DYNAMIC SIMULATION OF A MOORED AEROSTAT
S. P. JONES (Westinghouse Defense and Electronics Systems Co., Baltimore, MD) IN: AIAA Lighter-Than-Air Technology Conference, 7th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 72-77. refs
(AIAA PAPER 87-2505)

A six-degree-of-freedom, nonlinear dynamic simulation computer program for a moored aerostat was used to compute the forces and angular displacements of a newly-designed, 71-m aerostat on its mooring system. The latter includes a mooring tower, to which the aerostat's nose is attached, and a moveable boom to which the aerostat and boom are free to rotate about the tower on a circular track. The aerostat's aerodynamics is represented by a segmented semiempirical model derived from wind tunnel data. Frozen-field turbulence is propagated over the segments of the model at the mean wind speed. Two levels of turbulence, moderate and severe, are considered. The output consists of orthogonal components of the nose load, the tension in each mooring line, the aerostat's pitch, roll and heading and the boom heading. Both rms and peak values during 1000-sec simulations are presented. Author

A87-48687
CERTIFICATION OF BONDED COMPOSITE STRUCTURE
PAUL JONAS and TOM ALDAG (Beech Aircraft Corp., Wichita, KS) IN: Composites for general aviation aircraft; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1987, p. 1-5.
(SAE PAPER 871022)

New criteria were developed in coordination with the Federal Aviation Administration for the certification of adhesively bonded composite structure. The published FAA Special Condition requires residual strength and stiffness capability of bonded composite structure in the event of failure of critical bondlines. Methods available for meeting the requirements are discussed including: nondestructive investigation of joint strength, multiple load path design, mechanical fastening, and production unit proof testing. No single method has proven applicable for all designs. Examples of the different methods are given. Author

A87-48692
GENERAL AVIATION AIRCRAFT CRASH DYNAMICS; PROCEEDINGS OF THE GENERAL AVIATION AIRCRAFT MEETING AND EXPOSITION, WICHITA, KS, APR. 28-30, 1987
Meeting and Exposition sponsored by SAE. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-716), 1987, 77 p. For individual items see A87-48693 to A87-48698.
(SAE SP-716)

At the crash dynamics session, a review of accident data from the National Transportation Safety Board from 1981-1985 is presented; the data provide impact severity and summarize acceleration loads and velocity changes, and impact angles and speeds in survivable accidents. Other topics discussed include a retrofit design and installation that provides some crashworthy design features, and its application to crashworthiness concepts in aircraft design; and static test procedures for restraint anchorages in small aircraft. Consideration is given to a dynamic test methodology for aircraft seat and restraint systems; the impact response of composite fuselage frames; and a fuel system configuration study regarding fuel bladder cell installation. I.F.

A87-48693
SUMMARY REPORT ON THE NATIONAL TRANSPORTATION SAFETY BOARD'S GENERAL AVIATION CRASHWORTHINESS PROJECT FINDINGS
JOHN C. CLARK (National Transportation Safety Board, Washington, DC) IN: General aviation aircraft crash dynamics; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987 . Warrendale, PA, Society of Automotive Engineers, Inc., 1987, p. 1-20. refs
(SAE PAPER 871006)

The National Transportation Safety Board conducted a general aviation crashworthiness study from 1981 to 1985. Three reports were published that (1) validated crashworthiness investigative techniques; (2) defined the impact severity and potential injury prevention for survivable accidents; and (3) defined acceleration loads and velocity changes of survivable accidents. The Safety Board was also able to define the extent that post-crash fires affect survivability. This paper contains extensive excerpts from the three Safety Board reports and is intended as an overview of the Safety Board's effort. The original reports contain more detailed discussions of the points raised here. Author

A87-48694
STATIC TEST PROCEDURES FOR RESTRAINT ANCHORAGES IN SMALL AIRCRAFT
VAN GOWDY (FAA, Civil Aeromedical Institute, Oklahoma City, OK), RONALD K. RATHGEBER (FAA, Central Region Certification Div., Kansas City, KS), and JAMES W. ROSS (FAA, Aviation Standards National Field Office, Oklahoma City, OK) IN: General aviation aircraft crash dynamics; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987 . Warrendale, PA, Society of Automotive Engineers, Inc., 1987, p. 21-27.
(SAE PAPER 871007)

A series of static tests with a simulated small aircraft installation of a forward facing seat with the lap belts and shoulder harness attached to the airframe are described. The reaction forces conveyed to the restraint anchor points and seat legs when subjected to a 9 g forward static load of a 170 lb occupant were measured and analyzed. These data were utilized to compare test methods in terms of their ability to transfer the input forces to the belt anchors. The effects of various test variables are investigated. It is observed that the J384 body blocks can be used to statistically test combined restraint installations for small aircraft; the body blocks provide the representative geometry of a belted occupant and distribute the input load proportionally between the lower and upper torso; input loads react at the restraint anchors; forces detected at the seat legs are low; and the input load angle affects the transfer of input load to the restraint anchors. I.F.

A87-48695
A RETROFIT CRASH PROTECTION INSTALLATION IN TWO MODELS OF GENERAL AVIATION AIRPLANES
ODO SIAHAYA, WALT JARRETT (Mission Aviation Fellowship, Redlands, CA), and TERRY HEFFIELD (Jungle Aviation and Radio Service, Waxhaw, NC) IN: General aviation aircraft crash dynamics; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987 . Warrendale, PA, Society of Automotive Engineers, Inc., 1987, p. 29-42. refs
(SAE PAPER 871008)

This paper describes the testing and installation of certain retrofit crash protection measures in Cessna models 185 and 206 aircraft. These are the types of aircraft that are operated in a 'bush' type environment by Jungle Aviation and Radio Service (JAARS) and Mission Aviation Fellowship (MAF). The crash protection features described are in the areas of (1) maintaining a livable space; (2) reducing the 'scooping' effect; (3) seat and occupant retention, including energy attenuation, and (4) fuel spillage control. Multiple FAA Supplemental Type Certificates were obtained for each of the installations in each type aircraft. Author

A87-48697
DYNAMIC TEST METHODOLOGY FOR AIRCRAFT SEAT AND RESTRAINT SYSTEMS
RICHARD F. CHANDLER (FAA, Civil Aeromedical Institute, Oklahoma City, OK) IN: General aviation aircraft crash dynamics; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987 . Warrendale, PA, Society of Automotive Engineers, Inc., 1987, p. 55-65. refs
(SAE PAPER 871010)

Procedures used at the FAA Civil Aeromedical Institute for dynamic tests, which are utilized to evaluate seat and restraint system performance, are described. The conditions necessary for dynamic testing, in particular seat leg to floor loading, restraint system load measurement (anchorage load cells and restraint preload), and floor deformation on aircraft with seats with three legs, bulkhead mounted seats, floor/bulkhead mounted seats, sidewall mounted seats, and seats with more than two pairs of legs, are discussed. The type of anthropomorphic dummies used in dynamic seat/restraint system tests, the location of the load cell in the dummy, and the position of the dummy in the test seat are examined. I.F.

A87-48698
GENERAL AVIATION AIRCRAFT/FUEL SYSTEM CONFIGURATION STUDY REGARDING FUEL BLADDER CELL INSTALLATION
S. SOLTIS (FAA, Washington, DC) IN: General aviation aircraft crash dynamics; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987 . Warrendale, PA, Society of Automotive Engineers, Inc., 1987, p. 67-72. refs
(SAE PAPER 871011)

The effects of the installation of fuel bladder cells, which can reduce post-crash fuel tank spillage, on the aircraft design are investigated. Potential fuel volume reduction is examined in terms of fuel cavity liner and fuel bladder installations. It is observed that, for wing configurations where the airfoil thickness ratio is 16 percent or greater, the fuel volume decreases 8-10 percent for a bladder cell thickness of 0.030 in., 10-12 percent for a bladder cell thickness of 0.069 in., and 12-14 percent for a cell thickness of 0.108 in.; and for aircraft with a wing airfoil thickness ratio of 12-13 percent, fuel volume reductions are between 20-35 percent. Fuel system weight penalites due to the fuel cavity linear and bladder cell installation and airframe structural weight are estimated. It is noted that the rework of current fuel system configurations would increase the aircraft empty weight, and reduce the fuel volume, payload, and operational range of the aircraft. I.F.

A87-48761* Sverdrup Technology, Inc., Middleburg Heights, Ohio.
EVALUATION OF ICING DRAG COEFFICIENT CORRELATIONS APPLIED TO ICED PROPELLER PERFORMANCE PREDICTION
THOMAS L. MILLER (Sverdrup Technology, Inc., Middleburg Heights, OH), R. J. SHAW (NASA, Lewis Research Center, Cleveland, OH), and K. D. KORKAN (Texas A & M University, College Station) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 13 p. refs
(SAE PAPER 871-033)

Evaluation of three empirical icing drag coefficient correlations is accomplished through application to a set of propeller icing data. The various correlations represent the best means currently available for relating drag rise to various flight and atmospheric conditions for both fixed-wing and rotating airfoils, and the work presented here ilustrates and evaluates one such application of the latter case. The origins of each of the correlations are discussed, and their apparent capabilities and limitations are summarized. These correlations have been made to be an integral part of a computer code, ICEPERF, which has been designed to calculate iced propeller performance. Comparison with experimental propeller icing data shows generally good agreement, with the quality of the predicted results seen to be directly related to the radial icing extent of each case. The code's capability to properly predict thrust coefficient, power coefficient, and propeller efficiency is shown to be strongly dependent on the choice of correlation

selected, as well as upon proper specificatioon of radial icing extent. Author

A87-48774
IMPACTS OF REGULATIONS ON ENGINE AIRWORTHINESS
DONALD F. PERRAULT (FAA, Washington, DC) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 12 p.
(SAE PAPER 871-051)

This paper shows the impact of Federal Aviation Regulations (FARs) on engine airworthiness. A discussion of FARs 21 and 33 detailing engine type certification procedures, rules, and policies is provided. This is followed by discussion of the engine/airframe interface from an engine certification perspective. Further discussion focuses on the Airworthiness Directive process, FARs 11 and 39, as a means of restoring a minimum level of airworthiness for the in-service engine fleet. The concluding remarks reinforce the tenet that FAA regulations have a positive impact on engine airworthiness. Author

A87-48800
CONCLUSIONS OF THE INVESTIGATIVE COMMISSION ON AIR SAFETY OF THE COIA CONCERNING THE ACCIDENT OCCURRING IN BARAJAS ON DECEMBER 7, 1983 [CONCLUSIONES DE LA COMISION DE ESTUDIOS SOBRE SEGURIDAD AEREA DEL C.O.I.A. SOBRE EL ACCIDENTE ACAECIDO EN BARAJAS EL 7 DE DICIEMBRE DE 1983]
IAA/Ingenieria Aeronautica y Astronautica (ISSN 0020-1006)

A87-48945#
FURTHER STUDIES OF HELICOPTER ROTOR ICE ACCRETION AND PROTECTION
R. W. GENT, R. H. MARKIEWICZ, and J. T. CANSDALE (Royal Aircraft Establishment, Farnborough, England) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 26 p. refs

Recent research at RAE on icing on helicopter rotors is reviewed. Mathematical models have been developed to predict accretion of ice on rotor blades and the thermal behavior of electrothermal rotor deicing protection systems. The accretion model predicts ice formation on a rotor for both the hover and forward flight cases. Comparisons are presented between wind tunnel and flight accretion measurements and corresponding model predictions, and some preliminary assessment is made of the effects of forward flight on ice accretion. Both one- and two-dimensional models of electrothermally deiced rotors have been developed, and results are shown to illustrate their capabilities. Overall assessments are made of the models'limitations and their applicability to system design and certification. Results are also presented from an experimental study of the relative sensitivity of a NACA 0012 and an RAE cambered section airfoil to aerodynamic degradation by ice, represented by a simple geometric spoiler. Significant differences were found in the effects on the lift, pitching moment, and stall characteristics of the two sections. Author

A87-49174#
A FLIGHT SIMULATOR EVALUATION OF THE APPROACH PATH PARAMETERS FOR MLS CURVED APPROACHES
LOUIS J. J. ERKELENS (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: AIAA Flight Simulation Technologies Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1987. p. 141-151. Research supported by the Rijksluchtvaartdienst. refs (AIAA PAPER 87-2574)
(AIAA PAPER 87-2574)

The present flight simulator study aims at the evaluation of the typical approach path parameters for curved approaches. Seven curved approach paths have been investigated, varying in both final segment length and oblique angle, while the turn radius was fixed at 1.5 NM. The investigation was carried out for various operating minima (decision height, runway visual range and visibility), while also the effects of wind, turbulence and cloud base have been considered. The approaches were carried out as precision approaches, during which use was made of MLS guidance, derived from simulated MLS ground facilities. The simulated conditions included Cat. I and II visibility conditions, while wind shear gradients up to 10 kt/100 ft were considered. The experimental results consisted of both objective and subjective data. The objective data concerned statistical data of path deviations, aircraft state and control deflections. The subjective data were derived from pilot effort ratings, questionnaire responses and pilot comments. Author

A87-49202*# Arizona Univ., Tucson.
THE USE OF FLIGHT TEST TECHNIQUES IN AIRCRAFT ACCIDENT INVESTIGATIONS
E. K. PARKS (Arizona, University, Tucson), R. E. BACH, JR., and R. C. WINGROVE (NASA, Ames Research Center, Moffett Field, CA) IN: Society of Flight Test Engineers, Annual Symposium, 17th, Washington, DC, Aug. 10-14, 1986, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1986, p. 2.2-1 to 2.2-6. refs
(Contract NCC2-329)

Wind shear is a serious safety hazard to commercial aviation. Low level wind shear (downburst) was the cause of the takeoff accident in New Orleans, July 9, 1982, and the landing accident in Dallas, Aug. 2, 1985. Shear layer instability is a common cause of clear air turbulence (CAT) at cruising altitudes. A number of encounters with severe CAT, in which passengers were injured, have recently occurred (Hannibal, MO, April 1981; Morton, WY, July 1982; etc.). Improved accident investigation techniques can lead to a better understanding of the nature of the wind environment associated with downbursts and CAT and to better detection and avoidance procedures. For the past several years, NASA-Ames has worked closely with the National Transportation Safety Board in the investigation of wind related accidents. Author

A87-49203
INFLIGHT ANTI/DE-ICING EXPERIENCE FROM THE CERTIFICATION OF THE SF340
STURE RODLING (SAAB-Scania, AB, Linkoping, Sweden) IN: Society of Flight Test Engineers, Annual Symposium, 17th, Washington, DC, Aug. 10-14, 1986, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1986, p. 3.2-1 to 3.2-7.

Experience from the icing certification of the SF340 twin turboprop passenger aircraft is described, and results of the in-service operation of the aircraft during the winter period are examined. Despite a thorough test program (including laboratory tests, dry air flight tests, and natural icing tests), it was found that possible icing problems were not fully discovered until the aircraft had been in service for some time. Problems connected with distribution valves, engine air intakes, and tail ice are considered; and possible solutions are discussed. B.J.

A87-49642#
EQUIPMENT FOR NIGHT FIGHTING CAPABILITY IN HELICOPTERS [AUSTUESTUNG ZUR NACHTKAMPFFAEHIGKEIT VON HUBSCHRAUBERN]
W. SCHWARZ (Siemens AG, Munich, West Germany) IN: International Helicopter Forum, 16th, Bueckeburg, West Germany, June 11, 12, 1986 and International Aerospace Exhibition, Hanover, West Germany, June 6-15, 1986, Reports . Bueckeburg, West Germany, Helicopter Center, 1986, 21 p. In German.

Passive sensors for night-fighting helicopters are discussed. Optoelectronic sight assists and sensors are briefly examined, and criteria for night-fighting efficiency are addressed. The HOT-2 weapon system in the PAH-2 helicopter is described. C.D.

A87-50344#
TAKEOFF AND LANDING IN A DOWNBURST
K.-U. HAHN (Braunschweig, Technische Universitaet, Brunswick, West Germany) (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 2, p. 860-869) Journal of Aircraft (ISSN 0021-8669), vol. 24, Aug. 1987, p. 552-558. Previously cited in issue 24, p. 3538, Accession no. A86-49069. refs

A87-50714
A REVIEW OF MATHEMATICAL MODELLING OF AIRCRAFT CABIN FIRES
E. R. GALEA and N. C. MARKATOS (Thames Polytechnic, London, England) Applied Mathematical Modelling (ISSN 0307-904X), vol. 11, June 1987, p. 162-176. SERC-supported research. refs

Two deterministic modeling strategies for the mathematical modeling of aircraft fires, the field and zone modeling approaches, are discussed. The field modeling approach, typified by the UNDSAFE code, involves the solution of fluid dynamics and heat transfer equations as discrete points in time and space. However, the approach is restricted to two-dimensional analysis and it lacks the ability of the combustion model to accurately simulate fire growth and the release of heat, smoke, and toxic gases. The zone modeling approach, typified by the DACFIR code, divides the fire zone into a number of fire behavior zones within which experimentally based empirical expressions are used to describe fire behavior. The DACFIR-3 program includes an empirically-based combustion model. R.R.

N87-26884# Boeing Military Airplane Development, Seattle, Wash.
EFFECTS OF AIRCRAFT ENGINE BLEED AIR DUCT FAILURES ON SURROUNDING AIRCRAFT STRUCTURE Interim Report, 21 Mar. - 1 May 1986
ALAN M. JOHNSON Apr. 1987 122 p
(Contract F33615-84-C-2431)
(AD-A181071; D180-29965-1; AFWAL-TR-87-2004) Avail: NTIS HC A06/MF A01 CSCL 21E

Simulated bleed air impingement tests were conducted to explore the possibility that an engine bleed air leak contributed to the loss of an F-16 aircraft. A data base of the results of hot engine bleed air impinging on engine compartment walls was established for selected aircraft aluminum materials. Testing indicated the specific F-16 conditions could not have caused panel burnthrough; however, substituting other conditions did result in panel burnthrough. The results provide information which will assist in future mishap investigations. GRA

N87-26885# Naval Postgraduate School, Monterey, Calif.
COST ANALYSIS FOR AIRCRAFT SYSTEM TEST AND EVALUATION: EMPIRICAL SURVEY DATA STRUCTURING AND PARAMETRIC MODELING, VOLUME 2 M.S. Thesis
WILLIAM J. FOSTER and WALTER J. MOORE, JR. Mar. 1987 256 p
(AD-A181466) Avail: NTIS HC A12/MF A01 CSCL 05C

There is an increasing requirement from high levels within the Government that the Navy's aircraft cost estimators and analysts provide explicit estimates for the sub-elements of Aircraft System Test and Evaluation (AST and E) efforts. The data required to produce more accurate and detailed estimates represent lower levels in the Aircraft Work Breakdown Structure (WBS) than previously available. This is a two volume thesis. Beginning in this document (Volume 2), a relational data base system is introduced to more easily evaluate AST and E cost elements and physical/performance characteristics. A Contractor Flight Test cost estimating relationship (CER) is developed through step-wise multiple regression analysis of data gathered from Defense Contractors and Naval Air Systems Command (NAVAIR). GRA

N87-26886# Science and Engineering Associates, Inc., Seattle, Wash.
CREW ESCAPE CAPSULE TO AIRFRAME LATCH/DISCONNECT MECHANISMS Final Report, Jun. 1986 - Jan. 1987
WILLIAM S. RIPPI and C. G. ELCOCK Jan. 1987 97 p
(Contract F33615-86-C-3421)
(AD-A181565; AFWAL-TR-87-3013) Avail: NTIS HC A05/MF A01 CSCL 01C

Ejection seats still have performance shortfalls in the high speed regime typical of jet combat operations, i.e., at speeds above 450 knots. An alternative approach, operational in the F-111 aircraft, is that of the jettisonable crew escape capsule. Although providing improved aircrew survivability during high speed ejection, the F-111 capsule design is maintenance intensive. The capsule-to-airframe interface involves pyrotechnic devices which destroy the interface upon ejection. Therefore, inspection and maintenance procedures require extensive hardware disassembly. To reduce the complexity of these procedures, simplify the structural interface, reduce life cycle costs, and facilitate removal and replacement of the capsule at the operational level, a non-destructive, mechanical latch interface has been proposed. Described are the development of several mechanical latch concepts for use in proposed escape capsule/airframe interface. An evaluation of these concepts has produced a preferred design concept recommended for development and prototype demonstration. GRA

N87-26887# National Oceanic and Atmospheric Administration, Boulder, Colo. Environmental Research Labs.
CRASH OF DELTA FLIGHT 191 AT DALLAS-FORT WORTH INTERNATIONAL AIRPORT ON 2 AUGUST 1985: MULTISCALE ANALYSIS OF WEATHER CONDITIONS
F. CARACENA, R. ORTIZ, and J. A. AUGUSTINE Dec. 1986 38 p
(PB87-183455; NOAA-TR-ERL-430; ESG-2) Avail: NTIS HC A03/MF A01 CSCL 01C

The third microburst-related disaster in the decade since 1976 occurred when Delta Flight 191 cracked while on the landing approach to Runway 17L at Dallas-Fort Worth International Airport (DFW) on 2 August 1985. The microburst-producing storm occurred almost in the center of a large-scale high-pressure almost in the center of a large-scale high-pressure area that extended through a deep layer of the troposphere and was interrupted only near the surface by a thermal low-pressure area in combination with a low-pressure trough that was associated with a weak frontal boundary. A computer-generated analysis of the pattern of deep tropospheric forcing reveals that a high lapse rate in the lower troposphere was generated by a pattern of vertical motion that tended to stretch the atmospheric column. The very weak front that lingered over DFW, and resurged southward at about the time of the accident, lifted the shallow, moisture surface layer, triggering a line of discrete thunderstorm, one of which, situated along the approach to Runway 17L, produced the microburst that brought down Delta 191. In this case, a digital flight recorder has provided data from which the highest resolution analysis of microburst winds was possible. The analysis showed that the wind field within a microburst has a very complex structure with imbedded smaller scale vortices that inflict serious control problems on a penetrating aircraft, to compound the hazard of severe wind shear. GRA

N87-26889# National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
AIRCRAFT ACCIDENT REPORT: COLLISION OF AERONAVES DE MEXICO, S.A., MCDONNELL DOUGLAS DC-9-32, XA-JED AND PIPER PA-28-181, N4891F, CERRITOS, CALIFORNIA, AUGUST 31, 1986
7 Jul. 1987 115 p
(PB87-910409; NTSB/AAR-87/07) Avail: NTIS HC A06/MF A01 CSCL 01C

On August 31, 1986, about 1152 Pacific daylight time, Aeronaves de Mexico, S.A., flight 498, a DC-9-32, Mexican registration XA-JED, and a Piper PA-28-181, U.S. registration N4891F, collided over Cerritos, California. The National Transportation Safety Board determined that the probable cause of the accident was the limitations of the air traffic control system to provide collision protection, through both air traffic control procedures and automated redundancy. Factors contributing to the accident were: (1) the inadvertent and unauthorized entry of PA-28 into the Los Angeles Terminal Control Area, and (2) the limitations of the see and avoid concept to ensure traffic separation under the conditions of the conflict. Author

N87-27597*# Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
INVESTIGATION OF AIR TRANSPORTATION TECHNOLOGY AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY, 1985
ROBERT W. SIMPSON *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1985 p 3-6 Jul. 1987
Avail: NTIS HC A05/MF A01 CSCL 01C

Two areas of research are discussed, an investigation into runway approach flying with Loran C and a series of research topics in the development of experimental validation of methodologies to support aircraft icing analysis. Flight tests with the Loran C led to the conclusion that it is a suitable system for non-precision approaches, and that time-difference corrections made every eight weeks in the instrument approach plates will produce acceptable errors. In the area of aircraft icing analysis, wind tunnel and flight test results are discussed. Author

N87-27598*# Massachusetts Inst. of Tech., Cambridge.
EXPERIMENTAL METHODOLOGIES TO SUPPORT AIRCRAFT ICING ANALYSIS
R. JOHN HANSMAN, JR. and MARK S. KIRBY *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1985 p 7-25 Jul. 1987
Avail: NTIS HC A05/MF A01 CSCL 01C

The experimental methodologies are illustrated by graphs, charts and line drawings. Typical ultrasonic echo signals for dry and wet ice growth, ice accretion rates for various tunnel configurations, the experimental configuration for flight tests of the ultrasonic measuring system and heat balance models used to predict ice growth are among the topics that are illustrated and briefly discussed. R.J.F.

N87-27603*# Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.
INVESTIGATION OF AIR TRANSPORTATION TECHNOLOGY AT PRINCETON UNIVERSITY, 1985
ROBERT F. STENGEL *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1985 p 55-61 Jul. 1987
Avail: NTIS HC A05/MF A01 CSCL 01C

The program proceeded along five avenues during 1985. Guidance and control strategies for penetration of microbursts and wind shear, application of artificial intelligence in flight control and air traffic control systems, the use of voice recognition in the cockpit, the effects of control saturation on closed-loop stability and response of open-loop unstable aircraft, and computer aided control system design are among the topics briefly considered. 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 the subject of principal concern. Author

N87-27649# National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
AIRCRAFT ACCIDENT REPORT: PIPER PA-23-150, N2185P AND PAN AMERICAN WORLD AIRWAYS BOEING 727-235, N4743, TAMPA, FLORIDA, NOVEMBER 6, 1986
25 Jun. 1987 56 p
(PB87-910407; NTSB/AAR-87/06) Avail: NTIS HC A04/MF A01 CSCL 01C

On November 6, 1986, a Piper PA-23 Apache, N2185P, was cleared for an instrument landing system approach to runway 36L at Tampa International Airport, Florida. The pilot was unable to land during his first approach. On the second approach, the Apache touched down on taxiway W, parallel to and about 406 feet to the right (east) of runway 36L. At the same time, a Pan American Boeing B-727 was proceeding southbound on taxiway W. When the captain of the B-727 saw the Apache emerge from the fog directly ahead of him, he turned to the right in an attempt to avoid the impending collision. About 2 seconds later, the Apache's left engine struck the B-727 in the radome. Two passengers and a flight attendant were injured after they evacuated the airplane. The Apache was almost destroyed and the pilot, the sole occupant of the airplane, was killed. The safety issues discussed in this report include the pilot's decision to continue his approach below decision height when the visibility was below landing minimums and the adequacy of current Federal regulations that allow pilots operating under Part 91 to conduct approaches when the reported visibility is below the published minimum visibility for landing. Author

N87-27650# National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
AIRCRAFT ACCIDENT/INCIDENT SUMMARY REPORT, KEFLAVIK, ICELAND, JANUARY 29, 1986
1 May 1987 10 p
(PB87-910406; NTSB/AAR-87/01/SUM) Avail: NTIS HC A02/MF A01; also available on subscription, North American Continent HC $60.00/year, all others write for quote CSCL 01C

A summary of an aircraft accident investigated by the National Transportation Safety Board is given. The accident occurred in International Waters, 36 miles west of Keflavik, Iceland, on January 29, 1986. GRA

N87-27651*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
UNIQUE RESEARCH CHALLENGES FOR HIGH-SPEED CIVIL TRANSPORTS
CHARLIE M. JACKSON, JR. and CHARLES E. K. MORRIS, JR. Aug. 1987 19 p
(NASA-TM-100490; NAS 1.15:100490) Avail: NTIS HC A02/MF A01 CSCL 01C

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

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A87-48356#
AN OVERVIEW OF AERONAUTICAL SATELLITE COMMUNICATIONS
J. CLARK (International Maritime Satellite Organization, London, England) ITU Telecommunication Journal (ISSN 0497-137X), vol. 54, June 1987, p. 385-388.

The application of aeronautical satellite services to aviation communications is discussed. The satellite services can be used for air traffic services, aircraft operational control, aircraft operator business communications, and public correspondence. The satellite requirements for each of these types of communication traffic are described. The development of an aircraft antenna that is capable of providing adequate system gain and coverage volume while not requiring excessive dc power from the satellite in the forward direction is examined. A diagram of an aeronautical system is presented. I.F.

A87-49641#
NAVIGATION [NAVIGATION]
HORST SCHUETZENDUEBEL IN: International Helicopter Forum, 16th, Bueckeburg, West Germany, June 11, 12, 1986 and International Aerospace Exhibition, Hanover, West Germany, June 6-15, 1986, Reports . Bueckeburg, West Germany, Helicopter Center, 1986, 13 p. In German.

Navigation systems for combat and transport helicopters are discussed. A new integrated hybrid navigation system suitable to the movement of a modern combat helicopter is described. A ring laser unit for inertial and strap-down systems is discussed, and the use of GPS to support inertial navigation systems is examined. Finally, a helicopter mapping device is addressed. C.D.

A87-50465#
AN ANGLE-ONLY TRACKING FILTER IN MODIFIED SPHERICAL COORDINATES
DAVID V. STALLARD (Raytheon Co., Missile Systems Div., Bedford, MA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 542-550. refs
(AIAA PAPER 87-2380)

Among previous approaches to tracking with angle measurements only, the IBM filter for planar tracking appears to be superior because of its use of modified polar coordinates (MPC), which reduce problems with observability, range bias and covariance ill-conditioning. Here, this approach is extended to three dimensions by the use of modified spherical coordinates (MSC). In the MSC filter, the six state variables are two angles, their derivatives, inverse range and range-rate over range, which are transformable into Cartesian position and velocity. This filter successfully estimates the state of a nonmaneuvering aircraft with noisy angle measurements from a moderately weaving interceptor aircraft. Questions remain as to design refinements, desirable trajectories of the measuring vehicle, extension to a maneuvering target, and limitations of the MSC approach. Author

A87-50529*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AIR TRAFFIC CONTROLLER AIDS FOR PLANNING OF ARRIVAL TRAFFIC - AN AI APPROACH
RON CHRISLEY and LEONARD TOBIAS (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1210-1221. refs
(AIAA PAPER 87-2526)

Air traffic management is considered as an AI problem, and planning concepts are developed for incorporation into an automation aid for enroute arrival controllers being developed by NASA. An Assumption-Based Truth Maintenance System is modified to include the nonmonotonicities inherent in the Air Traffic Control (ATC) domain, and it is noted under what circumstances the advantages of the ATMS in standard problem-solving domains carry over to planning. The noninteracting actions of the conceptualization are contrasted with the interacting actions of other domains. It is shown that the noninteracting nature of the ATC domain makes it possible to provide an efficient planner that avoids the frame problem. R.R.

N87-26892# Allied-Bendix Corp., Baltimore, Md. Communications Div.
TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS-3) Final Engineering Report
E. A. HECHT and J. E. REED Apr. 1987 89 p
(Contract DTFA01-82-C-10019)
(BCD-TR-157; DOT/FAA/PM-87/14) Avail: NTIS HC A05/MF A01

The Task-1 contract on TCAS-11 produced a system concept and a design specification that show the 743 Aircraft L. A. Basin Model with peak densities well in excess of 0.4 aircraft per square nautical mile can be met. This Task-2 contract is for the design, construction, and testing of two enhanced TCAS-11 (TCAS-111) Engineering units. A description of the TCAS-111 engineering model is presented along with results from various flight tests of the system. System no. 1 has been installed on the FAA's 727 since 1983. Testing shows that angular accuracies in the order of 1 to 2 degrees are feasible and that Horizontal Resolution Advisories can be given on intruders. System no. 2 was delivered to the FAA Technical Center and installed on a Convair 580. Both systems will continue to fly as test beds for TCAS 111. Author

N87-26893*# McDonnell-Douglas Corp., Long Beach, Calif.
SIMULATION OF AUTOMATIC PRECISION DEPARTURES AND MISSED APPROACHES USING THE MICROWAVE LANDING SYSTEM
J. B. FEATHER Jul. 1987 66 p
(Contract NAS1-16202)
(NASA-CR-178312; NAS 1.26:178312) Avail: NTIS HC A04/MF A01 CSCL 17G

Results of simulated precision departures and missed approaches using MLS guidance concepts are presented. The study was conducted under the Terminal Configured Vehicle (TCV) Program, and is an extension of previous work by DAC under the Advanced Transport Operating System (ATOPS) Technology Studies Program. The study model included simulation of an MD-80 aircraft, an autopilot, and a MLS guidance computer that provided lateral and vertical steering commands. Precision departures were evaluated using a noise abatement procedure. Several curved path departures were simulated with MLS noise and under various environmental conditions. Missed approaches were considered for the same runway, where lateral MLS guidance maintained the aircraft along the extended runway centerline. In both the departures and the missed approach cases, pitch autopilot takeoff and go-around modes of operation were used in conjunction with MLS lateral guidance. Author

N87-26894# General Accounting Office, Washington, D. C. Resources Communication and Economic Development Div.
AIR TRAFFIC SYSTEM: PILOT PROGRAM TO CONTRACT OUT MAINTENANCE AT SELECTED FACILITIES
Apr. 1987 35 p
(PB87-186607; GAO/RCED-87-104BR; B-225200) Avail: NTIS HC A03/MF A01 CSCL 17G

This briefing report reviews the Federal Aviation Administration's (FAA) proposed pilot test program to contract out for maintenance at selected air traffic control facilities. The report provides information on pilot test design and status; evaluates the pilot test's potential for affecting air traffic safety and efficiency; determines if the proposed pilot program would adequately test a contractor's ability to independently perform the maintenance function; and assess FAA efforts to control and estimate pilot test costs. It was not within the scope of the review to evaluate the appropriateness, from a policy standpoint, of contracting out for maintenance in lieu of relying on the federal work force. GRA

N87-27600*# Ohio Univ., Athens.
LORAN-C MONITORING
JAMIE EDWARDS *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1985 p 39-41 Jul. 1987
Avail: NTIS HC A05/MF A01 CSCL 17G

The Loran-C monitor developed by Ohio University will collect Loran signal data for storage on magnetic tape. Stationed at the Ohio University Airport, Athens, Ohio, the monitor will provide valuable information concerning the daily and seasonal variation of the Loran-C signals for use in non-precision approach studies. With the aid of a second monitor, located in Gallion, Ohio, it can be determined if the errors found at a particular geographic location correlate with those found at another location. This will give some indication as to how far apart monitors can be positioned to obtain accurate non-precision approach data for various airports. Author

N87-27607*# Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.
AN EXPERT SYSTEM FOR AIR TRAFFIC CONTROL SYSTEM
TAKASHI SENSUI *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1985 p 99-103 Jul. 1987
Avail: NTIS HC A05/MF A01 CSCL 17G

The objective was to design a control logic which automates all or part of the guidance function for air traffic control systems. Particular interest was focused on automation of the terminal area control system. A preliminary study was done on the development of an expert system. The system may be used to assist controllers by providing them with feasible options in guiding each aircraft in the control area to its desired destination. Author

N87-27652# Federal Aviation Administration, Atlantic City, N.J.
LORAN C VNAV (VERTICAL NAVIGATION) APPROACHES TO THE TECHNICAL CENTER HELIPORT
MICHAEL MAGROGAN Mar. 1987 150 p
(AD-A182152; DOT/FAA/CT-TN86/56) Avail: NTIS HC A07/MF A01 CSCL 17G

This report documents the results of Loran C vertical navigation (VNAV) approaches to the Federal Aviation Administration (FAA) Technical Center Heliport. Results of this study show that the three dimensional (3D) Loran C Navigator met the requirements of Advisory Circular (AC) 90-45A for two dimensional (2D) error components of total system crosstrack (TSCT) and flight technical error (FTE). In addition, the 3D error component of vertical flight technical error (VFTE) met the requirements of AC 90-45A. GRA

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AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A87-47247
DORNIER AIMS THE DO328 AT THE 30-PASSENGER MARKET
PETER PLETSCHACHER Interavia (ISSN 0020-5168), vol. 42, July 1987, p. 711-713.

The Do328 next-generation commuter airliner whose development has been recently undertaken, is a 30-passenger pressurized turboprop with sufficiently advanced design features to possess decisive competitive advantages in the 1990s in such matters as performance, passenger comfort, and operating costs. A very long fairing over the wing root/fuselage junction, reaching from the cockpit back to the empennage, yields excellent streamlining and considerable volume for numerous subsystem components. The fuselage will be of exceptional width in order to maximize cabin volume. At cruise altitude of 25,000 ft, cabin altitude will be 8000 ft. With 30 passengers, and at a 310-kt cruise speed, range would be 700 nmi; range would increase to 1700 nmi with 16 passengers. O.C.

A87-47248
CASA CN-235 - LAST BUT NOT LEAST
JACQUES CLOSTERMANN Interavia (ISSN 0020-5168), vol. 42, July 1987, p. 719-723.

An account is given of the design features and performance capabilities of the CN-235 civil/military twin-turboprop transport. While half of the 114 orders placed to date for this aircraft are military and adaptable to such tasks as paratroop transport, the civil version is a 40-seat commuter airliner. Attention is given to the comparative features of the military CN-235's typical low-high-low tactical mission profile; the civil version's 250-mile sector flight performance; and the relationships between distance, fuel, and time over the distinct segments of each mission. O.C.

A87-47249
GULFSTREAM AEROSPACE GIV - THE MAXIMUM BUSINESS JET
MARK LAMBERT Interavia (ISSN 0020-5168), vol. 42, July 1987, p. 737-741.

The most recent, G IV variant of the Gulfstream business jets features a 4.5-ft stretch of the G III's fuselage, an entirely new wing incorporating winglets, the more powerful (12,000-lb thrust class) Tay engines, and advanced systems and avionics that extend to an 'all-glass' cockpit extensively employing CRT graphics displays in place of the conventional gages. One of the various cabin layouts offered numbers 14 seats, and includes galley and toilets as well as baggage compartment access in flight. Maximum payload allows for 19 passengers and baggage; with that maximum load, at the cruise speed of Mach 0.8, a range of 3800 nmi is obtainable. Maximum speed is Mach 0.85. O.C.

A87-47306
MORE EAGLES FOR THE USAF EYRIE
BILL GUNSTON Air International (ISSN 0306-5634), vol. 33, July 1987, p. 7-13, 47, 48.

The development history, design features, and performance capabilities of the F-15E variant of the Eagle family of fighter aircraft are presented. The F-15E is distinguished by totally upgraded avionics, a two-seat cockpit with entirely new control and display systems, new flight control and propulsion system hardware, and a substantially strengthened structure enabling the aircraft to bear the loading generated by the expanded stores carriage during up-to-9G maneuvers. USAF funding of $1.5 billion will procure the upgrading of 392 previously ordered Eagles to the F-15E standard. The second crewman carried is a Weapons System Officer, who can in emergencies function as copilot. A cutaway drawing of the aircraft is featured. O.C.

A87-47835
1986 REPORT TO THE AEROSPACE PROFESSION; PROCEEDINGS OF THE THIRTIETH SYMPOSIUM, BEVERLY HILLS, CA, SEPT. 24-27, 1986
Symposium sponsored by the Society of Experimental Test Pilots. Lancaster, CA, Society of Experimental Test Pilots, 1986, 279 p. For individual items see A87-47836 to A87-47847.

The present conference discusses preliminary airworthiness evaluation of an individual lift device, Harrier II digital engine control flight tests, a helicopter emergency flotation system's in-flight and water evaluation, the F-111's mission-adaptive wing test program, the myths and realities of canard configurations, and flight tests of the X-29. Also discussed are high altitude flutter and flutter boundary testing for the TR-1 and U-2R, departure resistance and combat maneuvering evaluation of the FA-18B, T-46A flight test results, F-16/F-111 weapons flutter testing, Space Shuttle redesign status, and Navy Blue Angels precision flying. O.C.

A87-47836
NOTAR (NO TAIL ROTOR) - PROOF OF CONCEPT
STEPHEN A. HANVEY (McDonnell Douglas Helicopter Co., Meza, CA) IN: 1986 report to the aerospace profession; Proceedings of the Thirtieth Symposium, Beverly Hills, CA, Sept. 24-27, 1986 . Lancaster, CA, Society of Experimental Test Pilots, 1986, p. 33-48.

The NOTAR concept eliminates the need for a tail rotor to provide anti-torque control on a conventional helicopter by using circulation control through a pressurized, slotted tail boom and a direct jet thruster. Efficiency and normal directional control responsiveness are achieved through the use of low pressure air and a 60-65 percent contribution from the circulation control effect on the tail boom in a hover. The NOTAR proof of concept program successfully completed its second flight phase with a dual slot (coanda effect) configuration and a composite fan in the boom. The flight program essentially doubled the sideward flight envelope of the conventional OH-6 from 15-20 kt to 40 kt and increased the rearward envelope from 15-20 kt to 30 kt. The previous limit was defined by controllability and varied with gross weight and density altitude. Greatly reduced pilot workload (Level 1 handling

qualities) was demonstrated with no stability augmentation in the directional axis. A new rotary wing aerodynamic phenomena for hover performance was investigated. Conventional OH-6 handling characteristics were demonstrated throughout the envelope. The proof of concept flight test program and theory of operation will be discussed. This concept could have a revolutionary impact on rotary wing operational flying. Reduced vibration level and lower noise levels, improved directional handling qualities, and increased inherent safety are direct results of the NOTAR design. Author

A87-47838
H-46 HELICOPTER EMERGENCY FLOTATION SYSTEM (HEFS) IN-FLIGHT AND WATER EVALUATION
COLLEEN NEVIUS (U.S. Navy, Naval Air Station, Norfolk, VA) and ROBERT BOWES (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: 1986 report to the aerospace profession; Proceedings of the Thirtieth Symposium, Beverly Hills, CA, Sept. 24-27, 1986 . Lancaster, CA, Society of Experimental Test Pilots, 1986, p. 71-83.

The Helicopter Emergency Flotation System (HEFS) for the U.S. Navy H-46 helicopter employs two removable and interchangeable pod assemblies, each of which contains one two-cell float for a total flotation volume of 280 cu ft; this equipment is attached to the fuselage and is inflated by cockpit switch-activated bottles. Scoops are incorporated for roll stability in high sea states. All qualities and performance characteristics of the test helicopter with the system in stowed form are qualitatively and quantitatively unchanged from those of the 'bare' H-46. O.C.

A87-47839* Air Force Flight Test Center, Edwards AFB, Calif.
MISSION ADAPTIVE WING TEST PROGRAM
FRANK T. BIRK (USAF, Flight Test Center, Edwards AFB, CA) and ROGERS E. SMITH (NASA, Flight Research Center, Edwards, CA) IN: 1986 report to the aerospace profession; Proceedings of the Thirtieth Symposium, Beverly Hills, CA, Sept. 24-27, 1986 . Lancester, CA, Society of Experimental Test Pilots, 1986, p. 86-100.

With the completion of the F-111 test-bed Mission Adaptive Wing (MAW) test program's manual flight control system, emphasis has been shifted to flight testing of MAW automatic control modes. These encompass (1) cruise camber control, (2) maneuver camber control, (3) maneuver load control, and (4) maneuver enhancement and load alleviation control. The aircraft is currently cleared to a 2.5-g maneuvering limit due to generally higher variable-incidence wing pivot loads than had been anticipated, especially at the higher wing-camber settings. Buffet is noted to be somewhat higher than expected at the higher camber settings. O.C.

A87-47840
CANARDS - THE MYTHS AND THE REALITIES
ALBERT W. BLACKBURN (FAA, Washington, DC) IN: 1986 report to the aerospace profession; Proceedings of the Thirtieth Symposium, Beverly Hills, CA, Sept. 24-27, 1986 . Lancaster, CA, Society of Experimental Test Pilots, 1986, p. 101-115.

An evaluation is made of the claims conventionally put forward by aircraft designers for canard configurations in executive aircraft, single-seat sporting aircraft, and motor gliders. Attention is given to the consequences of the configuration for such fundamental aerodynamic performance factors as drag minimization, stall stability, cruise efficiency, and weight and balance control. In all cases, objections are raised to the advantages assumed for canard configurations in light of experience with thoroughly tested aircraft of this type. O.C.

A87-47841* National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
FLIGHT TESTING THE X-29
ROGERS E. SMITH (NASA, Flight Research Center, Edwards, CA) and KURT C. SCHROEDER (Grumman Corp., Bethpage, NY) IN: 1986 report to the aerospace profession; Proceedings of the Thirtieth Symposium, Beverly Hills, CA, Sept. 24-27, 1986 . Lancaster, CA, Society of Experimental Test Pilots, 1986, p. 116-134. refs

A testing status report is presented for the X-29 forward-swept-wing experimental aircraft, which integrates such advanced technologies as an aeroelastically tailored composite wing, a thin supercritical airfoil, three-surface pitch control, discrete variable camber, full-authority close-coupled canards, static instability, and digital fly-by-wire flight controls. X-29 flight test results to date raise several issues pertinent to the design of future combat aircraft flight control systems; for example, they bring into question the current MIL-8785C requirements on control system time delays. O.C.

A87-47842
HIGH ALTITUDE FLUTTER INVESTIGATION AND EXPLORATION OF THE FLUTTER BOUNDARY OF THE TR-1 AND SPECIALLY CONFIGURED U-2R
KENNETH W. WEIR (Lockheed Corp., Burbank, CA) IN: 1986 report to the aerospace profession; Proceedings of the Thirtieth Symposium, Beverly Hills, CA, Sept. 24-27, 1986 . Lancaster, CA, Society of Experimental Test Pilots, 1986, p. 137-151.

The U-2R is a variant of the U-2 high altitude reconnaissance aircraft, with 28-percent larger wing span, 25-percent greater length, and considerably enhanced payload. The TR-1 version of the U-2R is configured with two large cylindrical pods at wing quarter-span that can be outfitted with various kinds of remote sensors. The U-2R was subsequently retrofitted with these pods as well. The dynamic characteristics of the wing structures of these aircraft were adversely affected by the addition of the pods, leading to the presently reported test program to ascertain flutter boundaries. Attention is given to dynamic excitation results. O.C.

A87-47844
T-46A FLIGHT TEST RESULTS
MICHAEL D. EDMONDSON (USAF, Edwards AFB, CA) IN: 1986 report to the aerospace profession; Proceedings of the Thirtieth Symposium, Beverly Hills, CA, Sept. 24-27, 1986 . Lancaster, CA, Society of Experimental Test Pilots, 1986, p. 178-186.

An evaluation is made of test results obtained to date with the T-46A trainer, encompassing basic airworthiness, flutter, preliminary handling qualities, engine/airframe compatibility, preliminary performance levels, and systems testing. Drag polars derived from flight test data show overall aircraft drag to be greater than wind tunnel predictions. Flight envelope expansion has proceeded more slowly than expected, primarily because of problems with the flutter excitation system used to test aircraft structural response. O.C.

A87-47879
HELICOPTERS CAN BE CLASSIFIED ACCORDING TO PERFORMANCE
A. BUBNOV and L. POTASHNIK (State Scientific and Research Institute of Civil Aviation, USSR) ICAO Bulletin, vol. 42, June 1987, p. 13-15.

Three helicopter performance classes are proposed. Class 1 is for a helicopter that is able to land on the rejected take-off area or safely continue the flight to an appropriate landing area in case of engine failure; a class 2 helicopter is able to safely continue the flight except if engine failure occurs immediately after take-off or prior to landing; and a class 3 helicopter is one with performance so that in case of engine failure a forced landing may be required. The classification scheme is applied to the Soviet Ka-32 helicopter; the conditions under which the performance of the helicopter could be considered class 1 or 2 are described. It is observed that the performance classification is applicable to the study of the performance of helicopters with different power-to-weight ratios and the main types and conditions for helicopter operations. It is

noted that the classifications are useful for evaluating helicopter airworthiness. I.F.

A87-48159
THRUST VECTORING - WHY AND HOW? [SCHUBVEKTORISIERUNG - WARUM UND WIE?]
W.-B. HERBST (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) IN: Yearbook 1986 II; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 513-552. In German.
(DGLR PAPER 86-111)

Aircraft designs incorporating thrust vectoring (TV), the performance improvements offered, and the problems involved in the practical implementation of TV are presented in a series of photographs, drawings, diagrams, tables, and graphs and briefly characterized. It is pointed out that fundamentally different types of TV have been applied to achieve several different purposes, making the use of TV as a single collective term questionable. T.K.

A87-48160
PROBLEMS IN SEAPLANE RESEARCH [DIE FORSCHUNGSPROBLEME DES WASSERFLUGZEUGS]
ELMAR WILCZEK (Dornier GmbH, Friedrichshafen, West Germany) IN: Yearbook 1986 II; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 577-621. In German. refs
(DGLR PAPER 86-126)

The current status of seaplane R&D at Dornier is reviewed. Consideration is given to resistance problems (hydrodynamic and aerodynamic design of the hull), hull strength requirements (to avoid or resist impact loading during takeoff and sea landing), static and dynamic stability problems, corrosion, and flight control. Extensive diagrams, drawings, graphs, and photographs are provided. T.K.

A87-48366
X-31 - BREAKING THE STALL BARRIER
NORMAN LYNN Flight International (ISSN 0015-3710), vol. 132, July 11, 1987, p. 27, 28.

The X-31 Enhanced Fighter Maneuverability experimental aircraft development program is a German-American joint project aimed at the expansion of maneuverability envelopes beyond those currently imposed by aerodynamics, propulsion systems, airframes, and pilot g-endurance. By flying at a higher angle of attack and lower speed, the aircraft will be capable of outstanding turn rates. These goals will be achieved through the integration of aerodynamic and thrust-vector control to break the stall barrier, taking the aircraft above the stall for brief periods to get a first-pass firing opportunity; within limits, the pilot will be able to slew his aircraft like a gun turret. Thrust vectoring will involve airframe-mounted vanes which deflect the engine exhaust stream through up to 10 deg in both pitch and yaw. O.C.

A87-48640#
INVESTIGATION OF HYBRID AIRSHIP RPV FOR ENTOMOLOGICAL RESEARCH
S. J. MILEY and P. A. MOSLEY (Texas A & M University, College Station) IN: AIAA Lighter-Than-Air Technology Conference, 7th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 11-14. refs
(AIAA PAPER 87-2304)

The operational problems of conventional heavier-than-air RPV's for airborne insect acquisition are discussed. The benefits of lighter-than-air configurations are offered. A program of development and test of two different hybrid airship RPV configurations is discussed and the results to date given. Author

A87-48643#
LARGE CRANE AIRSHIPS - DESIGN AND DYNAMICS
JAMES D. LOWE (Toronto, University, Canada) IN: AIAA Lighter-Than-Air Technology Conference, 7th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 32-44. refs
(AIAA PAPER 87-2378)

A heavy-lift airship has been developed by connecting a single large rotating wing assembly from a crane-type helicopter to a helium-filled streamlined envelope. This hybrid of LTD and helicopter technology produces a simple airship that lifts nearly twice as much payload as the largest of conventional V/STOL vehicles, and has good cruise performance and low-speed hovering capabilities. The paper discusses the airship and the design criteria upon which it is based, and presents a summary of the engineering analyses of the vehicle's aerodynamics and flight dynamics while hovering in a turbulent wind. The paper concludes by describing a small, derivative version of the airship that may be constructed at low cost to perform useful work and demonstrate some of the features of the full-size vehicle. Author

A87-48645#
DESIGN OR RADIAL-WIRE AIRSHIP BULKHEADS
D. E. WOODWARD (Airships International, Inc., Tustin, CA) IN: AIAA Lighter-Than-Air Technology Conference, 7th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 51-58.
(AIAA PAPER 87-2441)

The theory of radial-wire bulkheads in the deflated-cell condition is extended to wires at any angle to the vertical, under the small-slope assumption. In a fixed-center bulkhead, the total load is shown to divide two-thirds on frame and one-third on center, regardless of wire tensions, elasticity, etc. Several bulkhead designs that give uniform loaded tension in every wire are studied; these designs prevent rise of the center fitting under load and minimize bending moments in stiff-jointed frames. A sample relation for the effect of frame compression on wire effective modulus, useful in preliminary design studies, has been derived in terms of allowable strains of the wire and frame materials. An appendix shows the important of large-slope and indicates one possible numerical solution. Author

A87-48696* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
IMPACT RESPONSE OF COMPOSITE FUSELAGE FRAMES
RICHARD L. BOITNOTT (NASA, Langley Research Center; U.S. Army, Aviation Research and Technology Activity, Hampton, VA), EDWIN L. FASANELLA, LISA E. CALTON (PRC Kentron, Inc., Aerospace Technologies Div., Hampton, VA), and HUEY D. CARDEN (NASA, Langley Research Center, Hampton, VA) IN: General aviation aircraft crash dynamics; Proceedings of the General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987 . Warrendale, PA, Society of Automotive Engineers, Inc., 1987, p. 43-54. refs
(SAE PAPER 871009)

Graphite-epoxy frames were drop tested onto a concrete floor to simulate crash loadings. The frames have Z-shaped cross sections typical of designs often proposed for fuselage structure of advanced composite transports. A diameter of six feet for the frames was chosen to reduce specimen fabrication costs and to facilitate testing. Accelerometer, strain gage, and photographic measurements are presented which characterize the impact behavior of frames with differing masses to represent structural or seat/occupant masses. Failures of the graphite-epoxy frames involved complete separations through the cross section. All damage to the lightly loaded composite frames was confined to an area close to the impact point. Subsequent failures left and right of the impact point occurred for the more heavily loaded specimens. Author

A87-48713#
VIBRATION CONTROL OF FLEXIBLE MULTIBODY AIRCRAFT DURING TOUCHDOWN IMPACTS
A. A. SHABANA, R. D. PATEL, A. DEBCHAUDHURY, and R. ILANKAMBAN (Illinois, University, Chicago) ASME, Transactions, Journal of Vibration, Acoustics, Stress, and Reliability in Design (ISSN 0739-3717), vol. 109, July 1987, p. 270-276. refs

A method is presented for the dynamic analysis and vibration control of large scale flexible multibody aircraft during the touchdown impacts and rollover motion. The rollover motion is simulated by modeling the uneven runway profile as a stationary zero mean space dependent random process defined by its spectral shape. The prescribed motions at the two landing gears will then represent a different time dependent random process with spectral shapes changing with the change in velocity of the aircraft. Composite materials which provide higher stiffness-to-weight ratios are used as a passive control system to reduce the aircraft vibration. The results of the numerical example presented showed that the use of composites can have a significant effect on attenuating the vibration of the aircraft during the touchdown impact and rollover motion. The numerical results are obtained using the general purpose computer program DAMS (Dynamic Analysis of Multibody System). Author

A87-48727#
ABOUT THE DESIGN PHILOSOPHY OF LONG RANGE LFC TRANSPORTS WITH ADVANCED SUPERCRITICAL LFC AIRFOILS
W. PFENNINGER, C. S. VEMURU (Analytical Services and Materials, Inc., Hampton, VA), and J. VIKEN (Complere, Inc., Palo Alto, CA) AIAA, Fluid Dynamics, Plasma Dynamics, and Lasers Conference, 19th, Honolulu, HI, June 8-10, 1987. 66 p. refs
(AIAA PAPER 87-1284)

Attention is given to the aerodynamic and structural design requirements of long-range transport aircraft making extensive use of laminar flow control (LFC) technology, which can reach any point on earth at high subsonic speed with relatively large payloads and without refueling. The illustrative example of such a craft that is presently considered is a 180,000-kg (takeoff gross weight) LFC transport aircraft with the 50,000-kg payload that is typical of 250 passengers, together with cargo. Cruise condition L/D ratios of the order of 39.4 appear feasible with 70-percent laminar flow over lifting surfaces that are of suitable geometry and employ boundary-layer suction, while using a turbulent-flow fuselage. O.C.

A87-48759
POTENTIAL PERFORMANCE GAINS FOR LIGHT AIRCRAFT BY THE APPLICATION OF A STATOR BEHIND THE PROPELLER
B. W. MCCORMICK (Pennsylvania State University, University Park) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 8 p.
(SAE PAPER 871-029)

A preliminary analysis which predicts the propulsion performance gains to be realized by installing a stator in the wake of a typical light airplane propeller has been performed. The stator is predicted to increase the static thrust by approximately 6 percent. The gain decreases to 3.6 percent during the climb and to approximately 1 percent for cruising flight. The performance in cruising flight is sensitive to the profile drag of the stator blades and may be improved by careful attention to the stator blade airfoil section. Author

A87-48772
STRUCTURAL OPTIMIZATION OF LANDING GEARS USING STARSTRUC
R. SANTILLAN, JR. (Colt Industries, Menasco Aerosystems Div., Euless, TX) and A. M. ELSAIE SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 11 p. refs
(SAE PAPER 871-047)

Optimization technique tools and practices that have been successfully applied to landing gears are described. Typical design examples of landing gear components are presented that demonstrate the performance of STARSTRUC as an effective weight optimization design tool. The minimum weight design is achieved when the landing gear is subjected to behavior constraints on stresses, deflections, buckling, and vibrational frequencies. C.D.

A87-48799
AUTOROTATING WINGS - A CONCEPT THAT REMAINS VITAL [ALAS GIRATORIAS - UNA IDEA QUE SIGUE VIGENTE]
JOSE LUIS LOPEZ RUIZ (Escuela Tecnica Superior de Ingenieros Aeronauticos, Madrid, Spain) IAA/Ingenieria Aeronautica y Astronautica (ISSN 0020-1006), April 1987, p. 5-14. In Spanish.

A development history is presented for the autogyro aircraft concept first developed by Juan de la Cierva in Spain, whose first successful flight with an aircraft of this type occurred in 1923 and whose most advanced version, the Pitcairn PA-33, flew in 1935. A comprehensive series of performance comparisons is then undertaken with helicopters and fixed-wing aircraft to delimit the range of most highly efficient application for the autogyro concept. Attention is also given to the performance gains over classic de la Cierva designs which could be obtained through the use of state-of-the-art rotor airfoil profiles and planforms, composite blade structures, advanced flight controls, contemporary low specific mass engines, etc. O.C.

A87-48913#
SOUND INTENSITY MEASUREMENTS INSIDE AIRCRAFT
S. GADE and T. G. NIELSEN (Brueel og Kjaer A/S, Naerum, Denmark) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 9 p.

Results from sound intensity and sound pressure measurements performed inside a Fairchild 340 propeller aircraft are presented. An attempt was made to locate the sound paths from engine to cabin by mapping the sound intensity and sound pressure distribution from various interior surfaces for the first three harmonics of the propeller frequency. The validity of the intensity measurements was established by measuring the residual intensity index of the measuring system as well as the reactivity index of the sound field. K.K.

A87-48919#
RNLAF BO-105 C MISSION IMPROVEMENT PROGRAM
R. H. FRIEDERICY (Royal Netherlands Air Force, The Hague) and Y. P. BOERSMA (Royal Netherlands Air Force, Arnhem) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 12 p.

A test and evaluation program was carried out to select and integrate a cost effective package of night vision and mission supporting equipment that would provide the BO-105 C helicopter with round the clock operating capability. Attention is given to the selection of night vision goggles (NVG) and NVG compatible lighting. The low level night flight trials revealed the feasibilty of the concept. K.K.

A87-48920#
A NEW METHOD FOR LOW COST TESTING AND EVALUATION OF HELICOPTER COCKPITS DURING DESIGN AND DEVELOPMENT PHASES
ALOYS RAUEN (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 11 p.

The development of an advanced flight simulation facility consisting of a computer-generated image visual system and a rig for installing different cockpits is described. Particular attention is given to the cost reductions associated with the evolution of a second-generation dome cockpit from a first-generation beam splitter cockpit. The next-generation cockpit is expected to be even more economically feasible owing to a simplified movable platform and a fully modular simulation-cockpit layout. K.K.

A87-48936#
THREE-DIMENSIONAL COMPUTER AIDED DESIGN SYSTEMS - IMPACTS ON FUTURE HELICOPTER DESIGN WORK
WALTER HALAMEK, MAX HEYDER, and HORST-DIETER LUDWIG (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) European Motorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 8 p.

The application of three-dimensional CAD systems to the preliminary design of helicopters at MBB is considered. It is noted that such options as surface generation, spatial integration, and kinematic analysis make it possible to develop new approaches to design problems. Typical applications include the generation of helicopter geometry, subsystem integration, cockpit layout, and kinematic studies. It is concluded that the extensive application of three-dimensional systems will evolve the helicopter design to an optimization process during the early design phase. B.J.

A87-48937#
ELECTRO-MECHANICAL ACTUATORS FOR HELICOPTER BLADE FOLDING APPLICATION
PIERO BOZZOLA (Microtecnica S.p.A., Turin, Italy) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 14 p.

Two electromechanical actuators with application to blade folding operation are developed in order to reduce the overall aircraft dimensions, thus enabling high density storage. In the rotor indexing actuator, the change of speed is achieved without the need of an electronic control. The weight and power consumption are minimized using a high-efficiency gear reducer, and the requirements of high positional accuracy, high speed, and simple control are satisfied using a two-speed actuator. The blade fold actuator is a single motor multifunction actuator which provides the structural fulcrum around which the blade hinges and automaticaly unlocks/locks, folds, and spreads the blades. Operation is automatic, not requiring any external controller, and geared rotary actuators are used. R.R.

A87-48938#
COMPOSITE MAIN ROTOR BLADE OF PZL-SOKOL HELICOPTER
STANISLAV KAMINSKI (WSK PZL-Swidnik, Poland) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 20 p. refs

A survey of the static, dynamic, fatigue, and weather aging tests performed for PZL-Sokol blade qualification is presented, and the unique phenomena of the stall flutter and pylon resonance of low torsional stiffness blades, encountered in the preliminary flight tests, are discussed in detail. The blade cross section structure, blade geometry, and blade mass and stiffness distributions are considered, and resonance diagrams, including pylon flexibility, are given. Test results show that the swept-back tapered tip was less effective than the tapered tip in the PZL-Sokol blade configuration, and that upward deflection of the airfoil trailing edge tabs in the blade configuration resulted in decreased stall flutter margin, increased hub and control system loads, and increased helicopter vibration. R.R.

A87-48950#
EMC CHARACTERISTICS OF GROUNDING NETWORKS AND ELECTRICAL INTERFACES
G. MESCHI (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Gallarate, Italy) and B. AUDONE (Aeritalia S.p.A., Caselle Torinese, Italy) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 15 p.

The grounding concept of aircraft installations is addressed by comparing different schemes whose relevant merits are discussed and examined in detail. The final proposal is to use the Distributed Single Point Grounding (DSPG) system which suits the flexibility and complexity of modern aircraft. The adoption of the DSPG system puts in evidence the need of suitable I/O equipment interfaces which shall be designed with a high degree of common mode noise rejection and at the same time sufficiently hardened against the RF external environment. Some design guidelines are also given to improve the EMC equipment design. Author

A87-48951#
NOTES REGARDING FUNDAMENTAL UNDERSTANDINGS OF ROTORCRAFT AEROELASTIC INSTABILITY
RICHARD L. BIELAWA (Rensselaer Polytechnic Institute, Troy, NY) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 27 p. refs

An expanded description of the Force-Phasing Matrix (FPM) technique for understanding the physics of instabilities of linear dynamic systems is presented. The technique is a mathematically formalized procedure for identifying those forces acting on the system's component degrees-of-freedom which are in-phase with the velocities of these degrees-of-freedom. The FPM technique, originally defined only for the case of linear systems with constant coefficient, is expanded to the case with periodic coefficients. The technique is thus particularly well-suited to rotorcraft instability problems. Application of the technique is made to the cases of air resonance and blade flap-lag instabilities. Significant differences between ground resonance and air resonance instabilities, as identified using the FPM technique, are discussed. Finally, results obtained from applying the technique to the problem of flap-lag instability of a rotor in forward flight are also discussed. Author

A87-48952#
AN APPLICATION OF FLOQUET THEORY TO INVESTIGATE HELICOPTER MECHANICAL INSTABILITY USING A SPATIAL MODEL INCLUDING ROTOR BLADE FLAPPING
JOCHEN EWALD (Braunschweig, Technische Universitaet, Brunswick, West Germany) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 13 p. refs
(Contract BMFT-LFF-84318)

The mechanical instability of helicopters is analyzed using a spatial helicopter model that includes blade flapping and the coupling effects of rotor blade lag-flap motion. The linearized equations of motion are described and are solved, for a three bladed helicopter, using the Floquet theory and the Coleman and Feingold (1958) theory. The eigenvalues obtained using the two theories are compared. The comparison reveals that if the frequency-curve touches the rotor/2 axis or abscissa then the polarity of the frequency alternates and if the frequency-curve touches the rotor/2 axis then the multiplicity in the rotor angular frequency is raised or lowered around 1, contrary to the polarity alternation of the frequency. I.F.

A87-48953*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
EFFECTS OF BLADE-TO-BLADE DISSMILARITIES ON ROTOR-BODY LEAD-LAG DYNAMICS
MICHAEL J. MCNULTY (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 29 p. refs

Small blade-to-blade property differences are investigated to determine their effects on the behavior of a simple rotor-body system. An analytical approach is used which emphasizes the significance of these effects from the experimental point of view. It is found that the primary effect of blade-to-blade dissimilarities is the appearance of additional peaks in the frequency spectrum which are separated from the conventional response modes by multiples of the rotor speed. These additional responses are potential experimental problems because when they occur near a mode of interest they act as contaminant frequencies which can make damping measurements difficult. The effects of increased rotor-body coupling and a rotor shaft degree of freedom act to improve the situation by altering the frequency separation of the modes. Author

A87-48954*# Florida Atlantic Univ., Boca Raton.
AN EXPERIMENTAL AND ANALYTICAL INVESTIGATION OF ISOLATED ROTOR FLAP-LAG STABILITY IN FORWARD FLIGHT
GOPAL H. GAONKAR (Florida Atlantic University, Boca Raton) and MICHAEL J. MCNULTY (U.S. Army, Aeromechanics Laboratory, Moffett Field, CA) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 31 p. refs
(Contract NCC2-361)

For flap-lag stability of isolated rotors, experimental and analytical investigations are conducted in hover and forward flight on the adequacy of a linear quasi-steady aerodynamics theory with dynamic inflow. Forward flight effects on lag regressing mode are emphasized. Accordingly, a soft inplane hingeless rotor with three blades is tested at advance ratios as high as 0.55 and at shaft angles as high as 20 deg. The 1.62-m model rotor is untrimmed with an essentially unrestricted tilt of the tip path plane. By computerized symbolic manipulation, an analytical model is developed in substall to predict stability margins with mode indentification. It also predicts substall and stall regions to help explain the correlation between theory and data. The correlation shows both the strengths and weaknesses of the data and theory, and promotes further insights into areas in which further study is needed in substall and stall. Author

A87-48956#
AN ANALYTICAL STUDY OF IMPULSIVE DESTRUCTION OF THE TAIL-ROTOR-DRIVE-SHAFT
KEIJI KAWACHI (Tokyo, University, Japan) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 15 p.

The impulsive destruction of a drive shaft due to the sudden stop of the tail rotor is examined. A solution of the torsional equation of motion is derived using the separating variables method of Kreyszig (1983). It is observed that the drive shaft may be destroyed in two places by the reflection of the strain waves, when the tail rotor is suddenly stopped, and when the tail rotor is gradually constrained, the drive shaft is destroyed only near the tail rotor end. I.F.

A87-48957#
ELASTIC FUSELAGE MODES AND HIGHER HARMONIC CONTROL IN THE COUPLED ROTOR/AIRFRAME VIBRATION ANALYSIS
S. HANAGUD, M. MEYYAPPA, S. SARKAR, and J. I. CRAIG (Georgia Institute of Technology, Atlanta) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 20 p. refs
(Contract DAAG29-82-K-0094)

A coupled rotor/airframe vibration analysis model has been used to study variations in the control vector and vibration levels of the fuselage. The differences between minimization of the hub forces and the acceleration at selected fuselage locations have been discussed. Also the effects of nonideal conditions in the implementation of higher harmonic control and the resulting residual vibration levels in the fuselage have been discussed. The coupled rotor/airframe vibration model is based on the Hsu and Peters rotor model (1982), a finite-element fuselage model, and impedance-matching techniques. Author

A87-48958#
OPTIMAL CONTROL OF HELICOPTER AEROMECHANICAL STABILITY
F. K. STRAUB (McDonnell Douglas Helicopter Co., Culver City, CA) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 17 p.

Optimal control theory is applied to the design of a control system for the elimination of helicopter rotor/body aeromechanical instabilities. Control is introduced through actuators in the fixed system which drive the nonrotating swashplate. The entire range of rotor operating speeds is considered. For the particular configuration studied here, this includes coalescence of the regressing lag model with the longitudinal and lateral support modes. The optimal controller for the case of reduced blade leadlag damping is successful in stabilizing the system at all rotor speeds. Furthermore, through successive reduction in the number of measurements, it is shown that feedback of body degrees of freedom alone provides adequate damping augmentation to eliminate the need for lead-lag dampers. This is possible without gain scheduling. The resulting controller is shown to be relatively insensitive with respect to changes in rotor/body parameters. Author

A87-48967*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
IN-FLIGHT MEASUREMENT OF ROTOR HUB DRAG USING THE RSRA - A FEASIBILITY DEMONSTRATION
C. W. ACREE, JR. and ROBERT M. KUFELD (NASA, Ames Research Center, Moffett Field, CA) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 21 p. refs

The Rotor Systems Research Aircraft (RSRA) is a compound helicopter that was test flown as a fixed-wing aircraft, with the main rotor blades removed and the rotor hub installed. An onboard rotor load-measurement system measured the resulting rotor hub drag and lift. Measured hub drag and lift are plotted for comparison to that predicted by full-scale and 1/6-scale model wind-tunnel tests. The success of the demonstration gives confidence that planned improvements to the RSRA will allow high-accuracy hub drag and lift measurements to be made in flight on a routine research basis. Author

A87-48968#
WIND TUNNEL MEASUREMENTS OF SHIP INDUCED TURBULENCE AND THE PREDICTION OF HELICOPTER ROTOR BLADE RESPONSE
D. W. HURST and S. J. NEWMAN (Southampton, University, England) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 17 p. Research supported by the Ministry of Defence. refs

An investigation of the flowfield over the flight deck of a Royal Fleet Auxiliary (R.F.A.) ship has been undertaken. Results were obtained on board a full-scale ship and also by using a scale model in a wind tunnel. Mean- and time-dependent flow properties were measured in both cases. Comparison shows that satisfactory representation of the flowfield can be obtained by undertaking tests at model scale. A theoretical model has been assembled to predict the blade flapwise deflections, when operating on the deck of a ship, during rotor run-up and run-down. The results of the wind tunnel tests have been used as an input to this model; using the Lynx helicopter on an R.F.A. - sized ship, the blade motion has been calculated. Tail-cone strikes have not been predicted with a moderate gust, but encroachment on fatigue life is predicted. Author

A87-48969#
DYNAMIC INTERFACE FLIGHT TEST AND SIMULATION LIMITATIONS
DEAN CARICO, K. E. MCCALLUM, and JERRY HIGMAN (U.S. Navy, Naval Air Test Center, Patuxent River, MD) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 21 p. refs

The Naval Air Test Center has an ongoing parallel flight test and analytical effort to define helicopter shipboard operational envelopes. The DI Program flight test effort involves approximately 8-10 at-sea test programs per year, which is not sufficient to eliminate the large backlog of helicopter-ship (H/S) test combinations. An analytical effort was begun to develop the capability of substituting a major portion of the flight test effort with simulation. A review of the state-of-the-art H/S landing simulation shows that inadequate visual systems and ship airwake turbulence models are the major problems. It is noted that ship airwake turbulence model studies have commenced, but quantitative at-sea data are required for model verification. B.J.

A87-49061#
ULTRA HIGH BYPASS INSTALLATION DESIGN FOR TRANSPORT AIRCRAFT
D. M. PITERA, R. W. HOCH, and W. R. OLIVER (Douglas Aircraft Co., Long Beach, CA) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 113-123. Research supported by the Douglas Aircraft Co. refs
(AIAA 87-2280)

The interaction of ultrahigh bypass (UHB) powerplants with airframe aerodynamics calls for careful attention to installation design. Attention is presently given to CFD codes applicable to preliminary design studies and to the results thus obtained; the codes encompass subsonic panel methods and transonic potential flow methods. Sample applications include UHB nacelle/pylon design, flow field estimation, and power level effects estimation. Code accuracies are verified through comparisons of the theoretical estimates to wind tunnel test data. O.C.

A87-49065*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
REVIEW OF VORTEX FLOW FLIGHT PROJECTS ON THE F-106B
J. E. LAMAR, J. B. HALLISSY, N. T. FRINK, R. H. SMITH (NASA, Langley Research Center, Hampton, VA), T. D. JOHNSON, JR. (PRC Kentron, Inc., Hampton, VA) et al. IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 145-153. refs
(AIAA PAPER 87-2346)

NASA-Langley's F-106B research aircraft is being used in vortex flow-research flight experiments in order to determine the effects of Re number and Mach number on the lee-side vortex system generated at angles-of-attack up to maneuver condition, as well as to evaluate the aerodynamic characteristics of a sharp leading-edge vortex flap system. The wing vortex system is visualized at a fixed position by means of the vapor-screen technique. Comparisons are made between a measured value and two theoretical estimates of a pertinent vortex system property, core location. O.C.

A87-49075#
DEVELOPMENT OF AN AIRFRAME MODIFICATION TO IMPROVE THE MISSION EFFECTIVENESS OF THE EA-6B AIRPLANE
ROBERT J. HANLEY (U.S. Naval Air Systems Command, Washington, DC) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 241-247. refs
(AIAA PAPER 87-2358)

A higher-than-expected aircraft accident rate with the EA-6B aircraft has prompted an engineering study aimed at the quantitative characterization of its flying qualities at high angles-of-attack. Attention was given to the out-of-control flight regime, in order to arrive at an aerodynamic data base applicable to flight training simulators and, in addition, verify training manual procedures. Airframe modifications have been instituted to improve handling at high angles-of-attack; these encompass a wing glove strake, a vertical fin extension, inboard leading edge flap droop, and a trailing edge split flap. O.C.

A87-49076*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
WIND-TUNNEL TEST RESULTS OF AIRFOIL MODIFICATIONS FOR THE EA-6B
W. G. SEWALL, R. J. MCGHEE, and J. C. FERRIS (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 248-256. refs
(AIAA PAPER 87-2359)

Wind-tunnel tests have been conducted (to determine the effects on airfoil performance for several airfoil modifications) for the EA-6B Wing Improvement Program. The modifications consist of contour changes to the leading-edge slat and trailing-edge flap to provide a higher low-speed maximum lift with no high-speed cruise-drag penalty. Airfoil sections from the 28- and 76-percent span stations were selected as baseline shapes with the major testing devoted to the inboard airfoil section (28-percent span station). The airfoil modifications increased the low-speed maximum lift coefficient between 20 and 35 percent over test conditions of 3 to 14 million chord Reynolds number and 0.14 to 0.34 Mach number. At the high-speed test conditions of 0.4 to 0.80 Mach number and 10 million chord Reynolds number, the modified airfoils had either matched or had lower drag coefficients for all normal-force coefficients above 0.2 as compared to the baseline airfoil. At normal-force coefficients less than 0.2, the baseline (original) airfoil had lower drag coefficients than any of the modified airfoils. Author

A87-49077*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EA-6B HIGH-LIFT WING MODIFICATIONS
E. G. WAGGONER and D. O. ALLISON (NASA, Langley Research Center, Hampton, VA) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 257-269. refs
(AIAA PAPER 87-2360)

NASA-Langley has accomplished the computational design and experimental verification of EA-6B aircraft wing modifications for improved high lift capability. The modifications are comparatively simple, and attempt to improve low speed high lift performance while maintaining high speed cruise efficiency. Several two- and three-dimensional low speed and transonic computational techniques were employed, together with extensive wind tunnel tests. The modified inboard and outboard edge slat/flap system sections yielded efficiency improvements that were verified by three-dimensional wind tunnel experiments to amount to an 11-percent wing-body lift coefficient enhancement at low speed. O.C.

A87-49079#
INNOVATIVE AERODYNAMICS - THE SENSIBLE WAY OF RESTORING GROWTH CAPABILITY TO THE EA-6B PROWLER
W. GATO and M. F. MASIELLO (Grumman Corp., Aircraft Systems Div., Bethpage, NY) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 286-299. refs
(AIAA PAPER 87-2362)

An account is given of the design rationale behind a number of modifications that have furnished the EA-6B Prowler with a 22-30 percent increase in cruise configuration maximum usable lift, as well as substantially improved handling qualities near stall. The rationale involves the interplay of aerodynamic objectives, structural and operational constraints imposed by an existing aircraft configuration, ease of production implementation and retrofit, and cost considerations. The enhancement thus obtained in stall/maneuver margins will restore payload growth capacity to an otherwise overly burdened design. O.C.

A87-49108#
EXPERIMENTS WITH AN ADAPTABLE-WALL WIND TUNNEL FOR LARGE LIFT
DANIEL C. LEE and WILLIAM R. SEARS (Arizona, University, Tucson) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 564-571. refs
(Contract AF-AFOSR-82-0185)
(AIAA PAPER 87-2608)

Experiments have been carried out in a demonstration wind tunnel of the adaptable-wall type designed for the testing of high-lift configurations such as powered-lift V/STOL aircraft. The simulated flight vector makes a large angle (30 to 40 degrees) relative to the tunnel axis so that the model's wake lies in a benign position. Simulation of flight at the desired speed and angle is accomplished by iteratively matching conditions at an interface within the tunnel to the calculated, updated outer-flow field. Measurements were made with a traversing laser-Doppler-anemometer system. The test model in these experiments was a V/STOL transport aircraft model with lower-surface blown wing flaps. Under test conditions, the powered wing wake made a large angle with the flight direction; wake positions were measured and are shown. Results show that the iterative procedure successfully reduced matching discrepancies at the interface. Typically, the best match was reached after about six or eight iterations and represents precise simulation at the model to within 1 percent of stream speed.
Author

A87-49113#
AN EXPERIMENTAL INVESTIGATION OF THE INSECT SHIELDING EFFECTIVENESS OF A KRUEGER FLAP/WING AIRFOIL CONFIGURATION
T. L. B. TAMIGNIAUX, S. E. STARK, and G. W. BRUNE (Boeing Commercial Airplane Co, Seattle, WA) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 601-606.
(AIAA PAPER 87-2615)

The shielding effectiveness of a leading edge Krueger flap protecting a laminar flow wing against insect contamination was investigated experimentally. The investigation was conducted in a low speed atmospheric wind tunnel using a two-dimensional high lift airfoil model in a landing configuration and live insects. Three different species of insects were employed representing a wide range of the insect population encountered by laminar flow control airplanes. However, projected to full scale flight conditions, all insects were heavier than average. The test demonstrated that a Krueger flap can serve as an excellent shield against such heavy insects. Theoretical predictions, also reported in this paper, confirmed this finding. The paper includes a detailed discussion of a testing technique for live insects which will have application in future contamination studies of laminar flow control airplanes.
Author

A87-49170#
FLIGHT SIMULATION OF MULTIPLE AIRCRAFT AND HELICOPTERS USING A SINGLE HIGH-PERFORMANCE COMPUTER
R. M. HOWE (Michigan, University; Applied Dynamics International, Ann Arbor, MI) IN: AIAA Flight Simulation Technologies Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 107-110. refs
(AIAA PAPER 87-2499)

This paper describes the simultaneous simulation of multiple airframes in real time using a single high-speed computer, the AD 100. Examples include the simulation of up to 32 aircraft over their full flight envelopes, 8 helicopters with each helicopter simulated using the blade element method, the simultaneous simulation of multiple fighter aircraft together with six-degree-of-freedom missile simulations, and the simultaneous simulation of airframes and turbofan engine dynamics. A simple method for handling separate integration mode control (reset, operate, hold) for each of the airframes is also described.
Author

A87-49171#
DEVELOPMENT OF A REAL-TIME BLADE ELEMENT AEROELASTIC ROTOR
MARK E. DREIER (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: AIAA Flight Simulation Technologies Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 111-121. refs
(AIAA PAPER 87-2500)

The paper examines the development of a fully coupled real-time blade element aeroelastic rotor model and its incorporation into a manned simulation. The design goals include real-time operation within a total piloted simulation environment, tabular stall/compressible flow blade section aerodynamics, nonlinear distributed mass, preservation of rotor harmonics and transient response, two fully coupled flap/lag/torsion blade modes, chord and blade shape, single blade failure capability, and rapid data changes. These goals were met through the judicious utilization of state-of-the-art computers, formality of the mathematical model, parallel computation of aerodynamic and inertial models distributed between two processors, and reduction of computer frametime using preprocessed data. The rotor model, coupled with an airframe, power plant, and control system model, constitutes a comprehensive rotorcraft simulation. B.J.

A87-49206
F-14 SIMULATION IN A TOTAL G-FORCE ENVIRONMENT
DAVID E. BISCHOFF (Veda, Inc., Warminster, PA) and JACOB EYTH, JR. (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: Society of Flight Test Engineers, Annual Symposium, 17th, Washington, DC, Aug. 10-14, 1986, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1986, p. 4.1-1 to 4.1-9. refs

The Naval Air Development Center has adapted its man-rated centrifuge as a total G-force aircraft simulator. This Dynamic Flight Simulator (DFS) is capable of providing transient and sustained maneuvering forces in any of three mutually perpendicular axes, representative of tactical maneuvering and out-of-control flight. A high fidelity, high angle of attack F-14A aircraft model has been implemented in the DFS. It has been used to study the pilot's ability to recognize and recover from departures and flat spins and to investigate various control and display concepts applicable to this flight regime. F-14 departures from controlled flight were easily simulated as were recoveries from spins up to minus 5 G's (eyeballs out). The advantages of an automatic harness locking restraint and a spin warning display were also demonstrated. The DFS proved to be an effective, safe tool for high G maneuvering flight investigations and is planned to be further utilized to support a variety of aircraft development and flight test programs.
Author

A87-49209
NLR CONTRIBUTIONS TO THE FLUTTER CERTIFICATION OF AIRCRAFT WITH EXTERNAL STORES
J. J. MEIJER (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Society of Flight Test Engineers, Annual Symposium, 17th, Washington, DC, Aug. 10-14, 1986, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1986, p. 5.1-1 to 5.1-14. refs

The store flutter clearance (SFC) activities of the NLR carried out by order of the Royal Netherlands Air Force is outlined with emphasis on SFC for the F16 aircraft. Particular attention is given to aeroelastic analytical methods, unsteady aerodynamic methods, the aerodynamic influence of stores on flutter, and wing transonic effects on flutter. The NLR SFC procedure is described in detail, with emphasis on flutter calculations for F16 configurations with VER4 rack, ground resonance testing, and flutter flight testing. It is concluded that a national air force such as the RNLAF in cooperation with a laboratory such as the NLR is capable of

developing an adequate facility for the SFC of modern flighter aircraft such as the F16. B.J.

A87-49587#
PROGRAM EAGLE - NUMERICAL GRID GENERATION AS APPLIED TO ADVANCED AIRFRAME CONFIGURATIONS
AGUSTO MARTINEZ (USAF, Armament Laboratory, Eglin AFB, FL), JOE F. THOMPSON (Mississippi State University, Mississippi State), and YEON SEOK CHAE IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 88-96. refs
(AIAA PAPER 87-2294)

The USAF Armament Laboratory's EAGLE numerical grid generation system program, which encompasses three-dimensional algebraic and elliptic geometries, is presently applied to two advanced airframe configurations and a generic aircraft carriage configuration, in order to demonstrate its versatility and generality. A symbolic input stream is used for the in-carriage configuration, in order to achieve further generality. The grid system is also applicable to problems involving solutions of either finite-difference or finite-element methods that are not related to aerodynamics or fluid dynamics. O.C.

A87-49594#
FLOW VISUALIZATION TECHNIQUES APPLIED TO FULL-SCALE VEHICLES
JAMES P. CROWDER (Boeing Commercial Airplane Co., Seattle, WA) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 164-171. refs
(AIAA PAPER 87-2421)

The fluorescent minituft method is noted to be a practical system for the detection of surface separation with high spatial resolution in a variety of aircraft and automobile flow situations. Flow cones have demonstrated similar utility, with the additional advantage of easy photographic imaging in daylight conditions. The sunlight shadowgraph technique is shown to be a low-cost procedure for the documentation of wing shock wave conditions in flight. Attention is also given to the flying-strut traversing system for smoke plume dispensing and two-axis flowfield surveying. O.C.

A87-49621*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PARTITIONING OF FLIGHT DATA FOR AERODYNAMIC MODELING OF AIRCRAFT AT HIGH ANGLES OF ATTACK
JAMES G. BATTERSON (NASA, Langley Research Center, Hampton, VA) and VLADISLAV KLEIN (Joint Institute for Advancement of Flight Sciences, Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 444-451. refs
(AIAA PAPER 87-2621)

It is sometimes necessary to determine aerodynamic model structure and estimate associated stability and control derivatives for airplanes from flight data that cover a large range of angle of attack or sideslip. One method of dealing with that problem is through data partitioning. The main purpose of this paper is to provide an explanation of a data partitioning procedure and its application and to discuss both the power and limitations of that procedure for the analysis of large maneuvers of aircraft. The partitioning methodology is shown to provide estimates for coefficients of those regressors that are well excited in the aircraft motion. In particular, primary lateral stability and damping derivatives are identified throughout the maneuver ranges. Author

A87-49964#
INTERACTIVE DEVELOPMENT OF STRUCTURAL COMPONENTS FOR LIGHTWEIGHT FIBER-REINFORCED COMPOSITE DESIGNS - THE CASE OF THE AIRBUS VERTICAL TAILS [INTERAKTIVE BAUTEILENTWICKLUNG VON LEICHTBAU-FASERVERBUND-KONSTRUKTIONEN AM BEISPIEL VON SEITENLEITWERKEN DER AIRBUS FAMILIE]
H. BRENNEIS (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) Verein Deutscher Ingenieure, Seminar ueber Verbund- und Hybridwerkstoffe - neue Methoden fuer Konstruktion und Fertigung, Duesseldorf, West Germany, Feb. 17, 18, 1987, Paper. 61 p. In German.
(MBB-UT-023-86)

The application of CAD techniques to the design of the CFRP center boxes of the A 310-300 and A 320 vertical tails is illustrated with extensive drawings and diagrams and briefly characterized. The individual components making up the vertical tail are listed and described; the criteria used in selecting CFRP or Al alloys in each case are discussed; and the advantages of interactive CAD for CFRP structures are indicated. T.K.

A87-50224
PILOT REPORT - A TALE ABOUT FLYING THE NOTAR
DAVID GREEN Rotor and Wing International (ISSN 0191-6408), vol. 21, Aug. 1987, p. 38-41.

An evaluation is made of the flying qualities and performance advantages of the no-tail-rotor 'NOTAR' system installed aboard an OH-6A helicopter; this directional control apparatus employs a variable-pitch fan to supply low pressure air to a Coanda effect tail thruster. The air-jet thruster at the end of the tail boom generates yawing moments to the left or right in response to pedal diplacement by the pilot. The system yields a 360-deg yawing of the helicopter in less than four seconds, and eliminates the tail rotor vibration typical of conventional helicopters. NOTAR yields no immediate yaw response to main rotor torque variations due to collective pitch changes. O.C.

A87-50225
PILOT REPORT - AIR FORCE'S SIKORSKY HH-60 NIGHT HAWK
DAVID GREEN Rotor and Wing International (ISSN 0191-6408), vol. 21, Aug. 1987, p. 42-45, 57.

The USAF HH-60D combat search-and-rescue helicopter's cockpit incorporates four monochromatic CRTs that replace conventional avionics displays, with sensor data and symbology furnished by two redundant display generators. The HH-60D sensor suite encompasses FLIR and a multimode radar for terrain avoidance; provisions are also made for GPS and novel survivor-location systems. Attention is presently given to the flying qualities and pilot/cockpit interaction characteristics of the HH-60D, whose range is considerably extended over that of earlier HH-60 variants by the use of external fuel tanks and an aerial refueling probe. O.C.

A87-50336#
NEW TECHNOLOGICAL CONSIDERATIONS THAT IMPROVE AVIONIC RELIABILITY
ALAN H. BURKHARD and GEORGE KURYLOWICH (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) Journal of Aircraft (ISSN 0021-8669), vol. 24, Aug. 1987, p. 503-510. refs

Improvements in aircraft environmental control systems (ECSs) technologies are presently noted to be capable of yielding significant avionics reliability and flight performance enhancements, by relieving various, currently severe environmental stresses that can lead to the deterioration or failure of onboard electronics. Microprocessor-controlled ECSs can yield a system that adapts to mission requirements through reduction of junction temperatures and thermal cycling. The resulting performance envelope improvement for the host aircraft may be based on a 6-percent takeoff gross weight reduction, or could directly take the form of a 10-percent increase in range. O.C.

A87-50487#
APPLICATION OF MULTIVARIABLE CONTROL TO THE STOL AND MANEUVER TECHNOLOGY DEMONSTRATOR
RICHARD F. MOOMAW (McDonnell Aircraft Co., Saint Louis, MO) and DAVID J. LOWRY (Honeywell Systems and Research Center, Minneapolis, MN) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 773-783. refs
(AIAA PAPER 86-2403)

The STOL and Maneuver Technology Demonstrator (S/MTD) program is developing and validating technologies to provide future fighter aircraft with Short Takeoff and Landing (STOL) capability and increased maneuverability. Key technologies include two-dimensional (2D) thrust vectoring/reversing exhaust nozzles and an Integrated Flight/Propulsion Control (IFPC) system. The novel control capabilities provided by thrust vectoring and reversing, integration of the nozzles with the traditional aerodynamic control surfaces, and rigorous program requirements resulted in a challenging IFPC control law design problem. Both classical and multivariable control system design and analysis techniques were applied where appropriate. Multivariable control applications included Linear Quadratic Gaussian with Loop Transfer Recovery (LQG/LTR) synthesis and Structured Singular Value (SSV) analysis. This paper emphasizes development of coupled longitudinal and airspeed control laws for the Short Landing task. By blending multivariable and classical design features, and making practical tradeoffs in performance versus complexity, control laws were designed which provided excellent flying qualities during manned flight simulator evaluations. Author

N87-26895*# Texas A&M Univ., College Station. Dept. of Aerospace Engineering.
DEVELOPMENT OF DIRECT-INVERSE 3-D METHOD FOR APPLIED AERODYNAMIC DESIGN AND ANALYSIS Semiannual Progress Report, 1 Jul. - 31 Dec. 1986
LELAND A. CARLSON Jan. 1987 51 p
(Contract NAG1-619)
(NASA-CR-180646; NAS 1.26:180646; TAMRF-5373-87-01)
Avail: NTIS HC A04/MF A01 CSCL 01C

The primary tasks performed were the continued development of inverse design procedures for the TAWFIVE code, the development of corresponding relofting and trailing edge closure procedures, and the testing of the methods for a variety of cases. The period from July 1, 1986 through December 31, 1986 is covered. Author

N87-26896 ESDU International Ltd., London (England).
INTRODUCTION TO INSTALLATION EFFECTS ON THRUST AND DRAG FOR PROPELLER-DRIVEN AIRCRAFT
Jun. 1985 24 p
(ESDU-85015; ISBN-0-85679-521-6; ISSN-0141-397X) Avail: ESDU

ESDU 85015 first explains the definitions of propeller thrust and efficiency in free air, discussing the contributions to losses from blade profile drag and induced effects, the latter split further into those arising from axial and swirl velocities. The influence of propeller design on free air efficiency is considered. Then the effect of propeller installation, in tractor or pusher configuration, on propeller thrust and airframe drag is discussed for propeller-nacelle and propeller-nacelle-wing combinations, and the different thrust definitions commonly applied to the tractor propeller-nacelle situation in the US and the UK are explained. The interference effects due to cooling air inlets, and turbine engine exhaust jets, are also considered. The simple axial momentum theory is presented and used to establish the axial variation of the axial velocity, streamtube diameter and static pressure for a practical range of thrust coefficients. A thrust/drag accounting framework is provided in ESDU 85017. ESDU

N87-26897 ESDU International Ltd., London (England).
THRUST AND DRAG ACCOUONTING FOR PROPELLER/AIR-FRAME INTERACTION
Nov. 1985 15 p
(ESDU-85017; ISBN-0-85679-523-2; ISSN-0141-397X) Avail: ESDU

ESDU 85017 sets up an accounting framework for the split between thrust and drag for propeller-driven aircraft. It is assumed that free-air thrust is known either from calculations or from tunnel measurements of minimum-body, or net, thrust. The corrections to free-air thrust, due to blockage and induced effects, and to propeller-off airframe drag, due to pressure gradients and increased velocities in the streamtube, are tabulated to form a check list of all interference contributions. The use of the interference corrections in deducing the excess thrust is explained, and differences between the current approach in the US and the UK are highlighted. Discussion of the various propeller-airframe interference effects will be found in ESDU 85015. ESDU

N87-26898# Army Aviation Engineering Flight Activity, Edwards AFB, Calif.
FLIGHT CHARACTERISTICS TEST OF THE UH-60A WITH TAIL BOOM MOUNTED STRAKE Final Report, 11 - 19 Aug. 1986
ROY A. LOCKWOOD, WILLIAM A. KELLY, and RANDALL W. CARSON Oct. 1986 31 p
(AD-A180791; USAAEFA-85-07) Avail: NTIS HC A03/MF A01 CSCL 01C

The effect of a tail-boom mounted strake on the performance and handling qualities of the UH-60A helicopter was evaluated. A total of 2.0 productive flight hours were flown between 11 to 19 Aug. 1986. The UH-60A helicopter's overall performance in hover and sideward flight to 45 knots true airspeed (KTAS) is essentially unchanged by the strake installation. There was an overall effect of the strake installation on the UH-60A's flight control margins, except for a slight reduction in right cyclic control displacement (increase in control margin) required in right sideward flight. There was a minor improvement in longitudinal cyclic pilot workload in left and right sideward flight to 15 KTAS. The pilot did not detect a significant difference in flying qualities with the strake installed. This test reflected little change with the strake installed. Previous US Army Aviation Engineering Flight Activity performance and flying qualities evaluations of the UH-60A without a tail boom mounted strake have found no control margin or power required problems with sideward flight. Consequently, no further strake testing should be conducted on the UH-60A helicopter. The UH-1H helicopter, which has a documented problem with tail rotor control margins during hover and sideward flight, should be considered a candidate for a tail boom strake evaluation. GRA

N87-26899# McDonnell Aircraft Co., St. Louis, Mo.
FLIGHT WORTHINESS OF FIRE RESISTANT HYDRAULIC SYSTEMS. VOLUME 2: COMPONENT AND ENDURANCE TESTING Final Report, Jan. 1981 - Dec. 1986
J. R. JEFFERY, S. E. PEHOWSKI, N. J. PIERCE, J. A. WIELDT, and R. E. YOUNG 30 Dec. 1986 263 p
(Contract F33615-80-C-2074)
(AD-A180865; AFWAL-TR-84-2085-VOL-2) Avail: NTIS HC A12/MF A01 CSCL 13G

This document is the second of two volumes which make up the Flight Worthiness of Fire Resistant Hydraulic Systems final report. This document reports efforts involved in component procurement, analysis, qualification testing, the 750-hour endurance test, analytical model verification, and results of the teardown are included. The follow-on contract to perform a study of pump pulsation attenuation and actuator stiffness are reported in this volume. Components procured for the endurance tests setup included an 8000 psi hydraulic pump, servoactuator, utility actuator, filters, relief and check valves, and various required seals. The results of the endurance test show that 8000 psi CTFE hydraulic systems are a practical and feasible approach for next generation aircraft design. Two areas of concern, pump pulsations, and actuator stiffness were studied. Acceptable candidate solutions for both topics are included. GRA

N87-26900# Army Aviation Engineering Flight Activity, Edwards AFB, Calif.
EVALUATION OF THE OV-1D AIRCRAFT WITH THE YT53-L-704 ENGINE AND RUDDER AUGMENTATION SYSTEM, PHASE 2 Final Report, 16 Dec. 1985 - 7 Mar. 1986
GEORGE M. YAMAKAWA, JOSEPH C. MIESS, JEFFREY L. LINEHAN, and JOSEPH L. PIOTROWSKI Nov. 1986 106 p
(AD-A180966; USAAEFA-85-17) Avail: NTIS HC A06/MF A01 CSCL 21E

A 3-phase evaluation of the OV-1D aircraft with increased power YT53-L-704 engines and a prototype rudder augmentation system (RAS) installation was performed. Phase 1 involved engine build-up, initial engine and RAS installation, engine/propeller/airframe compatibility tests, and initial flight tests. The Louvered Scarfed Shroud Suppressor (LSSS) system was removed following a high power ground run due to high engine nacelle temperatures which caused extensive damage to the fire shield and seal. All subsequent tests were conducted without LSSS installed. In the Phase 2A tests, the directional control system as designed and modified with RAS was unsatisfactory. Phase 2B required 30.5 flight hours to complete. No problem of YT53-L-704 engine/OV-1D airframe compatibility were identified with the exception of the LSSS high nacelle temperature. With YT53-L-704 engines installed, the OV-1D takeoff and single-engine climb performance were significantly improved. Dual-engine level flight range and endurance decreased approximately 5 and 4%, respectively. Handling qualities of the OV-1D were essentially unchanged at the high powers attainable with the Y53-L-704. GRA

N87-26901# Aeronautical Research Labs., Melbourne (Australia).
VALIDATION OF THE ARL (AERONAUTICAL RESEARCH LABORATORIES) MATHEMATICAL MODEL OF THE SEA KING MK 50 HELICOPTER Aerodynamics Technical Memorandum
M. J. WILLIAMS and A. M. ARNEY Nov. 1986 50 p
(AD-A181314; ARL-AERO-TM-383) Avail: NTIS HC A03/MF A01 CSCL 01C

A mathematical model of the Sea King Mk 50 helicopter has been developed at ARL to allow prediction of the aircraft flight behavior for a wide range of specified conditions. Validation of the model has been performed by successive comparisons with flight data and model adjustment to achieve acceptable overall agreement. Such comparisons have been made for trimmed flight, dynamic responses to control inputs and automatic transitions associated with the ASW role. Some remaining deficiencies in the model could be addressed by modifications tailored to a specific application. GRA

N87-26902# Naval Postgraduate School, Monterey, Calif.
MICROCOMPUTER SOFTWARE SUPPORT FOR CLASSES IN AIRCRAFT CONCEPTUAL DESIGN M.S. Thesis
MICHAEL L. CRAMER Mar. 1987 92 p
(AD-A181450) Avail: NTIS HC A05/MF A01 CSCL 05I

The conceptual phase of aircraft design determines the general size and configuration of an aircraft. Many calculations are performed in assessing the optimum parameters. The calculations are often lengthy and iterative in nature and are thus highly appropriate for computer programming. This thesis develops a computer program to enhance learning about design by performing calculations for aircraft conceptual design which follow hand calculation methods. It is intended to be used in the aircraft design course taught by the Department of Aeronautics at the Naval Postgraduate School, Monterey (Calif.). The computer program written for this thesis is divided into ten chapters, which are addressed through a commom menu called the Chapter Selection Program: (1) Introductions; (2) Preliminary Estimate of Take-off Weight; (3) Meeting Performance Requirements; (4) Aspect Ratio Optimization; (5) Wing Geometry Design; (6) Estimating Fuselage Length; (7) Tail Design; (8) Determining Structural Weights (WS); (9) Refined Estimate of WTO Using WS; and (10) End Session. GRA

N87-26903# Aeronautical Research Labs., Melbourne (Australia).
AN INVESTIGATION OF SOME SIMPLE MODELS FOR THE F/A-18 FLIGHT DYNAMICS
M. IOB Jan. 1987 29 p
(AD-A181638; ARL/SYS-TM-90) Avail: NTIS HC A03/MF A01 CSCL 01A

Simplified mathematical models for both closed loop and open loop F/A-18 flight dynamics are presented. In each case a description of the model is given followed by a comparison of results produced with those published in the literature. Agreement is very good for the longitudinal dynamics and reasonable for the lateral dynamics. GRA

N87-26904# Royal Aircraft Establishment, Farnborough (England).
A METHOD FOR THE MANUFACTURE OF MODEL HELICOPTER ROTOR BLADES WITH TORSIONAL STIFFNESS REPRESENTATIVE OF FULL SCALE
A. R. LEE Nov. 1985 46 p
(RAE-TR-85094; RAE-MAT/STRUCT-149; BR99422; ETN-87-90090) Avail: NTIS HC A03/MF A01

A construction method which allows torsional stiffness of model rotor blades to be reduced to a level representative of full scale was developed. The blades consist of a CFRP spar, surrounded by a rigid foam aerodynamic fairing, covered in a thin glass fiber reinforced plastic skin. The reasoning behind each stage of development is discussed, and the manufacturing technique is described. This uses a twisted mold to manufacture the spar, and an aluminum alloy female mold to apply the glass fiber reinforced plastic skins. ESA

N87-26905 Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
ELEMENTARY DATA ANALYSIS OF MEASUREMENTS IN NONSTEADY LONGITUDINAL AND LATERAL FLIGHT TEST MANEUVERS
C. G. KRANENBURG, P. DELANGE, and J. A. MULDER 1986 133 p
(VTH-LR-409; ISBN-90-6275-239-X; B8650034; ETN-87-90193) Avail: Issuing Activity

Flight tests in nonsteady, symmetrical, and asymmetrical flight were carried out to prove the validity of a method for the simultaneous measurement of performance and stability and control characteristics. Analog dc voltage output signals of transducers or signal conditioners in the instrumentation system are passed through low-pass filters, fed to a multiplexer, and converted to a digital signal. The parallel digital output of the analog to digital converter is serialized and recorded on magnetic tape together with administrative data. After the flight the aircraft tape information is passed, in parallel format, to a digital computer. This computer produces a nine-track IBM-compatible tape suitable for further data reduction. Translation of the recorded voltages into the physical values is described. ESA

N87-26906*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, Calif.
PRELIMINARY FLIGHT ASSESSMENT OF THE X-29A ADVANCED TECHNOLOGY DEMONSTRATOR
JOHN W. HICKS and NEIL W. MATHENY Sep. 1987 15 p
Presented at the AIAA/AHS/ASEE Aircraft Design, Systems and Operations Meeting, St. Louis, Mo., 13-16 Sep. 1987
(NASA-TM-100407; H-1427; NAS 1.15:100407; AIAA-87-2949) Avail: NTIS HC A02/MF A01 CSCL 01C

Several new technologies integrated on the X-29A advanced technology demonstrator are being evaluated for the next generation of fighter aircraft. Some of the most noteworthy ones are the forward-swept wing, digital fly-by-wire flight control system, close-coupled wing-canard configuration, aeroelastically tailored composite wing skins, three-surface pitch control configuration, and a highly unstable airframe. The expansion of the aircraft 1-g and maneuver flight envelopes was recently completed over a two-year period in 84 flights. Overall flight results confirmed the

viability of the aircraft design, and good agreement with preflight predictions was obtained. The individual technologies' operational workability and performance were confirmed. This paper deals with the flight test results and the preliminary evaluation of the X-29A design and technologies. A summary of the primary technical findings in structural static loads, structural dynamic characteristics, flight control system characteristics, aerodynamic stability and control, and aerodynamic performance is presented. Author

N87-27604*# Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.
OPTIMIZATION OF AIRCRAFT TRAJECTORIES THROUGH SEVERE MICROBURSTS
MARK L. PSIAKI *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1985 p 63-72 Jul. 1987
Avail: NTIS HC A05/MF A01 CSCL 01C

A method of defining performance envelopes for aircraft microburst penetration is being developed. A trajectory is computed for a given aircraft/control law configuration and given microburst parameters (either a downdraft or a head/tailwind type microburst). The maximum deviation from the nominal altitude is recorded for that trajectory. Then the microburst parameters are varied, and the process is repeated. Thus a three dimensional plot of maximum altitude deviation versus microburst range scale and intensity is generated. Finally, a certain maximum altitude deviation, say 50 feet, is defined as the safe penetration limit. Then the 50 foot level contour becomes the performance limit for safe operation as a function of microburst intensity and range. Control inputs from deterministic trajectory optimization are used in the above described calculations to define the maximal performance limit. These limits provide targets for the designer of practical control laws. Author

N87-27653# Army Aviation Engineering Flight Activity, Edwards AFB, Calif.
FUEL CONSERVATION EVALUATION OF US ARMY HELICOPTERS. PART 6: PERFORMANCE CALCULATOR EVALUATION Final Report, period ending Jan. 1981
FLOYD DOMINICK and ROY A. LOCKWOOD Jul. 1986 205 p
(AD-A181645; USAAEFA-81-01-6) Avail: NTIS HC A10/MF A01 CSCL 01B

The US Army Aviation Engineering Flight Activity conducted an evaluation of Flight Management Calculator for the UH-1H. The calculator was a Hewlett-Packard HP-41CV. The performance calculator was evaluated for flight planning and in-flight use during 14 mission flights simulating operational conditions. The calculator was much easier to use in-flight than the operator's manual data. The calculator program needs improvement in the areas of pre-flight planning and execution speed. The mission flights demonstrated a 19 percent fuel saving using optimum over normal flight profiles in warm temperatures (15 degrees C above standard). Savings would be greater at colder temperatures because of increasing compressibility effects. Acceptable accuracy for individual aircraft under operational conditions may require a regressive analog model in which individual aircraft data are used to update the program. The performance data base for the UH-1H was expanded with level flight and hover data to thrust coefficients and Mach numbers to the practical limits of aircraft operation. GRA

N87-27654# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
ON THE CONCEPTUAL DESIGN OF SUBSONIC TRANSPORT AIRCRAFT FOR CRUISING FLIGHT OPTIMIZED FOR DIFFERENT MERIT FUNCTIONS
E. TORENBEEK Dec. 1985 53 p
(VTH-LR-451; B8707433; ETN-87-90200) Avail: NTIS HC A04/MF A01

An analytical approach to aircraft design optimization is presented. Design variables are mainly associated with wing design and powerplant sizing. Several figures of merit are studied as a function of the design variables and analytical expressions are derived for partial and combined optima. Merit functions are lift drag ratio, specific range, fuel plus powerplant weight as a fraction of the takeoff weight and of the design payload, fuel plus powerplant plus wing weight fraction, payload weight fraction, fuel burned per seat-km, and direct operating costs. The design variables studied are: engine size, (mean) cruise wing loading, pressure altitude, lift coefficient, Mach number, and wing aspect ratio. ESA

N87-27655*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, Calif.
AIRCRAFT GROUND VIBRATION TESTING AT NASA AMES-DRYDEN FLIGHT RESEARCH FACILITY
MICHAEL W. KEHOE Jul. 1987 21 p Presented at the 5th International Modal Analysis Conference, London, England, 6-9 Apr. 1987
(NASA-TM-88272; H-1374; NAS 1.15:88272) Avail: NTIS HC A02/MF A01 CSCL 01C

At the NASA Ames Research Center's Dryden Flight Research Facility at Edwards Air Force Base, California, a variety of ground vibration test techniques has been applied to an assortment of new or modified aerospace research vehicles. This paper presents a summary of these techniques and the experience gained from various applications. The role of ground vibration testing in the qualification of new and modified aircraft for flight is discussed. Data are presented for a wide variety of aircraft and component tests, including comparisons of sine-dwell, single-input random, and multiple-input random excitation methods on a JetStar airplane. Author

N87-27656# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
FATIGUE OF AIRCRAFT STRUCTURES
J. SCHIJVE Apr. 1986 34 p Presented at the International Symposium on Fatigue Prevention and Design, Amsterdam, The Netherlands, 21-23 Apr. 1986
(VTH-LR-486; B8707459; ETN-87-90225) Avail: NTIS HC A03/MF A01

The various steps of fatigue analysis are indicated, including mission analysis and load spectra, conceptual aspects of designing against fatigue, predictions of fatigue lives and crack growth, and experimental verifications. The significance of fatigue load monitoring and flight-simulation testing is emphasized. ESA

N87-27657# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
DESIGN AND EVALUATION OF DYNAMIC FLIGHT TEST MANEUVERS
J. A. MULDER Oct. 1986 306 p
(VTH-LR-497; B8707465; ETN-87-90230) Avail: NTIS HC A14/MF A01

The kinematic, aerodynamic, and measurement error models used for flight tests are presented. Analysis of dynamic flight test data is discussed, and a technique for the optimization of control input signals is outlined. The flight test program, flight test measurement system, automatic control system, and the method used for measuring aicraft moments and products of inertia are described. Five types of longitudinal and lateral control input signals as implemented in flight, one of these being the result of the optimization technique are considered. The results of the flight test program are summarized. ESA

N87-27658# Army Aviation Engineering Flight Activity, Edwards AFB, Calif.
LEVEL FLIGHT PERFORMANCE EVALUATION OF THE UH-60A HELICOPTER WITH THE PRODUCTION EXTERNAL STORES SUPPORT SYSTEM AND FERRY TANKS INSTALLED Final Report, 28 May - 19 Jun. 1986
ROBERT M. BUCKANIN, WILLIAM A. KELLY, JAMES L. WEBRE, THOMAS L. REYNOLDS, and ROY A. LOCKWOOD Sep. 1986 71 p
(AD-A181947; USAAEFA-86-01) Avail: NTIS HC A04/MF A01 CSCL 01C

Limited level flight performance testing was conducted on a sixth year production UH-60A helicopter equipped with a production

external stores support system (EESS) and four preproduction external fuel tanks. These tests were conducted to provide the US Army Aviation Systems Command with level flight power required data to determine if the UH-60A would still meet the self deployment requirement described in the Material Need Document if the General Electric T700-GE-700 engines were replaced with T700-GE-701's. Sikorsky Aircraft Division of United Technologies Corporation claimed a drag reduction for the production ESSS over the prototype previously tested. A total of 13.9 productive flight hours were flown at Edwards AFB, and Bakersfield, California between 28 May and 19 June 1986. The installation of the production ESSS and four external fuel tanks increased the drag of the normal utility configured UH-60A by approximately 4.5 square feet of equivalent flat plate area. This represents a drag reduction of approximately 4.5 square feet for the production ESSS from the prototype ESSS previously tested. The takeoff characteristics were similar to a normal utility configured UH-60A and remain a shortcoming. GRA

N87-27659# Boeing Vertol Co., Philadelphia, Pa.
USE OF BLADE SWEEP TO REDUCE 4/REV HUB LOADS
DARRELL K. YOUNG, FRANK J. TARZANIN, and DONALD L. KUNZ May 1987 11 p
(AD-A182247; AD-E951026) Avail: NTIS HC A02/MF A01 CSCL 01C

The effect of blade planform sweep on the 4/rev hub loads for a four-bladed, fully-articulated rotor was analytically investigated. Substantial vibratory hub load reductions could be achieved by using aft tip sweep. However, the mathematical model and the blade definition were too complex to understand the source of the reduction. To aid in understanding the physical mechanism, a model of a simplified blade was defined that still showed substantial hub load reductions. Using this simplified model, an extensive blade parameter sensitivity study was performed. It was determined that those properties which are related to the dynamic torsional response of the blade were important in determining the effectiveness of both aft and forward tip sweep in reducing the 4/rev vertical hub load. An extensive investigation into the source of the hub load reduction was performed, and a number of hypotheses were developed. GRA

N87-27660*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
APPLICATION OF GRASP (GENERAL ROTORCRAFT AEROMECHANICAL STABILITY PROGRAM) TO NONLINEAR ANALYSIS OF A CANTILEVER BEAM
HOWARD E. HINNANT and DEWEY H. HODGES Apr. 1987 11 p
(NASA-TM-89222; NAS 1.15:89222; AD-A182324) Avail: NTIS HC A02/MF A01 CSCL 01A

The General Rotorcraft Aeromechanical Stability Program (GRASP) was developed to analyse the steady-state and linearized dynamic behavior of rotorcraft in hovering and axial flight conditions. Because of the nature of problems GRASP was created to solve, the geometrically nonlinear behavior of beams is one area in which the program must perform well in order to be of any value. Numerical results obtained from GRASP are compared to both static and dynamic experimental data obtained for a cantilever beam undergoing large displacements and rotations caused by deformations. The correlation is excellent in all cases. GRA

N87-27661*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif. Ames Research Center.
DEMONSTRATION OF FREQUENCY-SWEEP TESTING TECHNIQUE USING A BELL 214-ST HELICOPTER
MARK B. TISCHLER, JAY W. FLETCHER, VERNON L. DIEKMANN, ROBERT A. WILLIAMS, and RANDALL W. CASON Apr. 1987 83 p
(Contract NASA ORDER-A-87073)
(NASA-TM-89422; NAS 1.15:89422; AD-A182361; USAAVSCOM-TM-87-A-1) Avail: NTIS HC A05/MF A01 CSCL 01C

A demonstration of frequency-sweep testing using a Bell-214ST single-rotor helicopter was completed in support of the Army's development of an updated MIL-H-8501A, and an LHX (ADS-33) handling-qualities specification. Hover and level-flight condition (Va = 0 knots and Va = 90 knots) tests were conducted in 3 flight hours by Army test pilots at the Army Aviation Engineering Flight Activity (AEFA) at Edwards AFB, Calif. Bandwidth and phase-delay parameters were determined from the flight-extracted frequency responses as required by the proposed specifications. Transfer-function modeling and verification demonstrates the validity of the frequency-response concept for characterizing closed-loop flight dynamics of single-rotor helicopters--even in hover. This report documents the frequency-sweep flight-testing technique and data-analysis procedures. Special emphasis is given to piloting and analysis considerations which are important for demonstrating frequency-domain specification compliance. GRA

N87-27662# Aeronautical Research Labs., Melbourne (Australia).
INTERPOLATION TECHNIQUES FOR THE TIME DOMAIN AVERAGING OF VIBRATION DATA WITH APPLICATION TO HELICOPTER GEARBOX MONITORING
P. D. MCFADDEN Sep. 1986 39 p
(AD-A182572; ARL/AERO/PROP-TM-437) Avail: NTIS HC A03/MF A01 CSCL 01C

Interpolation techniques provide an alternative to the phase-locked frequency multiplier for the calculation of the time domain average of a vibration signal. Higher order interpolation techniques produce flatter passbands and lower sidelobes in the stopband but require longer calculation times. Aliasing errors are introduced into the result by replication of the sidelobes during interpolation. In general, the errors are attenuated by time domain averaging, but under some conditions may be passed without attenuation. GRA

N87-27663*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, Calif.
FLUTTER CLEARANCE OF THE F-14 VARIABLE-SWEEP TRANSITION FLIGHT EXPERIMENT AIRPLANE, PHASE 1
MICHAEL W. KEHOE Sep. 1987 68 p
(NASA-TM-88287; H-1402; NAS 1.15:88287) Avail: NTIS HC A04/MF A01 CSCL 01C

An F-14 airplane was modified to become the test bed aircraft for the variable sweep transition flight experiment (VSTFE) program. The latter is a laminar flow program designed to measure the effects of wing sweep on boundary layer transition from laminar to turbulent flow. The airplane was modified by adding an upper surface foam-fiberglass glove over a portion of the left wing. Ground vibration and flight flutter testing were accomplished to clear a sufficient flight envelope to conduct the laminar flow experiments. Flight test data indicated satisfactory damping levels and damping trends for the elastic structural modes of the airplane. The data presented include frequency and damping as functions of Mach number. Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A87-47112
HELMET MOUNTED DISPLAYS FOR TACTICAL AIRCRAFT
WILLIAM A. SYLVESTER (Kaiser Aerospace and Electronic Corp., Kaiser Electronics Div., San Jose, CA) SAFE Journal, vol. 17, Summer 1987, p. 24-28.

The need for a helmet-mounted display in the tactical cockpit is examined. An integrated system approach, referred to as 'Agile Eye', for the helmet-mounted display is described. The proposed integrated helmet display system can protect the pilot's head from impact, provide oxygen, communication, and eye protection from the sun and wind blast, and weighs less than the currently used lightweight Air Force helmet and oxygen mask. The advanced electromagnetic head tracking system will provide targeting cues, weapon status, aircraft attitude, and performance parameters to the pilot. Diagrams of the components of the Agile Eye system are presented. I.F.

A87-47845
AN ORDINARY 3-AXIS HORIZON INSTRUMENT WHICH EVERY PILOT LIKES - CAN IT BE MISLEADING AND DANGEROUS? THE ANSWER IS 'YES'
ULF FRIEBERG and STIG HOLMSTROM (Saab-Scania, AB, Linkoping, Sweden) IN: 1986 report to the aerospace profession; Proceedings of the Thirtieth Symposium, Beverly Hills, CA, Sept. 24-27, 1986 . Lancaster, CA, Society of Experimental Test Pilots, 1986, p. 187-199.

A human factors evaluation is made of the type of three-axis horizon 'heading reference' instrument employed by the F-4 and Viggen fighters. While such an attitude reference instrument performs instrument flying functions very well, the changeovers from visual to instrument flying have been noted to result in a substantial, and potentially dangerous, degree of pilot disorientation. An account is given of the redesign effort and simulator assessment of design changes that were conducted to correct this tendency of the instrument toward misinterpretation. O.C.

A87-47869
THE ELECTRONIC COPILOT - A LOOK AT THE FUTURE OF COCKPIT AUTOMATION
TONY PALMIERI, STEVE DUNDORE, and R. A. MORRISON (Lockheed-California Co., Advanced Systems Div., Burbank) Lockheed Horizons (ISSN 0459-6773), Dec. 1986, p. 28-38.

The electronic copilot designated 'ECOP' will assist the pilot of such next-generation military aircraft as the Advanced Tactical Fighter (ATF) in the performance of control tasks through cockpit automation. The AI capabilities incorporated in the ECOP will encompass beyond-visual-range identification, combat situation assessment, sensor management, tactics, and mission planning. ECOP is conceived as a distributed network of cooperating electronic associates, each of which is a combination of expert systems programming and conventional algorithmic programming; ECOP will, moreover, be modular in the sense that the knowledge bases for each of the expert systems may be changed to accomodate different aircraft. A prototype of ECOP is being implemented in an ATF cockpit mock-up wich employs color graphic displays and speech synthesis/recognition. O.C.

A87-48061
COMBAT AIRCRAFT AVIONIC SYSTEMS - THE NEXT GENERATION
S. THOMPSON (British Aerospace, PLC, Military Aircraft Div., Preston, England) IN: Cost-effective avionic and weapon systems; Proceedings of the Spring Convention, London, England, May 14, 15, 1986 . London, Royal Aeronautical Society, 1987, p. 10.1-10.14.

Avionic system requirements for next-generation combat aircraft are discussed from the viewpoint of cost effectiveness. It is noted to be imperative that maintainability, reliability and testability criteria be clearly defined by purchaser and manufacturer, and that these criteria be adhered to by subsystem and auxiliary equipment suppliers. Attention is given to the description of an illustrative avionics system encompassing attack, electronic warfare, armaments-control, navigation, communications, display/control, recording, and utility interface subsystems, as well as to avionic system growth potential, mass reduction, and general cost aspects. O.C.

A87-48062
REAL COST SAVINGS THROUGH STANDARD INTERFACE HARDWARE
RICHARD A. DE VERTEUIL (GEC Avionics, Ltd., Rochester, England) IN: Cost-effective avionic and weapon systems; Proceedings of the Spring Convention, London, England, May 14, 15, 1986 . London, Royal Aeronautical Society, 1987, p. 11.1-11.9.

The adoption of comprehensive and detailed standards for high speed, multiplexed digital bus technology has resulted in dramatic weight and complexity reductions in aircraft wiring, and the establishment of data protocols has simplified the interfacing of user systems. Because component-level standards ensure similarity of performance, they allow multiple-manufacturer sourcing for the achievement of more competitive prices. At integrated-product level, the resulting interchangeability of equipment once more facilitates competitive practices among manufacturers and compatibility among different sources' spare parts, with attendant maintenance cost reductions. O.C.

A87-48278
HUD GUIDANCE IMPROVES LANDING PERFORMANCE
JOHN DESMOND Aerospace Engineering (ISSN 0736-2536), vol. 7, July 1987, p. 49-53.

If an inertial flight path is projected at infinity in the pilot's forward field-of-view by a HUD, the pilot is supplied with data on aircraft path relative to the ground. Attention is presently given to the results of a B 727 simulator study in which eight subject pilots flew difficult approaches with and without HUD flight information; the much better performance obtained with HUD prompted the development of a low visibility landing system encompassing a HUD and its guidance computer. This system, while independent of automatic landing, autothrottle, and flight director systems, still met FAA performance and safety requirements for fail-passive automatic landing systems. Touchdown dispersion and missed approach frequencies were shown to be reduced by the HUD system. O.C.

A87-48763
INTEGRATED AVIONICS SYSTEMS - WHERE ARE THEY HEADED
ROBERT E. FRIDAY (King Radio Corp., Olathe, KS) and M. ACE CARD (Allied-Signal, Inc., Bendix Avionics Div., Fort Lauderdale, FL) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 11 p. refs
(SAE PAPER 871-035)

Current trends leading to system integration within the general aviation fleet are examined, and some thoughts about the next generation of avionics are presented. Innovative features incorporated into the Beech Starship and the Gulfstream IV business jet are described, including display symbol generators built into each display unit, consolidated radio management unit, and remote-mounted card cage unit in the case of the Beech

Starship and cathode ray tube cockpit displays and a high-speed bidirectional data bus in the Gulfstream IV. The future trends examined include smart, general purpose flat panel displays, fly-by-wire, high-speed bidirectional data bus, voice control, and fault-tolerant data management computers. C.D.

A87-48764
HUMAN FACTORS ASSOCIATED WITH GLASS COCKPIT DESIGN
RANDLE JENNINGS (Honeywell, Inc., Minneapolis, MN) and LARRY HANNERT (Sperry Corp., Commercial Flight Systems Div., Phoenix, AZ) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 12 p.
(SAE PAPER 871-036)

The new symbology which is replacing some of the conventional displays currently found in the cockpit is described and its evolution is traced. Comparisons are made between early 5 x 6 EFIS (electronic flight instrument system) displays and the most recent 5 x 6 display formats. Next generation features include actual environment displays, three-dimensional displays, new guidance displays, advanced sensors and their improved presentation, and new display technology. K.K.

A87-48918#
FLIGHT TESTS CONFIRMING THE OPERABILITY OF NIGHT VISION DISPLAY COCKPITS FOR THE NEW HELICOPTERS
P. WOLFF and H. E. HAUCK (Dornier System GmbH, Friedrichshafen, West Germany) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 12 p.

Flight tests were performed to provide test data on new-generation helicopter cockpit avionics equipment. A UH-1D helicopter was equipped with a CRT display cockpit, a STANAG 3838 data (MIL 1553B) bus system, a FLIR sensor, and a Doppler navigation system. Nap-of-the-earth flights were performed over typical European terrain, day and night, throughout the year. A quantitive rating of display format acceptance was obtained. K.K.

A87-48921#
BEAM INDEX DISPLAY - THE ANSWER TO MODERN HELICOPTER COCKPIT DESIGN
R. FORSTMANN (AEG AG, Wedel, West Germany) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 12 p.

The advantages of beam index displays over current avionic displays are revealed. Particular attention is given to their superior performance under adverse environmental conditions. The beam index principle is discussed together with color generation, the deflection system, the video amplifier, and the focus. A comparison is made between shadow mask and beam index CRTs and it is noted that the most improved parameter for the beam index display is the brightness. K.K.

A87-48922#
EVALUATION OF A PILOT'S LINE-OF-SIGHT USING ULTRASONIC MEASUREMENTS
HERMANN CHRISTIANSEN (AEG-AG, Wedel, West Germany) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 12 p.

The task of evaluating a pilot's line-of-sight by determining the three angles of movement (azimuth, elevation, and roll) is described. A solution is described which is based on the measurement of the transmission time of ultrasonic signals between transmitters mounted on the cockpit structure and receivers on the pilot's helmet. A description is given of the complete system which includes a helmet-mounted display, a line-of-sight locator, and a three-axis controlled platform. Technical problems such as immunity from echoes and interference, immunity from cockpit noise, and air temperature and actual speed of sound are considered as well. K.K.

A87-48949#
H/W AND S/W REDUNDANCY TECHNIQUES FOR 90'S ROTORCRAFT COMPUTERS
A. DI GIOVANNI and P. GARRO (Selenia S.p.A., Pomezia, Italy) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 16 p. refs

The reliability of the hardware and software for fault tolerant computers, and the implementation of a highy reliable avionic computer based system are examined. Warm and hot stand-by solutions for implementing a fault tolerant system are described. In the warm solution, the master performs the application functions and updates the stand-by node; and in the hot stand-by solution, both the master and the stand-by node perform the application functions. The advantages of the hot stand-by solution compared to the warm solution are discussed. A finite state reliability model for the matched pair configuration is defined and presented. The error detection and switchover mechanism for an airborne computer are considered. Examples of systems implemented with these solutions are provided. I.F.

A87-49204
APPLICATION OF THE HYDRAULIC ANALOGY TO UNDERSTAND AN IN-FLIGHT TOTAL TEMPERATURE ANOMALY
DONALD J. JAMISON and D. KURT TIPPEY (McDonnell Aircraft Co., Saint Louis, MO) IN: Society of Flight Test Engineers, Annual Symposium, 17th, Washington, DC, Aug. 10-14, 1986, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1986, p. 3.4-1 to 3.4-5.

The original F-15 noseboom total temperature probe installation produced Mach number related anomalies in total temperature data. Testing with the noseboom angle of sideslip vane removed produced a marked improvement in total temperature data quality. This led to an investigation of the effects of the sideslip vane upon the total temperature probes. Water table testing showed that the total temperature irregularities were caused by shock waves from the sideslip vane being ingested by the total temperature probes. Based upon the results of the water table testing, the total temperature probes were moved further aft on the noseboom. The total temperature anomalies were thereby eliminated at Mach numbers less than 2.0 and greatly reduced at Mach numbers greater than 2.0. Author

A87-49205
FLIGHT TEST AND EVALUATION OF A PROTOTYPE AIRBORNE VIDEO AND PULSE CODE MODULATION MULTIPLEXING SYSTEM
GEORGE KAILIWAI and RICHARD MCQUILLAN (USAF, Edwards AFB, CA) IN: Society of Flight Test Engineers, Annual Symposium, 17th, Washington, DC, Aug. 10-14, 1986, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1986, p. 3.5-1 to 3.5-12.

This report presents the results of a limited evaluation of a prototype airborne video and PCM multiplexer. A video and PCM multiplexer is desirable because currently large and expensive tape recorders are installed on test aircraft to record PCM data, and a separate video home system (VHS) recorder is used to record video such as a radar presentation or a heads-up display. A PCM/video multiplexer combines the video and PCM data signals and sends the composite signal to a VHS recorder. This saves money, space, and weight; all of which are at a premium on a flight test program. The prototype airborne PCM/video multiplexer was installed in an RF-4C and flight tested throughout the aircraft's operational envelope to evaluate the multiplexer's airborne operation for future flight test programs. The prototype multiplexing system performed satisfactorily throughout the nineteen flight test sorties conducted at the Air Force Flight Test Center, Edwards AFB, CA, between April 5 and May 13, 1985. Author

A87-49207
TESTING AND DEVELOPMENT OF HOLOGRAPHIC HUD SYSTEMS
C. H. VALLANCE (GEC Avionics, Ltd., Rochester, England) IN: Society of Flight Test Engineers, Annual Symposium, 17th, Washington, DC, Aug. 10-14, 1986, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1986, p. 4.2-1 to 4.2-8.

Flight test of the F-16 LANTIRN HUD revealed characteristics specifically related to holographic HUDs. Of particular note was the overlapping of the binocular field of view, within which double vision can occur if parallax is not controlled. Results also indicate that the head motion box should be large because HUD performance is degraded outside its boundaries. Combiner photometric performance and physical configuration were examined; the flight test showed that a slight pink hue of the outside world caused by holographic combiners is acceptable, particularly in the LANTIRN configuration. The interaction between flight test and the development activity led to improvements which gave the F-16 LANTIRN HUD acceptable performance. B.J.

A87-49214
THE AV-8B FLIGHT TEST VIDEO SYSTEM
MICHAEL E. KRUPP (McDonnell Aircraft Co., Saint Louis, MO) IN: Society of Flight Test Engineers, Annual Symposium, 17th, Washington, DC, Aug. 10-14, 1986, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1986, p. 6.4-1 to 6.4-5.

The description and utilization of the flight test video system installed on the AV-8B Harrier II avionics and weapons systems test aircraft (Bu No. 161398) during the Full Scale Development (FSD) program is presented here. This video system consisting of a Heads Up Display (HUD) video camera and electronics unit, split screen unit, cockpit controls, video transmitter and a video tape recorder provided onboard video recording as well as transmitted video for ground station test monitoring. This system design improved the video recording reliability and telemetry ground station support. The real-time transmitted video proved to be a valuable test conduct aid to both the pilot and monitoring test team when interpreting an avionics or weapons systems display format. Author

A87-49640#
BUS SYSTEMS [BUSSYSTEME]
HEINZ HERMES (AEG, AG, Frankfurt am Main, West Germany) IN: International Helicopter Forum, 16th, Bueckeburg, West Germany, June 11, 12, 1986 and International Aerospace Exhibition, Hanover, West Germany, June 6-15, 1986, Reports . Bueckeburg, West Germany, Helicopter Center, 1986, 12 p. In German.

The optimization of the constantly increasing use of information processing in modern aircraft systems by the use of buses is discussed from the perspective of the German equipment industry. Military helicopter procurement projects are emphasized. The information processing demands of various sensors are listed, and architectures and standardized concepts designed to meet those demands are examined. C.D.

A87-50004#
TAILORING MIL-STD-461B FOR NAVAL AVIONICS APPLICATIONS
ROBERT G. SIEFKER (U.S. Navy, Naval Avionics Center, Indianapolis, IN) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 2, Aug. 1987, p. 13-18.

The tailored MIL-STD-461B specification has formed the basis for several EMI specifications for avionics systems including airborne communications, electronic warfare, and interior communications systems. This paper reports the product of the tailoring effort; i.e., a typical tailored EMI specification as used within the Naval Air Systems Command to procure carrier-based aircraft avionics is presented. The rationale for and the explanation of each modification are included along with an estimate of the electromagnetic environment found aboard U.S Navy aircraft carriers. B.J.

A87-50335#
AUTOMATED THERMAL AND RELIABILITY ANALYSIS OF AVIONICS DESIGNS
JOHN D. DIRE (General Dynamics Corp., San Diego, CA), DONALD E. FRANKS, and HOON S. CHOI (General Dynamics Corp., Fort Worth, TX) (AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology

A87-50419*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EVALUATION OF A TAKEOFF PERFORMANCE MONITORING SYSTEM
DAVID B. MIDDLETON (NASA, Langley Research Center, Hampton, VA) and RAGHAVACHARI SRIVATSAN (Kansas, University, Hampton, VA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 155-162. refs
(AIAA PAPER 87-2256)

A takeoff performance monitoring system (TOPMS) has been developed to provide the pilot with graphic/numeric information pertinent to his decision to continue or abort a takeoff. The TOPMS instrument display consists primarily of a runway graphic overlaid with symbolic status, predictive, and advisory information including: (1) current position and airspeed, (2) predicted locations for reaching decision speed and rotation speed, (3) groundroll limit for reaching the rotation speed, (4) predicted stop point for an aborted takeoff from current conditions, (5) engine-failure flags, and (6) an overall situation advisory flag which recommends continuation or rejection of the takeoff. In this study, over 30 experienced multiengine pilots evaluated the TOPMS display on the Langley B-737 real-time research simulator. The display was judged to be easy to monitor and comprehend. Author

N87-26907# Essex Corp., Warminster, Pa.
SYSTEMS TESTBED FOR AVIONIC RESEARCH (STAR) AUTOMATION CONCEPT DEVELOPMENT
PAUL G. STRINGER and DANIEL D. RILEY Apr. 1987 336 p
(Contract N62269-83-D-0115)
(AD-A180658; AVSCOM-TR-86-E-2) Avail: NTIS HC A15/MF A01 CSCL 01C

The primary purpose of the work performed under this contract has been to develop an automation and avionics integration design concept permitting single-pilot operations. Recommendations for that design concept are provided in this report. These recommendations were derived through analyses of the U.S. Army Scout and Utility mission concepts, identification of suitable automation-candidate functions for the performance of those missions, assessment of automation technologies available, and, finally, the establishment of system design option preferences. Ultimately, these recommendations will impact the definition of design specification requirements for the NUH-60 Systems Testbed for Avionics Research (STAR) aircraft. GRA

N87-27664# European Space Agency, Paris (France).
INVESTIGATION OF MAGNETOMETER ERRORS AND THEIR COMPENSATION IN THE BO-105 HELICOPTER
HANS-JUERGEN HOTOP and NORBERT NAWA Jan. 1987 63 p Transl. into ENGLISH of "Untersuchung des Fehlerverhaltens und der Kompensation eines Magnetometers im Hubschrauber BO-105, Brunswick, West Germany Original language document was announced as N87-11784
(ESA-TT-1015; DFVLR-FB-86-21; ETN-87-90013) Avail: NTIS HC A04/MF A01; original German version available from DFVLR, Cologne, West Germany DM 23.50

The errors of a magnetometer as a function of helicopter pitch and roll angles were investigated using flight test data. An error model for compensation is presented. The magnetometer was tested in different locations in the helicopter. Two possibilities of magnetometer error compensation are explained together with their accuracy as a mangetic sensor in an attitude and heading reference system. The use of an on-line algorithm allows compensation during

the flight, and leads to an improvement of the magnetic attitude information with increasing flight time. ESA

N87-27665*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INTEGRATION OF ALTITUDE AND AIRSPEED INFORMATION INTO A PRIMARY FLIGHT DISPLAY VIA MOVING-TAPE FORMATS: EVALUATION DURING RANDOM TRACKING TASK
TERENCE S. ABBOTT, MARK NATAUPSKY, and GEORGE G. STEINMETZ Sep. 1987 19 p
(NASA-TM-4010; L-16309; NAS 1.15:4010) Avail: NTIS HC A02/MF A01 CSCL 01D

A ground-based aircraft simulation study was conducted to determine the effects on pilot preference and performance of integrating airspeed and altitude information into an advanced electronic primary flight display via moving-tape (linear moving scale) formats. Several key issues relating to the implementation of moving-tape formats were examined in this study: tape centering, tape orientation, and trend information. The factor of centering refers to whether the tape was centered about the actual airspeed or altitude or about some other defined reference value. Tape orientation refers to whether the represented values are arranged in descending or ascending order. Two pilots participated in this study, with each performing 32 runs along seemingly random, previously unknown flight profiles. The data taken, analyzed, and presented consisted of path performance parameters, pilot-control inputs, and electrical brain response measurements. Author

07

AIRCRAFT PROPULSION AND POWER

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

A87-47081*# Garrett Turbine Engine Co., Phoenix, Ariz.
ADVANCED TECHNOLOGY PAYOFFS FOR FUTURE SMALL PROPULSION SYSTEMS
M. A. TURK and P. K. ZEINER (Garrett Turbine Engine Co., Phoenix, AZ) Journal of Propulsion and Power (ISSN 0748-4658), vol. 3, July-Aug. 1987, p. 313-319. Army-supported research. Previously cited in issue 20, p. 2918, Accession no. A86-42704.
(Contract NAS3-24544)

A87-47084#
A NAVIER-STOKES NOZZLE ANALYSIS TECHNIQUE
JEFFREY J. BROWN (Boeing Commercial Airplane Co., Seattle, WA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 3, July-Aug. 1987, p. 334-341. Previously cited in issue 20, p. 2921, Accession no. A86-42751. refs

A87-47090#
CHARACTERISTIC TIMES FOR LEAN BLOWOFF IN TURBINE COMBUSTORS
A. M. MELLOR (Drexel University, Philadelphia, PA) and W. S. DERR Journal of Propulsion and Power (ISSN 0748-4658), vol. 3, July-Aug. 1987 , p. 377-380. refs
(Contract N00140-84-D-3704)

A high correlation coefficient has been obtained for Naval Air Propulsion Center Hot Gas Facility data, confirming the applicability of the Plee and Mellor (1979) lean blowoff model to a J85 gas turbine engine combustor. These data are also well correlated with AGT-1500 and T63 rig data, demonstrating the model's ability to characterize lean blowoff limits independently of combustor type. O.C.

A87-47119#
DEVELOPMENT OF A NEW TECHNOLOGY SMALL FAN ENGINE
D. I. BOYD (Pratt and Whitney Canada, Longueil) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 33, June 1987, p. 84-90.

The small turbofan engine designated JT15D is a low specific fuel consumption powerplant for high speed, low noise executive aircraft; attention is presently given to the JT15D-5 variant of this turbofan, which incorporates electronic fuel control systems and a general enhancement of thrust to 3200 lb, from an original 2500 lb. The development history account presented highlights turbofan resonance-induced vibratory stress-reduction and foreign object ingestion damage-minimization efforts, which encompassed 4-lb bird ingestion tests, and the results of both rig and certification tests. O.C.

A87-47307
COUNTDOWN TO THE PROPFAN. II
KEN FULTON Air International (ISSN 0306-5634), vol. 33, July 1987, p. 16-21.

An account is given of the design features, projected performance capabilities, and economic feasibility of several next-generation, very high bypass turbofan and propfan engines for use by large airliners. In the case of propfan powerplants, the development of advanced single rotation and contrarotating gearboxes of 15,000 shp capacity becomes a major factor in overall energy efficiency and life cycle cost considerations. Attention is given to the details of the various engines' turbomechanical configurations, the bypass ratios achieved, and the advantages and problems that a given configuration may be anticipated to pose in various possible airliner airframe installations. Specific fuel consumption improvements over state-of-the-art high bypass turbofans of the order of 20-30 percent are sought. O.C.

A87-47837
HARRIER II - DIGITAL ENGINE CONTROL FLIGHT TESTS
LAURENCE A. WALKER (McDonnell Aircraft Co., Saint Louis, MO) IN: 1986 report to the aerospace profession; Proceedings of the Thirtieth Symposium, Beverly Hills, CA, Sept. 24-27, 1986 . Lancaster, CA, Society of Experimental Test Pilots, 1986, p. 49-70.

A novel digital engine control system for the AV-8B Harrier II's Pegasus engine has undergone 21 months of flight testing encompassing hovers, VTOLs, dynamic engine response and controllability tests, and formation flying, as well as surge boundary and inlet compatibility tests up to the maneuvering limits of the aircraft. Attention is given to such problems as vertical landing bounces and poor dynamic response. The production digital engine control system based on the solutions devised for problems encountered during the flight test program achieves a significant reduction in pilot workload. O.C.

A87-47867
PTA - RESEARCH AT FULL SCALE
DYCKMAN T. POLAND (Lockheed-Georgia Co., Marietta) Lockheed Horizons (ISSN 0459-6773), Dec. 1986, p. 2-11.

A status report is presented for the NASA-Lewis Propfan Test Assessment (PTA) program, which has undertaken the ground and flight testing of a full-scale propfan in order to validate the structural integrity of the propfan blades while investigating near- and far-field noise and evaluating associated cabin noise and vibration. A Gulfstream II aircraft is used as the PTA testbed. The predicted high level of cabin noise appears at this point to be the greatest obstacle to the successful application of propfan technology; the data presently obtained are thus essential for future development of cabin noise-attenuating technologies. O.C.

A87-48571*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUPERSONIC THROUGH-FLOW FAN DESIGN
JAMES F. SCHMIDT, ROYCE D. MOORE, JERRY R. WOOD, and RONALD J. STEINKE (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 20-July 2, 1987. 21 p. Previously announced in STAR as N87-22681. refs
(AIAA PAPER 87-1746)

The NASA Lewis Research Center has embarked on a program to experimentally prove the concept of a supersonic through-flow fan which is to maintain supersonic velocities throughout the compression system with only weak shock-wave flow losses. The detailed design of a supersonic through-flow fan and estimated off-design performance with the use of advanced computational codes are described. A multistage compressor facility is being modified for the newly designed supersonic through-flow fan and the major aspects of this modification are briefly described. Author

A87-48574#
DEVELOPMENT AND FLIGHT TEST OF THE F110-GE-400 FOR THE F-14D AIRCRAFT
H. MACLIN, J. EISWERTH (General Electric Co., Cincinnati, OH), J. ROCKENSIES, and K. YUNGER (Grumman Corp., Bethpage, NY) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 8 p.
(AIAA P:APER 87-1849)

The F110-GE-400 for the F14 Super Tomcat fighter is a derivative of the Air Force's F110/F101 engine. The engine was extensively modified to meet the aircraft installation requirements. This included adding 50 inches to the augmentor to maintain the aircraft/engine center-of-gravity relationship and moving the engine mounts from the frames to the outer casings to maintain the current aircraft/engine interface. The development of F110-GE-400 was initiated after the 'Great Engine War: decision in 1984. The engine initiated development testing in November, 1984, qualification testing in January 1986 and flight testing in September 1986. The aircraft system development of the Super Tomcat F14 with the F110-GE-400 has been on-going with relatively few problems. The excellent performance of this fighter system will assure that the F14 will remain the primary fleet defense aircraft well into the 21st century. Author

A87-48707#
PERFORMANCE DETERIORATION OF A TURBOFAN AND A TURBOJET ENGINE UPON EXPOSURE TO A DUST ENVIRONMENT
M. G. DUNN, C. PADOVA, J. E. MOLLER (Calspan Corp., Buffalo, NY), and R. M. ADAMS (DNA, Alexandria, VA) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 109, July 1987, p. 336-343. refs
(Contract DNA001-83-C-182)
(ASME PAPER 87-GT-111)

Results are reported for a measurement program designed to investigate the performance deterioration of a TF33 turbofan and a J57 turbojet engine upon exposure to a dust-laden environment. Engine parameters were measured in order to facilitate the recognition of incipient engine difficulties. In addition, a successful effort was made to operate the engines satisfactorily when they were severely damaged. Two TF33 engines have been operated in the same dust mixture but under different operating conditions and a J57 engine was operated at the same conditions as one of the TF33 engines. The J57 is the core engine of the TF33 with some differences that will be described in the paper. A description of the experimental technique, the operating experiences, photographs of the components taken from the J57 engine in a posttest teardown, and a discussion of the results are presented. Author

A87-48708#
INTERPRETATION OF GAS TURBINE RESPONSE DUE TO DUST INGESTION
P. F. BATCHO, J. C. MOLLER, C. PADOVA, and M. G. DUNN (Calspan Corp., Buffalo, NY) ASME, Transactions, Journal of Engineering for Gas Turbines and Power (ISSN 0022-0825), vol. 109, July 1987, p. 344-352. refs
(Contract DNA001-83-C-0182)
(ASME PAPER 87-GT-112)

A TF33 turbofan and a J57 turbojet were subjected to observations during dust ingestion in order to measure engine behavior. Solid particle ingestion is found to erode compressor blades and lead to significant performance deterioration, in the form of susceptibility to surge at low power settings. Antiice and intercompressor bleed air use for surge avoidance is discussed, together with the effect of a deteriorated engine's fuel controller behavior during steady state engine operation. Experiment results are compared with predictions predicated on the effects of tip clearance, blade profile, and secondary flows. O.C.

A87-48717#
UNDUCTED FAN AERODYNAMIC DESIGN
L. H. SMITH, JR. (General Electric Co., Aircraft Engine Business Group, Cincinnati, OH) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 109, July 1987, p. 313-324. refs
(ASME PAPER 87-GT-233)

A method being used to design unducted fans, which are counterrotating propellers with unusually high disk loadings, is described. The quasi-three-dimensional approach employed is similar to that used for ducted fan designs; it consists of a circumferential-average flowfield analysis followed by cascade designs that include secondary flow and sweep effects. The open-tip condition enters as a significant secondary flow contribution. Blade shapes defined by this process are analyzed by a three-dimensional Euler solver and final adjustments are made as necessary. Examples of application of the method are presented to elucidate the magnitudes of the phenomena involved. Author

A87-48720#
THE DESIGN OF AN ADVANCED CIVIL FAN ROTOR
R. B. GINDER and W. J. CALVERT (Royal Aircraft Establishment, Farnborough, England) ASME Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 109, July 1987, p. 340-345. refs
(ASME PAPER 87-GT-218)

The quasi-three-dimensional calculation system originally developed by Calvert and Ginder (1985) for the prediction of transonic compressor blade rows' internal flow field and overall performance is presently applied to the definition of design point efficiency for a high-efficiency transonic fan rotor of the kind employed in civil aviation turbofans. The predicted blade-to-blade aerodynamics for three blade profiles taken at different heights from such a rotor are used to illustrate the method; predicted performance levels are compared with those of conventional profiles, and significant loss reductions are predicted. O.C.

A87-48766* John Deere Technologies International, Inc., Wood-Ridge, N.J.
ADVANCED LIQUID-COOLED, TURBOCHARGED AND INTERCOOLED STRATIFIED CHARGE ROTARY ENGINES FOR AIRCRAFT
ROBERT E. MOUNT, JOHN BARTEL (John Deere Technologies International, Inc., Wood Ridge, NJ), and WILLIAM F. HADY (NASA, Lewis Research Center, Cleveland, OH) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 16 p. refs
(SAE PAPER 871039)

Developments concerning stratified-charge rotary (SCR) engines over the past 10 years are reviewed. Aircraft engines being developed using SCR technology are shown and described, and the ability of such technology to meet general aviation engine needs is considered. Production timing and availability of SCR

technology for the development of aviation rotary engines are discussed, and continuing efforts toward improving this technology, including NASA efforts, are described. C.D.

A87-48767
THE MERLYN DIESEL CONCEPT FOR PROPULSION
HUGH G. EVANS (In-Tech International, Inc., Spokane, WA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 11 p.
(SAE PAPER 871-040)

The concepts and state of development of the Merlyn engine are described. The background to the engine's development is reviewed, and the equations of its theoretical cycle are given and discussed. The overall specifications for a new generation aircraft power plant with performance advantages that cannot be met by existing air-cooled reciprocating or turboprop power plants are listed and discussed, and data on current production general aviation power plants, World War II major aircraft engines, and Merlyn aircraft engines are presented. C.D.

A87-48768
DESIGN AND DEVELOPMENT OF A LIGHT WEIGHT, HIGH PRESSURE RATIO AIRCRAFT TURBOCHARGER
RALPH BENWAY (Teledyne, Inc., Aircraft Products Div., Mobile, AL) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 12 p. refs
(SAE PAPER 871-041)

With the objective of developing technology capable of meeting the challenge of future aviation requirements, an advanced concept aircraft quality turbocharger has been designed and developed. This paper presents the detail design and development of a prototype model which incorporates improved component efficiencies, a high pressure ratio compressor stage, and lightweight design techniques. Details of the aerodynamic and mechanical design, with a review of development test results to date, are given. State-of-the-art aerospace technology is integrated into an on-purpose turbocharger design, yet with low technical risk. The result is a highly efficient turbocharger capable of providing a compressor pressure ratio in excess of 6:1 with a total weight less than 30 pounds. Author

A87-48769
DESIGN AND DEVELOPMENT OF THE VOYAGER 200/300 LIQUID COOLED AIRCRAFT ENGINE
R. E. WILKINSON (Teledyne, Inc., Aircraft Products Div., Mobile, AL) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28, 29, 1987. 23 p. refs
(SAE PAPER 871-042)

The Voyager 200 is a four-cylinder, liquid-cooled, 200 cubic inch engine with a 4.06 inch bore capable of producing 110 BHP at 2750 rpm with a high-turbulence HTCC combustion chamber at 11:4:1 CR for minimum fuel consumption. A six-cylinder, 300 cubic inch version utilizes the same cylinder assembly and can be rated at 170-190 BHP at 2700-3000 rpm. The background to the development of this engine is reviewed, and the engine is shown and described. The cooling system, coolant flow-rate and temperature, cylinder head thermal loading, piston/barrel cooling, thermal mapping, HTCC combustion chamber, cylinder firing pressure, heat rejection, breathing, inlet port flow bench tests, performance, fuel and oil consumption, and engine weight are discussed in detail. C.D.

A87-48776
EVOLUTION OF LIGHT GAS TURBINE ENGINE DURING THE LAST 30 YEARS
M. FAURY and J. P. MAZOYER (Turbomeca, Bizanos, France) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 10 p.
(SAE PAPER 871-053)

The development of the piston engine and the turboshaft engine is reviewed, comparing the merits of the two types of engine. The modern turboprop TP 319 is shown and described. The piston engine and turboprop characteristics are compared with regard to weight and size, ground and flight power, fuel economy, types of fuel utilized, installation, engine operation, life span, price, and improvements in specifications. C.D.

A87-48777
OPTIMIZED TURBOPROP PROPULSION SYSTEM THRUST AND FUEL BURN BY INTEGRATED DESIGN
J. L. OVERFIELD (Garrett Turbine Engine Co., Phoenix, AZ) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 8 p.
(SAE PAPER 871-054)

The benefits of integrating the propulsion system design to take advantage of the flow field shed by one aircraft component on another was demonstrated during the recent development of two Garrett-powered high-performance turboprop aircraft. Examination of the components' flow field shedding air to the engine indicated that engine and aircraft performance could be enhanced by integrating the spinner, propeller, inlet, and engine design. Subsequent development and flight tests demonstrated a significant improvement in engine and aircraft performance. This was due to the increased performance of the propeller and engine when standard components were replaced with components designed to improve the flow field to the engine. C.D.

A87-48778
ADVANCED ALLISON SMALL TURBOPROP ENGINES
DOUGLAS E. PEGORS (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 8 p.
(SAE PAPER 871-055)

To offer turboprop engines in power classes that support a variety of aircraft applications, Allison is developing two new turboprop engines in the Model 250 series engine line. The Model 250-B17C/D engines, rated at 420 shaft horsepower (shp), have formed the base for small Allison turboprop engines. The new engines under development incorporate features of advanced shaft engines and make the additional power available to the turboprop user for improved hot day, high altitude performance. Author

A87-48914#
PERFORMANCE AND NOISE ANALYSES OF ADVANCED TURBO-PROP
AKIRA AZUMA, KEIJI KAWACHAI, TADAAKI WATANABE (Tokyo, University, Japan), and YOSHIYA NAKAMURA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 15 p. refs

The local circulation method is used to analyze the performance and noise of an advanced turbo-prop operating under normal flight conditions. Good agreement is found between the present results and wind-tunnel data obtained at NASA Lewis. The analysis was extended to determine the variation of the airloading and sound pressure under yawed flight conditions. As the sideslip angle increases, the time-wise variations of the aerodynamic bending moment acting on the blade and of the sound pressure near the propeller disk significantly increase. K.K.

A87-48962#
T700/CT7 GROWTH ENGINE FOR EUROPEAN HELICOPTERS
H. G. DONOHIE (General Electric Co., Aircraft Engine Business Group, Lynn, MA) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 20 p.

The paper describes the design, development, and certification of the CT7-6, a 2000-hp growth turboshaft version of the T700/CT7 engine family. The engine is planned for the civil EH101 and NH-90 helicopters, and has potential for a possible single-engine version of the A129. The engine represents a 27 percent growth step compared with the initial T700-Ge-700 powering the Black Hawk; growth is accomplished by a 12 percent increase in airflow, technology infusions which provide improvements in the efficiency of the compressors and both turbines, and an increase in turbine temperature to the 1370 C class. B.J.

A87-48965#
A FULL AUTHORITY DIGITAL ELECTRONIC CONTROL SYSTEM FOR MULTI-ENGINE ROTORCRAFT
DAVID PETRO (Textron, Inc., Avco Lycoming Textron Div., Stratford, CT), ANTHONY J. GENTILE (Chandler Evans, Inc., West Hartford, CT), and ALEX B. FOULDS (Hawker Siddeley Dynamics Engineering, Ltd., Welwyn Garden City, England) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 18 p.

The basic requirements and need for the incorporation of a full-authority digital electronic control system (DECS) on an existing twin-engine military helicopter are reviewed using the RAF HC Mk1/T55-L-712E application as an example. Attention is given to the unique selection process and component configuration, involving internal collaboration among several organizations using the latest concepts in electronic technology. The technical details and functional performance of the DECS are described with reference to the fulfillment of the particular requirements of a tandem rotor helicopter. The operational and installation features of the engine control system, including reliability, maintainability, diagnostics, history recording, health monitoring, aircraft incorporation, and cost-of-ownership are reviewed. B.J.

A87-49210
EFFECTS OF INLET TEMPERATURE AND PRESSURE UPON THE GENERALIZED PERFORMANCE PARAMETERS OF THE T56 ENGINE
KEN HUBLEY (U.S. Navy, Naval Air Test Center, Patuxent River, MD) and ERIC LISTER (Veda, Inc., Arlington, VA) IN: Society of Flight Test Engineers, Annual Symposium, 17th, Washington, DC, Aug. 10-14, 1986, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1986, p. 5.2-1 to 5.2-9.

The paper presents steady state flight test data and subsequent analysis developed by the NATC from the T56 turboprop engine in a C-2A aircraft. Specifically, the investigation deals with the effects of nonstandard freestream total temperature (Theta) and pressure (delta) on the correlations of generalized engine fuel flow, turbine inlet temperature, and shaft horsepower. Using linear regression analysis, exponents on delta and Theta were derived experimentally that did not successfully correlate these data over a broad range of in-flight conditions. An analysis was carried out in an effort to understand this phenomenon, and it is suggested that delta, Theta, and the square root of Theta are sufficient to generalize T56 data as long as component performance does not shift with operating condition. The general conclusion is that the T56 performance data should be affected by system inlet conditions in a manner different from that which convention would suggest. B.J.

A87-49241#
EFFECTS OF TEMPERATURE TRANSIENTS ON THE STABILITY OF A TURBOJET ENGINE
YUANHU CAI, DIYI TANG, and HONGJI WANG Northwestern Polytechnical University, Journal (ISSN 1000-2758), vol. 5, July 1987, p. 309-316. In Chinese, with abstract in English. refs

This paper presents the authors' research on the unsteady response of an aircraft axial flow compressor to temperature transients and the effect of fuel flow reduction on engine stability when there is a sudden increase of engine inlet temperature. The unsteady response was simulated using a second-order delay model combined with the 'actuator-volume' model. The response to inlet temperature was calculated using numerical integration, and the results agree well with test data and other calculative results. It is also proposed here that the main reason for compressor surge is that the turbine nozzle row may be choked seriously during transient temperature rise at the engine inlet. Fuel flow reduction can reduce or eliminate the choke, and so can play a role in preventing compressor surge. C.D.

A87-49497
MODERN TURBOPROP ENGINES
H. I. H. SARAVANAMUTTOO (Carleton University; Gas TOPS, Ltd., Ottawa, Canada) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 24, no. 3, 1987, p. 225-248. NSERC-supported research. refs

A development history and current status evaluation is presented for turboprop engines, together with a projection of development trends characterizable as 'propfans' and their prospective performance gains. There is noted to have been very little recent development of high-power units, by comparison with turbofan engines. Attention is given to such milestone powerplants as the T56, PT6, PW100, and CT7, noting their configurational details and the solutions given to the critical problem of speed reduction power train design. Current trends appear to tend in the direction of a novel paradigm for engines in this category; these 'ultrahigh-bypass' systems encompass both geared-and-ducted propfans and unducted fans operating with direct, contrarotating turbine drives which obviate gearboxes. O.C.

A87-49530
STRUCTURAL DAMAGE AND REJUVENATION OF USED TURBINE BLADES
M. LAMBERIGTS, CH. LECOMTE-MERTENS (Centre de Recherches Metallurgiques, Liege, Belgium), and P. VIERSET (Fabrique Nationale, Herstal, Belgium) IN: High temperature alloys for gas turbines and other applications 1986; Proceedings of the Conference, Liege, Belgium, Oct. 6-9, 1986. Part 1 . Dordrecht, Netherlands, D. Reidel Publishing Co., 1986, p. 821-830. Research supported by the Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture. refs

The microstructural damage of turbine blades of directionally solidified Mar-M-200 + Hf from a used aircraft engine is examined by scanning electron microscopy, differential thermal analysis, and metallographic techniques. A method for simulating such damage in the laboratory is proposed. A blade rejuvenation procedure involving hot isostatic pressing, solutioning, and aging is then described and evaluated in terms of the remaining stress-rupture life. It is shown that the procedure proposed here makes it possible to restore the full strength of the blades and even exceed it. V.L.

A87-49633
USE OF COMPOSITES IN PROPULSION SYSTEMS
A. G. KITCHING (Rolls-Royce, PLC, London, England) and J. MARSHALL (Short Brothers, PLC, Belfast, Northern Ireland) IN: Designing for low cost fabrication; Proceedings of the Workshop, Loughborough, England, Apr. 16, 17, 1986 . London, Royal Aeronautical Society, 1987, p. 115-154.

A development history is presented for a major engine manufacturer's application of various polymer-matrix composites in aircraft powerplant components, where permitted by such considerations as operating temperatures, gas loads, inertia and mechanical loads, fire hazards, erosion, and foreign object impact. Epoxies are able to withstand up to 150 C, while polyimides reach up to nearly 300 C. Where substituted for aluminum, titanium, and steel, component weight savings of up to 25 percent are achievable with these composites. Typical applications are in nose cones, nacelle surfaces, thrust reverser doors, cowl doors, and various fairings. O.C.

A87-49644#
NEW ENGINE DEVELOPMENTS FOR HELICOPTERS IN WESTERN EUROPE AND THE U.S.A.
F. LEGRAND (Turbomeca, S.A., Bordes, France) IN: International Helicopter Forum, 16th, Bueckeburg, West Germany, June 11, 12, 1986 and International Aerospace Exhibition, Hanover, West Germany, June 6-15, 1986, Reports . Bueckeburg, West Germany, Helicopter Center, 1986, 17 p.

The improvements that the new generation of helicopter engines will provide over older engines are described. Improvements in the pressure ratio which can be achieved with good efficiency and in the maximum temperature which can be accepted at turbine

level are addressed, and the resulting simplifications in engine architecture are considered. The significance of electronic fuel control is discussed, and the price increases that may result from these improvements are indicated. The general lines of future advances are briefly considered. C.D.

A87-49976#
EXPERIMENTAL RESULTS OF AEROELASTIC INSTABILITY OF AN AXIAL COMPRESSOR
YUCHENG FENG, ZONGAN HU, XIUHUA ZHAO, and YUWEI WANG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power, vol. 2, April 1987, p. 97-100, 183. In Chinese, with abstract in English. refs

This paper describes the initial experimental results of aeroelastic instability tests of BF-1 rotors on a transonic axial compressor facility at BIAA. Designing of BF-1 rotors depends upon the principle that the total damping is equal to zero at the point near the stall flutter boundary. The experimental results show that the design principle of BF-1 rotors is correct. Two rotors, BF-1-1 and BF-1-2, have been run from 8000 to 16,500 rpm. Several flow-induced vibration phenomena such as stalling flutter, wake-induced vibration, and stall vibration of the blades, have been observed in experiments. In addition, a loud monotonous noise has been heard during the stalling flutter onset. A primary theoretical analysis of this sound is discussed. This paper also presents the experimental results of effects of the blade tip clearance and the airfoil shape on the stall flutter boundary. By comparison of empirical methods used to predict the stall flutter onset with the experimental results, it is believed that these prediction methods are acceptable. Author

A87-49979#
EXPERIMENTAL INVESTIGATION OF A DOUBLE CIRCULAR ARC CASCADE WITH 73 DEG CAMBER
GANG CHENG (Shenyang Aeroengine Research Institute, People's Republic of China) Journal of Aerospace Power, vol. 2, April 1987, p. 109-112, 184. In Chinese, with abstract in English.

A double circular arc (DCA) cascade with 73 deg camber has been tested, and according to the test results, its critical Mach number, optimum incidence, deviation angle, pressure distributions on airfoil surfaces, pressure losses, and incidence angle range, are analyzed. This cascade is also compared with a supercritical airfoil cascade. The results indicate that the DCA cascades with such large camber still can achieve good aerodynamic performances (large turning, high velocity, low loss and wide incidence angle range) and coincide well with the general principles of DCA cascades, provided that the cascade parameters are chosen correctly and distribution of passage area is reasonable. Author

A87-49985#
TRANSONIC VIBRATION INDUCED BY MISMATCHING BETWEEN ENGINE AND THRUST NOZZLE
YJYUN LUN (Shenyang Aeroengine Research Institute, People's Republic of China) Journal of Aerospace Power, vol. 2, April 1987, p. 137-140, 187, 188. In Chinese, with abstract in English. refs

The transonic vibration which occurred in flight tests of some combat aircraft at 3000-4000 m altitudes and Mach = 0.82-0.96 is analyzed in this paper. For nozzle pressure ratio of about 22.9-4.6, the vibration frequency ranged from 8 to 12 Hz. Some measures were taken to discover the vibration source, such as eliminating the clearance of the aircraft structure, blocking air inlet apertures in the tail section of the aircraft, streamline tracing with power and strapping, and model testing in wind tunnel, but all of them failed. On the basis of extensive investigations and calculations, it was decided to make a simulation test of the ejector nozzles with increased secondary flow rate or with the nozzle shroud apertured for a third flow. Finally, it was found out that the transonic vibration was induced by mismatching of engine with thrust nozzle. Author

A87-49993#
AN EXPERIMENTAL INVESTIGATION OF FORCED SURGE BY WATER INJECTION IN A TWIN-SPOOL TURBOJET ENGINE
JU ZHANG, YUEGENG WU, and QISHENG YUN (Li Yang Machinery Co., People's Republic of China) Journal of Aerospace Power, vol. 2, April 1987, p. 170-172, 191. In Chinese, with abstract in English.

An experimental investigation of forced surge by water injection in a twin-spool turbojet engine has been performed on a ground thrust bed. It is demonstrated that water injection into the main combustion chamber, coupled with the flow area scale-down of both turbine nozzle and jet nozzle, is satisfactory for the test. An optimum scale-down percentage of both areas was found from a large number of tests. During such a combined forced-surge process, the engine operating condition can approach the surging boundary accurately along the line of the corrected constant rotation speed. Hence, the exact stable operating margin as well as stable operating boundary for the compressor can be obtained. Author

A87-50188*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE OF TWO 10-LB/SEC CENTRIFUGAL COMPRESSORS WITH DIFFERENT BLADE AND SHROUD THICKNESSES OPERATING OVER A RANGE OF REYNOLDS NUMBERS
GARY J. SKOCH (NASA, Lewis Research Center; U.S. Army Propulsion Directorate, Cleveland, OH) and ROYCE D. MOORE (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 25 p. Previously announced in STAR as N87-23623. refs
(AIAA PAPER 87-1745)

Centrifugal compressors often cannot be directly scaled to very small flow sizes because of structural and manufacturing limitations. The inability to directly scale all design parameters leads to a performance loss other than that which can be associated with the lower Reynolds number. A 10-lb/sec centrifugal compressor was scaled down to 2-lb/sec where adjustments to blade and shroud thickness and fillet radii were required. The modified 2-lb/sec compressor was then directly scaled back up to 10 lb/sec so that the effect of the modifications could be determined. The performance of the two 10-lb/sec compressors is compared over a range of speed and mass flow. The effect of variations in Reynolds number, impeller tip clearance, and shroud thickness on compressor performance is also presented. Author

A87-50189*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LINER COOLING RESEARCH AT NASA LEWIS RESEARCH CENTER
WALDO A. ACOSTA (NASA, Lewis Research Center; U.S. Army, Propulsion Directorate, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 18 p. Previously announced in STAR as N87-23624. refs
(AIAA PAPER 87-1828)

Described are recently completed and current advanced liner research applicable to advanced small gas turbine engines. Research relating to the evolution of fuel efficient small gas turbine engines capable of meeting future commercial and military aviation needs is currently under way at NASA Lewis Research Center. As part of this research, a reverse-flow combustor geometry was maintained while different advanced liner wall cooling techniques were investigated and compared to a baseline combustor. The performance of the combustors featuring counterflow film-cooled (CFFC) panels, transpiration cooled liner walls (TRANS), and compliant metal/ceramic (CMC) walls was obtained over a range of simulated flight conditions of a 16:1 pressure ratio gas turbine engine and fuel/air ratios up to 0.034. All the combustors featured an identical fuel injection system, identical geometric configuration outline, and similar designed internal aerothermodynamics. Author

A87-50196*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE SUPERSONIC THROUGH-FLOW TURBOFAN FOR HIGH MACH PROPULSION
LEO C. FRANCISCUS (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 14 p. Previously announced in STAR as N87-23626. refs
(AIAA PAPER 87-2050)

A study was done to evaluate the potential improvements in aircraft turbine engine performance by incorporating unique supersonic through-flow fans. Engine performance, weight, and mission studies were carried out for conventional turbofan engines using supersonic through-flow fans. A Mach 3 commercial transport mission was considered. The advantages of the supersonic fan engines were evaluated in terms of mission range comparisons between the supersonic fan engines and conventional engines. The installed specific fuel consumption of the supersonic fan engines was 12 percent better than the conventional engines and the installed weight was projected to be 25 percent lighter. For a takeoff gross weight of 550,000 lbs, the aircraft powered by supersonic fan engines had a range capability of 6600 nm compared to 5300 nm (a 25 percent improvement) for conventional engines. Author

A87-50422*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FULL-SCALE ENGINE DEMONSTRATION OF AN ADVANCED SENSOR FAILURE DETECTION ISOLATION, AND ACCOMMODATION ALGORITHM - PRELIMINARY RESULTS
WALTER C. MERRILL, JOHN C. DELAAT, STEVEN M. KROSZKEWICZ, and MAHMOOD ABDELWAHAB (NASA, Lewis Research Center, Cleveland, OH) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 183-191. Previously announced in STAR as N87-22097. refs
(AIAA PAPER 87-2259)

The objective of the advanced detection, isolation, and accommodation (ADIA) program is to improve the overall demonstrated reliability of digital electronic control systems for turbine engines. For this purpose, algorithms were developed which detect, isolate, and accommodate sensor failures using analytical redundancy. Preliminary results of a full scale engine demonstration of the ADIA algorithm are presented. Minimum detectable levels of sensor failures for an F100 turbofan engine control system are determined and compared to those obtained during a previous evaluation of this algorithm using a real-time hybrid computer simulation of the engine. Author

A87-50588
INVESTIGATIONS OF THE AERODYNAMIC PERFORMANCE AND NOISE CHARACTERISTICS OF A DOWTY ROTOL R212 PROPELLER AT FULL-SCALE IN THE 24 FT WIND TUNNEL
W. J. G. TREBBLE (Royal Aircraft Establishment, Aerodynamics Dept., Farnborough, England) Aeronautical Journal (ISSN 0001-9240), vol. 91, June-July 1987, p. 275-284. refs

Propeller power absorption and thrust have been measured over a range of rotational speeds up to 1400 rev/min at mainstream airspeeds up to 48 m/s for a wide range of blade setting. In addition, cruise conditions have been simulated by maintaining the appropriate ratio of propeller tip speed to the airspeed. Generally good agreement is shown between these full scale experiments with results obtained at 1/5 scale though the effect of Mach number is observable when the propeller is highly loaded. Noise analysis demonstrates the predominance of multiple tones whose number and intensity increase with helical-tip Mach number. An empirical formula shows that the fundamental tone varies with tip speed and power loading in a similar manner to that observed on a 1/5 scale model. Author

N87-26909# Dayton Univ., Ohio. Research Inst.
RESEARCH ON MECHANICAL PROPERTIES FOR ENGINE LIFE PREDICTION Annual Report no. 2, Aug. 1985 - 31 Jul. 1986
NOEL E. ASHBAUGH, M. KHOBAIB, TUSIT WEERASOORIYA, GEORGE A. HARTMAN, III, and DAVID C. MAXWELL May 1987 70 p
(Contract F33615-84-C-5051)
(AD-A181243; UDR-TR-86-141; AFWAL-TR-87-4011) Avail: NTIS HC A04/MF A01 CSCL 11F

Analytical and experimental investigations have been performed to determine crack growth behavior of turbine engine disk and blade alloys under various loading conditions typical of service environments. Tests were performed at elevated temperature in vacuum also to evaluate the baseline crack growth behavior. Substructural analysis of creep rupture specimens were conducted to understand the basic mechanism of time-dependent elevated temperature deformation. The work performed can be divided into three categories-- development of experimental techniques, material characterization techniques, and data maintenance and test support activities. The capability of the IDG laser system to monitor extended gage length was analyzed and found feasible. New grips and specimens have been designed and fabricated for high temperature composite testing. Enhancements to existing systems for crack length and displacement measurements were made. A number of computer automation applications are also discussed. GRA

N87-26911# Rolls-Royce Ltd., Derby (England).
ADVANCED TURBINE BLADING: A CHALLENGE FOR DESIGNER, MATERIALS DEVELOPER AND MANUFACTURER
R. P. ARTHEY 5 Dec. 1986 7 p Presented at the Conference on Design with High Temperature Materials, York, England, 7-9 Apr. 1986
(PNR90365; ETN-87-90112) Avail: NTIS HC A02/MF A01

The concepts of wafer blading and spar shell construction for aircraft engine turbine blades are reviewed. The potential of hybrid blading is assessed. ESA

N87-26912# Rolls-Royce Ltd., Derby (England).
ROLLS ROYCE CIVIL ENGINES, THE NEXT GENERATION
G. LEWIS 23 Jan. 1987 7 p Presented at the Air India Symposium, 23 Jan. 1986
(PNR90370; ETN-87-90113) Avail: NTIS HC A02/MF A01

Aircraft powerplant demand to the year 2000 is assessed, and the role of propfans, contrafans, and propellers is estimated. Operating costs are shown and aircraft configurations are shown. ESA

N87-26913*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, Calif.
THE VALUE OF EARLY FLIGHT EVALUATION OF PROPULSION CONCEPTS USING THE NASA F-15 RESEARCH AIRPLANE
FRANK W. BURCHAM, JR. and RONALD J. RAY Sep. 1987 15 p Presented at the AIAA/AHS/ASEE Aircraft Design, Systems and Operations Meeting, St. Louis, Mo., 13-16 Sep. 1987
(NASA-TM-100408; H-1419; NAS 1.15:100408; AIAA-87-2877)
Avail: NTIS HC A02/MF A01 CSCL 21E

The value of early flight evaluation of propulsion and propulsion control concepts was demonstrated on the NASA F-15 airplane in programs such as highly integrated digital electronic control (HIDEC), the F100 engine model derivative (EMD), and digital electronic engine control (DEEC). (In each case, the value of flight demonstration was conclusively demonstrated). This paper described these programs, and discusses the results that were not expected, based on ground test or analytical prediction. The role of flight demonstration in facilitating transfer of technology from the laboratory to operational airplanes is discussed. Author

N87-26914*# General Electric Co., Lynn, Mass. Aircraft Engines.
CERAMIC HIGH PRESSURE GAS PATH SEAL Final Report, Jan. 1982 - Apr. 1987
G. C. LIOTTA Aug. 1987 138 p
(Contract NAS3-23174)
(NASA-CR-180813; NAS 1.26:180813) Avail: NTIS HC A07/MF A01 CSCL 20E

Stage 1 ceramic shrouds (high pressure turbine gas path seal) were developed for the GE T700 turbine helicopter engine under the Army/NASA Contract NAS3-23174. This contract successfully proved the viability and benefits of a Stage 1 ceramic shroud for production application. Stage 1 ceramic shrouds were proven by extensive component and engine testing. This Stage 1 ceramic shroud, plasma sprayed ceramic (ZrOs-BY2O3) and bond coating (NiCrAlY) onto a cast metal backing, offers significant engine performance improvement. Due to the ceramic coating, the amount of cooling air required is reduced 20% resulting in a 0.5% increase in horsepower and a 0.3% decrease in specific fuel consumption. This is accomplished with a component which is lower in cost than the current production shroud. Stage 1 ceramic shrouds will be introduced into field service in late 1987. Author

N87-27667# Rolls-Royce Ltd., Derby (England).
APPLICATION OF SPATE TO HIGH FREQUENCY VIBRATION MEASUREMENT OF AERO ENGINE COMPONENTS
STEPHEN R. TURNER and NEVILLE G. POLLARD 17 Feb. 1987 17 p Presented at the 2nd International Conference on Stress Analysis by Thermoelastic Techniques, 7-18 Feb. 1987
(PNR90373; ETN-87-90114) Avail: NTIS HC A02/MF A01

The application of a full field vibration stress measurement technique over the range 30 Hz to 5 kHz on blades and high energy components is described. The measurements were made to: validate a finite element model; measure the effect of local modifications; and solve development incidents. The relative successes of measuring at different frequencies are discussed. Full field stress measurements using Stress Pattern Analysis by Thermal Emission in the vibration investigation and its relation to other measurement techniques are summarized. ESA

N87-27669# Rolls-Royce Ltd., Derby (England). Advanced Projects Dept.
THE APPLICATION OF RADIATION PHYSICS AND PHOTOGRAMMETRIC TECHNIQUES FOR THE DIAGNOSIS AND SOLUTION OF MECHANICAL ENGINEERING PROBLEMS AND PERFORMANCE IMPROVEMENTS IN THE DEVELOPMENT OF AERO GAS TURBINE ENGINES AT ROLLS-ROYCE
P. A. E. STEWERT 19 May 1986 20 p Presented at the 67th AGARD PEP Symposium, Philadelphia, Penn., 19-23 May 1986
Previously announced as N87-21198
(PNR90388; ETN-87-90116) Avail: NTIS HC A02/MF A01

High Energy (8 MeV) X-rays were used to determine metal component movements for engine performance improvements and integrity confirmation, using film. Real time video was used for transient events. Low energy X-rays with high speed cine fluoroscopy were used to analyze molten metal flows in the turbine blade casting process. Cold neutrons and low energy X-rays were used to analyze two phase flows and oil distribution in an engine oil scavenge system. Positron emitting isotope techniques are being developed to determine fuel and lubrication system dynamics. The images captured by these systems are processed by digital techniques, and pattern recognition and cross correlation is carried out. Measurements are made from the film and video images using two and three dimensional photogrammetric methods. ESA

N87-27670# Rolls-Royce Ltd., Derby (England).
ADVANCED TECHNOLOGY AND ITS APPLICATION TO AERO ENGINES
P. C. RUFFLES and T. BROUGHTON 29 Jan. 1987 9 p Presented at the 15th GTSJ Gas Turbine Seminar, Japan, 29 Jan. 1987
(PNR90389; ETN-87-90117) Avail: NTIS HC A02/MF A01

Development trends in civil and military aircraft engines are reviewed. Honeycomb blades, turboshafts, fuel consumption, propulsive efficiency, and thrust/weight ratios are discussed. ESA

N87-27671# Rolls-Royce Ltd., Derby (England).
THE ROLLS-ROYCE WIDE CHORD FAN BLADE
G. A. FITZPATRICK and T. BROUGHTON 19 Oct. 1986 19 p Presented at the International Conference on Titanium Products and Applications, San Francisco, Calif., 19-22 Oct. 1986
(PNR90392; ETN-87-90118) Avail: NTIS HC A02/MF A01

A highly efficient fan for civil engine applications in the thrust range 22,000 to 58,000 lbs was developed. It is snubberless, hollow, and of wide chord. Its manufacturing method, particularly diffusion bonding, and component and metallurgical integrity, is described. ESA

N87-27672# Institute for Defense Analyses, Alexandria, Va.
POLICY OPTIONS FOR THE AIRCRAFT TURBINE ENGINE COMPONENT IMPROVEMENT PROGRAM Final Report, Dec. 1986 - May 1987
J. R. NELSON, BRUCE R. HARMON, and KAREN W. TYSON May 1987 110 p
(Contract MDA903-84-C-0031)
(AD-A182727; AD-E500873; IDA-P-2015; IDA/HQ-87-32146)
Avail: NTIS HC A06/MF A01 CSCL 01C

The aircraft turbine engine Component Improvement Program (CIP) is an important element in the acquisition and maturation of engines for military aircraft and helicopter applications. This report presents the results of an investigation into the role of CIP, its value to the military services, and the feasibility and practicality of certain policy options including: (1) transitioning CIP to the private sector, (2) competing CIP in whole or in part, and (3) comparing CIP to airframe and avionics engineering change processes. Recommendations for future actions are included. GRA

08

AIRCRAFT STABILITY AND CONTROL

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

A87-47683#
INVESTIGATION OF ACTIVE FLUTTER SUPPRESSION ON A DELTA WING MODEL
KUNYI CHENG (Chengdu Aircraft Corp., People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, Jan. 1987, p. A29-A39. In Chinese, with abstract in English.

By means of the fictitious structural modification method and the Nyquist criterion concept, control laws of active flutter-suppression systems were designed for a delta wing. Based on accurate determination of the model structural parameters and transfer behavior of the electrohydraulic actuation systems and on suitable position of the transducers, the lowest critical flutter speed was increased by 23 percent with different and simple control laws. Good agreement with wind-tunnel test results was achieved. Author

A87-47807*# Rice Univ., Houston, Tex.
OPTIMIZATION AND ACCELERATION GUIDANCE OF FLIGHT TRAJECTORIES IN A WINDSHEAR
A. MIELE, T. WANG (Rice University, Houston, TX), and W. W. MELVIN (Delta Air Lines, Inc., Atlanta, GA) (Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986, Technical Papers, p. 215-236) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, July-Aug. 1987, p. 368-377. Research supported by the Boeing Commercial Airplane Co. Previously cited in issue 23, p. 3408, Accession no. A86-47425. refs
(Contract NAG1-516)

A87-47843
NAVY DEPARTURE RESISTANCE AND AIR COMBAT MANEUVERING EVALUATION OF THE FA-18B AIRPLANE
RICHARD J. SHOWS and GINA D. MUMFREY (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: 1986 report to the aerospace profession; Proceedings of the Thirtieth Symposium, Beverly Hills, CA, Sept. 24-27, 1986 . Lancaster, CA, Society of Experimental Test Pilots, 1986, p. 152-177.

The FA-18B two-seat variant of the single-seat FA-18A Navy fighter exhibited markedly different characteristics when departures from controlled flight occurred in regions where the single seater was departure-resistant. A test program was accordingly instituted which carefully examined the maneuvering control inputs and training maneuvers that led to the departures from controlled flight; air combat maneuvering dogfights were conducted between the one-seat and two-seat variants of the aircraft in order to validate the differences noted. Attention is given to the effects of inboard pylons and asymmetric wing tip missiles on flying qualities. O.C.

A87-47884* Rice Univ., Houston, Tex.
QUASI-STEADY FLIGHT TO QUASI-STEADY FLIGHT TRANSITION IN A WINDSHEAR - TRAJECTORY OPTIMIZATION AND GUIDANCE
A. MIELE, T. WANG (Rice University, Houston, TX), and W. W. MELVIN (Delta Air Lines, Inc., Atlanta, GA) Journal of Optimization Theory and Applications (ISSN 0022-3239), vol. 54, Aug. 1987, p. 203-240. Research supported by the Boeing Commercial Aircraft Co. refs
(Contract NAG1-516)

The near-optimum guidance of an aircraft from quasi-steady flight to quasi-steady flight in a windshear is studied. The take-off problem is considered with reference to flight in a vertical plane; allowance is made for the presence of a downdraft as well as horizontal shear. It is assumed that the power setting is held at the maximum value and that the aircraft is controlled through the angle of attack. While the shear guidance and the initial aftershear guidance use constant gain coefficients, the final aftershear guidance employs a variable gain coefficient. The results show that the guidance scheme for quasi-steady flight recovery yields a transition from quasi-steady flight to quasi-steady flight which is close to that of the optimal trajectory; it guarantees the restoration of the initial quasi-steady state and has good stability properties. K.K.

A87-48276
INTEGRATING PITCH AND POWER CONTROL
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 7, July 1987, p. 5-8.

When a conventional autopilot system undertakes a landing approach, the autothrottle and elevator command are decoupled; in situations where the aircraft's total energy state is excessive or insufficient for the given conditions, errors with both the throttle and elevator settings may emerge. Attention is accordingly given to a Total Energy Control System (TECS) by means of which the throttle becomes the aircraft total energy controller, and the elevators become its coupled distributors of that energy between the speed and the approach flight path, by integrating the flight path angle error and the normalized acceleration error. The TECS has been evaluated through flight testing in a 737-100, meeting or exceeding all program objectives. O.C.

A87-48647#
THE EFFECT OF PERIODIC BALLONET JET EXHAUST ON THE STABILITY OF A TETHERED AEROSTAT
S. M. KANNAN (National Aeronautical Laboratory, Bangalore, India) and G. N. V. RAO (Indian Institute of Science, Bangalore, India) IN: AIAA Lighter-Than Air Technology Conference, 7th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 67-71.
(AIAA PAPER 87-2504)

Tethered aerostats operating under wide range of altitudes and atmospheric pressure conditions employ ballonets within the hull filled with air. These ballonets exhaust the air into the atmosphere whenever necessary to maintain the difference between the atmospheric pressure and the internal pressure within a desired range. Assuming that the air exhaust is made periodic, studies are made on the effect of the periodic jet force and the resulting pitching moment on the response of the aerostat system. In the first phase, the stability of the system is studied by analyzing the eigenvalues and eigenvectors. The result shows that the aerostat system is unstable in the windspeed range of 0-15 fps and stable in the windspeed range of 15-100 fps. When the system is subjected to a suitable periodic forcing from the exhaust jet, it is observed that it is not only possible to extend the stability boundary of 15 fps down to typically 5 fps, but much more interestingly, there exist forcing periods of the exhaust jet which render the system completely stationary. Author

A87-48649#
A COMPARISON OF A NONLINEAR FLIGHT DYNAMIC SIMULATION OF AN AIRSHIP WITH FLIGHT TEST RESULTS
JUSTIN H. AMANN (Toronto, University, Canada) IN: AIAA Lighter-Than-Air Technology Conference, 7th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 78-86. Research supported by Transport Canada and NSERC. refs
(AIAA PAPER 87-25007)

A six degree of freedom nonlinear airship flight dynamic simulation program has been adapted to apply to nonrigid airships. This report discusses the physical and aerodynamic models that underlie the simulation. The principle of the simulation and the structure of the program are described. The simulation was used to model the flight behavior of a new technology blimp, the Airship Industries Skyship 500, for which flight test data were available. Simulation predictions follow the same trends indicated by the flight test data. The computer simulation performed well in a wide variety of maneuvers. Author

A87-48650*# Systems Technology, Inc., Hawthorne, Calif.
PRE- AND POST-FLIGHT-TEST MODELS VERSUS MEASURED SKYSHIP-500 CONTROL RESPONSES
HENRY R. JEX, RAYMOND E. MAGDALENO (Systems Technology, Inc., Hawthorne, CA), PAUL GELHAUSEN (NASA, Ames Research Center, Moffett Field, CA), and MARK P. TISCHLER (U.S. Army, Aviation Research and Technology Activity, Moffett Field, CA) IN: AIAA Lighter-Than-Air Technology Conference, 7th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 87-99. refs
(AIAA PAPER 87-2508)

The dynamical equations-of-motion (EOM) for cruising airships require nonconventional terms to account for buoyancy and apparent-mass-effects, but systematic validation of these equations against flight data is not available. Using a candidate set of EOM, three comparisons are made with carefully-measured describing functions derived from frequency-sweep flight tests on the Skyship-500 airship. The first compares the pre-flight predictions to the data; the second compares the 'best-fit' equations to data at each of two airspeeds and the third compared the ability to extrapolate from one condition to another via airship-specific scaling laws. Two transient responses are also compared. The generally good results demonstrate that fairly simple, perturbation equation models are adequate for many types of flight-control analysis and flying quality evaluations of cruising airships. Author

A87-48758* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPIN RESISTANCE EVALUATION OF A LIGHT AIRPLANE
H. PAUL STOUGH, III, DANIEL J. DECARLO, and JAMES M. PATTON, JR. (NASA, Langley Research Center, Hampton, VA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 18 p. refs
(SAE PAPER 871-021)

A brief history of stall/spin technology for light general aviation airplanes and proposed criteria to describe desirable characteristics of a spin-resistant airplane are presented. Flight tests of a representative light airplane to evaluate compliance with and usefulness of the criteria are presented. The baseline airplane configuration would not meet the spin resistance criteria. Tests of the airplane with a wing leading edge modification to enhance its spin resistance showed compliance with the proposed criteria. Author

A87-48929#
A SIGNIFICANT IMPROVEMENT TO THE LOW SPEED YAW CONTROL OF THE SEA KING USING A TAIL BOOM STRAKE
ALAN BROCKLEHURST (Westland Helicopters, Ltd., Aerodynamics Dept., Yeovil, England) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 12 p.

The paper describes wind tunnel tests, a computer model, and flight tests which have led to a significant improvement in the Sea King's low-speed yaw control through the addition of a simple strake along the tail boom. The use of the strake has resulted in a significant improvement in yaw control and lower torques in right sideways flight. When tail rotor control power is a limiting factor, the maximum all-up-weight may be increased by at least 1500 lb. An aerodynamically tailored tail boom section has been proposed; the design is based on a nominally square section with small upper corner radii and large lower corner radii. B.J.

A87-48946#
FLIGHT CONTROL SYSTEMS FOR SEARCH AND RESCUE
R. PEDLEY, P. M. SMITH, and B. J. REGAN (Louis Newmark, PLC, Croydon, England) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 23 p.

The requirements for search and rescue (SAR) flight control system and their implementation in civil certified SAR systems are discussed. A basic SAR mission involves: (1) travel to the search area, (2) search and locate, (3) circle and transition to the hover, (4) winching operation, (5) transition from hover, and (6) return journey. The modes used to accomplish the SAR mission, for example the airspeed hold and overfly modes, are described. The safety requirements for uncoupled and coupled flight director systems are examined. The basic design and operation of flight path controllers are considered. I.F.

A87-48947#
V-22 TILTROTOR FLY-BY-WIRE FLIGHT CONTROL SYSTEM
BRUCE L. MCMANUS (Bell-Boeing, Philadelphia, PA) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 22 p.

The flight control system (FCS) for the V-22 Osprey tilt-rotor aircraft is examined. The architecture for the system was selected in terms of methods of channel failure monitoring and actuator control electronics. System design requirements include safety, fly qualities, reliability, and survivability. The operational elements of the V-22 FCS; equipment installation; the functions and interface between the primary FCS, automatic FCS, and aircraft; and the triplex channel architecture are discussed. The proposed cockpit controls, flight control electronics, power supplies, and flight control actuator for V-22 are described. The methods used for failure monitoring of the primary and automatic FCSs are considered. Diagrams of the FCS are presented. I.F.

A87-48948#
FLIGHT CONTROL SYSTEM PHILOSOPHY FOR ACTIVE CONTROL OF A HELICOPTER
D. J. TYLER and P. R. BRINSON (Westland Helicopters, Ltd., Yeovil, England) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 20 p.

The use of active control technology (ACT) to improve helicopter flight controls is evaluated using helicopter simulations. Control laws for flight control system (FCS) were developed. The design and implementation of the FCS are described. A conventional, cross-lane monitored quadruplex architecture using multimode fibers, LED transmitters, and PIN diode receivers, and a five-actuator swashplate system were selected for the baseline system. The costs and benefits of this system were assessed by comparing it with conventional flying controls. It is observed that procurement and in-service costs for the two systems are similar, but that the FCS provides improved handling qualities and survivability, reduced workload, and substantial weight savings without cost penalities. I.F.

A87-48960#
A REVIEW OF THE APPLICATIONS OF A HORIZONTAL TAIL IN THE SINGLE MAIN AND TAILROTOR HELICOPTER
A. E. CALDWELL, S. S. HOUSTON, and D. G. THOMSON (Glasgow, University, Scotland) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 25 p. refs

The effect of active control technology (ACT) on the sizing of the horizontal tail of helicopters is studied. The longitudinal stability and control of fixed-wing aircraft are compared with that of helicopters. A decoupled flight path/attitude control system is described, and simulation data from the application of this system to a helicopter are presented and analyzed. It is noted that the fuselage trimming of helicopters may be improved by using ACT with large tailplanes. I.F.

A87-48961#
A ROBUST GENERAL HELICOPTER TRIM PROGRAM
H. AZZAM and P. TAYLOR (Southampton, University, England) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 18 p. Research supported by the Ministry of Defence (Procurement Executive). refs

Several aerodynamic and dynamic simplifications have been introduced in most of the reported helicopter trim methods. Meanwhile, the solution of the trim equations has been obtained by using a simple iteration scheme. This scheme hardly satisfies the mathematical condition for convergence. The objective of this paper is to present a general algorithm which provides a convergent solution for the trim problem. Nonuniform induced velocity profiles and detailed aerodynamic data are used in the trim program to demonstrate that the general algorithm is capable of implementing arbitrary advanced mathematical models which simulate the various helicopter components. Author

A87-48964#
QUADRIFOGLIO - A NEW PHILOSOPHY IN THE CONFIGURATION OF THE SERVO-CONTROLS FOR HELICOPTERS
FRANCESCO VIOLANTE DE DIONIGI (Magnaghi Oleodinamica S.p.A., Milan, Italy) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 18 p.

In an effort to overcome difficulties connected with the tandem and side-by-side configurations, the Quadrigfoglio configuration has been developed for the main rotor servocontrol of the EH101 helicopter. The servovalves and the bypass systems are analyzed in cases of hydraulic failures, jammings, and lack of hydraulic pressure. The side-by-side and Quadrifoglio solutions are compared in terms of envelope and weight characteristics, operation, and reliability. B.J.

A87-49078*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
HIGH-ANGLE-OF-ATTACK STABILITY AND CONTROL IMPROVEMENTS FOR THE EA-6B PROWLER
FRANK L. JORDAN, DAVID E. HAHNE (NASA, Langley Research Center, Hampton, VA), MATTHEW F. MASIELLO, and WILLIAM GATO (Grumman Corp., Aircraft Systems Div., Bethpage, NY) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 270-285. refs
(AIAA PAPER 87-2361)

The factors involved in high-angle-of-attack directional divergence phenomena for the EA-6B ECM aircraft have been investigated in NASA-Langley wind tunnel facilities in order to evaluate airframe modifications which would eliminate or delay such divergence to angles-of-attack farther removed from the operational flight envelope of the aircraft. The results obtained indicate that an adverse sidewash at the aft fuselage and vertical tail location is responsible for the directional stability loss, and that the sidewash is due to a vortex system generated by the fuselage-wing juncture. Modifications encompassing a wing inboard leading edge droop, a wing glove strake, and a vertical fin extension, have significantly alleviated the stability problem. O.C.

A87-49161#
EFFECT OF TIME DELAY ON MANUAL FLIGHT CONTROL AND FLYING QUALITIES DURING IN-FLIGHT AND GROUND-BASED SIMULATION
RANDALL E. BAILEY, LOUIS H. KNOTTS (Calspan Advanced Technology Center, Buffalo, NY), SCOTT J. HOROWITZ, and HUGH L. MALONE, III (USAF, Human Resources Laboratory, Williams AFB, AZ) IN: AIAA Flight Simulation Technologies Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 30-38. refs
(Contract F33615-83-C-3603)
(AIAA PAPER 87-2370)

The results of an experiment whose goal was the generation of guidelines and the development of a data foundation for the specification of allowable time delay (TD) in ground-based simulators are examined. The effect of TD on flying qualities and manual flight control were studied during in-flight simulation where 'perfect' motion cuing was available. A ground-based no-motion replication of the in-flight experiment was also performed. Total delays of up to 150 msec were found to be tolerable in the simulation environment. This delay requirement reflects the most stringent condition of a highly maneuverable, highly responsive fighter aircraft simulation flown in a demanding task environment. B.J.

A87-49172*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NONLINEAR SIMULATION OF A FLEXIBLE AIRCRAFT IN MANEUVERING FLIGHT
CAREY S. BUTTRILL, P. DOUGLAS ARBUCKLE (NASA, Langley Research Center, Hampton, VA), and THOMAS A. ZEILER (PRC Kentron, Inc., Hampton, VA) IN: AIAA Flight Simulation Technologies Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 122-133. refs
(AIAA PAPER 87-2501)

A mathematical model integrating nonlinear rigid-body flight mechanics and linear aeroelastic dynamics is examined; the equations of motion for an elastic aircraft in accelerated flight are developed using Lagrangian mechanics. This approach is used to construct a simulation model of an F/A-18 (configured with tip missiles) which includes angular/elastic inertial coupling (IC). In general, the elastic modes significantly affected by IC were aerodynamically decoupled from the rest of the model. The affected modes were those which induced changes in total aircraft mass distribution. The elastic effect is noticeable if deformation-induced mass distribution changes are significant with respect to modal mass and modal frequencies. A modal parameter is presented which characterizes the level of IC between elastic momentum and rigid-body angular momentum. B.J.

A87-49577
AIAA ATMOSPHERIC FLIGHT MECHANICS CONFERENCE, MONTEREY, CA, AUG. 17-19, 1987, TECHNICAL PAPERS
Conference sponsored by AIAA. New York, American Institute of Aeronautics and Astronautics, 1987, 511 p. For individual items see A87-49578 to A87-49626.

The present conference discusses the simulation of translation-rate command systems for hover and low speed flight, alternative design guidelines for pitch tracking, a computational and experimental study of supersonic flow over a protruberance, the numerical simulation of three-dimensional transonic flows, a computational study for a projectile with standard and dome bases, flow visualization techniques for full-scale vehicles, and a comparison of water and wind tunnel flow visualization results on a generic fighter configuration at high angles-of-attack. Also treated are high spin effects on a finned projectile from free-flight tests, magnus characteristics of a high fineness ratio missile with circumferential vanes and helical wiring tunnels, the analytic prediction of slender wing rock, orbital changes during hypersonic aerocruise, maximum terminal velocity turns at constant altitude, and a comparison of horizontal and vertical launch into orbit. O.C.

A87-49578*# Systems Technology, Inc., Hawthorne, Calif.
A FLIGHT INVESTIGATION OF HELICOPTER LOW-SPEED RESPONSE REQUIREMENTS
DAVID G. MITCHELL, ROGER H. HOH (Systems Technology, Inc., Hawthorne, CA), and J. MURRAY MORGAN (National Aeronautical Establishment, Ottawa, Canada) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1-11. Army-supported research. refs
(Contract NAS2-11304)
(AIAA PAPER 87-2285)

A flight experiment has been conducted using the Canadian National Aeronautical Establishment's variable-stability airborne simulator to define the dynamic response requirements for operations at hover and low speeds. Fourteen Attitude Command/Attitude Hold, Rate, and Rate Command/Attitude Hold configurations were evaluated by six pilots using both conventional controls and a four-axis integrated sidestick over a low-speed course consisting of precision hover, landing, sidestep, and dash/quickstop tasks. The results indicate that with conventional controls all three response-types were acceptable as long as their response bandwidth was sufficiently high, and higher bandwidths were required in roll than in pitch. With the four-axis sidestick, there was a preference for the Rate systems. The range of acceptable bandwidths was lower, and the spread in pilot ratings smaller, than were found in a similar ground-based simulation. Author

A87-49579#
SIMULATION STUDIES OF TRANSLATION RATE COMMAND SYSTEMS FOR HOVER AND LOW SPEED FLIGHT
G. C. KREKELER, J. C. EHLERS, and D. J. WILSON (McDonnell Aircraft Co., Saint Louis, MO) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 12-22. refs
(AIAA PAPER 87-2286)

The flying qualities requirements for V/STOL shipboard landing operations in high sea states are investigated by a fixed-base piloted simulation, whose first phase replicated X-22 flight tests in order to validate predictions of in-flight translation rate command (TRC) and to evaluate the expanded range of TRC dynamics. The second phase gave attention to an expanded TRC test matrix, for the case of a shipboard landing aboard a small destroyer. The first phase confirmed that fixed-base simulation can be used to accurately predict in-flight pilot ratings. Since currently proposed time-domain criteria only inconsistently predicted flying qualities

levels for the fixed-base and X-22 flight data, TRC frequency response envelope and secondary TRC criteria were developed to improve flying qualities predictions; these conservatively predict flying qualities levels. O.C.

A87-49581#
DYNAMIC CHARACTERISTICS OF FLIGHT NEAR THE GROUND
H. H. LIU (Civil Aviation Institute of China, Tianjin, People's Republic of China) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 32-39. refs
(AIAA PAPER 87-2288)

Aircraft motion equations suitable for flight safety study are derived. It is illustrated that when an aircraft approaches the ground, the Phugoid mode degenerates into aperiodic divergent motions, one of which doubles amplitude in about 2-s. The most effective control input changes from altitude control at very low heights to attitude as height is increased. If pilot doesn't follow this change properly, induced oscillations may occur. Author

A87-49582#
ALTERNATIVE DESIGN GUIDELINES FOR PITCH TRACKING
MICHAEL P. BLAND, FRANK J. SHIRK, KEVIN D. CITURS (McDonnell Aircraft Co., Saint Louis, MO), and DAVID J. MOORHOUSE (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 40-48. refs
(AIAA PAPER 87-2289)

The unsatisfactory results obtained with a classical second-order longitudinal control system for the case of fine tracking during piloted simulation has prompted the use of alternative design criteria to develop a technique which increases the numerator lead time constant in the aircraft pitch rate response. When this value is augmented to a value higher than that of the basic airframe, a load factor is produced which, while improving flying qualities for air-to-air tracking, could degrade precise flightpath-control flying qualities. It is concluded that a classic second-order load factor response may not produce adequate fine tracking flying qualities for some aircraft. O.C.

A87-49583*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPARISON OF IN-FLIGHT AND GROUND-BASED SIMULATOR DERIVED FLYING QUALITIES AND PILOT PERFORMANCE FOR APPROACH AND LANDING TASKS
WILLIAM D. GRANTHAM (NASA, Langley Research Center, Hampton, VA) and ROBERT H. WILLIAMS (PRC Kentron, Inc., Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 49-60.
(AIAA PAPER 87-2290)

For the case of an approach-and-landing piloting task emphasizing response to the landing flare, pilot opinion and performance parameters derived from jet transport aircraft six-degree-of-freedom ground-based and in-flight simulators were compared in order to derive data for the flight-controls/flying-qualities engineers. The data thus obtained indicate that ground simulation results tend to be conservative, and that the effect of control sensitivity is more pronounced for ground simulation. The pilot also has a greater tendency to generate pilot-induced oscillation in ground-based simuation than in flight. O.C.

A87-49607*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXPLORATORY STUDIES OF ACTUATED FOREBODY STRAKES FOR YAW CONTROL AT HIGH ANGLES OF ATTACK
DANIEL G. MURRI (NASA, Langley Research Center, Hampton, VA) and DHANVADA M. RAO (Vigyan Research Associates, Inc., Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 279-295. refs
(AIAA PAPER 87-2557)

Wind-tunnel studies have been conducted to evaluate the potential of actuated forebody strakes to provide increased levels of yaw control on fighter aircraft at extremely high 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 ranges of angle-of-attack and sideslip. However, when lifting surfaces were placed in close proximity to the forebody/strake combination, significant interaction effects occurred which reduced the yaw control effectiveness of the strakes and induced coupled rolling and pitching moments. Author

A87-49609*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
USE OF THE UPDATED NASA LANGLEY RADIO-CONTROLLED DROP-MODEL TECHNIQUE FOR HIGH-ALPHA STUDIES OF THE X-29A CONFIGURATION
DAVID J. FRATELLO, MARK A. CROOM, LUAT T. NGUYEN (NASA, Langley Research Center, Hampton, VA), and CHRISTOPHER S. DOMACK (PRC Kentron, Inc., Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 305-317. refs
(AIAA PAPER 87-2559)

This paper presents an overview of the radio-controlled drop-model technique used for low-speed flight dynamics research at the NASA Langley Research Center. The overall test methodology is reviewed and the major elements of the system are discussed including model construction and equipment, the closed-loop control system, and the flight test facility. To illustrate the capabilities of the technique, selected results from an ongoing program to study the high-angle-of-attack flight dynamics of the X-29A configuration are reviewed. Three research areas are highlighted: motion prediction, control system effects, and motion analysis and modeling. Finally, several current upgrades to the overall technique are discussed along with the enhanced test capability that they will provide. Author

A87-49610#
AN EXPERIMENTAL STUDY TO DETERMINE THE FLOW AND THE SUBSONIC STATIC AND DYNAMIC STABILITY CHARACTERISTICS OF AIRCRAFT OPERATING AT HIGH ANGLES-OF-ATTACK
ALEX GOODMAN, CLINTON E. BROWN, and RONALD J. ALTMANN (Tracor Hydronautics, Inc., Laurel, MD) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 318-342. refs
(AIAA PAPER 87-2560)

A hydronautics test facility has been used to conduct a series of experiments aimed at determining the subsonic static and dynamic stability characteristics of a 3.5-foot span, 60-deg delta high wing configuration model operating at angles-of-attack as high as 68 deg. Flow visualization was conducted at Re numbers in the 200,000 to 1.6 million range, and the force and moment coefficients resulting from a simulated pitchup maneuver were obtained. These results are compared with static and dynamic stability results obtained in the mid-1950s in the NACA-Langley

Stability Tunnel for a similarly configured model operating over a range of reduced frequencies and angles-of-attack up to 36 deg; results are noted to be in good agreement. O.C.

A87-49611#
ANALYSIS AND APPLICATION OF AIRCRAFT DEPARTURE PREDICTION CRITERIA TO THE AV-8B HARRIER II
HERBERT L. TINGER (McDonnell Douglas Corp., Saint Louis, MO) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 343-352. refs
(AIAA PAPER 87-2561)

Attention is given to four reliable criteria for the accurate prediction of departure susceptibility in the AV-8B Harrier aircraft, at the high angles-of-attack typical of combat maneuvering. Departure boundaries are calculated from each of these prediction criteria, on the basis of an aerodynamic mathematical model of the aircraft which employs four types of control inputs. These boundaries represent the maximum angle-of-attack at which the aircraft is predicted to be departure-free; comparisons with actual departures indicate how accurately each criterion predicts aircraft departure tendencies for various control inputs. O.C.

A87-49612*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EVALUATION OF AIRPLANE SPIN RESISTANCE USING PROPOSED CRITERIA FOR LIGHT GENERAL AVIATION AIRPLANES
H. PAUL STOUGH, III, DANIEL J. DICARLO, and JAMES M. PATTON (NASA, Langley Research Center, Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 353-361. refs
(AIAA PAPER 87-2562)

Proposed criteria to describe desirable characteristics of a spin-resistant airplane are reviewed. Flight tests of two representative light airplanes to evaluate compliance with the criteria are also presented. The baseline airplane configurations would not meet the spin resistance criteria. Tests of the airplanes with a wing leading edge modification to enhance spin resistance showed compliance with the proposed criteria. The tests demonstrated the usefulness of the criteria when the criteria are applied in the manner described. Author

A87-49613*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE EFFECTS OF AEROELASTIC DEFORMATION ON THE UNAUGMENTED STOPPED-ROTOR DYNAMICS OF AN X-WING AIRCRAFT
MICHAEL G. GILBERT (NASA, Langley Research Center, Hampton, VA) and WALTER A. SILVA (PRC Kentron, Inc., Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 362-371. refs
(AIAA PAPER 87-2563)

A new design concept in the development of vertical takeoff and landing aircraft with high forward flight speed capability is that of the X-Wing. The X-Wing is a stiff, bearingless helicopter rotor system which can be stopped in flight and the blades used as two forward-swept wings and two aft-swept wings. Because of the unusual configuration in the fixed-wing mode, there is a high potential for aeroelastic divergence or flutter and coupling of blade vibration modes with rigid-body modes. An aeroelastic stability analysis of an X-Wing configuration aircraft was undertaken to determine if these problems could exist. This paper reports on the results of dynamic stability analyses in the lateral and longitudinal directions including the vehicle rigid-body and flexible modes. A static aeroelastic analysis using the normal vibration mode equations of motion was performed to determine the cause of a loss of longitudinal static margin with increasing airspeed. This loss of static margin was found to be due to aeroelastic 'washin' of the forward-swept blades and 'washout' of the aft-swept blades moving the aircraft aerodynamic center forward of the center of gravity. This phenomenon is likely to be generic to X-Wing aircraft. Author

A87-49622#
ESTIMATION OF THE AERODYNAMIC COEFFICIENTS OF THE NAVION AIRCRAFT AT HIGH ANGLES OF ATTACK AND SIDESLIP
XAVIER SILHOUETTE (Intergraph Corp., Paris, France) and ROBERT STENGEL (Princeton University, NJ) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 452-463. Research sponsored by the Schultz Foundation. refs
(AIAA PAPER 87-2622)

An estimation-before-modeling technique has been used to derive the aerodynamic coefficients of the Navion light aircraft from flight test data for 15 different maneuvers where angles of attack and sideslip above 30 deg were reached. Pitch rate was found to be a strong contributor to lift, generating a dynamic effect that could be mistaken for hysteresis. Both dihedral effect and yaw stiffness diminished as sideslip increased, and the aircraft stalled at an angle of attack higher than anticipated, as a result of thrust effects. Asymmetric effects on both longitudinal and lateral directional coefficients were determined by processing data for positive and negative sideslip angles separately. O.C.

A87-49624*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ANALYSIS OF LATERAL STABILITY OF X-29 DROP MODEL USING SYSTEM IDENTIFICATION METHODOLOGY
DAVID L. RANEY (NASA, Langley Research Center, Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 474-481. refs
(AIAA PAPER 87-2625)

A 22-percent dynamically scaled replica of the X-29 forward-swept-wing aircraft is currently being flown in radio-controlled drop tests at NASA Langley's Plumtree Test Site. Flight data were recorded from early flights in the test program, which consisted mainly of large amplitude maneuvers over wide angle-of-attack ranges with several uncontrolled wing rock episodes. A system identification study of the recorded data was undertaken to examine the stability and control derivatives which influence the lateral behavior of this vehicle with particular emphasis on the wing rock phenomenon. All major lateral stability derivatives and the damping-in-roll derivative were identified for 5-80 deg angle-of-attack by using a data partitioning methodology and a modified stepwise regression algorithm. No control effectiveness derivatives could be identified from the flights conducted so far. Author

A87-49960#
CONCEPTUAL STUDIES OF CONTROL SYSTEMS FOR THE VARIABLE-CAMBER WING [KONZEPTUNTERSUCHUNGEN ZU STEUERUNGSSYSTEMEN DES TRAGFLUEGELS VARIABLER WOELBUNG]
J. RENKEN and U. CARL (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) BMFT, Statusseminar, 4th, Munich, West Germany, Apr. 28-30, 1986, Paper. 8 p. In German. refs
(MBB-UT-221-86-PUB)

The current status of design studies on variable-camber wings (VCWs) for transport aircraft is surveyed and illustrated with extensive diagrams, drawings, and graphs. The history and physical principles of the VCW and its advantages for transport aircraft (enhanced fuel economy and aircraft adaptability to the route and payload being flown) are reviewed, and consideration is given to the geometric-kinematic realization of camber variability, profile and spanwise variability, flap actuation and control concepts, the effect of elastic flap deformation on camber changes, and the implementation of the VCW by means of existing systems and

functions. It is stressed that the VCW realization must maintain the normal primary and secondary functions of the control surfaces while avoiding large increases in the weight and complexity of the control systems. T.K.

A87-49965
COMPATIBILITY ASPECTS OF ACTIVE CONTROL TECHNOLOGIES WITH AIRCRAFT STRUCTURE DESIGN
J. BECKET, F. WEISS, and O. SENSBURG (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) International Symposium on Structural Control, 2nd, University of Waterloo, Canada, July 15-17, 1985, Paper. 25 p. refs
(MBB-LKE-292/S/PUB/200)

Typical examples of interference between structural design and active control technologies are presented to illustrate static elastic and structural dynamic effects on the vibration level of a structure. One example deals with active gust alleviation and ride improvement investigations on a transport aircraft. It is shown that an improvement in passenger comfort could be reached only with some adverse affects on handling and local dynamic design and with a resulting increase in fatigue loads. Another example illustrates the adverse effects of static elastic deformations on the handling and ride qualities of an originally unstable military aircraft with a flight-control system. V.L.

A87-50233
SOLUTIONS OF THE GRUMMAN F-14 BENCHMARK CONTROL PROBLEM
MELVYN RIEMR (Grumman Aerospace Corp., Aircraft Systems Div., Bethpage, NY) and DEAN K. FREDERICK (Rensselaer Polytechnic Institute, Troy, NY) (IEEE, Symposium on Computer-Aided Control System Design, Arlington, VA, Sept. 24-26, 1986) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 7, Aug. 1987, p. 36-40.

In March 1985, an analysis benchmark problem was proposed for the evaluation of software for computer-aided control system design. The control system involved the longitudinal dynamics of the Grumman F-14 aircraft in level flight. Seven solutions have been received and evaluated, and the results are summarized here. In addition, some observations are presented concerning the testing of software capabilities and the preparation of benchmark problems. Author

A87-50340#
SPHERICAL MAPPING AND ANALYSIS OF AIRCRAFT ANGLES FOR MANEUVERING FLIGHT
JURI KALVISTE (Northrop Corp., Aircraft Div., Hawthorne, CA) (Atmospheric Flight Mechanics Conference, Williamsburg, VA

A87-50402#
APPLICATION OF EIGENSTRUCTURE ASSIGNMENT TO SELF RECONFIGURING AIRCRAFT MIMO CONTROLLERS
V. F. GAVITO (U.S. Naval Postgraduate School, Monterey, CA) and D. J. COLLINS IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1-12. refs
(AIAA PAPER 87-2235)

An interactive algorithm which allows the full specification of a set of closed loop eigenvalues and the allowable elements of the corresponding closed loop eigenvector matrix is presented. The algorithm is then used to demonstrate the flexibility afforded by eigenstructure assignment by designing reconfiguring MIMO controllers for an aircraft that has undergone performance degradation. A linear model of the F18 at a given flight condition is used for demonstration purposes. Author

A87-50418*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SIMULATION EVALUATION OF THE CONTROL SYSTEM COMMAND MONITORING CONCEPT FOR THE NASA V/STOL RESEARCH AIRCRAFT (VSRA)
J. A. SCHROEDER (NASA, Ames Research Center, Moffett Field, CA; U.S. Army, Aviation Research and Technology Activity, E. MORALEZ, and V. K. MERRICK (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 133-154. refs
(AIAA PAPER 87-2255)

A control-system monitoring concept is described that has the potential of rapidly detecting computer command failures (hardware or software) in fly-by-wire control systems. The concept has been successfully tested on the NASA Vertical/Short Takeoff and Landing Research Aircraft (VSRA) in the Ames Research Center's Vertical Motion Simulator. The test was particularly stringent, since the VSRA is required to operate in a hazardous environment. The fidelity of the aircraft model used in the simulation was verified by flying both the simulated and actual aircraft in a precision hover task using specially designed targets. Author

A87-50420#
INFLIGHT EVALUATION OF A MODAL SUPPRESSION YAW DAMPER
ABHIJIT CHAKRAVARTY (Boeing Commercial Airplane Co., Seattle, WA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 163-169.
(AIAA PAPER 87-2257)

This paper will address the design procedure of a modal suppression yaw damper for a typical commercial jet transport and show the results obtained during an inflight evaluation of the system. The 'Proof of Concept' flight test results agree with the theoretical predictions. Power Spectral Density (PSD) plots will be shown comparing the performance of the airplane with yaw damper off, yaw damper on without modal suppression and yaw damper on with modal suppression. Flight tests were conducted in turbulence and in calm air using rudder kicks. The modal suppression effects will be shown for both the aft and front end of the aircraft. Author

A87-50421*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
DYNAMIC STABILITY AND HANDLING QUALITIES TESTS ON A HIGHLY AUGMENTED, STATICALLY UNSTABLE AIRPLANE
JOSEPH GERA and JOHN T. BOSWORTH (NASA, Flight Research Center, Edwards, CA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 170-182. refs
(AIAA PAPER 87-2258)

Novel flight test and analysis techniques in the flight dynamics and handling qualities area are described. These techniques were utilized at NASA Ames-Dryden during the initial flight envelope clearance of the X-29A aircraft. It is shown that the open-loop frequency response of an aircraft with highly relaxed static stability can be successfully computed on the ground from telemetry data. Postflight closed-loop frequency response data were obtained from pilot-generated frequency sweeps and it is found that the current handling quality requirements for high-maneuverability aircraft are generally applicable to the X-29A. K.K.

A87-50430#
RECURSIVE REAL-TIME IDENTIFICATION OF STEP-RESPONSE MATRICES OF HIGH-PERFORMANCE AIRCRAFT WITH NOISY SENSORS FOR ADAPTIVE DIGITAL FLIGHT CONTROL
B. PORTER and A. MANGANAS (Salford, University, England) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 247-256. refs
(Contract AF-AFOSR-85-0208)
(AIAA PAPER 87-2309)

It is shown that, by incorporating fast on-line recursive identifiers to provide updated step-response matrices for inclusion in digital PID control laws, highly effective adaptive digital set-point tracking controllers can be readily designed for multivariable plants with noisy sensors. The effectiveness of such an adaptive controller is illustrated by the design of an adaptive direct digital flight-mode control system for the X-29 aircraft with noisy sensors. Author

A87-50432*# Purdue Univ., West Lafayette, Ind.
THE SIGNIFICANCE OF ERROR DYNAMICS IN MODEL-FOLLOWING FOR FLIGHT CONTROL DESIGN
DAVID K. SCHMIDT (Purdue University, West Lafayette, IN) and MARK R. ANDERSON IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 267-276. Research supported by the McDonnell Aircraft Co. refs
(Contract NAG4-1)
(AIAA PAPER 87-2311)

The role of the system error dynamics in model-following control systems is discussed, along with the use of handling quality specifications, actuation bandwidth constraints, stability, and closed-loop performance requirements in flight control design. The model-following problem is formulated using both direct state-space and linear, quadratic, optimization techniques. The results are then demonstrated using several examples involving a generic forward-swept-wing vehicle and a conventional flight vehicle with large parameter uncertainty in order to illustrate the trade-off in closed-loop performance and control law complexity. Author

A87-50433#
RESTRUCTURABLE CONTROL USING PROPORTIONAL-INTEGRAL IMPLICIT MODEL FOLLOWING
CHIEN Y. HUANG (Grumman Aerospace Corp., Bethpage, NY) and ROBERT F. STENGEL (Princeton University, NJ) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 277-286. refs
(Contract DAAG29-84-K-0048)
(AIAA PAPER 87-2312)

Studies of a proportional-integral implicit model-following control law are presented. The research focuses on the ability of the control law to recover the performance of a failed system to its pre-failure level. Properties of the implicit model-following strategy are examined, and conditions for control reconfiguration are stated. The control law is applied to the lateral-directional model of a fighter aircraft, and control restructuring is shown for changes in control and system matrices. It is concluded that the implicit-model following scheme is a good candidate for control reconfiguration. Author

A87-50460*# Rice Univ., Houston, Tex.
OPTIMIZATION AND GUIDANCE OF ABORT LANDING TRAJECTORIES IN A WINDSHEAR
A. MIELE, T. WANG (Rice University, Houston, TX), W. W. MELVIN (Delta Airlines, Inc., Atlanta, GA), and C. Y. TZENG IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 483-509. Research supported by the Boeing Commercial Airplane Co. and Air Line Pilots Association. refs
(Contract NAG1-516)
(AIAA PAPER 87-2341)

The abort landing problem for flight trajectories in the presence of windshear is considered with reference to flight in a vertical plane. The optimal trajectory (OT) problem is a minimax problem or Chebyshev problem of optimal control which can be converted into a Bolza problem through suitable transformations. Numerical results for several combinations of windshear intensities and initial altitudes are presented. A guidance trajectory (GT) law is implemented in feedback control form, subject to prescribed bounds on the angle of attack and its time derivative. Simplified guidance trajectories (SGT) are then considered, leading to a safe target altitude guidance. Conclusions derived for strong-to-severe windshear conditions include GT and SGT preserving the basic properties of OT, and the peak altitude drop of GT and SGT being less than that of the constant pitch trajectory and the maximum angle-of-attack trajectory. R.R.

A87-50461#
BOEING WINDSHEAR SYSTEMS
R. HANSEN (Boeing Commercial Airplane Co., Seattle, WA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 510-516.
(AIAA PAPER 87-2342)

Cockpit wind-shear systems including the Windshear Alert, the Flight Director Takeoff/Go-Around (F/D TO/GA) guidance system, and the Pitch Limit Indicator (PLI) are discussed. For the Windshear Alert, it was determined that the airspeed loss should not exceed 20 knots at the time of alert for shear rates up to 8 knots/sec, and an acceptable margin on nuisance alerting has been established. Wind-shear guidance objectives for the F/D TO/GA guidance system are outlined, and it is suggested that the F/D guidance will reduce pilot workload and improve general performance. The PLI provides a continuous indication of alpha versus stick shaker alpha, and it is suggested that the PLI will limit nose-down excursions when encountering stick shaker operation. Autothrottle wind-shear features and wind-shear system certification are also discussed. R.R.

A87-50462*# Stanford Univ., Calif.
FEEDBACK CONTROL FOR PENETRATING A DOWNBURST
ARTHUR E. BRYSON, JR. (Stanford University, CA) and YIYUAN ZHAO IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 517-524. refs
(Contract NAG2-191)
(AIAA PAPER 87-2343)

Feedback logic is given that produces satisfactory penetration of an aircraft through a severe downburst. The logic has two parts: (1) A switch that calls for full throttle and tight climb-rate-hold feedback logic when the magnitude of headwind-rate exceeds a threshold level; this switch stays on until re-set by the pilot after penetration of the downburst. (2) A tight climb-rate-hold autopilot, using feedback of pitch-angle to angle-of-attack. After penetration, recovery to steady climbing flight is aided by using feedback of airspeed deviation to throttle. Insights on control strategy are gained from an analysis of energy changes during flight through a downburst. Closed-loop simulations are given for a 727 aircraft penetrating severe downbursts on take-off. Boeing's

recommendation of constant pitch angle was confirmed as an excellent feedback control strategy. Author

A87-50463#
TOTAL ENERGY CONTROL CONCEPTS APPLIED TO FLIGHT IN WINDSHEAR
J. EARL BAILEY (Alabama, University, Tuscaloosa) and KALMANJE KRISHNAKUMAR IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 525-532. Research sponsored by the University of Alabama. refs
(AIAA PAPER 87-2344)

Total energy control concepts for airplane flight control in windshear were investigated using a simplified longitudinal energy analysis to review microburst wind field detection concepts and to define potential performance indices for flight control system design application. Nine performance indices were compared by evaluating the height loss response of a transport airplane using a constant gain total energy and energy distribution controller. The controller gains were optimized with the aid of a genetic algorithm parameter optimization method. Results of the study emphasized the importance of controlling the specific energy distribution or total inertial energy distribution. The concept and interpretation of the total inertial energy distribution was introduced and performance indices based on this concept were shown to yield good control systems. Author

A87-50464#
STATISTICAL EVALUATION OF PERFORMANCE INDICES OF MICROBURST-GENERATED WIND EFFECT ON AIRPLANE FLIGHT
KIOUMARS NAJMABADI (Boeing Commercial Airplane Co., Seattle, WA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 533-541. refs
(AIAA PAPER 87-2345)

Wind profiles derived from mathematical models, tower measurements, and accident flight data records have been applied to studies on airplane response and used to evaluate pilot strategies and airplane control systems performance in the presence of wind shear. This paper introduces a set of airplane-specific energy-based performance indices that can be used to assess severity of derived winds and evaluate relative performance of different control strategies during wind shear encounters. The severity of a statistically defined collection of winds derived from a mathematical model is examined and the relative performance of two control strategies is evaluated. Author

A87-50488*# Arizona State Univ., Tempe.
SINGULAR TRAJECTORIES IN AIRPLANE CRUISE-DASH OPTIMIZATION
KARL D. BILIMORIA (Arizona State University, Tempe) and EUGENE M. CLIFF (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 784-792. refs
(Contract NAG1-203)
(AIAA PAPER 87-2404)

Optimal cruise-dash trajectories are obtained for the case of time-fuel optimization using a linear combination of time and fuel as the performance index. For the case of the steady-state arc being flown at full throttle, the skeletal transient trajectories are also flown at full throttle and the transients approach the cruise-dash points monotonically in an asymptotic fashion. When the steady-state arc is flown at an intermediate throttle, the transient trajectories follow a singular control law and exhibit a complex structure that differs from that of the full-throttle transients. With respect to optimality of the steady-state arc, it is found that although steady-state cruise fails a Jacobi-type condition, steady-state cruise-dash can satisfy this condition if the emphasis on time is sufficiently large. R.R.

A87-50489*# Cincinnati Univ., Ohio.
GUIDANCE ON MANEUVERING FLIGHT PATHS FOR ROTARY WING AIRCRAFT
G. L. SLATER (Cincinnati, University, OH) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug, 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 793-803. refs
(Contract NAG2-175)
(AIAA PAPER 87-2406)

A synthesis procedure for on-line determination of variable speed trajectories in known winds between fixed way points is presented. The primary application is toward rotorcraft approach guidance, although the methodology can be directly applied to other types of vehicles and other problem areas. Trajectories are generated by appropriate combination of straight and turning flight segments to determine the horizontal ground track plus a vertical synthesis based on an energy rate approach. Perturbation equations and feedback laws for four-dimensional trajectory guidance are presented. Author

A87-50491*# University of Western Michigan, Kalamazoo.
MODEL-FOLLOWING OUTPUT FEEDBACK CONTROLLER FOR OBLIQUE-WING AIRCRAFT
GURBUX SINGH ALAG (Western Michigan University, Kalamazoo, MI) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 815-818.
(Contract NCC2-362)
(AIAA PAPER 87-2408)

A variable-skew oblique-wing offers a substantial aerodynamic performance advantage for aircraft missions that require both high efficiency in subsonic flight and supersonic dash or cruise. The most obvious characteristics of the oblique-wing concept is the asymmetry of the wing-skew angle that causes a significant aerodynamic and inertial cross coupling between the aircraft longitudinal and lateral-directional axes. This paper presents a technique for synthesizing a decoupling controller while providing the desired stability augmentation. The use of output feedback in control law synthesis without the requirement of state estimation is presented. An explicit model-following control system with output feedback is developed. The effectiveness of the control laws developed in achieving the desired decoupling is illustrated for a given flight condition for an oblique-wing aircraft. Author

A87-50496#
HANDLING QUALITIES DESIGN OF A NORTHROP HIGH-PERFORMANCE FIGHTER
OBI ILOPUTAIFE and LILY MA (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 849-857. refs
(AIAA PAPER 87-2450)

The Northrop F-20 Tigershark flight control system was developed based on the criteria established and verified during the YF-17 prototype flight test program. A brief description of the aircraft and its flight control system is followed by a discussion of problems encountered in flight test during precision tracking tasks. The solutions to these problems are discussed along with modifications to the criteria. Ground-based simulator verification of control laws reduced the need for frequent flight software updates and expensive flight testing. Level 1 pilot ratings were achieved with only one control law change in pitch and two control law changes in yaw in four years of flight testing. Author

A87-50497#
MODEL FOLLOWING FLIGHT CONTROL SYSTEM DESIGN FOR ATTAS, DFVLR'S NEW IN-FLIGHT SIMULATOR
S. CHETTY and F. HENSCHEL (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 858-865. refs
(AIAA PAPER 87-2451)

The content of this paper describes the theoretical development and nonlinear digital simulation results of the model following flight control system for DFVLR's new in-flight simulator ATTAS. A detailed description of the manner in which the feedforward and feedback gains are obtained using an interactive computer aided design technique is given. The feedforward gain matrices are obtained using the controllable companion form. Additional filters in the forward loop enables the gains to be made independent of the model aircraft parameters. The feedback gains are obtained by using a vector optimization technique. Several time and frequency domain criteria are used to obtain the required performance. Modified robustness measures based on singular value decomposition are derived and used to constrain the feedback gains. The sensitivity of the model following system to changes in flight condition is minimized using a multimodel formulation. Nonlinear simulation results are presented to show the quality of model following and substantiate the theory and design procedure. Author

A87-50498#
INTEGRAL LQG CONTROLLER DESIGN FOR A FIGHTER AIRCRAFT
CLAY M. THOMPSON, EDWARD E. COLEMAN, and JAMES D. BLIGHT (Boeing Military Airplane Co., Seattle, WA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 866-895. refs
(AIAA PAPER 87-2452)

An integral LQG design technique is presented using a manual lateral command and stability augmentation control law as an example. Rudder and ailerons are used to control sideslip and roll rate. An integral linear quadratic model-following regulator is used to obtain steady-state command following and robustness to aircraft parameter variations. An integral Kalman estimator provides steady-state sensor estimate tracking and robustness. The design technique addresses performance and flying qualities through the specification of explicit models and obtains robustness via the integral structure of both the regulator and estimator. The example control law shows excellent performance and robustness characteristics at the nominal design point and over a wide flight envelope using minimal gain scheduling. Author

A87-50499#
STABILITY AUGMENTATION FOR A FREE FLYING DUCTED FAN
J. E. WHITE and J. R. PHELAN (Sandia National Laboratories, Albuquerque, NM) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 896-904. refs
(AIAA PAPER 87-2453)

A control system design for the Marine Corp's AROD (Airborne Remote Operated Device) vehicle is described. The AROD vehicle consists of a single gasoline engine and propeller enclosed in a circular airfoil shroud, with the engine throttle and four control vanes (which are located just aft of the shroud) providing the necessary control authority. Linear quadratic regulator (LQR) and classical controller synthesis techniques were evaluated, with LQR producing a superior design for the coupled dynamics attitude controller because of the relatively slow frequency response of the model airplane servos used to drive the control vanes. The controller design methodology is explained and a combination of time responses and singular value analyses are used to evaluate the performance of the control system. Preliminary flight test data confirm the validity of the control system design. Author

A87-50500#
7J7 MANUAL FLIGHT CONTROL FUNCTIONS
MITHRA M. K. V. SANKRITHI and W. F. BRYANT (Boeing Commercial Airplane Co., Seattle, WA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 905-913.
(AIAA PAPER 87-2454)

The advanced manual control functions to be implemented in the primary flight control system of the 7J7, projected for the 1990's, are discussed. The pilot will command flight path angle, track/roll angle, and sideslip angle rather than control surface positions, resulting in reduced pilot workload in adverse weather conditions and consistently good flying qualities regardless of aircraft weight, center of gravity, configuration, or location in the flight envelope. Envelope protection functions will enhance aircraft safety and further reduce pilot workload. The 7J7 manual control functions have been validated in simulation tests. R.R.

A87-50535*# Systems Technology, Inc., Hawthorne, Calif.
SIMULATION INVESTIGATION OF THE EFFECTS OF HELICOPTER HOVERING DYNAMICS ON PILOT PERFORMANCE
BIMAL L. APONSO, DAVID G. MITCHELL, and ROGER H. HOH (Systems Technology, Inc., Hawthorne, CA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1263-1272. refs
(Contract NAS2-11304)
(AIAA PAPER 87-2533)

A fixed base simulation has been performed to investigate the handling qualities requirements for the mid-term pitch response of a helicopter at hover and in low-speed flight. Pilot rating results from this simulation were compared with those from previous experiments to develop handling qualities limits on the frequency and damping of the oscillatory mode in the hovering cubic. Pilot performance data obtained during the experiment were used to confirm the pilot rating results. These data show the pilot performance to closely match that predicted by the theory of piloted control. A means of predicting pilot ratings from the open-loop aircraft dynamics is presented. Author

A87-50536*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SIMULATION EVALUATION OF THE ADVANCED CONTROL CONCEPT FOR THE NASA V/STOL RESEARCH AIRCRAFT (VSRA)
E. MORALEZ, V. K. MERRICK (NASA, Ames Research Center, Moffett Field, CA), and J. A. SCHROEDER (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1273-1294. refs
(AIAA PAPER 87-2535)

Two candidate control systems for the Vertical/Short Takeoff and Landing (V/STOL) Research Aircraft (VSRA) are described, both of which are limited-authority, digital, fly-by wire variants of the original YAV-8B Harrier control system. The performance of these systems was compared with that of an ideal, full-authority system in simulated, adverse-weather V/STOL shipboard operations using the Ames Research Center's Vertical Motion Simulator. Both systems showed some performance degradation relative to the ideal, but both were adequate to meet VSRA program objectives. The favored system, selected because of safety considerations, was further simulated using a precision visual hovering task that verified its acceptability. Author

A87-50537#
LOOP SEPARATION PARAMETER - A NEW METRIC FOR LANDING FLYING QUALITIES
J. J. MARTZ, D. J. BIEZAD (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH), and E. D. DIDOMENICO (USAF, Aerospace Research Test Pilot School, Edwards AFB, CA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1295-1302. refs
(AIAA PAPER 87-2536)

Loop Separation Parameter is a metric used to evaluate the longitudinal flying qualities of aircraft in the landing flight phase. It combines simple pilot models with classical root locus and frequency response methods to predict Cooper-Harper pilot ratings for aircraft in the landing phase. Loop Separation Parameter was originally developed using fighter-type aircraft flight test data; in this paper the concept is extended and shown to be a good tool for predicting pilot ratings for large bomber, transport, and highly augmented Space Shuttle configurations. Loop Separation Parameter anticipates the tendency for and predicts the frequency of pilot induced oscillations. The effects of control system time delay and altitude lag time constant are discussed. It is recommended that Loop Separation Parameter be included in the Flying Qualities Handbook. Author

A87-50538#
INVESTIGATING AIRCRAFT HANDLING QUALITIES USING A STRUCTURAL MODEL OF THE HUMAN PILOT
R. A. HESS (California, University, Davis) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1303-1311. refs
(AIAA PAPER 87-2537)

A structural model of the human pilot is applied to investigating the handling qualities of a variety of aircraft configurations and tasks. A procedure for selecting parameter values for the model is introduced. Fifty-four different configurations from six data bases involving single and multi-loop single-axis flight tasks are analyzed. A metric for mapping closed-loop model signal statistics into Cooper-Harper pilot ratings is demonstrated. In order to use this method for handling qualities prediction, however, one must analyze a variety of vehicle configurations in the same task to establish an average inner-loop mean square performance. The model is used to suggest a plausible mechanism for the development of the 'roll-ratchet' phenomenon. Author

A87-50549#
FLY-BY-WIRE SYSTEM AND CONTROL LAWS OF THE T-2 CONTROL CONFIGURED VEHICLE
MASAHIRO YASUE, HIDEKI KANNO (Japan Defense Agency, Tokyo), HIROSHI ABE (Air Self-Defense Force, Tokyo, Japan), HIDEAKI OHMIYA, RYOJI KATAYANAGI (Mitsubishi Heavy Industries, Ltd., Nagoya, Japan) et al. IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1396-1404. refs
(AIAA PAPER 87-2586)

The T-2 Control Configured Vehicle (CCV) is the advanced research aircraft which was modified from the T-2 advanced supersonic trainer protootype, sponsored by the Technical Research and Development Institute (TRDI), Japan Defense Agency. The purposes of the research program are realization and demonstration of CCV concept and acquisition/assessment of engineering data. Triplex digital fly-by-wire (FBW) flight control system of the T-2 CCV made it possible to demonstrate various CCV modes which included longitudinal, lateral and directional control augmentation system (CAS) modes, maneuver load control (MLC) mode, direct lift control (DLC) modes, direct sideforce control (DSC) modes and relaxed static stability (RSS) mode. The T-2 CCV research program was successfully completed after a total of 162 flight tests conducted between August 1983 and March 1986. The paper provides the design concepts, development and flight test results of the system and control laws of the T-2 CCV. Author

A87-50550#
LONGITUDINAL HANDLING QUALITIES OF THE T-2 CONTROL CONFIGURED VEHICLE
KATSUHEI SHIBATA, MASATO NAKAO (Japan Defense Agency, Tokyo), HIDETOSHI HIRATA (Air Self-Defense Force, Tokyo, Japan), and TETSUROU HISANO (Mitsubishi Heavy Industries, Ltd., Nagoya, Japan) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1405-1413. refs
(AIAA PAPER 87-2587)

Improvement of the T-2 Control Configured Vehicle longitudinal control, in order to resolve problems encountered in longitudinal handling qualities, is considered. A six-degree-of-freedom mathematical simulation program is developed to achieve good frequency response characteristics of the pitch attitude/longitudinal stick force transfer function. The effectiveness of the new control law was demonstrated using a Handling Qualities During Tracking (HQDT) technique. The HQDT technique, employing a HUD for the simulated target, is found to be a simple and accurate method of evaluating the closed loop handling qualities. R.R.

A87-50553*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LINEAR OPTIMUM TRIM SOLUTION FOR AIRCRAFT WITH THREE LONGITUDINAL CONTROL EFFECTORS
KENNETH H. GOODRICH and STEVEN M. SLIWA (NASA, Langley Research Center, Hampton, VA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1433-1441. refs
(AIAA PAPER 87-2590)

A simple and fast linear optimum method for trimming aircraft with a combination of three longitudinal aerodynamic or propulsive control effectors is developed, with application to preliminary design or in-flight scheduling. A Lagrangian formulation is used to determine the longitudinal load distribution which minimizes trim drag. Trim drag results obtained with the linear optimum method are similar to those obtained with a nonlinear optimum method, and significant trim drag reductions are found using either optimum method, in comparison with results obtained using various ad hoc methods. R.R.

A87-50555#
TERMINAL GUIDANCE WITH LOW UPDATE RATES
STEPHEN F. ROUNDS (Singer Co., Electronic Systems Div., Wayne, NJ) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1454-1458.
(AIAA PAPER 87-2592)

A mechanization is presented in which a terminal sensor is tightly integrated with a navigation system. One of the important advantages of this mechanization is that the high frequency commanded vehicle rates required by the autopilot can be provided by the navigation system, with the terminal sensor used to solve the low frequency problem of error in target location. The conceptual design of such a system is presented, and simulation results are used to explore its further advantages. Author

A87-50564#
DYNAMIC PERFORMANCE AND STABILITY OF INTEGRATED COMMUNICATION AND CONTROL SYSTEMS
ASOK RAY, YORAM HALEVI, and LUEN-WOEI LIOU (Pennsylvania State University, University Park) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1538-1544. Sponsorship: Research suspported by the Allied-Signal, Inc. refs
(AIAA PAPER 87-2603)

Integrated communication and control systems (ICCSs) of advanced aircraft utilize communication networks for distributed information processing. The ICCS networks coordinate mission, avionics, subsystem utility, engine control, and flight-control and management functions to improve aircraft performance and utilization of available resources. The control system signals in ICCS networks are subject to time-varying time delays due to data latency and rejection of messages in the communication network, in addition to the sampling time delay. The paper identifies this problem and presents an approach and the initial results for its solution. The objective of this ongoing research is to analyze the dynamic performance and stability of feedback control systems that will lead to the development of a standard methodology for ICCS design. Author

A87-50569#
TECHNOLOGY REQUIREMENTS OF INTEGRATED, CRITICAL DIGITAL FLIGHT SYSTEMS
ANTHONY DETHOMAS (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) and PIO DE FEO (Sparta, Inc., Laguna Hills, CA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1579-1583. USAF-supported research.
(AIAA PAPER 87-2602)

An analysis of the available technology for Digital Flight Systems development and verification is presented, and the technology requirements of the flight control system for the next generation of highly integrated military aircraft are discussed. The major technology needs in the two critical areas of system architecture design and analysis, and software development and verification, are identified. Tools and techniques for the support of the development of these systems, including data stress tests and timing stress tests for software verification, are considered. R.R.

N87-26915*# Purdue Univ., West Lafayette, Ind. School of Aeronautics and Astronautics.
MULTI-INPUT MULTI-OUTPUT SYSTEM CONTROL FOR EXPERIMENTAL AIRCRAFT Final Technical Report
DAVID K. SCHMIDT 20 Aug. 1987 58 p
(Contract NCC2-288)
(NASA-CR-181197; NAS 1.26:181197) Avail: NTIS HC A04/MF A01 CSCL 01C

Results from the synthesis of control laws for an advanced short takeoff aircraft in a low-speed approach flight condition are given. Two of four candidate synthesis techniques are reported: direct eigenspace assignment and explicit model following via a linear quadratic regulator (LQR) formulation. A fundamental objective of this work is to obtain low-order feedback compensators, synthesized via the above techniques, and the judicious use of state estimation, thus allowing the use of a reasonable number of sensors for feedback. Author

N87-26916# Aeronautical Research Labs., Melbourne (Australia).
THE COMPUTED GUST RESPONSE OF AN AIRCRAFT. THE RELATIVE EFFECT OF VARIOUS DEGREES OF FREEDOM
S. C. GALEA Jul. 1986 135 p
(AD-A180968; ARL-STRUC-TM-447) Avail: NTIS HC A07/MF A01 CSCL 01A

A typical jet transport aircraft has been modelled with increasing numbers of degrees of freedom. Transfer functions and spectral parameters, A and N sub o, were evaluated using two gust models. The first gust model consisted of gust variations in the streamwise direction alone. The second model, a two dimensional gust model, is made up of variations in both the streamwise and spanwise direction. In both of these cases a von Karman gust spectrum, with integral scale of turbulence of 688m, was assumed. As the degree of flexibility of the model was augmented from one to five degrees of freedom the spectral parameter, A, increased by 8%. The value of N sub o was strongly biased by the high frequency response of the model. Therefore it was concluded that trends in N sub o with system flexibility, could not be determined accurately until the asymptotic behavior of the response is known. For the five degree of freedom model the introduction of spanwise variations in gust caused only slight variations in the spectral parameters A and N sub o. GRA

N87-26917# Calspan Advanced Technology Center, Buffalo, N.Y.
EXPERIMENTAL INVESTIGATION OF THE SHORT-PERIOD REQUIREMENTS OF MIL-F-8785C, VOLUME 2 Interim Report, Jun. 1984 - Dec. 1985
RANDALL E. BAILEY Nov. 1986 211 p
(Contract F33615-83-C-3603)
(AD-A181475; CALSPAN-7205-9-VOL-2; AFWAL-TR-86-3109-VOL-2) Avail: NTIS HC A10/MF A01 CSCL 01D

An investigation of the short period frequency requirements of MIL-F-8785C was performed using an in-flight simulator. Thirty-five evaluations of eighteen configurations were conducted. The experiment examined the minimum frequency boundary at three values of alpha for one true airspeed. The experiment included the effects of pilot location and evaluation task. The data indicate that the current requirement is essentially valid. The minimum acceptable frequency boundary may be relaxed, however, when the pilot station is forward of the center of rotation. Also, the phasing between the normal acceleration and pitch rate responses has been shown to be a critical determinant of longitudinal short period flying qualities. The results are analyzed also using the equivalent systems methodology. GRA

N87-26918*# Boeing Commercial Airplane Co., Seattle, Wash.
NASA B737 FLIGHT TEST RESULTS OF THE TOTAL ENERGY CONTROL SYSTEM
KEVIN R. BRUCE Jul. 1987 103 p
(Contract NAS1-17509)
(NASA-CR-178285; NAS 1.26:178285) Avail: NTIS HC A06/MF A01 CSCL 01C

The Total Energy Control System (TECS) is an integrated autopilot/autothrottle developed by BCAC that was test flown on NASA Langley's Transport System Research Vehicle (i.e., a highly modified Boeing B737). This systems was developed using principles of total energy in which the total kinetic and potential energy of the airplane was controlled by the throttles, and the energy distribution controled by the elevator. TECS integrates all the control functions of a conventional pitch autopilot and autothrottle into a single generalized control concept. This integration provides decoupled flightpath and maneuver control, as well as a coordinated throttle response for all maneuvers. A mode hierarchy was established to preclude exceeding airplane safety and performance limits. The flight test of TECS took place as a series of five flights over a 33-week period during September 1985 at NASA Langley. Most of the original flight test plan was completed within the first three flights with the system not exhibiting any instabilities or design problems that required any gain adjustment during flight. Author

N87-26919*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PILOTED SIMULATOR STUDY OF ALLOWABLE TIME DELAY IN PITCH FLIGHT CONTROL SYSTEM OF A TRANSPORT AIRPLANE WITH NEGATIVE STATIC STABILITY
WILLIAM D. GRANTHAM, PAUL M. SMITH, LEE H. PERSON, JR., ROBERT T. MEYER, and STEPHEN A. TINGAS (Lockheed-Georgia Co., Marietta.) Sep. 1987 32 p
(NASA-TM-89147; L-16282; NAS 1.15:89147) Avail: NTIS HC A03/MF A01 CSCL 01C

A piloted simulation study was conducted to determine the permissible time delay in the flight control system of a 10-percent statically unstable transport airplane during cruise flight conditions. The math model used for the simulation was a derivative Lockheed L-1011 wide-body jet transport. Data were collected and analyzed from a total of 137 cruising flights in both calm- and turbulent-air conditions. Results of this piloted simulation study verify previous findings that show present military specifications for allowable control-system time delay may be too stringent when applied to transport-size airplanes. Also, the degree of handling-qualities degradation due to time delay is shown to be strongly dependent on the source of the time delay in an advanced flight control system. Maximum allowable time delay for each source of time delay in the control system, in addition to a less stringent overall maximum level of time delay, should be considered for large aircraft. Preliminary results also suggest that adverse effects of control-system time delay may be at least partially offset by variations in control gearing. It is recommended that the data base include different airplane baselines, control systems, and piloting tasks with many pilots participating, so that a reasonable set of limits for control-system time delay can be established to replace the military specification limits currently being used.
Author

N87-26920*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, Calif.
DYNAMIC STABILITY AND HANDLING QUALITIES TESTS ON A HIGHLY AUGMENTED, STATICALLY UNSTABLE AIRPLANE
JOSEPH GERA and JOHN T. BOSWORTH Aug. 1987 16 p
Presented at the AIAA Guidance, Navigation and Control Conference, Monterey, Calif., 17-19 Aug. 1987and at SFTE 18th Annual Symposium, Amsterdam, Netherlands, 28 Sep. - 2 Oct. 1987
(NASA-TM-88297; H-1422; NAS 1.15:88297; AIAA-87-2258-CP)
Avail: NTIS HC A02/MF A01 CSCL 01C

Initial envelope clearance and subsequent flight testing of a new, fully augmented airplane with an extremely high degree of static instability can place unusual demands on the flight test approach. Previous flight test experience with these kinds of airplanes is very limited or nonexistent. The safe and efficient flight testing may be further complicated by a multiplicity of control effectors that may be present on this class of airplanes. This paper describes some novel flight test and analysis techniques in the flight dynamics and handling qualities area. These techniques were utilized during the initial flight envelope clearance of the X-29A aircraft and were largely responsible for the completion of the flight controls clearance program without any incidents or significant delays.
Author

N87-26922*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PILOTED-SIMULATION STUDY OF EFFECTS OF VORTEX FLAPS ON LOW-SPEED HANDLING QUALITIES OF A DELTA-WING AIRPLANE
JAY M. BRANDON, PHILIP W. BROWN, and ALFRED J. WUNSCHEL Sep. 1987 38 p
(NASA-TP-2747; L-16307; NAS 1.60:2747) Avail: NTIS HC A03/MF A01 CSCL 01C

A piloted-simulation study was conducted to investigate the effects of vortex flaps on low-speed handling qualities of a delta-wing airplane. The simulation math model was developed from wind tunnel tests of a 0.15 scale model of the F-106B airplane. Pilot evaluations were conducted using a six-degree-of-freedom motion base simulator. The results of the investigation showed that the reduced static longitudinal stability caused by the vortex flaps significantly degraded handling qualities in the approach-to-landing task. Acceptable handling qualities could be achieved by limiting the aft center-of-gravity location, consequently reducing the operational envelope of the airplane. Further improvement were possible by modifying the flight control force-feel system to reduce pitch-control sensitivity.
Author

N87-27605*# Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.
FAULT-TOLERANT FLIGHT CONTROL SYSTEM COMBINING EXPERT SYSTEM AND ANALYTICAL REDUNDANCY CONCEPTS
DAVE HANDELMAN *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1985 p 73-85 Jul. 1987
Avail: NTIS HC A05/MF A01 CSCL 01C

This research involves the development of a knowledge-based fault-tolerant flight control system. A software architecture is presented that integrates quantitative analytical redundancy techniques and heuristic expert system problem solving concepts for the purpose of in-flight, real-time failure accommodation.
Author

N87-27673 Purdue Univ., West Lafayette, Ind.
AN INTERACTIVE SYNTHESIS APPROACH FOR ROBUST ACTIVE FLUTTER SUPPRESSION CONTROL LAW DESIGN Ph.D. Thesis
TA KANG CHEN 1986 275 p
Avail: Univ. Microfilms Order No. DA8709786

Computer-aided, graphical, frequency-domain synthesis approach is employed in the control law design process for robust active flutter suppression (AFS). The relatively high dynamic order of such problems are dealt with effectively with a computer-aided approach, while interactive computer graphics allows frequency-domain graphical techniques to be utilized. Key design information is displayed for variations in flight conditions such that simple control laws are obtained that are robust over various flight conditions under consideration. Through visualization of the pole and zero migration with dynamic pressure, control synthesis, evaluation can be performed almost by inspection. Several candidate control laws are analytically shown to compare very favorably to several others taken from the literature. For the AFS problem, it is found that the aeroelastic mode dipole orientations significantly impact the easiness in the control synthesis process and the possibly achievable overall system performance and controller robustness. The selection of sensor location plays an important role in the determination of advantageous dipole orientations.
Dissert. Abstr.

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RESEARCH AND SUPPORT FACILITIES (AIR)

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

A87-47118#
THE BHTC FLIGHT TEST FACILITY - AN OVERVIEW
J. ST-LAURENT, R. C. SMITH, and B. G. QUART (Bell Helicopter Textron, Laval, Canada) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 33, June 1987, p. 76-83.

This paper will present an overview of the Bell Helicopter Textron, Canada (BHTC) flight test facility, which is planned to start operations in October 1987. A brief history of the flight test facility development is given and its capabilities and architecture are discussed from the perspective of the flight test engineer. In particular, the following topics will be discussed: (1) flight test

requirements, (2) the airborne data acquisition system, (3) telemetry capability, and (4) the computer-aided flight test analysis system.
Author

A87-47316#
CLASSIFICATION OF THE LOAD-CARRYING CAPACITY OF RUNWAY SURFACES BY THE ACN-PCN METHOD. IV [KLASYFIKACJA NOSNOSCI NAWIERZCHNI LOTNISKOWYCH METODA ACN-PCN. IV]
KRZYSZTOF CZARNECKI (Instytut Techniczny Wojsk Lotniczych, Warsaw, Poland) Technika Lotnicza i Astronautyczna (ISSN 0040-1145), vol. 42, April 1987, p. 7-9. In Polish.

A87-47691#
A TENTATIVE OPTION FOR VENTILATION RATIO OF SLOTTED WALL IN TWO-DIMENSIONAL TRANSONIC WIND TUNNEL
LIXIA WANG, SHIJUN LOU, YAOXI SU, and ZHIMIN CHEN (Northwestern Polytechnical University, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, Jan. 1987, p. A103-A109. In Chinese, with abstract in English. refs

The effect of a slotted wall with ventilation ratio 2 or 5 percent on the flow over a NACA 0012 profile at Mach numbers 0.6, 0.75, and 0.9 and angles of attack 0-3 deg is investigated experimentally in a two-dimensional transonic wind tunnel. The results are presented graphically and compared with the predictions of numerical computations based on the transonic small-disturbance pressure equation. It is found that wall interference can be significantly reduced or even eliminated by an unevenly ventilated wall. T.K.

A87-47880
BASIC PRINCIPLES FOR THE DESIGN AND OPERATION OF OFF-SHORE HELIDECKS
V. I. BEREZIN and V. G. GAVKO (Research Institute Aeroproject, USSR) ICAO Bulletin, vol. 42, June 1987, p. 17-20.

The requirements for designing offshore landing areas for helicopters on floating drill rigs are described. In designing these areas, consideration must be given to the conditions under which it is to be used. It is necessary for the landing area to be a sufficient size in order to operate flights with maximum intensity and take-off mass. It is determined that the cantilever arrangement of the landing area is most preferable. The advantages and disadvantgaes of locating the cantilevered helideck next to two rig supports or next to only one rig support are examined. The data reveal that the location of the helideck near only one support rig is most advantageous. The equipment necessary to ensure the helicopter flight safety and the safety of the rig personnel and helicopter passengers is discussed. A diagram of a typical helideck landing area is presented. I.F.

A87-47881
FIRST RESULTS OF PARALLEL-RUNWAY SEPARATION STUDIES IN THE USSR
V. I. BLOKHIN, I. V. TSIPRIIANOVICH (Kievskii Institut Inzhenerov Grazhdanskoi Aviatsii, Kiev, Ukrainian SSR), and V. I. BEREZIN (Research Institute Aeroproject, USSR) ICAO Bulletin, vol. 42, June 1987, p. 26-29.

Three runway patterns are examined in order to determine safe distances for various operations. The patterns considered include: (1) two independent nonspecialized parallel runways; (2) two independent specialized parallel runways which are not longitudinally displaced with respect to each other; and (3) two independent specialized parallel runways which are longitudinally displaced with respect to each other. The minimum permissible distances between runways is estimated as a function of aircraft traffic characteristics, random value distribution parameters, and the assigned level of flight safety. Data from 3000 take-offs and landings at 10 USSR airports are analyzed, and minimum safety distances are derived. I.F.

A87-48162
THE FUTURE USE OF THE EUROPEAN TRANSONIC WIND TUNNEL ETW IN THE DEVELOPMENT OF ADVANCED AIRCRAFT [DER ZUKUENFTIGE EINSATZ DES EUROPAEISCHEN TRANSSCHALL-WINDKANALS ETW GEI DER ENTWICKLUNG FORTSCHRITTLICHER FLUGZEUGE]
W. HEINZERLING (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Yearbook 1986 II; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 700-711. In German. refs
(DGLR PAPER 86-140)

A87-48165
FROM OETZTAL TO MODANE - FROM THE HISTORY OF THE LARGE HIGH-SPEED WIND TUNNEL 'BAUVORHABEN 101' OF THE LUFTFAHRTFORSCHUNGSANSTALT MUENCHEN (LFM), LATER ONERA FACILITY S1 MA [VON OETZTAL NACH MODANE - AUS DER GESCHICHTE DES GROSSEN HOCHGESCHWINDIGKEITS-WINDKANALS 'BAUVORHABEN 101' DER LUFTFAHRTFORSCHUNGSANSTALT MUENCHEN /LFM/, SPAETER ANLAGE S1 MA DER ONERA]
ERNSTFRIED THIEL (Dornier GmbH, Friedrichshafen, West Germany) IN: Yearbook 1986 II; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 773-795. In German. refs

The history, design, and facilities of the 8-m-diameter S1 MA high-speed (up to M = 1.0) wind tunnel at ONERA Modane are reviewed and illustrated with extensive diagrams, drawings, graphs, and photographs. The directly water-powered 76-MW tunnel was originally designed in the 1940s (as 'Construction Project 101') for a site at Oetztal in the Tirolean Alps, but was only partially completed in 1945. It was disassembled and then completely installed at Modane during 1946-1952, and has been in continuous service since that time. T.K.

A87-48277
WIND TUNNEL TESTING OF COUNTER-ROTATING PROPS
EUGENE G. SEVIGNY Aerospace Engineering (ISSN 0736-2536), vol. 7, July 1987, p. 14-18.

A wind tunnel model contrarotating propfan of 1-ft diameter has been used in a study of its aerodynamic interactions with the nacelle structures and fuselage of an airliner afterbodylike configuration. Distance variations between nacelle and fuselage affect fan characteristics; blade settings for fixed torque ratio and constant power are a function of local flow field, which is in turn affected by fuselage proximity. Data are presented on rotor performance trends for changes in the gradient of thrust with angle of attack. It is shown by the data that torque ratios or power levels shift dramatically with changes in the angle of attack. O.C.

A87-48288* Notre Dame Univ., Ind.
THE WATER TOWING TANK AS AN EXPERIMENTAL FACILITY
M. GAD-EL-HAK (Notre Dame, University, IN) Experiments in Fluids (ISSN 0723-4864), vol. 5, no. 5, 1987, p. 289-297. refs
(Contract NSF ISI-85-60825; F49620-82-C-0020; N00014-81-C-0453; NAS1-17951; NAS1-18292; NAS1-18213)

Wind tunnels and flumes have become standard laboratory tools for modeling a variety of aerodynamic and hydrodynamic flow problems. Less available, although by no means less useful, are facilities in which a model can be towed (or propelled) through air or water. This article emphasizes the use of the water towing tank as an experimental tool for aerodynamic and hydrodynamic studies. Its advantages and disadvantages over other flow rigs are discussed, and its usefulness is illustrated through many examples of research results obtained over the past few years in a typical towing tank facility. Author

A87-48294
BOUNDARY LAYER TWO-DIMENSIONALITY IN WIND TUNNELS
R. D. MEHTA (Stanford University, CA) and P. H. HOFFMANN (Royal Melbourne Institute of Technology, Australia) Experiments in Fluids (ISSN 0723-4864), vol. 5, no. 5, 1987, p. 358-360. refs

An experimental finding is presented which is intended to serve as a warning to wind tunnel designers and users. Results from a detailed experimental study (Mehta and Hoffmann, 1986) show that the open-area ratio of the screen alone is not enough to define the stability of the emerging flow field. For wind tunnel applications, screens should be selected with beta greater than 0.57, to minimize the production of directional instabilities, and a wire diameter such that the Reynolds number based on it is less than 50, to avoid vortex shedding. However, for suppression of preexisting variations, the present results show that a criterion based on screen open-area ratio alone is not adequate. B.J.

A87-48971#
THEORETICAL AND EXPERIMENTAL INVESTIGATIONS ON A SIX-COMPONENT ROTOR BALANCE
G. LEHMANN (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) and K.-H. FU European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 20 p. refs

The paper examines the estimation of the dynamic characteristics of the six-component balance used with the rotor test stand of the DFVLR Institute of Flight Mechanics for testing in large wind tunnels. Three methods were used to determine the dynamic characteristics: a mathematical model with six degrees of freedom; a transfer function (TF) measurement technique; and two system identification techniques, least squares and maximum likelihood. It is shown that the dedicated balance cannot be described with a 6-DOF rigid body model. The TF measurement technique yields good estimates in the calibration case; however, in the measurement case, numerous unidentifiable errors lead to inexact results. System identification can yield a satisfactory estimation of the input-output relations for the balance. Combined with Kalman-filter data reduction, this approach appears to be a good way to perform dynamic force measurements. B.J.

A87-49110#
INVESTIGATION OF WALL INTERFERENCE AT HIGH ANGLE OF ATTACK IN A LOW SPEED WIND TUNNEL WITH SLOTTED WALL
WANG SHUJIE, YUAN RONGXI, and CHANG RUIQIN (Chinese Aeronautical Establishment, Harbin Aerodynamics Research Institute, People's Republic of Ch IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 578-584. refs
(AIAA PAPER 87-2611)

A slotted-wall low speed wind tunnel test section has been developed in order to minimize wall interference at high angle of attack. Tunnel performance is determined by the testing of a model whose span/tunnel test section diameter ratio is 0.49 under a variety of wall geometry conditions. It is found that wall interference can be substantially reduced. Slotted wall results are compared with known results lacking wall interference effects, in order to determine the optimum open/close wall ratio. The vortex lattice method is employed to evaluate the average residual lifting interference. O.C.

A87-49111#
PSEUDO REYNOLDS NUMBER TRENDS
FELIX AULEHIA (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: AIAA Applied Aerodynamics Conference, 5th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 585-595. refs
(AIAA PAPER 87-2612)

Until the mid-1970s, many variable-density wind tunnels were calibrated at only the nominal freestream total pressure, rather than over the entire Re number range; this led to freestream Mach number and axial pressure gradient errors that yielded spurious Re number effects. The mean value of wall pressures in an empty wind tunnel test section is an excellent tool for the detection of even very small errors in the freestream Mach number and axial pressure gradient during Re variation, while all other parameters, including wall porosity and divergence, are kept constant. True transonic Re number effects are up to 100 percent smaller than those obtained in sensitive wind tunnel experiments without full Re number calibration, as shown for the cases of afterbody pressure drag, transonic maximum lift, and transonic shock location. O.C.

A87-49158#
MULTI-AIRCRAFT SIMULATION - SOME PROBLEMS AND PROSPECTS
STEVE SEIDENSTICKER (Logicon, Inc., San Diego, CA) IN: AIAA Flight Simulation Technologies Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 8-16. refs
(AIAA PAPER 87-2300)

The application of multiaircraft simulation (MAS) to formation flying, mutual support, and many-vs-many engagements is examined. Consideration is also given to MAS problems involving intersimulator communication, interface standards, and geographic separation constraints. Finally, attention is given to several programs whose goals involve MAS, including the MODSIM, SIMNET, and F-14D WST programs. B.J.

A87-49168#
OPERATING EXPERIENCE OF A SMALL SIX AXIS MOTION SYSTEM INSIDE A DOME WITH A WIDE ANGLE VISUAL SYSTEM
A. G. BARNES (British Aerospace, PLC, Warton, England) IN: AIAA Flight Simulation Technologies Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 86-95. refs
(AIAA PAPER 87-2437)

A new research simulator at British Aerospace, Warton utilizes a McFadden six degree of freedom motion system, operating inside a 30 foot diameter dome. Computer Generated Images giving a wide field of view are displayed on the dome by fixed projectors. This novel configuration has clear performance advantages over other solutions. As well as providing an uncluttered cockpit, it utilizes proven technology. Details of the installation are described, and the configuration trade-offs are discussed. Author

A87-49173*# CAE Electronics Ltd., Montreal (Quebec).
SIMULATION IN SUPPORT OF ADVANCED COCKPIT DEVELOPMENT
P. A. LYPACZEWSKI (CAE Electronics, Ltd., Montreal, Canada), A. D. JONES (NASA, Ames Research Center, Moffett Field, CA), and J. W. VOORHEES (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: AIAA Flight Simulation Technologies Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 134-140.
(AIAA PAPER 87-2572)

It is noted that the system complexity and high workload of the next generation of light scout/attack (SCAT) helicopters are areas of great interest to the U.S. Army. This paper describes the Crew Station Research and Development Program established by the Army to study the issues of battle captain performance for one-man vs. two-man crews. A Crew Station Research and Development Facility (CSRDF) has been contracted for which consists of a distributed computer system with several stations which play different roles in experiments. Coordination of experiments is effected from the Experimenter/Operator Console where a team of Army experimenters and NASA personnel controls and monitors the mission scenario used to test the crew members. B.J.

A87-49176#
AH-64 COMBAT MISSION SIMULATOR TACTICAL SYSTEM
EDWARD DREW, GARY GEORGE, and SAMUEL KNIGHT (Singer Co., Link Flight Simulation Div., Binghamton, NY) IN: AIAA Flight Simulation Technologies Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 155-164.
(AIAA PAPER 87-2575)

This paper describes the design of the heart of the CMS, the tactical system. Included are the Fire Control System, Target Acquisition and Designation System (TADS), Pilot Night Vision Sensor (PNVS), Laser Rangefinder/Designator, Laser Tracker, Integrated Helmet and Display Sighting System, Hellfire Point Target Weapon System, 2.75-inch Aerial Rocket control and Delivery System, 30-mm gun, and airborne survivability equipment, as well as the interative threat environment simulated. It also discusses the implementation of these systems in the total mission scenario required by the Army for training. Author

A87-49201
SATISFYING THE FLIGHT TEST DATA REQUIREMENTS OF FLIGHT TRAINING SIMULATORS
GREGORY A. SHOALES (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: Society of Flight Test Engineers, Annual Symposium, 17th, Washington, DC, Aug. 10-14, 1986, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1986, p. 2.1-1 to 2.1-9. refs

The paper presents illustrations of six flight training simulator procurement programs. The illustrations describe the simulator and the particular problems faced by each program in satisfying the flight test data requirements. It is presented that an adequate set of validation tests is vital to assuring quality of a high fidelity simulation. The key to a successful validation test is having a sufficient flight test data base to satisfy the requirements of those tests. The quality of the data base and thus the simulation is vastly improved through early coordination with the corresponding aircraft test organizations. Finally, it is concluded that simulation programs must concern themselves with satisfying the flight test data requirements from program day one and throughout the entire acquisition cycle. Author

A87-49990#
SUPERSONIC AND TRANSONIC AERODYNAMIC CHARACTERISTICS OF SB301 TWO-DIMENSIONAL CASCADE WIND TUNNEL
ZHENGLI JIANG and JINXIAN MA (Gas Turbine Establishment, People's Republic of China) Journal of Aerospace Power, vol. 2, April 1987, p. 162-164, 189, 190. In Chinese, with abstract in English.

The SB301 wind tunnel was designed to test the two-dimensional cascades of compressors in subsonic, transonic and supersonic flow. The wind tunnel has been equipped with advanced instrumentation that enables to accomplish a wide range of experimentation, such as testing the two-dimensional cascades of compressor in transonic and supersonic flow. It provides a new test rig for Chinese research and development of aircraft engines with high performance. Author

A87-50190*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
REACTIVATION STUDY FOR NASA LEWIS RESEARCH CENTER'S HYPERSONIC TUNNEL FACILITY
JEFFREY E. HAAS (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 14 p. Previously announced in STAR as N87-23664. refs
(AIAA PAPER 87-1886)

The Hypersonic Tunnel Facility (HTF) at NASA Lewis Research Center's Plum Brook Station is a blowdown, free-jet, nonvitiated propulsion facility capable of Mach 5, 6, and 7 with true temperature, altitude, and air composition simulation. The facility has been in a deactivated status for 13 years. Discussed are the capabilities of HTF, and the results of a deactivation study recently conducted to determine the cost, schedule, and technical effort required to restore HTF to its original design operating capabilities are summarized. Author

N87-26923*# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
IMPLEMENTATION AND VALIDATION OF A WAKE MODEL FOR VORTEX-SURFACE INTERACTIONS IN LOW SPEED FORWARD FLIGHT Semiannual Status Report, 1 Oct. 1986 - 31 Mar. 1987
NARAYANAN M. KOMERATH and OLIVIER A. SCHREIBER Mar. 1987 27 p
(Contract NAG1-693)
(NASA-CR-180623; NAS 1.26:180623) Avail: NTIS HC A03/MF A01 CSCL 14B

The wake model was implemented using a VAX 750 and a Microvax II workstation. Online graphics capability using a DISSPLA graphics package. The rotor model used by Beddoes was significantly extended to include azimuthal variations due to forward flight and a simplified scheme for locating critical points where vortex elements are placed. A test case was obtained for validation of the predictions of induced velocity. Comparison of the results indicates that the code requires some more features before satisfactory predictions can be made over the whole rotor disk. Specifically, shed vorticity due to the azimuthal variation of blade loading must be incorporated into the model. Interactions between vortices shed from the four blades of the model rotor must be included. The Scully code for calculating the velocity field is being modified in parallel with these efforts to enable comparison with experimental data. To date, some comparisons with flow visualization data obtained at Georgia Tech were performed and show good agreement for the isolated rotor case. Comparison of time-resolved velocity data obtained at Georgia Tech also shows good agreement. Modifications are being implemented to enable generation of time-averaged results for comparison with NASA data. B.G.

N87-27675# Illinois Univ., Urbana. Civil Engineering Lab.
DEVELOPMENT OF MECHANISTIC FLEXIBLE PAVEMENT DESIGN CONCEPTS FOR THE HEAVYWEIGHT F-15 AIRCRAFT Final Report, Aug. 1983 - May 1986
HENRY F. KELLY Sep. 1986 228 p
(Contract F08637-85-M-6023)
(AD-A181596; AFESC/ESL-TR-86-32) Avail: NTIS HC A11/MF A01 CSCL 01E

This technical report describes a mechanistic method proposed for design of flexible airfield pavements. The report reviews the CBR Flexible Airfield Pavements Design currently used by DOD and the FAA. Then follows a description of the ILLIPAVE finite element computer model and pavement performance transfer functions developed using ILLIPAVE. Actual test data using aircraft-sized loads was used to correlate the constants used in the computer model. The proposed method was then used to design a flexible pavement to support a heavyweight F-15 (30,600 lb SWL, 355 psi). Finally, the subsequent design is compared to the design resulting from the CBR method. GRA

N87-27677# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction de l'Aerodynamique.
SEARCH FOR A PRINCIPLE TO GENERATE HIGH FREQUENCY GUSTS Final Report [RECHERCHE D'UN PRINCIPE DE GENERATEUR DE RAFALES HAUTE FREQUENCE]
H. CONSIGNY Mar. 1986 59 p In FRENCH
(Contract DRET-85-34-001)
(ONERA-RSF-92/1865-AY; ETN-87-90125) Avail: NTIS HC A04/MF A01

Gust generators of three different kinds were tested in a small (180x180 mm) wind tunnel. These were resonant cavities, fixed spoilers, and rotating cams mounted on the wall. The measurements carried out with laser velocimeters and clinometric transducers show that the cam device generates gusts of 1 to 3 deg amplitude and frequency up to 600 Hz with acceptable homogeneity. ESA

N87-27678*# Old Dominion Univ., Norfolk, Va. Dept. of Electrical and Computer Engineering.
SUPPORT OF THE EIGHT-FOOT HIGH TEMPERATURE TUNNEL MODIFICATION PROJECT Final Report, period ended 16 Aug. 1987
KIM CHI NGO and ROLAND R. MIELKE Aug. 1987 28 p
(Contract NAS1-17993)
(NASA-CR-181280; NAS 1.26:181280) Avail: NTIS HC A03/MF A01 CSCL 14B

In order to meet the need for propulsion testing in the high supersonic range from Mach 4 to Mach 7, NASA has undertaken the modification of the Langley Eight Foot High Temperature Tunnel to add alternate Mach number capability and oxygen enrichment to allow the testing of operating engines at these Mach numbers and at true temperature tunnel. The transfer of liquid oxygen (LOX) from a storage vessel to a rocket engine generally requires the use of a pressurizing gas at high pressures. Although nitrogen is preferred, unfortunately, when gaseous nitrogen (GN2) is used as the pressurant to transfer liquid oxygen from a storage tank to the tunnel combustor, it contaminates the liquid oxygen and effects a loss of performance in the engine. The contamination of the LOX by the pressurizing GN2 is described, which may prove to be an important operational constraint. It is desirable to have reliable data concerning the penetration of GN2 into LOX during pressurization and the subsequent of self cleaning after blowdown. Author

N87-27680*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
TIME-AVERAGED AERODYNAMIC LOADS ON THE VANE SETS OF THE 40- BY 80-FOOT AND 80- BY 120-FOOT WIND TUNNEL COMPLEX
KIYOSHI AOYAGI, LAWRENCE E. OLSON, RANDALL L. PETERSON, GLORIA K. YAMAUCHI, JAMES C. ROSS, and THOMAS R. NORMAN Aug. 1987 190 p
(NASA-TM-89413; A-87039; NAS 1.15:89413) Avail: NTIS HC A09/MF A01 CSCL 14B

Time-averaged aerodynamic loads are estimated for each of the vane sets in the National Full-Scale Aerodynamic Complex (NFAC). The methods used to compute global and local loads are presented. Experimental inputs used to calculate these loads are based primarily on data obtained from tests conducted in the NFAC 1/10-Scale Vane-Set Test Facility and from tests conducted in the NFAC 1/50-Scale Facility. For those vane sets located directly downstream of either the 40- by 80-ft test section or the 80- by 120-ft test section, aerodynamic loads caused by the impingement of model-generated wake vortices and model-generated jet and propeller wakes are also estimated. Author

N87-27681*# Southampton Univ. (England). Dept. of Aeronautics and Astronautics.
HIGH ANGLE OF ATTACK POSITION SENSING FOR THE SOUTHAMPTON UNIVERSITY MAGNETIC SUSPENSION AND BALANCE SYSTEM Progress Report, Jan. 1986 - Mar. 1987
DAVID H. PARKER Aug. 1987 38 p
(Contract NSG-7523)
(NASA-CR-178358; NAS 1.26:178358; AASU-87/3) Avail: NTIS HC A03/MF A01 CSCL 14B

An all digital five channel position detection system is to be installed in the Southampton University Magnetic Suspension and Balance System (SUMSBS). The system is intended to monitor a much larger range of model pitch attitudes than has been possible hitherto, up to a maximum of a 90 degree angle of attack. It is based on the use of self-scanning photodiode arrays and illuminating laser light beams, together with purpose built processing electronics. The principles behind the design of the system are discussed, together with the results of testing one channel of the system which was used to control the axial position of a magnetically suspended model in SUMSBS. The removal of optically coupled heave position information from the axial position sensing channel is described. 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.

A87-47776
HOTOL - A MULTI-ROLE AEROSPACECRAFT FOR EUROPE
B. R. A. BURNS (British Aerospace, PLC, Warton, England) Aerospace (UK) (ISSN 0305-0831), vol. 14, July-Aug. 1987, p. 8-15.

A development history and current configurational and component design status is presented for the 'Hotol' horizontal takeoff and landing/single stage to low earth orbit vehicle, which will employ the hybrid airbreathing propulsion system designated RB545 to both operate as an aircraft within the atmosphere and as a spacecraft in orbital space. Attention is given to the takeoff trolley horizontal launch system, the airframe's metallic thermal protection system, airframe structural and aerodynamic design rationales, and the function of forward vertical fin control during landings. The proposed operating base is projected to be very simple by comparison to the Space Shuttle's Kennedy Space Center. Hotol development program funding will come from the ESA partner nations. O.C.

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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.

A87-47681#
STATE-OF-ART AND PROSPECT FOR MATERIALS AND HOT WORKING TECHNOLOGY FOR GAS TURBINE DISK
CHANGGAN XU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 8, Jan. 1987, p. A10-A19. In Chinese, with abstract in English. refs

Advances in the development of materials and hot processing techniques for gas-turbine disks in the PRC are surveyed. It is pointed out that the service life of disks for high-thrust/weight-ratio turbines is affected more by manufacturing-induced defects than by inadequate alloy formulations. Improved fabrication approaches based on powder metallurgy, isothermal hot working, and HIP are evaluated. Uniformity and stability problems of powder techniques are found to limit the low-cycle fatigue life of the disks, but the latter two methods are considered promising. The parallel development of new alloys and processes is recommended. T.K.

A87-47821
ULTRASONIC CHARACTERISTICS OF GRAPHITE/EPOXY COMPOSITE MATERIAL SUBJECTED TO FATIGUE AND IMPACTS
HAMID NAYEB-HASHEMI, MENASHI D. COHEN, JOHN ZOTOS, and RAYMOND POORMAND (Northeastern University, Boston, MA) Journal of Nondestructive Evaluation (ISSN 0195-9298), vol. 5, Dec. 1986, p. 119-131. Research supported by the Engineering Foundation, NSF, and U.S. Army. refs

The effects of fatigue and impact loadings on unidirectional graphite epoxy composites are investigated. The mechanical properties, residual fatigue life, and post-impact damage for the

composites subjected to impact energies of 0.567 J, 1.1334 J, and 1.571 J are evaluated. The relation between tensile and fatigue testing and ultrasonic characteristics is examined. It is observed that the mechanical properties of the composite vary linearly with the number of impacts; and that the damage mechanism at low impact energy is the initiation of microcracks at the point of impact and at high impact energy, degradation is due to macrocracks and fiber fracture. It is also detected that microcracks and macrocracks do not affect attenuation, but affect strength and fatigue behavior; and the stress wave factor and attenuation are good ultrasonic parameters for degradation measurement. I.F.

A87-47938
ALUMINIUM-LITHIUM ALLOYS
ENRIQUE J. LAVERNIA and NICHOLAS J. TGRANT (MIT, Cambridge, MA) Journal of Materials Science (ISSN 0022-2461), vol. 22, May 1987, p. 1521-1529. refs

A development history as well as a current development status evaluation are presented for Al-Li alloys, usable in both ingot metallurgy and rapid solidification, which promise aircraft structure element weight reductions of the order of as much as 15 percent. Attention is given to the suboptimal behavior in deformation and fracture due to strain localization that is generated by the planar slip of shearable Al3Li precipitates, as well as to the bases in physical metallurgy of various approaches taken to improve Al-Li deformation behavior. Ingot-processed alloy problems have been in some degree alleviated by rapid solidification/powder metallurgy techniques, although oxide contamination has then emerged as a drawback. It is noted that spray atomization processes can produce rapidly solidified, wrought, fully dense alloys which overcome the faults of rapid solidification-derived alloy powders. O.C.

A87-47978
THE CURRENT APPLICATION OF TITANIUM IN JAPAN AND AN OUTLOOK FOR THE FUTURE
Y. DOI (Osaka Titanium Co., Ltd., Japan), Y. ITO (Kobe Steel Co., Ltd., Tokyo, Japan), and H. KUSAMICHI (Japan Titanium Society, Japan) IN: Titanium 1986: Products and applications; Proceedings of the International Conference, San Francisco, CA, Oct. 19-22, 1986. Volume 1 . Dayton, OH, Titanium Development Association, 1987, p. 12-22.

A87-47985
MECHANICAL PROPERTY TAILORING TITANIUM ALLOYS FOR JET ENGINE APPLICATIONS
G. W. KUHLMAN, T. L. YU (Alcoa, Forgings Div., Cleveland, OH), A. K. CHAKRABARTI, and R. PISHKO (Alcoa Laboratories, Alcoa Center, PA) IN: Titanium 1986: Products and applications; Proceedings of the International Conference, San Francisco, CA, Oct. 19-22, 1986. Volume 1 . Dayton, OH, Titanium Development Association, 1987, p. 122-153. refs

The aircraft turbine engine market, due to pressures for reduced life cycle costs, improved performance requirements, and the advent of advanced design techniques, has been actively seeking current and advanced titanium alloys in forgings with enhanced and/or tailored final part properties for critical rotating components. Advances in the state-of-the-art of hot die forging technology, and therefrom an improved capacity to impart unique thermomechanical process (TMP) schemes in the fabrication of forged titanium components, has resulted in major improvements in jet engine disk forgings' first and second tier mechanical properties. This important forging and TMP tool has been successfully employed on several engine alloys including Ti-6Al-4V, Ti-6Al-2Sn-4Zr-6Mo, Ti-17, Ti-6Al-2Sn-4Zr-2Mo + Si, IMI 685 and IMI 829 to enhance fracture related properties such as fracture toughness and fatigue crack propagation, to improve creep resistance, to enhance low cycle fatigue lives, to fabricate more cost effective near-net shapes and to develop less costly processes that have been successfully applied under production-scale conditions. Thus the control of the final part characteristics provided by this advanced forging technology is such that it is now possible to provide near-net, hot die forged disk forgings with superior performance capability. Author

A87-47992
THE EFFECT OF NEAR NET SHAPE PROCESSING METHODS ON THE TITANIUM INDUSTRY
WARD W. MINKLER IN: Titanium 1986: Products and applications; Proceedings of the International Conference, San Francisco, CA, Oct. 19-22, 1986. Volume 1 . Dayton, OH, Titanium Development Association, 1987, p. 359-375. refs

The use of near-net-shape processing methods to produce cost-effective aircraft structures is examined. Particular attention is given to power metallurgical fabrication, precision casting, precision forging, and superplastic forming/diffusion bonding. The factors limiting the application of these methods to production of aircraft structures are discussed. The effects of net shape technologies on the demand for Ti products are studied. An example in which a structure is manufactured using conventional and net shape techniques is presented. I.F.

A87-47993
PRECISION FORGING OF TITANIUM ALLOYS
ROBERT PISHKO (Alcoa Laboratories, Alcoa Center, PA), T. L. YU, and G. W. KUHLMAN (Alcoa, Forgings Div., Cleveland, OH) IN: Titanium 1986: Products and applications; Proceedings of the International Conference, San Francisco, CA, Oct. 19-22, 1986. Volume 1 . Dayton, OH, Titanium Development Association, 1987, p. 376-406. refs

Precision, near-net titanium airframe forgings emerged in the 1970's from research on isothermal forging technology for existing alpha-beta alloys; however, production scale precision titanium forging production did not become a reality until early in the 1980's with commercialization of Hot Die Forging technology and availability of more readily forgeable near-beta alloys, such as Ti-10V-2Fe-3Al. Precision titanium airframe forgings are now on the threshold of a revolution in terms of shape sophistication and size of NET precision forging, that requires no subsequent machining, manufacturable by the Forging Industry. Within the last three years, Hot Die Forging process technology for titanium alloys has advanced rapidly, providing titanium precision forging capabilities comparable to aluminum alloys, including design sophistication and tolerances, segmented tooling concepts and a scale-up of precision forging size to 300 sq in. plan view area with proven final part cost reduction when compared with other manufacturing techniques. Complementing precision forging manufacturing capabilities has been development and exploitation of thermomechanical processing of near-beta alloys such as Ti-10V-2Fe-3Al to enhance precision forging process control, to improve forging consistency, and to provide precision forging users with a range of attractive mechanical property combinations for critical airframe applications. Author

A87-48002
ELECTRON BEAM WELDED TITANIUM ALLOYS IN ROLLS ROYCE AERO ENGINES
R. W. BROOMFIELD (Rolls-Royce, PLC, Bristol, England) IN: Titanium 1986; Products and applications; Proceedings of the International Conference, San Francisco, CA, Oct. 19-22, 1986. Volume 2 . Dayton, OH, Titanium Development Association, 1987, p. 653-62.

Application of electron beam welding to high-temperature, creep resistant titanium alloys, such as IMI 685 and 829 (Ti5331S), is examined with particular reference to the joining of compressor disks for aircraft engines. The welding equipment, fixtures, and welding techniques are described, and the mechanical properties of the welds are evaluated. The advantages of electron beam welding over a bolted construction are outlined, and a comparison is made with inertia welding, a process offering similar weight savings. V.L.

A87-48007
POWDER METALLURGY (P/M) NEAR-NET SHAPE TITANIUM COMPONENTS FROM PREALLOYED POWDER
C. F. YOLTON (Crucible Materials Corp., Pittsburgh, PA) and J. H. MOLL IN: Titanium 1986; Products and applications; Proceedings of the International Conference, San Francisco, CA, Oct. 19-22, 1986. Volume 2 . Dayton, OH, Titanium Development Association, 1987, p. 782-800. refs

Powder metallurgy (P/M) production of structural components potentially offers substantial cost savings over conventional processes. One of the P/M techniques which holds considerable promise is the ceramic mold process. In this process, hot isostatic pressing (HIP) of prealloyed powder is used to produce near-net shape components. The components produced are fully dense and exhibit properties comparable to cast plus wrought product. Material losses and machining costs can be significantly reduced with application of the P/M process. The ceramic mold process has been used to make developmental components for airframes, turbine engines and implant devices. In this paper, the various components produced by the ceramic mold process will be reviewed, Mechanical properties of the P/M components will also be reviewed. Author

A87-48012
DEVELOPMENTS OF MELTING AND CASTING TECHNOLOGY OF TITANIUM BASE ALLOYS
MIHIR SEN (Burn Standard Co., Ltd., Corporate Research and Development Centre, Calcutta, India IN: Titanium 1986; Products and applications; Proceedings of the International Conference, San Francisco, CA, Oct. 19-22, 1986. Volume 2 . Dayton, OH, Titanium Development Association, 1987, p. 884-893. refs

Melting and casting processes for the production of titanium alloy components for aerospace, power, chemical, and medical applications are examined. In particular, it is shown that large components of titanium alloys can be efficiently produced by sand casting. With reference to results obtained for Ti-6Al-4V sand castings, it is shown that sand cast components of titanium alloys are characterized by high creep resistance, fatigue strength, fracture toughness, and tensile strength properties. V.L.

A87-48018
SUPERPLASTIC FORMING/DIFFUSION BONDING OF TITANIUM - AN AIR FORCE OVERVIEW
JOHN R. WILLIAMSON IN: Titanium 1986; Products and applications; Proceedings of the International Conference, San Francisco, CA, Oct. 19-22, 1986. Volume 2 . Dayton, OH, Titanium Development Association, 1987, p. 1087-1106.

The programs conducted by the U.S. Air Force over the past twelve years to bring superplastic forming with concurrent diffusion bonding (SPF/DB) of titanium to a production status and the current place of SPF/DB technology in the manufacture of military aircraft are reviewed. It is noted that many companies now have the necesssary production facilities and that the technology is utilized on most of the aircraft in production. SPF and SPF/DB are used to replace expensive assemblies, machined components, and structures that have experienced maintenance problems. Specific examples of applications are given, including the redesign of the F-15 fuselage, and future applications are briefly examined. V.L.

A87-48019
PRODUCTION IMPLEMENTATION OF TITANIUM SUPERELASTICALLY FORMED/DIFFUSION BONDED STRUCTURE
WALTER LEODOLTER (Douglas Aircraft Co., Long Beach, CA) IN: Titanium 1986; Products and applications; Proceedings of the International Conference, San Francisco, CA, Oct. 19-22, 1986. Volume 2 . Dayton, OH, Titanium Development Association, 1987, p. 1107-1112.

This paper discusses the engineering development effort, the preliminary and final airworthiness qualification of a test door, and the manufacture of 30 titanium main landing gear strut doors for the Northrop T-38 aircraft using superplastic forming and concurrent diffusion bonding (SPF/DB) as the principal fabrication method. The structural concept of the new door is a variable-thickness sandwich panel having an internal core structure with rectangular cells. Although acquisition costs for the SPF/DB doors are higher than those for the currently used aluminum honeycomb doors, significant life-cycle cost savings can be achieved. The discussion on costs deviates from the standard, and highlights the implications from the time lag between front-end investments and later benefit accrual a a potential barrier for technology implementation. Another factor affecting the introduction of new technology into production programs in general is thought to lie in the fundamental ideological differences of, and ineffective communication between, researchers and shop floor personnel. Author

A87-48020
SPF/TITANIUM AND THE B-1B AIRCRAFT
G. W. STACHER (Rockwell International Corp., Los Angeles, CA) IN: Titanium 1986; Products and applications; Proceedings of the International Conference, San Francisco, CA, Oct. 19-22, 1986. Volume 2 . Dayton, OH, Titanium Development Association, 1987, p. 1126-1135.

The use of SPF and SPF/DB titanium technology on the B-1B aircraft, where titanium represents 17 percent of the aircraft's structural weight, is examined. In particular, attention is given to the advantages afforded by the use of SPF and SPF/DB technology, the contained tooling and the hot box concepts of SPF fabrication, and specific applications of SPF/DB on the B-1B. The applications discussed include the windshield hot air blast nozzle, the manifold assembly, frames, panels, doors, and ducting. V.L.

A87-48531
TOUGHENED COMPOSITES SELECTION CRITERIA
CLIFFORD Y. KAM and JEFF V. WALKER (Douglas Aircraft Co., Long Beach, CA) IN: Toughened composites; Proceedings of the Symposium, Houston, TX, Mar. 13-15, 1985 . Philadelphia, PA, American Society for Testing and Materials, 1987, p. 9-22.

The selection of composite material systems for use in large commercial transport aircraft depends on a number of material characteristics such as mechanical and physical properties, behavior in a hot-wet environment, resistance to delamination, ease of processing, and whether use of thick plies to reduce lay-up time is beneficial. This paper review the design requirements and the key material characteristics needed by the structural designers. It has been well established that the current epoxy systems can be easily delaminated by the impact of external forces. This ease of delamination has resulted in a requirement to increase the toughness of the resin system so that its delamination resistance is two to four times higher than that of current epoxies. Other parameters include hot-wet requirements, low assembly cost potential, long shelf life, ease of processing, drapability requirements, and smoke generation. Author

A87-48532
DAMAGE TOLERANCE OF TOUGHENED RESIN GRAPHITE COMPOSITES
CHARLES F. GRIFFIN (Lockheed-California Co., Burbank) IN: Toughened composites; Proceedings of the Symposium, Houston, TX, Mar. 13-15, 1985 . Philadelphia, PA, American Society for Testing and Materials, 1987, p. 23-33. refs

The weight savings potential of graphite composites for wing structures in transport aircraft is directly related to design strength values. These values must reflect the influence of defects, notches, impact damage, and environmental conditions on material strength. Within the last several years, improvements have been made in the constituents of graphite/epoxy composites. Fiber tensile strengths have increased and tougher resins have been formulated. Tension, impact, and compression tests were conducted on several of these advanced materials to evaluate their performance. Based on these tests, it was concluded that increased values for design allowable tensile strength can be obtained. However, similar increases in compressive strength allowables cannot be obtained until additional improvements are made to resin matrices. Author

A87-48752
AUTOMOTIVE GASOLINE USAGE IN RECIPROCATING AIRCRAFT ENGINES
PAUL O. PENDLETON (FAA, Dept. of Transportation, Washington, DC) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-29, 1987. 27 p.
(SAE PAPER 871-012)

The paper describes current progress and problems associated with the use of automotive gasoline in aircraft and reciprocating aircraft engines employed in the US. The potential of future blends consisting of high percentages of oxygenates (alcohols and cosolvents) for aircraft and aircraft engines is evaluated. Tables are presented showing a comparison of octane values obtained by the research and motor methods and the average of these two methods. It is noted that octane values have remained consistent over the last five years. K.K.

A87-48753
MONITORING OF GAS TURBINE ENGINES - USED OIL
J. E. VAN TILBORG (Castrol, Ltd., Reading, England) and J. W. A. PRAGNELL (Burmah Castrol /UK/, Ltd., Swindon, England) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-29, 1987. 32 p.
(SAE PAPER 871014)

A study being carried out to improve understanding of what happens to oil used in airline gas turbine engines is described. The used lubricant property limits and the engine oil consumption are discussed, and the analytical techniques employed to measure the various physical and chemical properties of the oil are listed. Findings obtained with regard to additive depletion and the impact of antioxidant depletion on oxidation stability in the used oil are discussed. C.D.

A87-49502
MATERIALS FOR ADVANCED GAS TURBINES
G. W. MEETHAM (Rolls-Royce, Ltd., Derby, England) IN: High temperature alloys for gas turbines and other applications 1986; Proceedings of the Conference, Liege, Belgium, Oct. 6-9, 1986. Part 1 . Dordrecht, Netherlands, D. Reidel Publishing Co., 1986, p. 1-18. refs

Increases in the maximum operating temperature capability and usable strength of gas turbine blades depend on novel alloy and component manufacturing processes. While some further development of nickel-based superalloys and cooled-airfoil technology may be expected, augmented by thermal barrier coatings, the most promising prospects emerge from monolithic and composite systems of such ceramics as silicon carbide, silicon nitride, and carbon/carbon. Accurate means for the prediction of component behavior by three-dimensional thermal and stress analyses will be required for ceramic turbine blade and combustor design, and net-shape manufacturing processes are needed for the achievement of the requisite microstructural control levels. O.C.

A87-49553
BURNER RIG TESTS ON COATED ANISOTROPIC HIGH TEMPERATURE ALLOYS
H.-J. RAETZER-SCHEIBE, K. FRITSCHER, and G. WIRTH (DFVLR, Institut fuer Werkstoff-Forschung, Cologne, West Germany) IN: High temperature alloys for gas turbines and other applications 1986; Proceedings of the Conference, Liege, Belgium, Oct. 6-9, 1986. Part 2 . Dordrecht, Netherlands, D. Reidel Publishing Co., 1986, p. 1205-1214.

Anisotropic high-temperature alloys for use or as candidates for aircraft engines without or with a 100-micron coating were tested in air and in hot gases. Hot-gas tests were conducted at Mach 0.3 under 1 h cyclic conditions at 900 and 1050 C top temperatures in a kerosene-operated burner rig without and with 5 ppm synthetic sea salt additions for 100 hrs supplemented by weight change measurements. Mechanisms of oxidative/corrosive failure were metallographically elucidated by support of thermogravimetric and dilatometric data. A ranking of coating/substrate systems is understood by the respective protection effect of oxide films generated on the specimen surfaces during burner rig testing. The oxidative/corrosive attack is governed by the conditions of these oxide films (crystallographic phase, fissures, and adhesion). The conditions depend on metal chemistry, presence and distribution of oxide dispersions from LPPS process, mechanical compatibility of system, salt additions, and temperature. Author

A87-50097
MICROSTRUCTURAL ENGINEERING OF CERAMICS FOR HIGH-TEMPERATURE APPLICATION
M. H. LEWIS (Warwick, University, England) IN: Tailoring multiphase and composite ceramics; Proceedings of the Twenty-first University Conference on Ceramic Science, University Park, PA, July 17-19, 1985 . New York, Plenum Press, 1986, p. 713-730. Research supported by Lucas-Cookson-Syalon, Ltd., Wolfson Foundation, and Rolls-Royce, PLC. refs

The evolution and refinement of the microstructure of high-temperature (up to 1400 C) ceramics prepared by liquid-phase sintering and postsintering heat treatment are reviewed. In particular, monolithic ceramics based on oxinitride phases in the Si-Al-O-N system are examined, with emphasis on gas turbine applications. The discussion covers crystallography of the major phases, system selection, fabrication routes, and high-temperature properties. It is noted that near-net-shape ceramics with good high-temperature properties can be obtained by the pressureless-sintered fabrication route, provided the initial composition is tailored to generate a completely crystalline ceramic during a postsintering heat treatment. In addition, it may be necessary to accomodate the problem of high-temperature oxidation by surface transformation or diffusion-barrier coating. V.L.

A87-50617
HIGH-PERFORMANCE ADHESIVES ON THE LINE
Advanced Materials and Processes (ISSN 0882-7958), vol. 132, Aug. 1987, p. 82-87.

Thermoplastic hot-melt adhesive use is growing more rapidly than all other adhesive categories, in virtue of the simplicity of this process and the industrial environment and safety advantages of a solventless material. Attention is presently given to urethane-based, moisture-cured hot-melt engineering adhesives, which possess higher-temperature performance (200 C) than conventional hot melts (110 C), improved chemical resistance, longer times for structural component positioning, and lower application temperatures (100-150 C). Epoxies are, however, the most widely used of all structural adhesives, with total dominance in aircraft manufacture. An account is given of the use of fillers in epoxy adhesives for high-precision applications. O.C.

N87-26988*# Georgia Inst. of Tech., Atlanta. Center for Rotary Wing Aircraft Technology.
ANALYSIS, DESIGN AND ELASTIC TAILORING OF COMPOSITE ROTOR BLADES Final Report, 12 Feb. 1986 - 11 Aug. 1987
LAWRENCE W. REHFIELD and ALI R. ATILGAN Sep. 1987 28 p
(Contract NAG1-638)
(NASA-CR-181234; NAS 1.26:181234) Avail: NTIS HC A03/MF A01 CSCL 11D

The development of structural models for composite rotor blades is summarized. The models are intended for use in design analysis for the purpose of exploring the potential of elastic tailoring. The research was performed at the Center for Rotary Wing Aircraft Technology.

N87-26989*# Georgia Inst. of Tech., Atlanta. Center for Rotary Wing Aircraft Technology.
A STRUCTURAL MODEL FOR COMPOSITE ROTOR BLADES AND LIFTING SURFACES
LAWRENCE W. REHFIELD and ALI R. ATILGAN *In its* Analysis, Design and Elastic Tailoring of Composite Rotor Blades 11 p Sep. 1987
(Contract DAAS29-82-K-0097)
Avail: NTIS HC A03/MF A01 CSCL 11D

Composite material systems are currently candidates for aerospace structures, primarily for the design flexibiity they offer i.e., it is possible to tailor the material and manufacturing approach to the application. Two notable examples are the wing of the Grumman/USAF/DARPA X-29 and rotor blades under development by the U.S.A. Aerostructures Directorate (AVSCOM), Langley Research Center. A working definition of elastic or structural tailoring is the use of structural concept, fiber orientation, ply stacking sequence, and a blend of materials to achieve specific performance goals. In the design process, choices of materials and dimensions are made which produce specific response characteristics which permit the selected goals to be achieved. Common choices for tailoring goals are preventing instabilities or vibration resonances or enhancing damage tolerance. An essential, enabling factor in the design of tailored composite structures is structural modeling that accurately, but simply, characterizes response. The objective of this paper is to improve the single-cell beam model for composite rotor blades or lifting surfaces and to demonstrate its usefullness in applications. Author

N87-27029*# Pratt and Whitney Aircraft, East Hartford, Conn. Engineering Div.
MATERIALS FOR ADVANCED TURBINE ENGINES (MATE). PROJECT 4: EROSION RESISTANT COMPRESSOR AIRFOIL COATING
J. M. RASHID, M. FRELING, and L. A. FRIEDRICH May 1987 88 p
(Contract NAS3-20072)
(NASA-CR-179622; NAS 1.26:179622; PWA-5574-206) Avail: NTIS HC A05/MF A01 CSCL 11F

The ability of coatings to provide at least a 2X improvement in particulate erosion resistance for steel, nickel and titanium compressor airfoils was identified and demonstrated. Coating materials evaluated included plasma sprayed cobalt tungsten carbide, nickel carbide and diffusion applied chromium plus boron. Several processing parameters for plasma spray processing and diffusion coating were evaluated to identify coating systems having the most potential for providing airfoil erosion resistance. Based on laboratory results and analytical evaluations, selected coating systems were applied to gas turbine blades and evaluated for surface finish, burner rig erosion resistance and effect on high cycle fatigue strength. Based on these tests, the following coatings were recommended for engine testing: Gator-Gard plasma spray 88WC-12Co on titanium alloy airfoils, plasma spray 83WC-17Co on steel and nickel alloy airfoils, and Cr+B on nickel alloy airfoils. Author

N87-27736# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
MODERN COMPOSITES FOR PRIMARY AIRCRAFT STRUCTURES
G. J. SPIES Nov. 1985 12 p
(VTH-LR-480; B8707453; ETN-87-90219) Avail: NTIS HC A02/MF A01

Properties of composite laminates are mentioned, such as the elastic behavior, and the strength and fatigue characteristics. Composite wing sections are described. ESA

N87-27806# Naval Air Development Center, Warminster, Pa. Air Vehicle and Crew Systems Technology Directorate.
DEVELOPMENT OF A PRIMER/TOPCOAT AND FLEXIBLE PRIMER FOR ALUMINUM Phase Report, Oct. 1984 - Sep. 1986
CHARLES R. HEGEDUS 20 Mar. 1987 36 p
(AD-A182132; NADC-87016-60) Avail: NTIS HC A03/MF A01 CSCL 11C

Two corrosion preventive organic coatings have been developed for use on aluminum and specifically for application on Navy aircraft. They provide two alternatives for improving aircraft paint systems. The first coating can be applied directly to an aluminum substrate and perform as a self-priming topcoat. It consists of a two component, aliphatic polyurethane binder with titanium dioxide, zinc molybdate, zinc phosphate, an organo-zinc salt, and titanium dioxide vesiculated bead pigments. This primer/topcoat meets or exceeds all of the critical performance requirements of the current Navy aircraft paint system: Mil-P-23377 epoxy primer and Mil-C-83286 polyurethane topcoat. It exhibits good adhesion, corrosion inhibition, flexibility, chemical and weather resistance. The use of this coating will reduce: Paint application and removal time and manpower; Aircraft weight; Aircraft downtime; and Volatile organic component (VOC) and chromate emissions. The second coating is a flexible primer which was developed using the above polyurethane binder. It contains strontium chromate zinc chromate, barium chromate, and zinc molybdate corrosion inhibiting pigments. The primer meets or exceeds all of the performance requirements of Mil-P-23377 and has significantly more flexibility. Aluminum specimens coated with the NADC flexible primer remained in 5% salt spray for one year without any corrosion of the aluminum or damage to the coating. GRA

N87-27812# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
CAPILLARY GC DETECTION METHODS FOR NITROGEN AND SULFUR COMPOUNDS IN SHALE-DERIVED JET PROPULSION FUELS Final Report, Mar. 1985 - Mar. 1986
ELLEN M. STEWARD and EDWARD W. PITZER Dec. 1986 43 p
(AD-A181865; AFWAL-TR-86-2043) Avail: NTIS HC A03/MF A01 CSCL 21D

Correlations have been drawn between nitrogen and sulfur content in jet propulsion fuel and poor fuel performance. Recent studies have suggested that certain nitrogen and sulfur compound classes are more detrimental to fuel performance than others. This report emphasizes the importance of knowing which nitrogen and sulfur compound classes are present in jet propulsion fuel and demonstrates the ability of several capillary gas chromatographic (GC) detectors to selectively detect individual nitrogen and sulfur compounds in these fuels. GRA

N87-27816# Partnership Ltd., Lawrenceville, N.J.
ADVANCED AIRCRAFT FUEL EVALUATION, PHASE 1 Final Report, Jun. 1986 - Jan. 1987
PARTHA S. GANGULI and PAUL H. KYDD Mar. 1987 78 p
(Contract F33615-86-C-2663)
(AD-A182029; AFWAL-TR-87-2034) Avail: NTIS HC A05/MF A01 CSCL 21D

The objective of this project was to provide estimates of the availability, cost and quality of naphthenic hydrocarbon fuels for advanced hypersonic vehicle propulsion as a function of time. To accomplish this objective a proposed specification of the fuel was established. Potential sources of feedstocks were surveyed with particular attention to petroleum based refinery streams. Three promising feedstocks were identified in addition to purchased petroleum derived naphthalene, which served as the bases of comparison. Processing routes to convert the feeds to specification fuel were identified. These are based on existing refining technology and require no process innovation or research for successful fuel production. The samples of the proposed fuel substantially met the desired properties of the advanced fuel. In addition rate constants were derived for the hydrogenation of naphthalene and the cis--trans-isomerization of decalin. Other rate constants relevant to the production of advanced fuel from refinery feedstocks were

also measured. The requirements for the design of the aircraft system to use these fuels were estimated. The availability and cost of advanced fuels from the identified refinery streams were estimated and a possible scenario for supplying this fuel through the year 2000 was developed. The advanced fuel in question is intended for application in hypersonic aircraft of the future, particularly those intended for high Mach flight. GRA

N87-27818# Federal Aviation Agency, Atlantic City, N.J.
LABORATORY CHARACTERIZATION TESTS FOR ANTIMISTING FUEL Final Report
JOSEPH J. WILSON Mar. 1987 127 p
(AD-A182196; DOT/FAA/CT-86/23) Avail: NTIS HC A07/MF A01 CSCL 21D

Experiments have shown that FM-9 antimisting fuel had the potential for precluding the fine mist and associated fireball generation in aircraft post-crash situations while allowing for the restoration of the filtration and antomizing characteristics required for aircraft operation. The Federal Aviation Administration, the Aircraft Establishment, the National Aeronautics and Space Administration, the Jet Propulsion Laboratory, Southwest Research Institute, and Pratt and Whitney Aircraft developed many specialized laboratory characterization tests throughout the antimisting fuel program to evaluate the antimisting properties, the degradability, the composition, and rheological properties of FM-9 antimisting fuel and the physical properties of FM-9 slurry used in the inline blending process for antimisting fuel. This report documents all the laboratory characterization tests that were successfully developed and used as a standardized test method during the program. GRA

N87-27819# Strat Co., Salt Lake City, Utah.
PRODUCTION OF HIGH ENERGY AVIATION FUELS FROM ADVANCED COAL LIQUIDS, PHASE 1 Final Report, Jun. 1986 - Feb. 1987
JOHN DOWNEN Apr. 1987 80 p
(Contract F33615-86-C-2660)
(AD-A182333; AFWAL-TR-87-2036) Avail: NTIS HC A05/MF A01 CSCL 21B

The objective of this program was to assess the feasibility of producing advanced fuels from coal liquids. The coal liquids used in this program were produced from the Close Coupled Integrated Two Stage Liquifaction System (ISTL) plant at Wilsonville, Alabama. The liquids were derived from subituminous coal, Wydodack upper seam, from Gillete, Wyoming. The coal liquids were distilled into a 300 to 625 F fraction. Hydrogenation experiments were conducted on this distillate fraction using the Hydrogenation Reactor System (HRS) located at Wright-Patterson AFB, Ohio. Shell 424 nickel/molybdenum catalyst was used for heteroatom removal and aromatics saturation. The report details the analysis of these hydrogenated candidate fuels. GRA

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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.

A87-47120#
SOME IMPORTANT CONSIDERATIONS IN THE DESIGN OF COMPOSITE BONDED JOINTS IN AEROSPACE STRUCTURES
P. GRANT and J. A. LEWINGTON (Canadair, Ltd./Ltee, Montreal, Canada) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 33, June 1987, p. 91-98. refs

Analytical techniques neglecting the low, out-of-plane shear stiffness that can have a significant influence on adhesive peel and shear-stress distributions in many composites may err on the conservative side, but may obtain close agreement with experimental data at the stress peaks. Stress peaks predicted by nonlinear shear-lag analysis closely agree with those obtained by FEM analysis. Nonlinearity in shear has a significant influence on joint strength, especially in the longer joints exhibiting sensitivity to adhesive failure strain. Elastic analyses of thermal stresses suggest that metal/composite joints are impracticable. O.C.

A87-47165
RADIATION HEAT TRANSFER IN COMBUSTION SYSTEMS
R. VISKANTA (Purdue University, West Lafayette, IN) and M. P. MENGUC (Kentucky, University, Lexington) Progress in Energy and Combustion Science (ISSN 0360-1285), vol. 13, no. 2, 1987, p. 97-160. Research supported by CONOCO, Inc. refs

An adequate treatment of thermal radiation heat transfer is essential to a mathematical model of the combustion process or to a design of a combustion system. This paper reviews the fundamentals of radiation heat transfer and some recent progress in its modeling in combustion systems. Topics covered include radiative properties of combustion products and their modeling and methods of solving the radiative transfer equations. Examples of sample combustion systems in which radiation has been accounted for in the analysis are presented. In several technologically important, practical combustion systems coupling of radiation to other modes of heat transfer is discussed. Research needs are identified and potentially promising research topics are also suggested. Author

A87-47192
OPTIMIZATION OF AIRPLANE WING STRUCTURES UNDER TAXIING LOADS
S. S. RAO (Purdue University, West Lafayette, IN) Computers and Structures (ISSN 0045-7949), vol. 26, no. 3, 1987, p. 469-479. refs

A methodology is presented for the optimum design of aircraft wing structures subjected to taxiing loads. The dynamic stresses induced in the wing as the airplane accelerates or decelerates on the runaway during takeoff or landing are computed by considering the interaction between the landing gear and the flexible airplane structure. The procedure is capable of taking into account both the effects of discrete runway bumps and the effects of runway unevenness. A numerical step-by-step method is developed for solving the nonlinear differential equations of motion. The optimization methodology is illustrated with two examples. The first example deals with the design of the typical section (symmetric double-wedge airfoil). This example is studied by using a graphical procedure mainly to understand qualitatively the behavior of wing structures under taxiing loads and also to obtain a physical insight into the nature of the optimum solution. The second example is concerned with the design of a more realistic wing structure. In this case, the problem is formulated and solved as a constrained nonlinear programming problem based on finite-element modeling. Author

A87-47355
FREE VIBRATION OF A THIN CYLINDRICAL SHELL WITH PERIODIC CIRCUMFERENTIAL STIFFENERS
D. J. MEAD and N. S. BARDELL (Southampton, University, England) Journal of Sound and Vibration (ISSN 0022-460X), vol. 115, June 22, 1987, p. 499-520. refs

The theory is developed for obtaining the propagation constants of a thin uniform cylindrical shell, periodically stiffened by uniform circular frames of general cross-section. The free wave motion is analyzed and the stop and pass bands of free wave motion in the structure are located. Hysteretic damping is included. The natural frequencies of two stiffened finite cylindrical shells are deduced. The relative effects of the frame cross section and pitch on the free vibration characteristics of the whole structure are discussed. Author

A87-47642
EQUIVALENT TESTING TEMPERATURE
NILS-OLOV AKERBLOM (Saab-Scania AB, Linkoping, Sweden) Society of Environmental Engineers, Journal (ISSN 0374-356X), vol. 26-2, June 1987, p. 7, 8.

The use of the equivalent testing temperature to establish the proper thermal environment for aircraft equipment is examined. The equivalent testing temperature is defined as an ambient temperature in a test chamber. Testing in free-air conditions is used as a reference, and it is necessary to calculate the reference point temperatures for both the test case and for the installed case. An example in which the calculation of the equivalent testing temperature is applied to the avionics rack in the SF340 is presented. I.F.

A87-47715#
A RELIABILITY EVALUATION SYSTEM FOR CERAMIC GAS TURBINES
JUN-ICHI HAMANAKA, YOSHIHIRO HASHIMOTO, AKIO OHKOSHI, and NORIO WATANABE Ishikawajima-Harima Engineering Review (ISSN 0578-7904), vol. 27, March 1987, p. 73-77. In Japanese, with abstract in English.

A reliability evaluation system for ceramic gas turbines has been developed by IHI. The system is based on results of the finite element stress analysis with a probabilistic analysis of ceramic structures. In the system, a new probabilistic method was used to estimate time and cycles to failure of multiaxially stressed ceramic structures. Using the system, fast fracture, static fatigue, and dynamic fatigue can be evaluated. Also, the effect of the proof test on these failure modes can be evaluated quantitatively. This reliability evaluation is performed by using the stress analysis of the general purpose program NASTRAN. The necessary data base for the above evaluation is constructed by the preprocessor of the system based on the calculation results of NASTRAN and user input data. Evaluation results are shown on the graphic display and the plotter. Author

A87-47717#
LATERAL FLUID FORCES ON WHIRLING CENTRIFUGAL IMPELLER. I - THEORY. II - EXPERIMENT IN VANELESS DIFFUSER
H. SHOJI (Tsukuba, University, Japan) and H. OHASHI (Tokyo, University, Japan) ASME, Transactions, Journal of Fluids Engineering (ISSN 0098-2202), vol. 109, June 1987, p. 94-106. refs

Lateral fluid forces acting on a rotating centrifugal impeller in whirling motion are analyzed using unsteady potential flow theory. Impellers operating in diffusers with and without vanes are modeled and the fluid forces calculated for different whirl speeds and flow rates. The influences of these parameters are clarified by parametric calculations. The results for whirling impellers operating in vaneless diffusers show that the fluid forces exert a damping effect on the rotor whirling motion at all operating conditions. The results for impellers operating in vaned diffusers or guide vanes show that the time averaged values of fluid forces remain almost unchanged, while there are significant instantaneous fluctuations due to the impeller/guide vane interactions. Author

A87-47784
SOME EFFECTS OF LOAD SPECTRUM REPRESENTATION ON CRACK GROWTH PREDICTIONS AND PROBLEMS IN PREDICTION VALIDATION
R. L. HEWITT (National Aeronautical Establishment, Structures and Materials Laboratory, Ottawa, Canada) International Journal of Fatigue (ISSN 0142-1123), vol. 9, July 1987, p. 157-162. refs

A series of life predictions has been made for an aircraft component using variations in the method of application of the same basic load spectrum. It is shown that this can have a substantial effect on predicted life and that even seemingly small changes in approach can have a significant effect. The importance of validation experiments is discussed particularly in regard to the accuracy of the stress intensity solution and the current trend towards using finite element solutions for stress intensity factors in complex structures. Author

A87-48004
THE ROLLS-ROYCE WIDE CHORD FAN BLADE
G. A. FITZPATRICK (Rolls-Royce, PLC, Barnoldswick, England) and T. BROUGHTON (Rolls-Royce, PLC, Derby, England) IN: Titanium 1986; Products and applications; Proceedings of the International Conference, San Francisco, CA, Oct. 19-22, 1986. Volume 2 . Dayton, OH, Titanium Development Association, 1987, p. 685-702.

The design of a hollow wide-chord fan blade developed for high-bypass-ratio civil turbofan engines in the thrust range 22,000-58,000 lbs is described. In the new fan-blade design, the snubber has been deleted, the chord width of the blade has been increased by 40 percent for natural stability, and the number of blades per module set has been reduced by a about a third. The weight problem has been solved by using a low-density honeycomb core, which also provides a smooth airfoil for enhanced aerodynamic performance. The basic structure of the wide-chord fan blade, a three-piece titanium assembly joined by a proprietory activated diffusion bonding process, is shown schematically, and the development of the manufacturing process is discussed. V.L.

A87-48021
QUALITY ASSURANCE - THE KEY TO ADVANCED AIRCRAFT ENGINE APPLICATIONS OF THE SPF/DB PROCESS
A. F. EVANS and J. L. BARTOS (General Electric Co., Aircraft Engine Group, Cincinnati, OH) IN: Titanium 1986; Products and applications; Proceedings of the International Conference, San Francisco, CA, Oct. 19-22, 1986. Volume 2 . Dayton, OH, Titanium Development Association, 1987, p. 1136-1152.

A quality assurance evaluation has been developed for the high volume production of consistent, reproducible aircraft engine components using SPF/DB titanium technology. The main objectives of the SPF/DB quality assurance study are (1) to define allowable process parameter limits using mechanical property response, metallographic results, and NDE; (2) to minimize future production problems; and (3) to generate data for correlating NDE with mechanical properties and part integrity. The range of process variables examined, types of measurements used, and rationale for selection are discussed. V.L.

A87-48022
SPF DB APPLICATIONS FOR MILITARY AIRCRAFT
B. ROLLAND (Avions Marcel Dassault Breguet Aviation, Vaucresson, France) IN: Titanium 1986; Products and applications; Proceedings of the International Conference, San Francisco, CA, Oct. 19-22, 1986. Volume 2 . Dayton, OH, Titanium Development Association, 1987, p. 1153-1162.

Applications of SPF/DB titanium technology to some aircraft parts are examined. In particular, attention is given to a process for fabricating a four-sheet sandwich structure, the manufacture of leading edge slats, the manufacture of the Mirage 2000 strake, and SPF/DB tools. Some aspects of quality assurance are discussed, with reference to the control of process parameters, radiography, inspection of diffusion bonds, and thickness measurements. V.L.

A87-48044
TIMOSHENKO BEAMS AND FLEXIBLE MULTIBODY SYSTEM DYNAMICS
E. M. BAKR and A. A. SHABANA (Illinois, University, Chicago) Journal of Sound and Vibration (ISSN 0022-460X), vol. 116, July 8, 1987, p. 89-107. refs

In the present dynamic analysis method for flexible multibody systems, which takes rotary inertia and shear deformation effects into account, flexible system components are discretized by FEM, and a set of reference coordinates is used to describe the motion of a selected body reference. Element mass and stiffness matrices accounting for rotary inertia and shear deformation effects are identified by the derivation of kinetic and strain energies for each

element, and a new set of time-invariant element matrices describing the coupling between reference motion and elastic deformation is developed. The formulation presented is exemplified by a two-dimensional flexible multibody aircraft whose numerical results indicate significant rotary inertia and effects on dynamic response. O.C.

A87-48064
THE IMPACT OF NEW TECHNOLOGIES ON THE LIFE CYCLE COST OF AVIONIC SYSTEMS
G. W. WILCOCK and D. OLDFIELD (Royal Aircraft Establishment, Farnborough, England) IN: Cost-effective avionic and weapon systems; Proceedings of the Spring Convention, London, England, May 14, 15, 1986 . London, Royal Aeronautical Society, 1987, p. 13.1-13.17. refs

An assessment is made of the likely impact of foreseeable hardware and software advancements of future avionics systems. It is anticipated that VLSI will be a primary factor in the enhancement of performance and reduction of life cycle costs, through the generation of custom chips for specific applications. Software changes will be of greater significance to cost reduction than system performance, and demand that attention be given to software reliability. Future hardware will consist of a mixture of LRUs and LRMs. LRM-based subsystems are likely to lead to a radical change in maintenance philosophies, and therefore in life cycle costs. O.C.

A87-48066
DATA BUS SYSTEMS
P. T. GARDINER (Smiths Industries, PLC, London, England) IN: Cost-effective avionic and weapon systems; Proceedings of the Spring Convention, London, England, May 14, 15, 1986 . London, Royal Aeronautical Society, 1987, p. 15.1-15.15. refs

Higher-performance data transmission system architectures required by future military aircraft may encompass a family of data buses. Since the development of a totally new data bus standard, together with the necessary interface hardware, is costly and time-consuming, attention is presently given to performance-enhancement techniques applicable to existing transmission systems as an interim solution. Attention is accordingly given to the classification of data bus characteristics, the various types of protocols and interconnect topologies, the design implications of fiber-optic transmission systems, and the next-generation technology concept of wavelength-division multiplexing. O.C.

A87-48164
POSSIBILITIES AND METHODS OF STRUCTURAL OPTIMIZATION [MOEGLICHKEITEN UND METHODEN DER STRUKTUROPTIMIERUNG]
H. ROEHRLE and D. MATHIAS (Dornier GmbH, Friedrichshafen, West Germany) IN: Yearbook 1986 II; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 731-739. In German. refs
(DGLR PAPER 86-166)

Structural optimization (O) techniques are described and demonstrated. The fundamental principles of O are reviewed; the special cases of shape O, geometrical O, and cross-sectional O are discussed; and consideration is given to classical methods (with and without secondary conditions), sampling-type (systematic and stochastic) methods, optimality criteria (stress-ratio and Lagrange-multiplication methods), and mathematical procedures (sequential linear O and nonlinear O). The construction of O algorithms is explained, and numerical results for the O of an aircraft wing of laminated uniaxially fiber-reinforced composite are presented in graphs and diagrams and briefly characterized. T.K.

A87-48313* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OPPORTUNITIES AND CHALLENGES IN HEAT TRANSFER - FROM THE PERSPECTIVE OF THE GOVERNMENT LABORATORY
ROBERT J. SIMONEAU (NASA, Lewis Research Center, Cleveland, OH) Heat Transfer Engineering (ISSN 0145-7632), vol. 7, no. 3-4, 1986, p. 76-81.

The technological problems in which heat transfer research is required are briefly reviewed, discussing the role of the government laboratory in this research. The Hot Section Technology Program at NASA Lewis is addressed as an example. A building-block approach to turbine aerothermal research is shown, as is an interactive computational/experimental synergism and an interdisciplinary research methodology for life prediction of turbine engine hot-section components. The main issues for government laboratories as organizers and focusers in this area of research are listed, and challenges and opportunities for the future are indicated. C.D.

A87-48576#
AN EXPERIMENTAL AND NUMERICAL INVESTIGATION OF SWIRLING FLOWS IN A RECTANGULAR NOZZLE
THOMAS H. SOBOTA and FRANK E. MARBLE (California Institute of Technology, Pasadena) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 23rd, San Diego, CA, June 29-July 2, 1987. 13 p. refs
(AIAA PAPER 87-2108)

An experimental and numerical study is presented to determine the effects of swirl on the flowfield developing in a rectangular transition section, and the formation of axial vortices in the nozzle is found to be dependent on the vorticity distribution at the turbine exhaust. The computational investigation confirmed the relationship between the turbine exhaust vorticity and the vortex patterns formed at the nozzle, and it provided details of the flowfield between the turbine discharge and the nozzle exit. The present results make it possible to tailor the vortex distribution at the nozzle exit by design of the turbine discharge and the intervening passage. R.R.

A87-48646#
A HEAT TRANSFER MODEL FOR A HOT HELIUM AIRSHIP
R. M. RAPERT (U.S. Naval Academy, Annapolis, MD) IN: AIAA Lighter-Than-Air Technology Conference, 7th, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 59-66. refs
(AIAA PAPER 87-2443)

Basic heat transfer empirical and analytic equations are applied to a double envelope airship concept which uses heated Helium in the inner envelope to augment and control gross lift. The convective and conductive terms lead to a linear system of five equations for the concept airship, with the nonlinear radiation terms included by an iterative solution process. The graphed results from FORTRAN program solutions are presented for the variables of interest. These indicate that a simple use of airship engine exhaust heat gives more than a 30 percent increase in gross airship lift. Possibly more than 100 percent increase can be achieved if a 'stream injection' heating system, with associated design problems, is used. Author

A87-48755* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ADVANCES IN FLOW VISUALIZATION USING LIQUID-CRYSTAL COATINGS
BRUCE J. HOLMES (NASA, Langley Research Center, Hampton, VA) and CLIFFORD J. OBARA (PRC Kentron, Inc., Hampton, VA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 10 p. refs
(SAE PAPER 871017)

This paper discusses a new four-part mixing method for visualizing boundary layer flows, including transitions, separation, and shock locations, by the use of liquid-crystal coatings. The method controls the event temperature and color-play bandwidth best suited to specific experimental conditions, and is easily

learned. The method is applicable almost throughout the altitude and speed ranges for subsonic aircraft flight envelopes, and is also applicable to supersonic flow visualization and for general use in high- and low-speed wind tunnel and water tunnel testing. C.D.

A87-48765
EQUIPMENT RELIABILITY REAL AND PERCEIVED
A. J. HAUTER (Rockwell International Corp., Collins Government Avionics Div., Addison, TX) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 10 p.
(SAE PAPER 871-038)

Environmental factors influencing the reliability of avionics equipment are discussed and the most important factor, heat, is quantified. The impact of operating time on equipment reliability is described and the reason why identical equipment in identical aircraft have different reliability levels is explained. The importance of including avionics in the overall aircraft design is demonstrated. It is noted that the following factors all affect the mean time between failure: environmental stresses imposed, equipment design, maintenance capability, route structure, interface with other systems, and operating time per year. K.K.

A87-48773
OPTIMIZATION OF AIRCRAFT STRUCTURES USING STARSTRUC
B. E. KLINDERA, M. H. LOVE, W. A. ROGERS (General Dynamics Corp., Fort Worth Div., TX), and A. M. ELSAIE SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 12 p. refs
(SAE PAPER 871049)

A structural optimization tool, STARSTRUC, that can be applied to many aircraft components is presented. STARSTRUC is a new generation, large-scale software system which is based on finite element method and can provide significant improvements in structural weight. Structural design constraints can be applied simultaneously with STARSTRUC to produce a single design. The STARSTRUC design variables are the element sizes. Typical aircraft components are presented that demonstrate the important features of the structural optimization system, such as large-size models, multiple constraints, load combinations, and the effects of the initial design variables on the final solution. C.D.

A87-48966#
THE ROLE AND THE DETECTION OF RESIDUAL STRESS IN HELICOPTER AND AIRCRAFT COMPONENTS
VITTORIANO WAGNER, MARIO REGINA, and FRANCESCO PORRO (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Laboratorio Technologie Sperimentali, Gallarate, I European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 18 p.

After a brief review of the origins of residual stresses, the paper examines the advantages and limitations of using X-ray diffraction for residual-stress measurements in helicopter and aircraft components. It is shown that X-ray diffraction is particularly applicable to such typical aeronautical steels as quenched and tempered AISI 4340 ESR and case-carburized AISI 9310 ESR. Owing to the shallow penetration of the X-rays, this technique is especially suitable when either surface residual stresses (such as those produced by electron beam welding) or in-depth gradients (such as those produced by surface hardening treatments) are to be evaluated. It is concluded that, in this case, X-ray diffraction is one of the few industrial techniques capable of detecting even small changes in the metallurgical and mechanical state of the material. B.J.

A87-49507
APPLICATION OF JOINING PROCESSES TO AERO ENGINE CRITICAL PARTS - PRODUCTION AND REPAIR
R. SPINAT and Y. HONNORAT (Societe Nationale d'Etude et Construction de Moteurs d'Aviation, Direction Technique, Evry, France) IN: High temperature alloys for gas turbines and other applications 1986; Proceedings of the Conference, Liege, Belgium, Oct. 6-9, 1986. Part 1 . Dordrecht, Netherlands, D. Reidel Publishing Co., 1986, p. 151-173.

Electron-beam welding, inertia welding, diffusion brazing, and diffusion welding are state-of-the-art joining methods often employed in aircraft engines for high temperature alloys. Attention is presently given to the specific steps, material characteristics, and mechanical properties of the bonding areas obtainable by these means, as well as the inspection procedures used and the typical defects encountered. Electron-beam welding is the most versatile of these processes; inertia welding is less easily applied, and only to axisymmetric joining operations; diffusion brazing is easily used in repair activities; and diffusion welding requires too delicate an implementing operation for wide application. O.C.

A87-49555
PROCESS AND EQUIPMENT FOR PVD AND LPPS OVERLAY COATINGS ON AIRCRAFT GAS TURBINE PARTS
A. FEUERSTEIN, W. DIETRICH (Leybold-Heraeus GmbH, Hanau, West Germany), E. MUEHLBERGER, and PH MEYER (Electro-Plasma, Inc., Irvine, CA) IN: High temperature alloys for gas turbines and other applications 1986; Proceedings of the Conference, Liege, Belgium, Oct. 6-9, 1986. Part 2 . Dordrecht, Netherlands, D. Reidel Publishing Co., 1986, p. 1227-1244. refs

The Physical Vapor Deposition (PVD) and Low Pressure Plasma Spray (LPPS) processes are easily automated coating technologies for the deposition of thermal protection coatings on gas turbine blade surfaces. The essential differences between the two processes are the higher deposition rate of LPPS and the directional character of its material flow; these features require more sophisticated and accurate movement of both the substrate and the plasma gun. Nevertheless, LPPS achieves very uniform coating thicknesses and, by comparison with PVD, is ideally suited for single-part processing of larger part sizes. O.C.

A87-49628
COST EFFECTIVENESS USING CONVENTIONAL MATERIALS
N. A. MASOM (British Aerospace, PLC, London, England) IN: Designing for low cost fabrication; Proceedings of the Workshop, Loughborough, England, Apr. 16, 17, 1986 . London, Royal Aeronautical Society, 1987, p. 11-21.

Cost effectiveness in aircraft manufacture employing such currently familiar materials and fabrication methods as sheet metal cutting and bending, welding, casting, and forging, is presently understood to entail the reduction of complexity, improvement of assembly worker access during assembly, reduction of tooling costs and waste material, and accurate matching of tasks with workforce skills. Attention is given to the comparative advantages of superplastic forming and more traditional sheet metal-forming technologies at various levels of component complexity and detailing. O.C.

A87-49637
LOW COST MANUFACTURE IN TITANIUM AND ALUMINIUM ALLOYS USING THE PROCESSES OF SUPERPLASTIC FORMING (SPF) AND DIFFUSION BONDING
D. STEPHEN (British Aerospace, PLC, London, England) IN: Designing for low cost fabrication; Proceedings of the Workshop, Loughborough, England, Apr. 16, 17, 1986 . London, Royal Aeronautical Society, 1987, p. 198-217.

An evaluation is made of the structural component weight and cost savings that are obtainable throught the use of superplastic forming and diffusion bonding for such titanium alloys as Ti-6Al-4V, and recently developed superplastic aluminum alloys possessing good structural properties. Diffusion bonding in the course of superplastic forming yield a metallurgically continuous material. Cost savings accrue to the formation of complex structures from

such simple feedstocks as sheet metal, as well as from reductions of parts counts, obviation of mechanical fasteners, and the figuring of novel structural forms not otherwise obtainable. O.C.

A87-49981#
EQUIVALENT LINEARIZATION OF A NONLINEAR ELEMENT WITH RESPECT TO SUBHARMONIC MOTIONS
SONGQI CHEN and JIANKANG XU (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power, vol. 2, April 1987, p. 117-120, 185. In Chinese, with abstract in English.

In the present linearization technique for nonlinear force by means of the harmonic balance method, the element generating nonlinear force is incorporated into the multidegree-of-freedom system, and the steady-state motions at the element have components that are nonsynchronous with the external harmonic force exerted on the system. While the first part of the equivalent force component is composed of an average force, a linear spring force, and a linear force, the second is the sum of the equivalent external harmonic forces having frequencies akin to those present in the nonsynchronous motion components at the element. The method is demonstrated and verified for the case of the subharmonic whirling of an unbalanced rigid rotor incorporating a squeeze-film damper without centering spring; the results obtained agree with those from the full transient solutions obtained with the Runge-Kutta method. O.C.

A87-50333#
TRANSLATING SUPPORTABILITY REQUIREMENTS INTO DESIGN REALITY
J. BUCHE and I. COHEN (Grumman Aerospace Corp., Bethpage, NY) (AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology

A87-50334#
TRANSLATING AIRCRAFT RELIABILITY AND MAINTAINABILITY INTO MEASURES OF OPERATIONAL EFFECTIVENESS
DENNIS C. DIETZ (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) (AIAA, AHS, and ASEE, Aircraft Systems, Design and Technology

A87-50587
FLOW VISUALISATION ON ROLLING MODELS USING MINITUFTS
C. O. O'LEARY and W. DREW (Royal Aircraft Establishment, Bedford, England) Aeronautical Journal (ISSN 0001-9240), vol. 91, June-July 1987, p. 269-274.

Minitufts are increasingly used for flow visualization on static wind tunnel models because they can be applied in larger numbers for increased detail and with less interference compared with conventional tufts. This Memorandum describes an extension of their use to continuously rotating models where the heavier conventional tufts are inadequate. Tests on two combat aircraft models in the 4 m x 2.7 m Low Speed Wind tunnel are described. Measured variations of rolling moment are explained with the aid of the minituft photographs. Author

N87-27124*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Aerospace Engineering.
AN EXPERIMENTAL STUDY OF THE PROPERTIES OF SURFACE PRESSURE FLUCTUATIONS FOR SEPARATING TURBULENT BOUNDARY LAYERS Final Report, 15 Mar. 1984 - 15 Sep. 1986
ROGER L. SIMPSON 12 Nov. 1986 11 p
(Contract NAG1-446)
(NASA-CR-180295; NAS 1.26:180295) Avail: NTIS HC A02/MF A01 CSCL 20D

Noise generated by helicopter and turbomachine rotors is a nuisance that designers would like to predict and to minimize within other design constraints. A key element for the noise calculation procedure is knowledge relating the flowfield structure to the surface pressure fluctuation structure. Surface pressure turbulent boundary layers were obtained. The zero-pressure-gradient turbulent boundary layers were examined with freestream velocities of 72 and 105 fps. Mean and fluctuation velocity profiles and streamwise velocity spectra and wavespeeds were obtained for momentum thickness Reynolds numbers up to 18000 for the zero-pressure-gradient case and up to 4000 for the favorable-pressure-gradient case. The wall shearing stress was estimated from a Clauser plot of the near wall data. It is clear that turbulent pressure fluctuations are produced by turbulent velocity fluctuations. Detailed simultaneous measurements of all of these fluctuations are needed to determine in more detail the structural relationships between velocity and pressure fields. Although some measurements were made for unseparated flows, none were made for separated flows. B.G.

N87-27130*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
COMPUTATIONAL METHODS FOR VORTEX DOMINATED COMPRESSIBLE FLOWS Final Report, 1 Apr. 1983 - 30 Jun. 1987
EARLL M. MURMAN 4 Aug. 1987 4 p
(Contract NAG1-358)
(NASA-CR-181144; NAS 1.26:181144; MIT-OSP-93666) Avail: NTIS HC A02/MF A01 CSCL 20D

The principal objectives were to: understand the mechanisms by which Euler equation computations model leading edge vortex flows; understand the vortical and shock wave structures that may exist for different wing shapes, angles of incidence, and Mach numbers; and compare calculations with experiments in order to ascertain the limitations and advantages of Euler equation models. The initial approach utilized the cell centered finite volume Jameson scheme. The final calculation utilized a cell vertex finite volume method on an unstructured grid. Both methods used Runge-Kutta four stage schemes for integrating the equations. The principal findings are briefly summarized. B.G.

N87-27154*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXPERIMENTAL STUDY OF SHOCK WAVE INTERFERENCE HEATING ON A CYLINDRICAL LEADING EDGE Ph.D. Thesis
ALLAN R. WIETING May 1987 267 p
(NASA-TM-100484; NAS 1.15:100484) Avail: NTIS HC A12/MF A01 CSCL 20D

An experimental study of shock wave interference heating on a cylindrical leading edge representative of the cowl of a rectangular hypersonic engine inlet at Mach numbers of 6.3, 6.5, and 8.0 is presented. Stream Reynolds numbers ranged from 0.5 x 106 to 4.9 x 106 per ft. and stream total temperature ranged from 2100 to 3400 R. The model consisted of a 3' dia. cylinder and a shock generation wedge articulated to angles of 10, 12.5, and 15 deg. A fundamental understanding was obtained of the fluid mechanics of shock wave interference induced flow impingement on a cylindrical leading edge and the attendant surface pressure and heat flux distributions. The first detailed heat transfer rate and pressure distributions for two dimensional shock wave interference on a cylinder was provided along with insight into the effects of specific heat variation with temperature on the phenomena. Results show that the flow around a body in hypersonic flow is altered significantly by the shock wave interference pattern that is created by an oblique shock wave from an external source intersecting the bow shock wave produced in front of the body. Author

N87-27242*# Dynamic Engineering, Inc., Newport News, Va.
THE USE OF NASTRAN IN THE DESIGN OF WIND TUNNEL RESEARCH AIRCRAFT
MICHAEL COOPER *In* COSMIC, 15th NASTRAN Users' Colloquium p 166-183 Aug. 1987
Avail: NTIS HC A14/MF A01; also available from COSMIC, Athens, Ga. 30602 CSCL 20K

The relationship between NASTRAN and the wind tunnel model design process is discussed. Specific cases illustrating the use of NASTRAN for static, heat transfer, dynamic, and aeroelastic

analyses are presented. Advantages and disadvantages of using NASTRAN are summarized. Author

N87-27267*# Pratt and Whitney Aircraft, East Hartford, Conn. Engineering Div.
3-D INELASTIC ANALYSIS METHODS FOR HOT SECTION COMPONENTS. VOLUME 2: ADVANCED SPECIAL FUNCTIONS MODELS Annual Status Report No. 3
R. B. WILSON and P. K. BANERJEE Aug. 1987 87 p
(Contract NAS3-23697)
(NASA-CR-179517; NAS 1.26:179517; PWA-5940-46-VOL-2)
Avail: NTIS HC A05/MF A01 CSCL 20K

This Annual Status Report presents the results of work performed during the third year of the 3-D Inelastic Analysis Methods for Hot Sections Components program (NASA Contract NAS3-23697). The objective of the program is to produce a series of computer codes that permit more accurate and efficient three-dimensional analyses of selected hot section components, i.e., combustor liners, turbine blades, and turbine vanes. The computer codes embody a progression of mathematical models and are streamlined to take advantage of geometrical features, loading conditions, and forms of material response that distinguish each group of selected components. Author

N87-27851# Council for Scientific and Industrial Research, Pretoria (South Africa).
RESULTS OF NUMERICAL AND PHYSICAL MODELLING OF AIRBORNE ADCOCK ARRAYS FOR VHF DF (DIRECTION FINDING) APPLICATIONS
D. C. BAKER, L. BOTHA, D. A. MCNAMARA, and G. W. REED *In* Illinois Univ., Proceedings of the Antenna Applications Symposium held in Urbana, Illinois on 17-19 September 1986, Volume 2 p 655-685 Feb. 1987
(AD-P005423) Avail: NTIS HC A15/MF A01 CSCL 17C

This paper describes an attempt to predict the received voltages on a VHF direction finding (DF) array using the geometrical theory of diffraction and the principle of reciprocity. Once the received voltages are known bearing errors can be predicted from the phase information. The predicted receive mode radiation patterns are compared with a simple model of a C130 Hercules transport aircraft. Further comparison is made with models representing a low-wing jetliner with underwing engines. The latter aircraft models use either a blunt capped cylinder or a sectional cylinder with a emispherical cap and a conic section. The comparison between predicted and measured results are reasonable. GRA

N87-27869*# Ohio State Univ., Columbus. ElectroScience Lab.
ANALYSIS OF AIRBORNE ANTENNA SYSTEMS USING GEOMETRICAL THEORY OF DIFFRACTION AND MOMENT METHOD COMPUTER CODES
RICHARD G. HARTENSTEIN, JR. Aug. 1985 76 p
(Contract NSG-1498)
(NASA-CR-181248; NAS 1.26:181248; REPT-716199-6) Avail: NTIS HC A05/MF A01 CSCL 20N

Computer codes have been developed to analyze antennas on aircraft and in the presence of scatterers. The purpose of this study is to use these codes to develop accurate computer models of various aircraft and antenna systems. The antenna systems analyzed are a P-3B L-Band antenna, an A-7E UHF relay pod antenna, and traffic advisory antenna system installed on a Bell Long Ranger helicopter. Computer results are compared to measured ones with good agreement. These codes can be used in the design stage of an antenna system to determine the optimum antenna location and save valuable time and costly flight hours. Author

N87-27870*# Ohio State Univ., Columbus. ElectroScience Lab.
SIMULATION AND ANALYSIS OF AIRBORNE ANTENNA RADIATION PATTERNS
J. J. KIM and WALTER D. BURNSIDE Dec. 1984 345 p
(Contract NSG-1498)
(NASA-CR-181250; NAS 1.26:181250; REPT-716199-1) Avail: NTIS HC A15/MF A01 CSCL 20N

The objective is to develop an accurate and efficient analytic solution for predicting high frequency radiation patterns of fuselage-mounted airborne antennas. This is an analytic study of airborne antenna patterns using the Uniform Geometrical Theory of Diffraction (UTD). The aircraft is modeled in its most basic form so that the solution is applicable to general-type aircraft. The fuselage is modeled as a perfectly conducting composite ellipsoid; whereas, the wings, stabilizers, nose, fuel tanks, and engines, are simulated as perfectly conducting flat plates that can be attached to the fuselage and/or to each other. The composite-ellipsoid fuselage model is necessary to successfully simulate the wide variety of real world fuselage shapes. Since the antenna is mounted on the fuselage, it has a dominant effect on the resulting radiation pattern so it must be simulated accurately, especially near the antenna. Various radiation patterns are calculated for commercial, private, and military aircraft, and the Space Shuttle Orbiter. The application of this solution to numerous practical airborne antenna problems illustrates its versatility and design capability. In most cases, the solution accuracy is verified by the comparisons between the calculated and measured data. Author

N87-27929*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
NUMERICAL SOLUTIONS OF NAVIER-STOKES EQUATIONS FOR A BUTLER WING Final Report, 1 Jan. 1986 - 1 Jan. 1987
JAMSHID S. ABOLHASSANI and SURENDRA N. TIWARI Jan. 1987 32 p
(Contract NCC1-68)
(NASA-CR-180331; NAS 1.26:180331) Avail: NTIS HC A03/MF A01 CSCL 20D

The flow field is simulated on the surface of a Butler wing in a uniform stream. Results are presented for the Mach number 3.5 and Reynolds number of 2,000,000. The simulation is done by integrating the viscous Navier-Stokes equations. These equations govern the unsteady, viscous, compressible and heat conducting flow of an ideal gas. The equations are written in curvilinear coordinates so that the wing surface is represented accurately. O-type and H-type grids have been used for this study, and results are compared. The governing equations are solved by the McCormack time-split method, and the results are compared with other theoretical and experimental results. The codes are written in FORTRAN, vectorized and currently run on the CDC Vector Processing System (VPS-32) computer. Author

N87-27931 Maryland Univ., College Park.
AN EXPERIMENTAL INVESTIGATION OF SHOCK WAVES AND TURBULENT BOUNDARY LAYER INTERACTIONS IN A SUPERSONIC FLOWFIELD THROUGH AN ANNULAR DUCT Ph.D. Thesis
RICHARD DREXEL STOCKBRIDGE 1986 120 p
Avail: Univ. Microfilms Order No. DA8709465

An experimental investigation of compression fields in a supersonic flow through an annular duct is discussed. A data correlating equation that predicts the starting point of the compression fields in the annular duct as a function of the test variables is derived and evaluated. This correlating equation predicts the minimum length of the isolator duct which conducts air from the external compressor field of a dual combustion ramjet inlet to the supersonic flow combustor that is required to prevent undesirable combustor/inlet interactions. Dissert. Abstr.

N87-27936*# Georgia Inst. of Tech., Atlanta. School of Mechanical Engineering.
MODELING OF TRANSIENT HEAT PIPE OPERATION Semiannual Status Report, 19 Aug. 1986 - 18 Feb. 1987
GENE T. COLWELL 1 Jul. 1987 36 p
(Contract NAG1-392)
(NASA-CR-180280; NAS 1.26:180280) Avail: NTIS HC A03/MF A01 CSCL 20D

The use of heat pipes is being considered as a means of reducing the peak temperature and large thermal gradients at the leading edges of reentry vehicles and hypersonic aircraft and in nuclear reactors. In the basic cooling concept, the heat pipe covers the leading edge, a portion of the lower wing surface, and a portion of the upper wing surface. Aerodynamic heat is mainly absorbed at the leading edge and transported through the heat pipe to the upper and lower wing surface, where it is rejected by thermal radiation and convection. Basic governing equations are written to determine the startup, transient, and steady state performance of a haet pipe which has initially frozen alkali-metal as the working fluid. Author

N87-27943*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
EXPERIMENTAL AND ANALYTICAL STUDIES IN FLUIDS Final Report, period ending 31 Aug. 1984
GENE L. GOGLIA and ADEL IBRAHIM Sep. 1984 101 p
(Contract NSG-1177)
(NASA-CR-181242; NAS 1.26:181242) Avail: NTIS HC A06/MF A01 CSCL 20D

The first objective was to analyze and design a true airspeed sensor which will replace the conventional pitot-static pressure transducer for small commercial aircraft. The second objective was to obtain a numerical solution and predict the frequency response which is generated by the vortex whistle at a certain airspeed. It was concluded flow rate measurements indicate that the vortex tube sound frequency is linearly proportional to the frequency response. The vortex tube whistle frequency is dependent upon geometrical parameters to such an extent that: an increase in vortex tube length produces a decrease in frequency response and that an increase in the exhaust nozzle length produces an increase in the frequency precession. An increase in the vortex tube diameter produces a decrease in frequency precession. An increase in swirler diameter produces a decrease in frequency. An increase in the location distance of the microphone pickup signal point from the inside edge of the exit nozzle produces an increase in frequency response. The experimental results indicate that those parameters most significantly effecting frequency are in descending order of importance microphone location, vortex tube diameter, exit nozzle length, vortex tube length, and swirler diameter. B.G.

N87-27970# Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.
TO ENHANCE THE CAPABILITY AND INCREASE THE PRODUCTIVITY OF A GROUP WORKING ON CRITICAL PROBLEMS OF HIGH SPEED FLUID MECHANICS - BOTH EXPERIMENTALLY AND THROUGH NUMERICAL CALCULATIONS Final Report, 1 Sep. 1983 - 31 Mar. 1986
SEYMOUR M. BOGDONOFF 22 May 1987 14 p
(Contract AF-AFOSR-0360-83)
(AD-A182559; MAE-1753; AFOSR-87-0793TR) Avail: NTIS HC A02/MF A01 CSCL 20D

A new test channel has been designed and constructed to operate off the present high pressure air supply. The new facility is characterized by low turbulence, variable geometry (LTVG) , and supersonic operation (currently designed for Mach 3) at stagnation pressures from 50 to 150 psia. This facility provides a new and unique capability to study two- and three-dimensional supersonic turbulent boundary layers interacting with gradients and shock waves. A new and enhanced data acquisition processing system has been installed in the Laboratory. It is based on the DEC VAX-750 which provides multi-channel high frequency, data acquisition and data processing capability for all of the Laboratory facilities. GRA

N87-28052# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
SEQUENCE EFFECTS OF HIGH-AMPLITUDE LOADS IN THE MOST SEVERE FLIGHTS OF MINITWIST ON FATIGUE CRACK GROWTH IN AL-ALLOY SHEET MATERIAL
U. H. PADMADINATA Aug. 1968 27 p
(VTH-LR-493; B8707461; ETN-87-90226) Avail: NTIS HC A03/MF A01

Fatigue crack propagation was studied under modified miniTWIST load sequences applied to 2024-T3 alclad specimens to explore the sequence effect of the maximum amplitudes occurring in the most severe flights on fatigue. The main variable was the sequence of the high upward gusts and the high downward gusts. Tests were also carried out with the severe upward gusts occurring before the severe downward gusts (max-min) and with severe upward gusts occurring after the severe downward gusts (min-max). The modified min-max sequence gives slower crack growth than the max-min sequence. This trend qualitatively agrees with sequence effects observed in overload cycles. The max-min sequence gives a similar crack growth to the original miniTWIST. The severe flights give large contributions to the crack extension, followed by retardation in subsequent flights. The effect of an artificial starter crack has to be considered in crack growth prediction. ESA

N87-28056*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE EFFECTS OF AEROELASTIC DEFORMATION ON THE UNAUGMENTED STOPPED-ROTOR DYNAMICS OF AN X-WING AIRCRAFT
MICHAEL G. GILBERT and WALTER A. SILVA Jun. 1987 12 p Presented at the AIAA Atmospheric Flight Mechanics Conference, Monterey, Calif., 19 Aug. 1987
(NASA-TM-100480; NAS 1.15:100480) Avail: NTIS HC A02/MF A01 CSCL 20K

A new design concept in the development of VTOL aircraft with high forward flight speed capability is that of the X-Wing, a stiff, bearingless helicopter rotor system which can be stopped in flight and the blades used as two forward-swept and two aft-swept wings. Because of the usual configuration in the fixed-wing mode, there is a high potential for aeroelastic divergence or flutter and coupling of blade vibration modes with rigid-body modes. An aeroelastic stability analysis of an X-Wing configuration aircraft was undertaken to determine if these problems could exist. This paper reports on the results of dynamic stability analyses in the lateral and longitudinal directions including the vehicle rigid-body and flexible modes. A static aeroelastic analysis using the normal vibration mode equations of motion was performed to determine the cause of a loss of longitudinal static margin with increasing airspeed. This loss of static margin was found to be due to aeroelastic washin of the forward-swept blades and washout of the aft-swept blades moving the aircraft aerodynamic center forward of the center of gravity. This phenomenon is likely to be generic to X-Wing aircraft. Author

N87-28058*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A COMPUTATIONAL PROCEDURE FOR AUTOMATED FLUTTER ANALYSIS
DURBHA V. MURTHY (Toledo Univ., Ohio.) and KRISHNA RAO V. KAZA Aug. 1987 17 p
(NASA-TM-100171; E-3736; NAS 1.15:100171) Avail: NTIS HC A02/MF A01 CSCL 20K

A direct solution procedure for computing the flutter Mach number and the flutter frequency is applied to the aeroelastic analysis of propfans using a finite element structural model and an unsteady aerodynamic model based on a three-dimensional subsonic compressible lifting surface theory. An approximation to the Jacobian matrix that improves the efficiency of the iterative process is presented. The Jacobian matrix is indirectly

approximated from approximate derivatives of the flutter matrix. Examples are used to illustrate the convergence properties. The direct solution procedure facilitates the automated flutter analysis in addition to contributing to the efficient use of computer time as well as the analyst's time. Author

N87-28065# Rockwell International Corp., Thousand Oaks, Calif. Science Center.
PROCESSING AND PROPERTIES OF AIRFRAME MATERIALS Final Report, 1 Jan. 1983 - 28 Feb. 1986
C. G. RHODES, J. C. CHESTNUTT, J. A. WERT, and A. K. GHOSH Jun. 1987 119 p
(Contract F49620-83-C-0055)
(AD-A182159; SC5358-4FR; AFOSR-87-0815TR) Avail: NTIS HC A06/MF A01 CSCL 01C

This report describes the results of a three-year research program to study the relationship between microstructure and processing conditions and the effects of processing conditions on the performance of structural airframe materials. Part 1 of the program was an examination of the influence of beta processing methods on the interaction of fatigue cracks with microstructural elements. These beta-phase processing methods were chosen to provide variations in beta-phase volume fraction and continuity, alpha plate size, and alpha colony size in plate and forging material. The microstructures of the beta-processed materials were quantitatively characterized using scanning electron microscopy (SEM) and scanning transmission electron microscopy (STEM). Linear regression analyses revealed that beta phase volume fraction was most influential and colony size least influential on fatigue crack growth rates. GRA

N87-28067# Lehigh Univ., Bethlehem, Pa.
ANALYSIS OF STRUCTURES WITH ROTATING, FLEXIBLE SUBSTRUCTURES
A. S. HOPKINS and PETER LIKINS 1987 11 p
(AD-A182318) Avail: NTIS HC A02/MF A01 CSCL 20K

A new method has been developed for dynamic analysis of flexible structures, parts of which may be experiencing discrete motion relative to other parts. This method provides the capability of representing the continuum deformations typically treated using finite element methods. It also provides the capability of representing the discrete motion at joints traditionally available with multibody methods. After decomposing the structure into substructures and associating a frame of reference with each substructure, the equations of motion for each substructure can be written explicitly including contributions due to the frame of reference generalized coordinates. By expanding the set of constraints to include constraints that eliminate the redundancy introduced by the frame generalized coordinates, the equations of motion become amenable to solution. The first digital computer program using this method, the General Rotorcraft Aeromechanical Stability Program (GRASP), was introduced in 1986. Although GRASP is limited to applications involving steady-state-rotation, extension to arbitrary motions (including spin-up) can be accomplished. GRA

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GEOSCIENCES

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

A87-49368* National Center for Atmospheric Research, Boulder, Colo.
THE MICROBURSTS OF 22 JUNE 1982 IN JAWS
M. R. HJELMFELT (National Center for Atmospheric Research, Boulder, CO) Journal of the Atmospheric Sciences (ISSN 0022-4928), vol. 44, June 15, 1987, p. 1646-1665. Research supported by the National Center for Atmospheric Research, NSF, and NOAA. refs
(Contract NASA ORDER H-59314B; DOT-FA01-82-Y-10513)

The development of several large thunderstorms that occurred on June 22, 1982 within the Joint Airport Weather Studies (JAWS) network near Denver, Colorado is examined together with that of six microbursts and one microburst line produced by the storms. From the analysis of single and multiple Doppler radar and surface network data, it is concluded that the microbursts on June 22 were predominantly driven by microphysical and related thermodynamic effects due to precipitation loading and water-phase change; dynamic effects did not appear to be of primary importance. Surface network observations permitted identification of some of the microbursts, but early detection was not possible. I.S.

A87-50459*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SEVERE WINDS IN THE DFW MICROBURST MEASURED FROM TWO AIRCRAFT
R. C. WINGROVE and R. E. BACH, JR. (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 477-482. refs
(AIAA PAPER 87-2340)

Advanced analytical methods are applied to the digital flight data and Air Traffic Control radar records from two airliners, Delta flight 191 and American flight 539, that penetrated a microburst at the Dallas/Ft. Worth airport on August 2, 1985. The results for Delta 191 (which crashed) show that the aircraft encountered a strong downburst followed by a strong outflow accompanied by large and rapid changes in the vertical wind. The rapid changes in the vertical wind detected near the ground are attributed to vortex-induced turbulence. The next following aircraft, American 539, made a go-around 110 sec after Delta 191 and traversed the microburst at an altitude of about 2500 ft above the ground. The measured winds during this go-around indicate a broad pattern of downflow in the microburst, with regions of upflow at the extreme edges. The combined results indicate a microburst that was increasing in size with vortex-induced turbulence embedded in a strong outflow near the ground. These wind measurements provide a realistic description of the microburst wind environment that can be used in simulator studies and pilot training, and provide a standard of comparison for ongoing experiments and modeling of microbursts involving vortex rings. Author

N87-28229# National Oceanic and Atmospheric Administration, Norman, Okla. National Severe Storms Lab.
OKLAHOMA DOWNBURSTS AND THEIR ASYMMETRY Final Report
MICHAEL D. EILTS and RICHARD J. DOVIAK Nov. 1986 50 p
(Contract DTFA01-80-Y-10524)
(AD-A182097; DOT/FAA/PM-87/7) Avail: NTIS HC A03/MF A01 CSCL 04B

Doppler radar data, collected each spring from 1979 to 1984, with the two Doppler radars operated by the National Severe Storms Laboratory (NSSL), are used to investigate the asymmetry

of low-altitude divergent outflows of convective storm downbursts in central Oklahoma. Outflows in Oklahoma storms can be highly asymmetric with horizontal shear along the axis of maximum divergence as much as 5.5 times the shear along the axis of minimum divergence. The downbursts observed in central Oklahoma, all large-scale (4 to 10 km) events, were superposed with the maximum reflectivity core of the storms. However, scanning strategies may have precluded detection of smaller scale (less than 4 km) microbursts. Typical downbursts observed during the Joint Airport Weather Studies (JAWS) Project were of smaller scale (less than 4 km) and were often associated with little or no rain at the surface. The mechanisms for the initiation of the majority of JAWS microbursts was most likely evaporative cooling, which occurred when precipitation fell into a dry, deep and nearly adiabatic boundary layer. It appears that, because of a lower cloud base and a moister and slightly more stable boundary layer, the mechanisms for the initiation of the observed Oklahoma downbursts include low-level melting, as well as evaporation of precipitation, low-level precipitation loading, and evaporational cooling at middle levels due to entrainment of dry hair. GRA

N87-28232*# FWG Associates, Inc., Tullahoma, Tenn.
DEVELOPMENT OF A MICROBURST TURBULENCE MODEL FOR THE JOINT AIRPORT WEATHER STUDIES WIND SHEAR DATA
HO-PEN CHANG and WALTER FROST Mar. 1987 79 p
(Contract NASA ORDER H-59314-B; DTFA01-82-Y-10513)
(NASA-CR-180374; NAS 1.26:180374; DOT/FAA/PM-87/12)
Avail: NTIS HC A05/MF A01 CSCL 04B

A turbulence model is developed to supplement the microburst quasi-steady wind shear model established earlier from the JAWS Doppler radar sets. The wind shear model is, in effect, a quasi-steady, spatially varying wind field. The spatial scale of the wind variation is on the order of 500 to 750 ft. Airborne sensor response (i.e., angle of attack, stall warning, pitot tubes, etc.), structural dynamics, pilot workload, and other such factors, however, respond to much higher frequency wind effects. To account for these effects, a first cut turbulence model based on Doppler radar second moment data is presented. Superimposing the turbulent fluctuation from this turbulence model on the quasi-steady JAWS wind field is believed to provide a more realistic simulation of the microburst flow for aviation application. Author

N87-28233# National Oceanic and Atmospheric Administration, Norman, Okla.
LOW-ALTITUDE WIND SHEAR DETECTION WITH DOPPLER RADAR Final Report
MICHAEL D. ELLIS Feb. 1987 41 p
(Contract DTFA01-80-Y-10524)
(AD-A181900; DOT/FAA-PM-87/6) Avail: NTIS HC A03/MF A01 CSCL 04B

The feasibility of using the next generation weather radar (NEXRAD) system to detect low-altitude horizontal wind shear airports is investigated. We compare surface measured horizontal shear with that observed aloft with Doppler radar to determine how the radar-estimated shear above the surface relates to the surface-measured shear. For five Oklahoma gust fronts, the Doppler radar shear (at heights between 50 and 600 m) averaged 1.6 times the shear measured at the surface. For none of the 43 comparisons was the surface radial velocity difference across the gust front stronger than the radial velocity difference measured by the Doppler radar aloft. When the five gust fronts passed an instrumented tower a vertical profile through the lowest 440 m of the gust front could be determined. In all cases the wind speed and wind shear increased in the lowest 90 m of the atmosphere. In one case, the 90 m height had the peak wind shear; in all other cases the peak wind shear was at a much higher altitude. GRA

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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.

A87-47806#
PARAMETER-INSENSITIVE TECHNIQUE FOR AIRCRAFT SENSOR FAULT ANALYSIS
R. J. PATTON, S. W. WILLCOX (York, University, Heslington, England), and J. S. WINTER (Royal Aircraft Establishment, Bedford, England) (Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986, Technical Papers, p. 165-179) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 10, July-Aug. 1987, p. 359-367. Research supported by the Ministry of Defence (Procurement Executive). Previously cited in issue 23, p. 3402, Accession no. A86-47420. refs

A87-48603#
LESSONS LEARNED FROM PAST PROGRAMS - AIR TRAFFIC CONTROL
B. N. ETHERIDGE and R. W. PEAK, JR. (Martin Marietta Corp., Air Traffic Control Div., Washington, DC) AIAA and NASA, International Symposium on Space Information Systems in the Space Station Era, Washington, DC, June 22, 23, 1987. 10 p.
(AIAA PAPER 87-2222)

The application of system engineering management to the modernization of large systems, in particular to the National Airspace System (NAS), is examined. The classical approach to system engineering, and the four-level scheme for the design of the NAS are discussed. Consideration is given to system and subsystem requirements, design, and integration, and system verification, deployment, and activation. I.F.

A87-48935#
S.I. PREL. - A METHODOLOGY FOR MONITORING THE PRELIMINARY DESIGN TASKS
ROBERTO CASTAGNA, GIAMPIETRO TAMBORINI, and TIZIANO PIAZZA (Costruzioni Aeronautiche Giovanni Agusta S.p.A., Gallarate, Italy) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 15 p. refs

S.I. PREL has the aim of supporting the sizing stage (feasibility study) of helicopter design. This instrument has been planned to aid the designer in using application programs and in entering data into files, and consists in a series of menus which show the possible selections in a user-oriented language. The characteristics, structure, and benefits of the system developed are described, and an example of its utilization is given. B.J.

A87-48959
UK RESEARCH INTO SYSTEM IDENTIFICATION FOR HELICOPTER FLIGHT MECHANICS
G. D. PADFIELD, R. THORNE (Royal Aircraft Establishment, Bedford, England), D. MURRAY-SMITH, C. BLACK, and A. E. CALDWELL (Glasgow, University, Scotland) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 29 p. refs

The integration of input design, state estimation, model structure estimation, and parameter identification into a methodology and its application to helicopter flight dynamics are examined. The three levels for modeling of rotorcraft flight behavior and related loadings are discussed. The integrated methodology developed for helicopter system identification and its implementation in the parameter estimation package are described. The methodology was validated using data from simulation models, and an example of flight data analysis using the integrated methodology is presented. I.F.

A87-49157#
SIMULATION IN ADA - HOW DO YOU GET THERE FROM HERE?
D. MCCABE, A. LA PLANTE, and S. RAMACHANDRAN (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AIAA Flight Simulation Technologies Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1-7.
(AIAA PAPER 87-2299)

This paper addresses the issues involved in transitioning to an Ada programming environment for simulation application. The advantages and disadvantages of Ada are examined from the perspective of an engineering simulation organization. System architecture, software development environment, Ada compilers/cross-compilers and software engineering methodologies are discussed. Simulation architecture selected by McDonnell Douglas Helicopter company and lessons learned are presented. Author

A87-49159#
PART-TASK SIMULATION TECHNIQUES
ANNIE M. SIZER (General Dynamics Corp., Fort Worth, TX) IN: AIAA Flight Simulation Technologies Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 17-23.
(AIAA PAPER 87-2301)

The testing of real-time software models without the use of cockpit hardware is considered. Two typical methods of part-task simulation utilities are addressed: real-time emulation (RTE) and off-line simulation (OLS). A method for using an off-line development system to analyze avionics models in an approximation of operational conditions is presented. The techniques considered have been demonstrated to be extremely useful tools in the implementation and debugging of the avionic system models. The RTE and OLS methods were developed on two different types of computers (Gould 32/97 and Harris H1000), yet similar logic was used in this development. This illustrates that a part-task simulation could be accomplished on almost any type of development system. B.J.

A87-49165#
PREDICTIVE COMPENSATION OF VISUAL SYSTEM TIME DELAYS
DONALD J. SOBISKI (IBM Corp., Federal Systems Div., Oswego, NY) and FRANK M. CARDULLO (New York, State University, Binghamton, NY) IN: AIAA Flight Simulation Technologies Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 59-70. refs
(AIAA PAPER 87-2434)

Time delays in systems dependent on loop closure by a human operator in series with a visual display can cause degraded system performance and altered workload. A simulation of executive class jet aircraft dynamics with a flight director type display and programmable delays has been developed to explore these types of delays, and to develop and test a predictive method of compensation in an experimental environment. This predictive method uses the state transition matrix in a feedback loop to compensate for time delays. The experiment consisted of a compensatory tracking task which required nulling of the roll angle error of the simulated aircraft while it was being perturbed with random-appearing noise. A multidimensional measurement space was used to quantify performance through analysis of the experimentally obtained results. This analysis shows that the state predictor filter can achieve performance comparable to an undelayed, unfiltered system. A cluster analysis revealed that the delayed system with the state predictor filter and the original, undelayed system are fundamentally similar. A metric for evaluating workload is also presented. Author

A87-49166#
FREQUENCY RESPONSE IDENTIFICATION OF A COMPUTER-GENERATED IMAGE VISUAL SIMULATOR WITH AND WITHOUT A DELAY COMPENSATION SCHEME
WAYNE F. JEWELL, WARREN F. CLEMENT, and JEFFERY R. HOGUE (Systems Technology, Inc., Mountain View, CA) IN: AIAA Flight Simulation Technologies Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 71-76. refs
(AIAA PAPER 87-2425)

Most modern flight simulators employ computer-generated images (CGIs) to display outside visual cues to the pilot. While these CGIs have excellent low-frequency characteristics, their high-frequency bandwidth is inherently limited by the update rate of the combined host computer and visual simulator. In addition, the complex architecture of the overall system (i.e., combined simulator/CGI system) makes the analysis of the frequency response extremely difficult. The frequency response technique presented in this paper permits the dynamics of the overall system to be measured and analyzed very easily. The technique, which is based on hardware and software that are compatible with an IBM PC, identifies the simulator response from the pilot's control inputs to the output of the CGI, as measured by a photometric sensor attached to the visual display monitor. The data show that a novel delay compensation scheme can extend the bandwidth of CGI visual simulators. The frequency response identification technique could be used to document further improvements to visual simulators such as advanced architectures and parallel processors. Author

A87-49169*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A NEW SIMULATION MODEL BUILDING PROCESS FOR USE IN DYNAMIC SYSTEMS INTEGRATION RESEARCH
P. DOUGLAS ARBUCKLE, CAREY S. BUTTRILL (NASA, Langley Research Center, Hampton, VA), and THOMAS A. ZEILER (PRC Kentron, Inc., Hampton, VA) IN: AIAA Flight Simulation Technologies Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 96-106. refs
(AIAA PAPER 87-2498)

A framework to build simulation models for aircraft dynamic systems integration is described. The objective of the framework is increased simulation model fidelity and reduced time required to develop and modify these models. The equations of motion for an elastic aircraft and their impact on the framework are discussed in broad terms. A software tool which automatically generates FORTRAN routines for tabular data lookups, the language used to develop a simulation model, and the structures for passing information into a simulation are discussed. A simulation variable nomenclature is presented. The framework has been applied to build an open-loop F/A-18 simulation model. This example model is used to illustrate model reduction issues. Current deficiencies in the framework are identified as areas for future research. Author

A87-49200
CAFTA - THE LATEST IN FLIGHT TEST DATA ANALYSIS SYSTEMS
RANDALL C. SMITH (Bell Helicopter Textron, Fort Worth, TX) IN: Society of Flight Test Engineers, Annual Symposium, 17th, Washington, DC, Aug. 10-14, 1986, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1986, p. 1.3-1 to 1.3-11.

CAFTA (the Computer-Aided Flight Test Analysis system) is Bell Helicopter-Textrons's new flight test data processing system. CAFTA is an interactive multiuser flight test data system which is built around VAX computers and front-end multiprocessors. This paper presents a brief history of the development of the CAFTA system and considers the capabilities and architecture of the system from the perspective of the test engineer. It is concluded that CAFTA will greatly increase the real-time analysis and display capability in addition to interactive postflight analysis and shake test support. It is noted that CAFTA will play an important role in

the V-22, LHX, and other BHTI flight test programs through the next decade. B.J.

A87-49623*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFICIENT COMPUTATION OF PARAMETER CONFIDENCE INTERVALS
PATRICK C. MURPHY (NASA, Langley Research Center, Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 464-473. refs
(AIAA PAPER 87-2624)

An important step in system identification of aircraft is the estimation of stability and control derivatives from flight data along with an assessment of parameter accuracy. When the maximum likelihood estimation technique is used, parameter accuracy is commonly assessed by the Cramer-Rao lower bound. It is known, however, that in some cases the lower bound can be substantially different from the parameter variance. Under these circumstances the Cramer-Rao bounds may be misleading as an accuracy measure. This paper discusses the confidence interval estimation problem based on likelihood ratios, which offers a more general estimate of the error bounds. Four approaches are considered for computing confidence intervals of maximum likelihood parameter estimates. Each approach is applied to real flight data and compared. Author

A87-50408#
ESTIMATING PROJECTIONS OF THE PLAYABLE SET
T. L. VINCENT (Arizona, University, Tucson) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 50-55. refs
(AIAA PAPER 87-2242)

The playable set in differential game theory is the set of points in state space where a pursuer can guarantee capture of an evader under all possible control actions of the evader to the contrary. For problems of low dimension (one, two, and perhaps three dimensions), the playable set can usually be constructed using the necessary conditions provided by the playability max-min principle. This principle provides controls for both the pursuer and evader which will drive the system along the boundary of the playable set. It is shown here that for a number of higher dimensional problems, the playability max-min principle can still be used to estimate the projection of a higher dimensional playable set on to a lower dimension (usually one or two dimensions). This is done by finding both an overestimate and an underestimate for such a projection. This procedure is used to re-examine some previously published results on aircraft collision avoidance. Author

A87-50435#
A GENERAL METHODOLOGY FOR POLE PLACEMENT IN LINEAR QUADRATIC REGULATOR DESIGN OF MULTIVARIABLE CONTROL SYSTEMS
GEORGES A. BECUS (Cincinnati, University, OH) and CHI-YAU LUI IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 1 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 295-305. refs
(Contract F49620-85-C-0013)
(AIAA PAPER 87-2314)

A methodology to satisfy a pole placement criterion in designing linear multivariable control systems is proposed. The poles of closed-loop systems are assigned using Linear Quadrtic Regulator synthesis and the problem of choosing approriate state and control weighting matrices to achieve a desired pole placement is considered. A method for shifting open-loop poles to any desired closed-loop poles locations is developed based on the relationship between weighting matrices elements and prescribed closed-loop poles. An algorithm for pole placement synthesis based on a combination of analytical methods and numerical optimization procedures is presented. The method guarantees robustness of the closed loop system. Illustrative examples involving simple two-state systems as well as an application to the design of the longitudinal control for landing approach of a propulsive lift short take-off and landing aircraft are presented. Author

A87-50565#
FAILURE DETECTION IN DYNAMIC SYSTEMS WITH MODELING ERRORS
D. T. HORAK (Bendix Aerospace Technology Center, Columbia, MD) IN: AIAA Guidance, Navigation and Control Conference, Monterey, CA, Aug. 17-19, 1987, Technical Papers. Volume 2 . New York, American Institute of Aeronautics and Astronautics, 1987, p. 1545-1553. refs
(AIAA PAPER 87-2604)

This paper determines the theoretical limits of failure detectability in systems with modeling errors. Such errors are the main obstacle to accurate failure detection in aircraft, jet engines, power generation systems, and most other systems which include mechanical components and/or thermo-fluid processes. The paper then introduces the Reachable Measurement Intervals (RMI) failure detection method which performs at the limit of detectability. RMI is capable of detecting the smallest theoretically detectable failures in systems with modeling errors, and is implementable in real time on single-board computers. The method is illustrated on a jet engine example. Author

N87-28275*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TRADITIONAL VERSUS RULE-BASED PROGRAMMING TECHNIQUES: APPLICATION TO THE CONTROL OF OPTIONAL FLIGHT INFORMATION
WENDELL R. RICKS and KATHY H. ABBOTT Jul. 1987 15 p
(NASA-TM-89161; NAS 1.15:89161) Avail: NTIS HC A02/MF A01 CSCL 12A

To the software design community, the concern over the costs associated with a program's execution time and implementation is great. It is always desirable, and sometimes imperative, that the proper programming technique is chosen which minimizes all costs for a given application or type of application. A study is described that compared cost-related factors associated with traditional programming techniques to rule-based programming techniques for a specific application. The results of this study favored the traditional approach regarding execution efficiency, but favored the rule-based approach regarding programmer productivity (implementation ease). Although this study examined a specific application, the results should be widely applicable. Author

N87-28277*# Carnegie-Mellon Univ., Pittsburgh, Pa. Dept. of Computer Science.
VALIDATION OF A FAULT-TOLERANT MULTIPROCESSOR: BASELINE EXPERIMENTS AND WORKLOAD IMPLEMENTATION
FRANK FEATHER, DANIEL SIEWIOREK, and ZARY SEGALL 22 Jul. 1985 53 p
(Contract NAG1-190)
(NASA-CR-181238; NAS 1.26:181238; CMU-CS-85-145) Avail: NTIS HC A04/MF A01 CSCL 09B

In the future, aircraft must employ highly reliable multiprocessors in order to achieve flight safety. Such computers must be experimentally validated before they are deployed. This project outlines a methodology for validating reliable multiprocessors. The methodology begins with baseline experiments, which tests a single phenomenon. As experiments progress, tools for performance testing are developed. The methodology is used, in part, on the Fault Tolerant Multiprocessor (FTMP) at NASA-Langley's AIRLAB facility. Experiments are designed to evaluate the fault-free performance of the system. Presented are the results of interrupt baseline experiments performed on FTMP. Interrupt causing exception conditions were tested, and several were found to have unimplemented interrupt handling software while one had an unimplemented interrupt vector. A synthetic workload model for realtime multiprocessors is then developed as an application level

performance analysis tool. Details of the workload implementation and calibration are presented. Both the experimental methodology and the synthetic workload model are general enough to be applicable to reliable multiprocessors beside FTMP. Author

N87-28299*# Boeing Commercial Airplane Co., Seattle, Wash.
DEVELOPMENT OF INTEGRATED PROGRAMS FOR AEROSPACE-VEHICLE DESIGN (IPAD)
O. L. ANDERSON, A. L. CALVERY, D. A. DAVIS, L. DICKMANN, D. H. FOLGER, E. N. JOCHEM, C. M. KITTO, and G. VONLIMBACH 19 Dec. 1977 316 p
(Contract NAS1-14700)
(NASA-CR-181274; NAS 1.26:181274; D6-IPAD-70040-D) Avail: NTIS HC A14/MF A01 CSCL 09B

Integrated Programs for Aerospace Vehicle Design (IPAD) system design requirements are given. The information is based on the IPAD User Requirements Document (D6-IPAD-70013-D) and the Integrated Information Processing Requirements Document (D6-IPAD-70012-D). General information about IPAD and a list of the system design requirements that are to be satisfied by the IPAD system are given. The system design requirements definition is to be considered as a baseline definition of the IPAD system design requirements. Author

N87-28309# Maryland Univ., College Park. Dept. of Computer Science.
REAL TIME PROGRAMS. DESIGN IMPLEMENTATION OF VALIDATION: A SURVEY
SHEM-TOV LEVI and ASHOK K. AGRAWALA Apr. 1987 88 p
(Contract N00014-87-K-0124)
(AD-A182144; AD-E900674; CS-TR-1837) Avail: NTIS HC A05/MF A01 CSCL 09B

The use of real-time systems is wide spread today, and involves very large and sophisticated programs. In addition to the constraints imposed on regular very large programs, real-time very large programs are subjected to stringent real-time constraints that the designer tries to meet, to satisfy, and to validate. Those very large programs (systems) are of a very complicated nature, and need special methodologies. This review tries to summarize the methods, approaches, techniques and tools which are used today during a real time system's life cycle. The review deals with three important phases of a real-time system: the design phase, the implementation phase, and the validation phase. GRA

N87-28348*# Brown Univ., Providence, R. I.
THE JACOBI MATRIX TECHNIQUE IN COMPUTATIONAL FLUID DYNAMICS Ph.D. Thesis
H. THOMAS SHARP *In its* Research on Computational Fluid Dynamics and Turbulence 59 p 1986
Avail: NTIS HC A05/MF A01 CSCL 12A

The Jacobi matrix technique was applied to the direct calculation of inviscid supersonic flow about two dimensional airfoils of varying thickness, angle of attack and camber and axisymmetric bodies of varying thickness and taper; and the design (inverse) calculation of inviscid supersonic flow past airfoils described by a given family of pressure distributions and axisymmetric bodies described by a given family of pressure distributions. The method was also applied to subsonic potential flow about two dimensional airfoils by modifying Jameson's FLO36. Results are discussed. B.G.

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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.

A87-47352* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INTERACTION OF AIRBORNE AND STRUCTURE-BORNE NOISE RADIATED BY PLATES
M. C. MCGARY (NASA, Langley Research Center, Hampton, VA) Journal of Sound and Vibration (ISSN 0022-460X), vol. 115, June 22, 1987, p. 387-403. refs

The interaction of airborne and structure-borne noise radiated by aircraft structures is studied analytically and experimentally for the case of noise radiating from thin, isotropic, rectangular aluminum plates as a result of fully coherent, combined acoustic and vibrational inputs. Attention is given to the great influence of the relative phase between inputs on the combined noise radiation characteristics of the plates; these phase-dependent effects, which are manifest as cross-terms in both the dynamic and acoustic portions of the analysis, can radically alter the combined sound power radiated by airframe structure plates. Such interactive effects have heretofore been neglected in analyses of results from analytical and experimental studies of propeller-driven aircraft interior noise. O.C.

A87-48760* Sverdrup Technology, Inc., Arnold Air Force Station, Tenn.
THE ACOUSTIC EXPERIMENTAL INVESTIGATION OF COUNTERROTATING PROPELLER CONFIGURATIONS
JOHN A. GAZZANIGA (Sverdrup Technology, Inc., Arnold Air Force Station, TN) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 21 p. refs
(Contract NAG3-354)
(SAE PAPER 871-031)

An experimental study of scale counterrotating propellers operating in an anechoic facility has been conducted. Various configurations of counterrotation for equal numbers of blades per disk have been tested along with single-rotation propellers, underscoring the fundamental acoustic differences between single and counterrotation propeller operation. In addition it is shown that, as the loading on the counterrotating system is increased, the overall sound-pressure level is also increased in both the disk plane and axial direction. Author

A87-48762
MEASURED SOUND LEVELS OF THE RAISBECK QUIET TURBOFAN PROPELLERS ON MEDIUM-TWIN AIRCRAFT
JAMES D. RAISBECK (Raisbeck Engineering, Inc., Seattle, WA) and JOHN F. MILLS (BBN Laboratories, Inc., Cambridge, MA) SAE, General Aviation Aircraft Meeting and Exposition, Wichita, KS, Apr. 28-30, 1987. 7 p.
(SAE PAPER 871-034)

Sound reduction accomplished in several different types of medium-twin aircraft using Raisbeck Quiet Turbofan propellers is reported. Sound level reductions of up to 13 dBa have been achieved in both cockpit and cabin noise and vibration, and reductions in flyover sound levels were also achieved. At the same time, the overall performance levels of the aircraft were retained or improved. C.D.

A87-48909#
THEORETICAL AND EXPERIMENTAL CORRELATION OF LOW-SPEED MODEL HELICOPTER BLADE SLAP
DANIEL CHIN-LEUNG CHAN (General Motors Corp., Detroit, MI) and JAMES E. HUBBARD, JR. (MIT, Cambridge, MA) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 17 p. refs

The operating conditions under which the assumptions made in the Widnall and Wolf (1980) model of low-speed helicopter blade slap are correct are investigated. Using a limited number of miniature pressure transducers on a scale model helicopter rotor blade, the load distribution near the tip is estimated and used as input to the Widnall and Wolf model to determine the structure of the trailing vortex. The geometry of the blade-vortex interaction is determined by smoke visualization techniques. The unsteady load on the blade resulting from the blade-gust interaction is modeled as a distribution of acoustic dipoles. The predicted sound pressure level is compared with the experimentally obtained far-field acoustic signature. Good agreement is found between the Widnall and Wolf model and the experimental results for the blade-vortex interactions in the region outside the vortex core. C.D.

A87-48910*# General Electric Co., Syracuse, N.Y.
MACH NUMBER SCALING OF HELICOPTER ROTOR BLADE/VORTEX INTERACTION NOISE
KENNETH P. LEIGHTON (General Electric Co., Syracuse, NY) and WESLEY L. HARRIS (MIT, Cambridge, MA) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 22 p. refs
(Contract NSG-1583)

A parametric study of model helicopter rotor blade slap due to blade vortex interaction (BVI) was conducted in a 5 by 7.5-foot anechoic wind tunnel using model helicopter rotors with two, three, and four blades. The results were compared with a previously developed Mach number scaling theory. Three- and four-bladed rotor configurations were found to show very good agreement with the Mach number to the sixth power law for all conditions tested. A reduction of conditions for which BVI blade slap is detected was observed for three-bladed rotors when compared to the two-bladed baseline. The advance ratio boundaries of the four-bladed rotor exhibited an angular dependence not present for the two-bladed configuration. The upper limits for the advance ratio boundaries of the four-bladed rotors increased with increasing rotational speed. C.D.

A87-48911#
BLADE/VORTEX INTERACTIONS AND NOISE ABATEMENT TECHNIQUES DURING DESCENT
J. S. POLLARD (Westland Helicopters, Ltd., Yeovil, England) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 17 p. Research supported by the Ministry of Defence of England.

Investigations conducted to obtain a fundamental understanding of the impulsive blade slap noise characteristic of helicopters in descent and to recommend noise abatement procedures are described. The aerodynamic modeling utilized is outlined; the acoustic pressure formulation is shown; the correction of ground reflection effects is summarized; and the model verification is described. Boundary mapping and noise level variability results which provide guidance for slap noise reduction are discussed. C.D.

A87-48912*# Rockwell International Corp., Canoga Park, Calif.
ON HELICOPTER ROTOR LOW FREQUENCY BROADBAND NOISE
MORGAN WILLIAMS (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) and WESLEY L. HARRIS (MIT, Cambridge, MA) European Rotorcraft Forum, 11th, London, England, Sept. 10-13, 1985, Paper. 32 p. refs
(Contract NSG-1583)

The effect of shear-layer-type inflow turbulence on the low-frequency broadband noise of a model helicopter rotor is experimentally studied. The measurements and the one-dimensional energy spectral density indicate that the upstream airfoil wake turbulence is nonisotropic, but approaches isotropy at high wavenumbers. Turbulence measurements also indicate that the wake turbulence is weak. The effect of the inflow turbulence intensity on the peak sound pressure level follows an intensity-velocity squared scaling law. A number of length scales and turbulence intensities exist which can be measured in the airfoil wake depending on the position at which the measurements are taken. Comparison of experimental and theoretical sound pressure power spectral densities indicates that the initial anisotropy of the inflow turbulence does not invalidate the isotropic turbulence assumption made in noise prediction models as long as measured turbulence intensities and length scales are used. C.D.

N87-27248*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NASTRAN APPLICATION FOR THE PREDICTION OF AIRCRAFT INTERIOR NOISE
FRANCESCO MARULO and TODD B. BEYER *In* COSMIC, 15th NASTRAN Users' Colloquium p 266-285 Aug. 1987
Avail: NTIS HC A14/MF A01; also available from COSMIC, Athens, Ga. 30602 CSCL 20K

The application of a structural-acoustic analogy within the NASTRAN finite element program for the prediction of aircraft interior noise is presented. Some refinements of the method, which reduce the amount of computation required for large, complex structures, are discussed. Also, further improvements are proposed and preliminary comparisons with structural and acoustic modal data obtained for a large, composite cylinder are presented. Author

N87-27479*# Purdue Univ., West Lafayette, Ind. School of Mechanical Engineering.
A STUDY OF METHODS TO PREDICT AND MEASURE THE TRANSMISSION OF SOUND THROUGH THE WALLS OF LIGHT AIRCRAFT Semiannual Status Report, 15 May - 15 Nov. 1986
R. J. BERNHARD, J. S. BOLTON, B. GARDNER, J. MICKOL, C. MOLLO, and C. BRUER Dec. 1986 27 p
(Contract NAG1-58)
(NASA-CR-180632; NAS 1.26:180632; HL-86-48; REPT-0353-5)
Avail: NTIS HC A03/MF A01 CSCL 20A

Several research investigations are discussed. The development of a numerical/empirical noise source identification procedure using boundary element techniques, the identification of structure-borne paths using structural intensity and finite element methods, the development of a design optimization numerical procedure to be used to study active noise control in three-dimensional geometries, and the measurement of the dynamic properties of acoustical foams and the incorporation of these properties in models governing three-dimensional wave propagation in foams are discussed. Author

N87-27484*# Duke Univ., Durham, N. C. Dept. of Mechanical Engineering and Materials Science.
INTERIOR NOISE REDUCTION BY ALTERNATE RESONANCE TUNING Semiannual Progress Report
DONALD B. BLISS, JAMES A. GOTTWALD, and JEFFREY W. BRYCE Aug. 1987 39 p
(Contract NAG1-722)
(NASA-CR-181189; NAS 1.26:181189) Avail: NTIS HC A03/MF A01 CSCL 20A

Existing interior noise reduction techniques for aircraft fuselages perform reasonably well at higher frequencies, but are inadequate at low frequencies, particularly with respect to the low blade passage harmonics with high forcing levels found in propeller aircraft. A method is studied which considers aircraft fuselages lined with panels alternately tuned to frequencies above and below the frequency that must be attenuated. Adjacent panel would oscillate at equal amplitude, to give equal acoustic source strength, but with opposite phase. Provided these adjacent panels are acoustically compact, the resulting cancellation causes the interior acoustic modes to be cut off, and therefore be nonpropagating

and evanescent. This interior noise reduction method, called Alternate Resonance Tuning (ART), is being investigated theoretically and experimentally. Progress to date is discussed.
B.G.

N87-27485*# Purdue Univ., West Lafayette, Ind. School of Mechanical Engineering.
A STUDY OF METHODS TO PREDICT AND MEASURE THE TRANSMISSION OF SOUND THROUGH THE WALLS OF LIGHT AIRCRAFT. NUMERICAL METHOD FOR ANALYZING THE OPTIMAL PERFORMANCE OF ACTIVE NOISE CONTROLLERS Thesis
CHRISTOPHER G. MOLLO and ROBERT J. BERNHARD Aug. 1987 242 p
(Contract NAG1-58)
(NASA-CR-181186; NAS 1.26:181186; REPT-0353-8; HL-87-25P)
Avail: NTIS HC A11/MF A01 CSCL 20A

An optimal active noise controller is formulated and analyzed for three different active noise control problems. The first problem formulated is the active control of enclosed or partially enclosed harmonic sound fields where the noise source strengths and enclosure boundary description are known. The enclosure boundary is described by either pressure, velocity, or impedance boundary conditions. The second problem formulated is the active control of the free field power radiated from a distributed noise source with a known time harmonic surface velocity. The third problem formulated is the active control of enclosed or partially enclosed harmonic sound field where the noise source strengths of enclosure boundary description may not be known. All three formulations are derived using an indirect boundary element technique. Formulation and verification of an indirect boundary element method is presented. The active noise controller formulations for enclosures are capable of analyzing systems with generalized enclosure shapes, point noise sources, and/or locally reacting impedance boundary conditions. For each formulation, representative results of optimal active noise controller case studies are presented, and some general conclusions are drawn. Author

N87-27489*# Old Dominion Univ., Norfolk, Va. Research Foundation.
INFLUENCE OF LARGE DEFLECTION AND TRANSVERSE SHEAR ON RANDOM RESPONSE OF RECTANGULAR SYMMETRIC COMPOSITE LAMINATES TO ACOUSTIC LOADS
CHUH MEI and C. B. PRASAD Jun. 1987 71 p
(Contract NAS1-17993)
(NASA-CR-178313; NAS 1.26:178313) Avail: NTIS HC A04/MF A01 CSCL 20A

Nonlinear equations of motion of symmetrically laminated anisotropic plates are derived accounting for von Karman strains. The effect of transverse shear is included in the formulation and the rotatory inertia effect is ignored. Using a single-mode Galerkin procedure the nonlinear modal equation is obtained. Direct equivalent linearization is employed. The response of acoustic excitation on moderately thick composite panels is studied. Further, the effects of transverse shear on large deflection vibration of laminates under random excitation are studied. Mean-square deflection and mean-square inplane stresses are obtained for some symmetric graphite-epoxy laminates. Using equilibrium equations and the continuity requirements, the mean-square transverse shear stresses are calculated. The results obtained will be useful in the sonic fatigue design of composite aircraft panels. The analysis is presented in detail for simply supported plate. The analogous equations for a clamped case are given in the appendix. Author

N87-27491# Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
A STUDY OF ENVIRONMENTAL NOISE WITH A VIEW TO AIRCRAFT WITH PROP-FANS
STEN LJUNGGREN Feb. 1987 12 p Sponsored by the Swedish National Board for Technical Development
(FFA-TN-1987-15; ETN-87-90075) Avail: NTIS HC A02/MF A01

Swedish legislation concerning noise from prop-fan aircraft in cruising flight is discussed. A limit of 55 dB(A) is recommended if night flights increase considerably, 60 dB(A) being acceptable for other conditions.
ESA

N87-28396*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE EFFECT OF FRONT-TO-REAR PROPELLER SPACING ON THE INTERACTION NOISE OF A MODEL COUNTERROTATION PROPELLER AT CRUISE CONDITIONS
JAMES H. DITTMAR Aug. 1987 18 p
(NASA-TM-100121; E-3667; NAS 1.15:100121) Avail: NTIS HC A02/MF A01 CSCL 20A

The effect of front-to-rear propeller spacing on the interaction noise of a counterrotation propeller model was measured at cruise conditions. The data taken at an axial Mach number of 0.80 behaved as expected: interaction noise was reduced with increased spacing. The data taken at M=0.76 and M=0.72 did not behave as expected. At some of the test conditions the noise was unchanged; others even showed noise increases with increased spacing. A possible explanation, involving the amount of downstream blade area impacted by the tip vortex, is presented.
Author

N87-28398*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CRUISE NOISE OF THE 2/9TH SCALE MODEL OF THE LARGE-SCALE ADVANCED PROPFAN (LAP) PROPELLER, SR-7A
JAMES H. DITTMAR and DAVID B. STANG (Sverdrup Technology, Inc., Cleveland, Ohio.) Sep. 1987 52 p Prepared for presentation at the 11th AIAA Aeroacoustics Conference, Sunnyvale, Calif., 19-21 Oct. 1987
(NASA-TM-100175; E-3746; NAS 1.15:100175) Avail: NTIS HC A04/MF A01 CSCL 20A

Noise data on the Large-scale Advanced Propfan (LAP) propeller model SR-7A were taken in the NASA Lewis Research Center 8 x 6 foot Wind Tunnel. The maximum blade passing tone noise first rises with increasing helical tip Mach number to a peak level, then remains the same or decreases from its peak level when going to higher helical tip Mach numbers. This trend was observed for operation at both constant advance ratio and approximately equal thrust. This noise reduction or, leveling out at high helical tip Mach numbers, points to the use of higher propeller tip speeds as a possible method to limit airplane cabin noise while maintaining high flight speed and efficiency. Projections of the tunnel model data are made to the full scale LAP propeller mounted on the test bed aircraft and compared with predictions. The prediction method is found to be somewhat conservative in that it slightly overpredicts the projected model data at the peak.
Author

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A87-48053
COST EFFECTIVE AVIONICS - CUSTOMER'S VIEWS: EXPERIENCE WITH CIVIL AIRCRAFT
J. MILLS (British Airways, London, England) IN: Cost-effective avionic and weapon systems; Proceedings of the Spring Convention, London, England, May 14, 15, 1986 . London, Royal Aeronautical Society, 1987, p. 2.1-2.7.

The cost of civilian aircraft avionics encompasses initial procurement costs, the cost of support spares, the cost of carrying the avionic system's weight, periodic maintenance, and original development costs. An assessment of development trends seen

in recent and state-of-the-art civil aircraft avionics points to: the integration of conventionally separate systems into single units, as in full authority digital engine control systems; the simultaneous use of satellites for both communication and navigation, and even for passenger telephony; the incorporation of entire avionic systems in the form of software 'file cards', rather than black boxes; and the use of fiber-optic circuits in avionics. O.C.

A87-48056
FORECASTING DEVELOPMENT AND PRODUCTION COSTS
D. FADDY (Ministry of Defence, London, England) IN: Cost-effective avionic and weapon systems; Proceedings of the Spring Convention, London, England, May 14, 15, 1986 . London, Royal Aeronautical Society, 1987, p. 5.1-5.14.

Methods used in the projection of aircraft weapon and avionic system development and production costs are similar to those used for aircraft structures and engines, but contain differences in emphasis that are primarily due to the relative shortage of data. The two primary cost estimate methodologies are the synthetic, or 'bottom-up', and the parametric. The former is built up from estimates for individual subsystems or hardware elements, while the latter involves the statistical derivation of parametric relationships using multiple explanatory variables. Attention is presently given to the special problems of avionics systems, and to life cycle costs. O.C.

A87-48065
THE IMPACT ON COST OF NEW SENSOR TECHNOLOGIES
W. H. MCKINLAY (Ferranti Defence Systems, Ltd., Edinburgh, Scotland) IN: Cost-effective avionic and weapon systems; Proceedings of the Spring Convention, London, England, May 14, 15, 1986 . London, Royal Aeronautical Society, 1987, p. 14.1-14.10.

An evaluation is made of the consequentiality of novel technologies' application to various types of sensors, which are for the purposes of discussion divided into three classes: airframe-based sensors, earth-referenced or navigation sensors, and sensors of the external environment. Attention is given to the mechanisms involved in the incurring of costs attributable to sensors, sensor cost-capability relationships, the impact of a novel sensor on an inertial navigation system, and the correlation of sensor configuration with its cost. In such complex sensors as combat aircraft radars, cost reduction prospects are often overwhelmed by the need to more fully exploit the performance capabilities that a novel technology offers. O.C.

A87-48067
INTEGRATED AVIONICS SYSTEM - IMPACT ON COSTS
J. H. HOUSE (Racal Avionics, Ltd., New Malden, England) IN: Cost-effective avionic and weapon systems; Proceedings of the Spring Convention, London, England, May 14, 15, 1986 . London, Royal Aeronautical Society, 1987, p. 16.1-16.8.

An assessment is made of the benefits that accrue to avionics system integration, in view of the associated development cost and support issues as well as the cost-related aspects of such key technological factors as chip customization and the use of fiber-optics. Attention is given to the potential contribution of integrated avionics to system performance; the incorporation of low-utilization functions in order to share such system resources as processing, control, and display and recording media; and the relationship of connectivity to redundancy. In general, full system integration offers a tradeoff of lower overall equipment costs against higher development and support costs, with possibly higher risks. O.C.

A87-49199
MANAGEMENT OF UNITED STATES AIR FORCE (USAF) OPERATIONAL TEST AND EVALUATION (OT&E) FLIGHT TEST PROGRAMS
STEPHEN P. HERRLINGER (USAF, Edwards AFB, CA) IN: Society of Flight Test Engineers, Annual Symposium, 17th, Washington, DC, Aug. 10-14, 1986, Proceedings . Lancaster, CA, Society of Flight Test Engineers, 1986, p. 1.1-1 to 1.1-5.

USAF Operational Test and Evaluation (OT&E) objectives during flight test are similar, yet distinctively different from Developmental Test and Evaluation (DT&E) objectives. The interactions and relationships required between DT&E and OT&E teams in accomplishing their respective charters will be highlighted. Specifically, inputs from the 31st Test and Evaluation Squadron (TES), Strategic Air Command (SAC), to various OT&E projects at Edwards AFB, CA, will be reviewed to illustrate the interaction between the Systems Program Office (SPO), the Air Force Operational Test and Evaluation Center (AFOTEC), the Combined Test Force (CTF), the Air Force Flight Test Center (AFFTC), and contractors. Author

A87-49630
AIRFRAME COST ENGINEERING
R. E. WOOLLER (British Aerospace, PLC, London, England) IN: Designing for low cost fabrication; Proceedings of the Workshop, Loughborough, England, Apr. 16, 17, 1986 . London, Royal Aeronautical Society, 1987, p. 52-73.

The last two decades of airframe structures engineering have witnessed a substantial increase in the need to include cost as a design parameter, together with mass, performance, operational effectiveness and mechanical strength. Attention is presently given to the relationship between mass and cost, as well as to that between committed cost and actual expenditure. Evaluations are also undertaken of the significance of the various phases in a project's life to costs, cost-related tradeoff criteria during the definition phase, the cost-evaluation of materials and construction methods, design-to-cost procedures and reporting practices, and manufacturing phase cost controls. O.C.

A87-49966#
COOPERATION KNOW-HOW IN HIGH-TECH PRODUCTS
HORST PREM (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) Binational Conference on Asia-Pacific Dimensions of International Business: A Joint French-German Approach, Universitaet Hohenheim, Stuttgart, West Germany, Oct. 16, 17, 1986, Paper. 26 p.
(MBB-Z-101-86-PUB)

European cooperation in the development of high-tech aircraft is discussed. The rationale for this cooperation is briefly reviewed, and the main technological targets of this cooperation are summarized. Examples of this cooperative development are examined, including helicopters, Airbus, combat aircraft, and possible hypersonic aircraft. C.D.

A87-49968
VALUE-ORIENTED PRODUCT PLANNING - THE CASE OF CIVIL-AIRCRAFT MANUFACTURING [WERTORIENTIERTE PRODUKTPLANUNG AM BEISPIEL DES ZIVILEN FLUGZEUG-BAUS]
WERNER ZABKA (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) VDI-Berichte (ISSN 0083-5560), no. 619, 1986, p. 53-81. In German.
(MBB-UT-002-87-PUB)

The economic analysis processes involved in the decision to develop and build a new civil transport aircraft are described from the perspective of a European manufacturer. Topics examined include the effects of overall economic conditions, the factors weighed by airlines in selecting an aircraft, market analyses, cash-flow analyses, techniques for estimating the economic break-even point in the life of an aircraft model, risk assessment, the influence of design on manufacturing costs, and the role of value engineering in the planning process. Concrete examples

based on the planning for the Airbus series of aircraft are described in detail and illustrated with diagrams and graphs. T.K.

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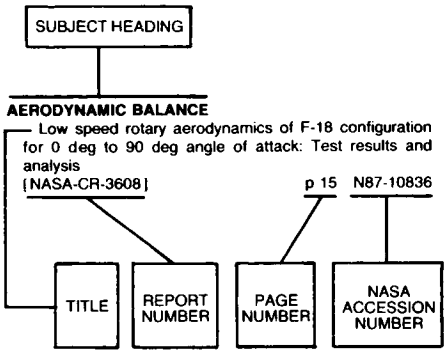
GENERAL

A87-48166
REMARKS ON THE DEVELOPMENT HISTORY OF THE TIP-JET-ROTOR HELICOPTER [BETRACHTUNGEN ZUR ENTWICKLUNGSGESCHICHTE DES STRAHLSCHRAUBERS]
THEODOR LAUFER (European Pioneers Day, 11th Garmisch-Partenkirchen, West Germany, Sept. 24, 25, 1986) IN: Yearbook 1986 II; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 796-811. In German.

The history of tip-jet-rotor helicopter (TJRH) development in Europe is reviewed on the basis of the author's personal experience. The phases described (in some detail) include 1941-1945 in Austria, 1946-1960 in France (leading to series production of a two-seat military TJRH), 1960-1964 in the FRG, and 1964-1971 in France. The fact that helicopters with mechanically driven rotors eventually won out over TJRHs is attributed to the relatively high fuel consumption of the TJRH.
T.K.

Typical Subject Index Listing



The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of the document content, the title extension is added, separated from the title by three hyphens. The (NASA or AIAA) accession number and the page number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document. Under any one subject heading, the accession numbers are arranged in sequence with the AIAA accession numbers appearing first.

A

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Wind-tunnel test results of airfoil modifications for the EA-6B
[AIAA PAPER 87-2359] p 748 A87-49076
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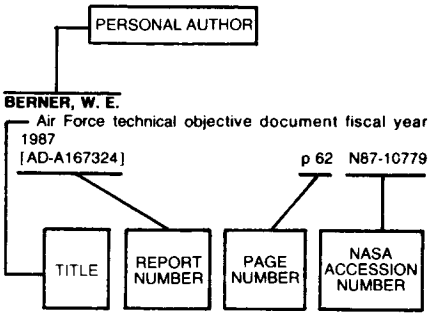

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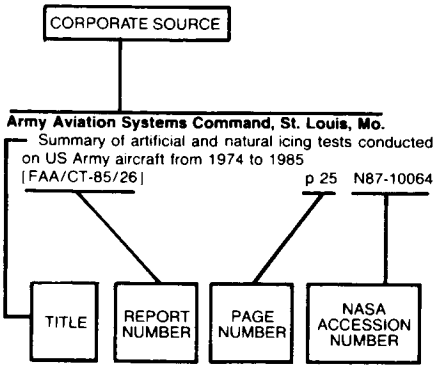

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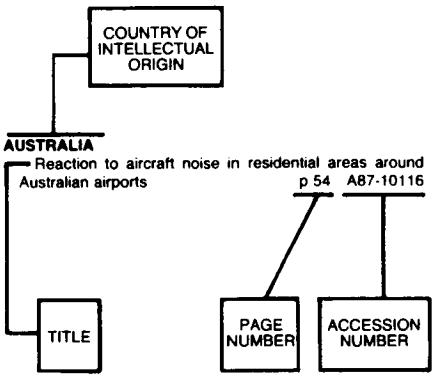

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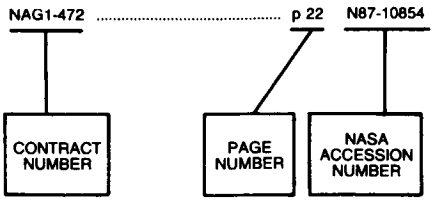

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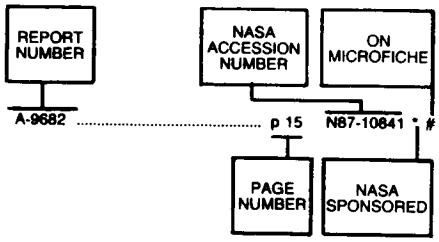

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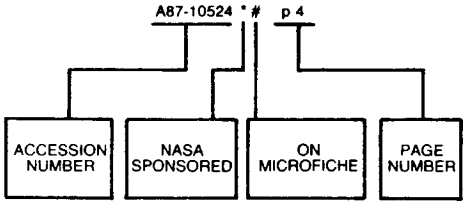

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