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A Continuing Bibliography with Indexes

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Aeronautical Engineering Aeronautical Engineering Aeronautical Engineering Aeronautical Engineering

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NASA SP-7037(233)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 233)

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 1988 in

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

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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 637 reports, journal articles and other documents originally announced in November 1988 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

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

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

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

An annual cummulative index will be published.

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

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TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

ACCESSION NUMBER → **N88-10026*#** National Aeronautics and Space Administration. ← CORPORATE SOURCE
Ames Research Center, Moffett Field, Calif.

TITLE → **HIMAT FLIGHT PROGRAM: TEST RESULTS AND PROGRAM ASSESSMENT OVERVIEW**

AUTHORS → DWAIN A. DEETS, V. MICHAEL DEANGELIS, and DAVID P. LUX

PUBLICATION DATE → Jun. 1986 30 p ← AVAILABILITY SOURCE

REPORT NUMBERS → (NASA-TM-86725; H-1283; NAS 1.15:86725) Avail: NTIS HC

PRICE CODE → A03/MF A01 CSCL 01C ← COSATI CODE

The Highly Manueverable Aircraft Technology (HiMAT) program consisted of design, fabrication of two subscale remotely piloted research vehicles (RPRVs), and flight test. This technical memorandum describes the vehicles and test approach. An overview of the flight test results and comparisons with the design predictions are presented. These comparisons are made on a single-discipline basis, so that aerodynamics, structures, flight controls, and propulsion controls are examined one by one. The interactions between the disciplines are then examined, with the conclusions that the integration of the various technologies contributed to total vehicle performance gains. An assessment is made of the subscale RPRV approach from the standpoint of research data quality and quantity, unmanned effects as compared with manned vehicles, complexity, and cost. It is concluded that the RPRV technique, as adopted in this program, resulted in a more complex and costly vehicle than expected but is reasonable when compared with alternate ways of obtaining comparable results. Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

ON MICROFICHE

ACCESSION NUMBER → **A88-10095#**

TITLE → **SYNTHESES OF REDUCED-ORDER CONTROLLERS FOR ACTIVE FLUTTER SUPPRESSION**

AUTHORS → ATSUSHI FUJIMORI and HIROBUMI OHTA Japan Society for ← JOURNAL TITLE
Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 35, no. 402, 1987, p. 353-362. In Japanese, with abstract in English. refs

Reduced-order controllers for active flutter suppression of a two-dimensional airfoil are studied using two design approaches. One is based on the generalized Hessenberg representation (GHR) in the time domain, and the other, called the Nyquist frequency approximation (NFA), is a method in the frequency domain. In the NFA method, the reduced-order controllers are designed so that the stability margin of the Nyquist plot may be increased over a specific frequency range. To illustrate and to make a comparison between the two methods, numerical simulations are carried out using a thirteenth-order controlled plant. It is to be noted that the GHR method can yield quasi-optimal controllers in the sense of minimizing quadratic performance indices. The designed controllers, however, do not have enough stability margin, and the order reduction resulting from full state controllers may not be satisfactory. On the other hand, reduced-order controllers in the NFA method can be designed with increased stability margin at the expense of the performance index. For all simulation cases, the NFA method yields second-order controllers with a better stability margin than those by the GHR method. Thus, the NFA method provides an effective method for synthesizing robust reduced-order controllers. Author

AERONAUTICAL ENGINEERING

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AERONAUTICS (GENERAL)

A88-50576

AIAA ATMOSPHERIC FLIGHT MECHANICS CONFERENCE, MINNEAPOLIS, MN, AUG. 15-17, 1988, TECHNICAL PAPERS

Conference sponsored by AIAA. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, 473 p. For individual items see A88-50577 to A88-50619.

The present conference discusses such topics in the field of atmospheric flight mechanics as control/display augmentation effects in a compensatory tracking task, the effect of variable tail dihedral on aircraft stability and control, moving surface effects on airfoil boundary layer control, optimal plane change during constant-altitude hypersonic flight, aeroassisted transfer between elliptical orbits using lift control, overall forces and moments on wing-bodies at high incidence, the longitudinal long-period dynamics of aerospace craft, and a computational analysis of underexpanded jets in the hypersonic regime. Also discussed are the extraction of initial conditions from projectile free-flight test data, the modeling of large-amplitude high-alpha maneuvers, performance limits for optimal microburst encounter, the effect of wing position on lift for supersonic delta wing missile configurations, and automatic control system concepts for general aviation airplanes. O.C.

A88-50781

BONDED REPAIR OF AIRCRAFT STRUCTURES

ALAN A. BAKER, ED. and R. JONES, ED. (Defence Science and Technology Organisation, Aeronautical Research Laboratories, Melbourne, Australia) Dordrecht, Martinus Nijhoff Publishers (Engineering Application of Fracture Mechanics. Volume 7), 1988, 227 p. No individual items are abstracted in this volume.

Adhesive-bonding techniques for repairing metallic and composite aircraft structures are described. Chapters are devoted to the general properties and advantages of bonded repairs; surface treatments for bonded repairs of metallic components; the design and analysis of bonded repairs; theoretical analysis, design aspects, experimental investigations, and practical applications of crack patching; and repair of composites. Diagrams, drawings, graphs, photographs, and tables of numerical data are provided. T.K.

A88-50926

NAECON 88; PROCEEDINGS OF THE IEEE NATIONAL AEROSPACE AND ELECTRONICS CONFERENCE, DAYTON, OH, MAY 23-27, 1988. VOLUMES 1, 2, 3 & 4

Conference sponsored by IEEE. New York, Institute of Electrical and Electronics Engineers, 1988, p. Vol. 1, 446 p.; vol. 2, 459 p.; vol. 3, 453 p.; vol. 4, 474 p. For individual items see A88-50927 to A88-51053.

The present conference discusses topics in the fields of digital electronics and their applications, signal processing methods, airborne computers, cartographic uses of electronic data, data transmission, advanced avionics, fiber-optics, information control and display, airborne imaging/target recognition, airborne radar and fire control, navigation, air data/weapons guidance, Kalman filtering, computer-aided control system design, stability and control design methods, and flying qualities-related systems. Also discussed are fault-tolerant systems technology, self-repairing flight control systems, flight management, multivariable control theory, ADA software design and development, advanced software tools, software design methodology, advanced software concepts, software management and cost estimation, computer graphics/visual systems software, the integration of artificial neural systems and expert systems, voice-interaction applications, man-machine interfacing, crew station design techniques, pilot-acceleration protection research, AI support of human decision-making, avionics simulation, embedded training, maintenance-training systems, instructional systems for simulators, C3I, space communications, management-decision models, EMI/EMC hardening, automated mission planning, avionics integrity, modular avionics, expert systems, AI languages and knowledge representation, logistics data distributed processing, life cycle costs, readiness, automated testing, and maintenance diagnostics. O.C.

A88-51040#

THE C-17 PROGRAM: A MODEL IN SUPPORTABILITY/SUSTAINABILITY

JEANNE ZEKOWSKI (USAF, Directorate of Acquisition Logistics, Wright-Patterson AFB, OH) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1443-1447.

The C-17 acquisition strategy requires the contractor to demonstrate successful achievement of key supportability parameters before system acceptance by the government. To implement this strategy, the C-17 full-scale development, production, spares, and Interim Contractor Support contract requirements were negotiated and definitized, placing the responsibility of providing an integrated, comprehensive effort to field and initially support the C-17 with defined supportability criteria on the contractor. In addition, the C-17 program has been structured with major emphasis on utilizing advancing computer data systems technologies to truly integrate logistics support requirements. These logistics initiatives can serve as a model for development of future computer-aided acquisition and logistics support (CALS) tools for other programs. The elements of this supportability/sustainability strategy for the C-17 program are described. I.E.

A88-51434

SKUNK WORKS PROTOTYPING

HAROLD C. FARLEY and RICHARD ABRAMS (Lockheed Aeronautical Systems Co., Burbank, CA) IN: 1987 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 31st, Beverly Hills, CA, Sept. 23-26, 1987, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1987, p. 138-168.

An historical and management-practices account is presented for 'skunk works' prototype aircraft development efforts, such as those developed by Lockheed's Clarence Johnson during the Second World War in order to minimize security risks and program durations. These methods have produced the P-38, F-80, and F-104 fighters, as well as the U-2 and 'Blackbird' families of spy aircraft. It is noted that overly ambitious prototype program objectives unacceptably increase time and costs. When the outcome of a new technology is unpredictable, competitive prototype fly-offs are useful. Mission requirements should be stated in terms of broad priorities rather than contractually binding detailed specifications. O.C.

A88-51441
THE CHALLENGE OF X-30 FLIGHT TEST
STUART O. SCHMITT, THEODORE J. WIERZBANOWSKI, and JOHN H. JOHNSON (USAF, National Aero-Space Plane Joint Program Office, Wright-Patterson AFB, OH) IN: 1987 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 31st, Beverly Hills, CA, Sept. 23-26, 1987, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1987, p. 273-288.

The National Aerospace Plane program, which is charged with the design, construction, and flight testing of the X-30 hypersonic research vehicle, is a joint effort of DOD and NASA. The X-30 will be capable of both SSTO and HST operation, but will not be a payload-carrying operational vehicle of Space Shuttle or projected 'Orient Express' type; its missions will be entirely devoted to technology integration-related developmental flight testing. Attention will be given to the correlation between CFD aerothermodynamic and flight test-measured values. X-30 flight test mission profiles between the Kennedy Space Center and Edwards Air Force Base are discussed. O.C.

A88-51451
FLIGHT TESTING - PAST, PRESENT, AND FUTURE
RONALD ASHFORD (Civil Aviation Authority, London, England) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 1-1 to 1-11.

Changes in the history of flight testing are illustrated here by discussing the flight testing of one aircraft type from the 1950s and a recent airliner which entered service only a few years ago. The changes made in the 1950s DH 110 aircraft due to the test results are summarized and depicted. For the Boeing 757, depictions of various flight test arrangements are shown and the changes made in the aircraft as a result of the tests are described. Changes in flight development time over the past few decades are indicated. The aspects of flight testing which most need modification are discussed. C.D.

A88-51475
NATO E-3A PRODUCTION ACCEPTANCE TESTING - A REVIEW OF A HISTORICAL INTERNATIONAL PROGRAM
W. K. REUTHER (Dornier Reparaturwerft GmbH, Oberpfaffenhofen, Federal Republic of Germany) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 27-1 to 27-8.

This article presents an overview of the NATO E-3A AEW Program 'Production Acceptance Testing' performed between 1980-1985. It outlines the historical situation, the approach, test operation requirements in the European environment, test flow in its structural set-up, and a sample of the 'Flight Acceptance Testing' for IFF. It will give an impression of the huge operational task and the outstanding industrial collaboration and effort accomplished during this program. Author

A88-51478
U.S. AIR FORCE FLIGHT TEST CENTER - TODAY AND TOMORROW
R. R. HILDEBRAND (USAF, Flight Test Center, Edwards AFB, CA) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 32-1 to 32-9. refs

Tests conducted at the U.S. Air Force Flight Test Center and the methodologies used in these tests are reviewed. Programs include the Advanced Fighter Technology Integration/F-16, the F-11 Mission Adaptive Wing, the X-29, the F-16 Fighting Falcon, the F-15 Eagle, and the B-1B. Future programs are presented, including the C-17 Transport, the Advanced Tactical Fighter, and the National Aero-Space Plane. The methods involved in testing aircraft performance, stability and control/handling qualities, avionics, navigation systems, weapon delivery accuracy, radar, airborne instrumentation, and data processing are examined. R.B.

A88-51751
INTERNATIONAL CONFERENCE ON ROTORCRAFT BASIC RESEARCH, 2ND, UNIVERSITY OF MARYLAND, COLLEGE PARK, MD, FEB. 16-18, 1988, PROCEEDINGS
Conference sponsored by the University of Maryland and AHS. Alexandria, VA, American Helicopter Society, 1988, 542 p. For individual items see A88-51752 to A88-51785.

The papers presented in this volume provide an overview of current theoretical and experimental research related to rotorcraft technology. The contributions are grouped under the following headings: performance and loads; rotor/body interactional dynamics and wake studies; dynamics; system identification, active controls and flight safety; CFD applications in rotorcraft; and composite analyses. Specific topics discussed include rotor-airframe aerodynamic interaction phenomena; minimum weight design of rectangular and tapered helicopter rotor blades with frequency constraints; advancements in frequency-domain methods for rotorcraft system identification; and flow field prediction for helicopter rotors with advanced blade tip shapes using CFD techniques. V.L.

A88-51936#
UNMANNED FLIGHT VEHICLES - FROM CONCEPT TO PROTOTYPE: AN UNDERGRADUATE DESIGN EXPERIENCE
STEPHEN M. BATILL, ROBERT C. NELSON, and PATRICK F. DUNN (Notre Dame, University, IN) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 12 p. Research supported by the University of Notre Dame. refs
(AIAA PAPER 88-4414)

This paper presents details on a new approach that the undergraduate Aerospace Systems design course at the University of Notre Dame has taken over the past three years. The course is intended to present the students with a realistic design challenge that will introduce them to the preliminary aircraft design process. It also provides them with the opportunity to realize the satisfaction associated with seeing the results of their design efforts actually fly. The design course has focused on a unique class of aircraft, namely, unmanned flight vehicles which are either remotely piloted or controlled by an 'intelligent' onboard system - RPVs (Remotely or Robotically Piloted Vehicles). This paper presents an overview of the organization of the course and the methods used to develop the designs. Some differences between RPV design and the conventional aircraft design methodologies are included along with examples of design studies and prototype aircraft developed at the University of Notre Dame. Author

A88-51977#
THE HIGH TECHNOLOGY TEST BED - LOCKHEED'S FLYING LABORATORY
H. W. COPELAND, JR. (Lockheed Aeronautical Systems Co., Marietta, GA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 7 p.
(AIAA PAPER 88-4510)

Future tactical transport aircraft must be capable of landing in rough field or short-runway conditions in adverse weather; the High Technology Test Bed modification of a C-130 aircraft for advanced technologies integration development and flight testing addresses four areas that will serve as bases for such capabilities: STOL, survivability, advanced cockpit systems, and advanced electronics. An account is presently given of both the design features incorporated by the aircraft and the flight test data obtained to date. O.C.

N88-27148*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
INTEGRATED TECHNOLOGY ROTOR METHODOLOGY ASSESSMENT WORKSHOP
MICHAEL J. MCNULTY, ed. and WILLIAM G. BOUSMAN, ed. Jun. 1988 381 p Workshop held in Moffett Field, Calif., 21-22 Jun. 1983; sponsored by NASA, Ames Research Center and the Army Prepared in cooperation with Army Aviation Systems Command, Moffett Field, Calif. Sponsored by NASA, Washington, D.C.
(NASA-CP-10007; A-86381; NAS 1.55:10007; USAAVSCOM-CP-88-A-001) Avail: NTIS HC A17/MF A01 CSCL 01B

The conference proceedings contains 14 formal papers and the results of two panel discussions. In addition, a transcript of discussion that followed the paper presentations and panels is included. The papers are of two kinds. The first seven papers were directed specifically to the correlation of industry and government mathematical models with data for rotorcraft stability from six experiments. The remaining 7 papers dealt with related topics in the prediction of rotor aeroelastic or aeromechanical stability. The first of the panels provided an evaluation of the correlation that was shown between the mathematical models and the experimental data. The second panel addressed the general problems of the validation of mathematical models.

N88-27149*# Army Aeromechanics Lab., Moffett Field, Calif.
A COMPARISON OF THE VARIOUS HELICOPTER MATHEMATICAL MODELS USED IN THE METHODOLOGY ASSESSMENT
WENDELL B. STEPHENS *In* NASA, Ames Research Center, Integrated Technology Rotor Methodology Assessment Workshop p 1-6 Jun. 1988
Avail: NTIS HC A17/MF A01 CSCL 01B

Various features of the computer codes used in the helicopter industry and by government agencies for rotorcraft aeroelastic stability analysis are compared. Mathematical rigor in modeling rotorcraft is given primarily to the rotor-system dynamic behavior; the aerodynamic modeling is still limited to strip theory and to uneven application of corrections for stall, reversed flow, yawed flow, radial flow, and unsteady aerodynamic effects. The forward-flight regime analysis is included in five of the 11 codes surveyed. However, only two of these codes are capable of a Floquet analysis for aeroelastic stability. For the hover regime, nine of the 11 codes use eigen-analysis approach. The remaining codes perform a harmonic analysis of the transient response of system. Author

N88-28001# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugfuehrung.
PROCEEDINGS OF THE 14TH SYMPOSIUM ON AIRCRAFT INTEGRATED MONITORING SYSTEMS
HELMUT HARDEGEN, comp. Jan. 1988 615 p Symposium held in Friedrichshafen, Fed. Republic of Germany, 15-17 Sep. 1987
(DFVLR-MITT-88-04; ISSN-0176-7739; ETN-88-92939) Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

Methods and systems used to monitor and record aircraft performance to improve safety, reliability, and economy were discussed. ESA

N88-28004# Ministry of Defence, London (England).
BACKGROUND TO THE UK MILITARY REQUIREMENTS FOR ENGINE USAGE, CONDITION AND MAINTENANCE MANAGEMENT SYSTEMS
N. A. BAIRSTO (Royal Air Force, London, England) *In* DFVLR, Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems p 51-72 Jan. 1988
Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

The expense involved with traditional lifing and maintenance policies for engines is considered. Major exercises in engine health monitoring are outlined and include engine usage, oil debris, blade condition, and engine gas path parameter analysis as well as on-board life calculation. The benefits of engine usage condition and maintenance management systems are discussed with examples of the cost savings that individual measures can achieve. Aircraft systems being introduced show how lessons learnt are being implemented. The major military engine deficiencies are identified and stated as priorities for action in the research and development fields. ESA

N88-28011# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
TORNADO: AIRFRAME FATIGUE LIFE MONITORING
R. NEUNABER *In* DFVLR, Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems p 205-230 Jan. 1988
Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

Based on the principles of structural fatigue and the Tornado fatigue tests, which should prove a sufficient fatigue life, the necessity for fatigue life monitoring of the operational aircraft is shown. The Tornado fatigue life monitoring concept is presented, including the maintenance recorder for the comprehensive damage analysis, and the onboard life monitoring system structural life program for individual aircraft tracking. The additional equipment used for high frequency load analysis is described. Data evaluation, results, and the logistic integration of the calculated structural maintenance activities are mentioned. ESA

N88-28012# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
MAINTENANCE SUPPORT FOR MILITARY AIRCRAFT BY INTELLIGENT ON-BOARD MAINTENANCE DATA PANEL
A. SCHICK *In* DFVLR, Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems p 231-252 Jan. 1988
Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

An intelligent onboard maintenance data panel (MDP) for an aircraft onboard monitoring and recording system is described. Easy access to the nonvolatile stored and distributed test information during ground maintenance actions and without removing or opening units can be achieved by an MDP positioned behind a maintenance access door. Its interfaces to aircraft equipment are the MIL STD 1553 serial data bus and discrete input lines as well. Data transfer to a maintenance ground station for further evaluation is performed by a removable nonvolatile data storage. ESA

N88-28019# Flight Data Co., London (England).
THE MANAGEMENT OF SOFTWARE IN AIRBORNE RECORDING SYSTEMS
PETER WALLER *In* DFVLR, Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems p 371-388 Jan. 1988
Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

Trends towards increasing power of the airborne computer coupled with the introduction of data links such as ACARS, resulting in more analyses moving from the ground into the air are considered. The necessary control of the resulting airborne software and the suppliers' wish to standardize programs result in the user suffering from a compromise solution when the programs are supplied by the equipment vendor. Problems likely to be experienced by an operator who wishes to free himself from this constraint by taking the responsibility for program writing himself are assessed. It is concluded that many operators could benefit from this, but only if given full management support. ESA

02

AERODYNAMICS

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

A88-49387#

SEPARATED FLOW ON A WING AT LOW REYNOLDS NUMBERS

ALLEN E. WINKELMANN (Maryland, University, College Park) AIAA, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988. 24 p. refs

(AIAA PAPER 88-3548)

New flow visualization studies have revealed further details of the trailing edge separated flow field on a plane rectangular wing (aspect ratio = 3) operating at low Reynolds numbers. The surface patterns observed at low angles of attack using smoke flow visualization are very similar to the 'mushroom shaped' trailing edge stall cells previously observed in oil flow tests on the same wing at higher Reynolds numbers and stall angles of 25.4 deg. The centers of dual swirl patterns in the low Reynolds number laminar separation mushroom cell appear to be the attachment points for a spanwise vortes flow. The mushroom vortex flow can be seen to alternately shed from the upper surface of the wing along with another spanwise vortex shedding off the bottom. This type of flow model was previously proposed by the author to explain the higher Reynolds number turbulent separation mushroom patterns observed in earlier oil flow tests. Although the spanwise vortex type flow has not been conclusively observed at the high Reynolds number test case, the implication is that the same flow phenomena are occurring for both the low Reynolds number (laminar) separation case and for the higher Reynolds number (turbulent) separation case. Author

A88-50002

CALCULATION OF TRANSONIC FLOW PAST AN ENGINE NACELLE [RASCHET OBTEKANIIA MOTOGONDOLY TRANSZVUKOVYM POTOKOM]

N. A. ERMOLAEVA and IU. A. ZABELIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 1, 1986, p. 14-25. In Russian. refs

The problem of transonic flow past an engine nacelle is stated for the case of moderate energy input to the flow in the internal flow path. A solution is obtained in the form of a superposition of shear vortex and axisymmetric potential flows. As an example, calculations are presented for flow past a propeller engine nacelle and a body with a channel. V.L.

A88-50003

AERODYNAMIC CHARACTERISTICS OF A DELTA WING IN HYPERSONIC FLOW AT LARGE ANGLES OF ATTACK [AERODINAMICHESKIE KHARAKTERISTIKI TREUGOL'NOGO KRYLA V GIPERZVUKOVOM POTOKE PRI BOL'SHIKH UGLAKH ATAKI]

V. N. GOLUBKIN and V. V. NEGODA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 1, 1986, p. 26-32. In Russian. refs

The problem of hypersonic flow over a delta wing at large angles of attack is investigated analytically using the thin shock layer method. Flow regimes near the windward surface are classified. A similarity law is derived for the normal force coefficients; simple formulas are obtained for some aerodynamic characteristics of the wing. The formulas produce results that are found to be in good agreement with numerical and experimental data. V.L.

A88-50004

FLOW NEAR THE AXIS OF A SHOCK LAYER IN THE CASE OF A TWO-PHASE UNDEREXPANDED SUPERSONIC JET IMPINGING ON A NORMAL OBSTACLE [TECHENIE V PRIOSEVOI CHASTI UDARNOGO SLOIA PRI NATEKANII DVUKHFAZNOI SVERKHZVUKOVOI NEDORASSHIRENNOI STRUI NA PERPENDIKULIARNUIU PREGRADU]

L. I. KAMINSKAIA and E. I. SOKOLOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 1, 1986, p. 33-40. In Russian. refs

Flow in a shock layer formed in the case of a two-phase underexpanded supersonic jet impinging on a normal obstacle is investigated analytically using the traditional phenomenological model of interpenetrating continua to describe the motion of a mixture of gas and particles. The resulting system of equations with boundary conditions allowing for the nonuniformity of undisturbed flow in the two-phase jet has two solutions corresponding to the radial flow of the carrier gas and to flow with an intermediate stagnation point in the shock layer, respectively. For these two solutions, the effect of the particles on the velocity distribution of the carrier gas and distributions of other mixture parameters is analyzed. V.L.

A88-50011

EFFECT OF FLAP AND TIP DEFLECTION ON THE NONLINEAR AERODYNAMIC CHARACTERISTICS OF A WING OF COMPLEX PLANFORM [VLIIANIE OTKLONENIIA ZAKRYLKOV I NOSKOV NA NELINEINYE AERODINAMICHESKIE KHARAKTERISTIKI KRYLA SLOZHNOI FORMY V PLANE]

M. I. NISHT TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 1, 1986, p. 97-100. In Russian.

The effect of flap and tip deflection on the nonlinear aerodynamic characteristics of a wing of complex planform is investigated numerically for low subsonic velocities using a computer program based on the discrete vortex method. In particular, attention is given to the case of mixed flow around the wing consisting of separated flow past the strake with the formation of leading-edge vortices and nonshock transition to the leading edge of the cantilever part. Examples of calculations are presented. V.L.

A88-50012

PRESSURE PULSATIONS ON THE UPPER SURFACE OF A DELTA WING WITH SHARP EDGES [PUL'SATSII DAVLENIIA NA VERKHNEI POVERKHNOSTI TREUGOL'NOGO KRYLA S OSTRYMI KROMKAMI]

R. K. KARAVOSOV and A. G. PROZOROV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 1, 1986, p. 101-104. In Russian.

Pressure pulsations on the surface of a thin delta wing with an aspect ratio of 2.3 are investigated experimentally in the range of angles of attack 0-10 deg and Re (1.52-3.42)x10 to the 6th. The laws governing changes in the statistical characteristics of pressure pulsations on the wall under vortex cores, formed by the vortex shed from the leading edge, are determined. V.L.

A88-50013

HEAT TRANSFER AT BLUNT LEADING EDGES AT LOW REYNOLDS NUMBERS [TEPLOOBMEN NA ZATUPLENNYKH PEREDNIKH KROMKAKH PRI MALYKH CHISLAKH REINOL'DSA]

V. N. GUSEV and V. P. PROVOTOROV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 1, 1986, p. 105-110. In Russian. refs

A study is made of the effect of various physical processes and shape of the blunted part of the leading edge on local and integral heat transfer toward the leading edges of a hypersonic flight vehicle. It is shown that heat transfer is largely determined by the boundary conditions on the surface, while the integral heat flux depends nonmonotonically on the aspect ratio of the body. V.L.

A88-50018
ELIMINATION OF THE VORTEX 'EXPLOSION' ON A DELTA WING THROUGH LOCAL JET EJECTION INTO THE VORTEX CORE REGION [LIKVIDATSIIA 'VZRYVA' VIKHREI NA TREUGOL'NOM KRYLE S POMOSHCH'IU VYDUVA LOKAL'NOI STRUI V OKRESTNOST' IADRA VIKHRIA]
E. S. VOZHDAEV, V. A. GOLOVKIN, M. A. GOLOVKIN, V. P. GORBAN', and E. V. SIMUSEVA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 2, 1986, p. 1-8. In Russian. refs
Vortex cores formed near the leading edge of a delta wing are investigated experimentally using flow visualization techniques. It is found that an 'explosion' (i.e., breakdown) of secondary vortices may occur in addition to a loss of flow stability in the primary vortex core. It is further shown that the ejection of a local turbulent jet into the primary vortex core region may, under certain conditions, delay (with respect to the angle of attack) or completely eliminate the vortex breakdown phenomenon, with an ordered vortex structure retained up to large angles of attack both in stationary and nonstationary flow regimes. V.L.

A88-50019
THREE-DIMENSIONAL TRANSONIC GAS FLOW WITH VAPORIZABLE PARTICLES [TREKHMERNOE TRANSZVUKOVOE TECHENIE GAZA S ISPARIAIUSHCHIMISIA CHASTITSAMI]
M. M. GILINSKII, A. L. STASENKO, and A. V. SHUINOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 2, 1986, p. 9-17. In Russian. refs
Vapor-drop flow in a three-dimensional nozzle (with two planes of symmetry) is investigated numerically with allowance for phase transitions on the surface of dispersed particles. It is shown that drop vaporization in a gas whose parameters vary in space in a complex manner leads to essentially nonmonotonic changes in the radial and azimuthal drop dimensions; it also gives rise to annular zones and azimuthal anisotropy of the two-phase flow. The deformation of the nozzle walls makes it possible to efficiently control the cross-sectional shape of particle flow in the two-phase jet. V.L.

A88-50029
AN EXPERIMENTAL STUDY OF THE EFFECT OF LEADING-EDGE BLUNTNESS ON THE UNSTEADY AERODYNAMIC CHARACTERISTICS OF A PROFILE AT HIGH SUPERSONIC VELOCITIES [EKSPERIMENTAL'NOE ISSLEDOVANIE VLIIANIIA ZATUPLENIIA PEREDNEI KROMKI PROFILIA NA NESTATSIONARNYE AERODINAMICHESKIE KHARAKTERISTIKI PRI BOL'SHIKH SVERKHZVUKOVYKH SKOROSTIAKH]
V. F. LEVKIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 2, 1986, p. 94-98. In Russian.
Results of aerodynamic moment coefficient measurements are presented for oscillating models of rectangular wings with a wedge-shaped profile in plane-parallel flow at Mach 4, 5, and 6. It is shown that the bluntness of the profile's leading edge leads to a decrease in the aerodynamic moment coefficient derivative with respect to the deflection angle and an increase in the derivative with respect to the angular velocity. The results obtained are compared with the available experimental data. V.L.

A88-50030
CORRELATION DEPENDENCE FOR THE DRAG COEFFICIENTS OF BODIES IN HYPERSONIC FLOW OF A RAREFIED GAS [KORRELIATSIONNAIA ZAVISIMOST' DLIA KOEFFITSIENTOV LOBOVOGO SOPROTIVLENIIA TEL V GIPERZVUKOVOM POTOKE RAZREZHENNOGO GAZA]
P. I. GORENBUKH TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 2, 1986, p. 99-105. In Russian. refs
Based on the available experimental data and numerical calculations, a new method is proposed for calculating the characteristic dimension in an expression for the rarefaction criterion. A correlation expression for the drag coefficients of various bodies in the intermediate region of hypersonic flows of a rarefied gas is then obtained which is more accurate and applies to a wider class of bodies in comparison with other existing correlations. V.L.

A88-50031
HEAT TRANSFER ON CONES WITH AN ISOENTROPIC COMPRESSION SURFACE [TEPLOOBMEN NA KONUSAKH S IZOENTROPICHESKOI POVERKHNOST'IU SZHATIIA]
V. N. BRAZHKO and N. N. SHKIRIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 2, 1986, p. 106-111. In Russian. refs
Flow over and heat transfer toward axisymmetric cones with an isoentropic compression surface are investigated experimentally for free-stream Mach 5, Re 10 to the 6th, angles of attack 0-5 deg, and relative surface temperatures of 0.65-0.75. It is shown that, at the end of the isoentropic compression surface, the distribution of local Stanton numbers in the transverse direction is periodic both in laminar and turbulent flow. The presence of an angle of attack leads to increased nonuniformity of heat transfer distribution in the circumferential direction. V.L.

A88-50032
ATTENUATION OF MACH NUMBER NONUNIFORMITY IN COMPRESSIBLE GAS FLOW IN SUBSONIC AND SUPERSONIC NOZZLES [VYRAVNIVANIE NERAVNOMERNOSTI CHISLA M PRI TECHENII SZHIMAEMOGO GAZA V DOZVUKOVOM I SVERKHZVUKOVOM SOPLE]
O. V. LYZHIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 2, 1986, p. 112-115. In Russian.
An expression is obtained which describes the attenuation of the nonuniformity of the Mach number field in flow of a compressible gas in a converging subsonic nozzle as a function of the degree of nozzle contraction and Mach number at the nozzle exit section. It is shown that, in a supersonic nozzle, nonuniformities level off to a much lesser extent than in a subsonic nozzle. V.L.

A88-50034
EFFECT OF A DIVIDING PLATE ON THE SYMMETRICITY OF SEPARATED FLOW OVER A LOW-ASPECT-RATIO DELTA WING [VLIIANIE RAZDELITEL'NOI PLASTINY NA SIMMETRICHNOST' OTRYVNOGO OBTEKANIIA TREUGOL'NOGO KRYLA MALOGO UDLINENIIA]
S. B. ZAKHAROV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 3, 1986, p. 1-8. In Russian. refs
The question of the nonuniqueness of solutions to the problem of separated flow over a low-aspect-ratio delta wing in the presence of a triangular dividing plate on the windward side of the wing in the plane of symmetry is investigated in the approximation of the theory of oblong bodies. A refined version of the finite difference scheme used for solving self-similar vortex sheet problems is proposed which improves the accuracy of the solutions. In addition to symmetric solutions, substantially nonsymmetric solutions are obtained for symmetric incoming flow. Solution bifurcation and hysteresis of the aerodynamic characteristics are discussed. V.L.

A88-50035
PRESSURE PULSATIONS ON A PLATE IN FRONT OF A STEP [PUL'SATSII DAVLENIIA NA PLASTINE PERED USTUPOM]
V. N. BIBKO, B. M. EFIMTSOV, and V. B. KUZNETSOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 3, 1986, p. 9-19. In Russian. refs
Pressure pulsation spectra on a plate near the mean position of an oscillating shock wave induced by boundary layer separation ahead of a plane step are investigated experimentally in the Re1 range (0.9-5)x10 to the 7th/m and free-stream Mach 2.5 and 3.5. Some problems associated with the selection of the governing parameters are examined, and similarity criteria are established.
V.L.

A88-50041
EQUALIZATION OF TEMPERATURE NONUNIFORMITY IN FLOWS WITHIN AIR INTAKE CHANNELS [VYRAVNIVANIE TEMPERATURNOI NERAVNOMERNOSTI POTOKA V KANALAKH VOZDUKHOZABORNIKOV]
E. A. MESHCHERIAKOV, V. A. SABEL'NIKOV, and V. N. SHARIKOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 3, 1986, p. 61-70. In Russian. refs
Results of an experimental study of temperature nonuniformity of flows within the channels of cylindrical and typical supersonic air intakes (Mach 2; Re 4.6x10 to the 6th) are reported. A similarity parameter is proposed which makes it possible to describe changes in the integral parameters of the temperature field within the air intake channel by simple correlation expressions containing three empirical constants. Calculation results for a cylindrical air intake are shown to be in good agreement with experimental data. V.L.

A88-50045
CIRCULATION DISCONTINUITY AT THE BEND POINT OF A SWEPT WING OF LARGE ASPECT RATIO [SKACHOK TSIRKULIATSII V TOCHKE IZLOMA STRELOVIDNOSTI NA KRYLE BOL'SHOGO UDLINENIIA]
O. IU. STARIKOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 3, 1986, p. 95-100. In Russian.
The Prandt-Van Dyke lifting line theory and the method of matched asymptotic expansion are applied to the analysis of a swept wing of large aspect ratio. The effective angle of attack and the circulation discontinuity at the sweep bend point are determined. Details of the analytical procedure are given. V.L.

A88-50046
CHARACTERISTICS OF TRANSONIC FLOW OVER A PROFILE NEAR THE EARTH SURFACE [OSOBENNOSTI OKOLOZVUKOVOGO OBTEKANIIA PROFILIA VBLIZI POVERKHNOSTI ZEMLI]
S. V. LIAPUNOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 3, 1986, p. 101-105. In Russian. refs
A brief description is presented of a method for calculating flow of an ideal gas over a profile near the earth surface in the presence of local supersonic waves and shock waves. Some typical characteristics of flows of this type at high transonic velocities are discussed with reference to specific examples. It is shown that, in certain cases, the development of local supersonic waves may significantly affect the aerodynamic characteristics of a profile. V.L.

A88-50047
EFFECT OF THE LEADING EDGE SWEEP OF A TRIANGULAR PLATE ON THE FRICTION DRAG OF ITS WINDWARD SURFACE AT SUPERSONIC VELOCITIES [VLIIANIE STRELOVIDNOSTI PEREDNEI KROMKI TREUGOL'NOI PLASTINY NA SOPROTIVLENIE TRENIIA EE NAVETRENNOI POVERKHNOSTI PRI SVERKHZVUKOVYKH SKOROSTIAKH]
V. V. KELDYSH TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 3, 1986, p. 106-109. In Russian. refs
The effect of the leading edge sweep of a triangular plate on the friction drag of its windward surface at supersonic velocity in a turbulent boundary layer is estimated for the case where viscous interaction is negligible. It is shown that an increase in the leading edge sweep from 0 to 80 deg leads to a 1-15-percent decrease in the friction drag of the windward surface of the plate at maximum aerodynamic efficiency. It is further shown that the maximum aerodynamic efficiency calculated with allowance for the effect of the three-dimensional nature of external flow over the wing on its friction drag is 2-3 percent higher than the value calculated without allowing for this effect. V.L.

A88-50048
CONSIDERATION OF FRICTION IN SELECTING OPTIMAL NOSE SHAPES FOR BODIES OF REVOLUTION IN SONIC FLOW [UCHET TRENIIA PRI VYBORE OPTIMAL'NYKH FORM NOSOVYKH CHASTEI TEL VRASHCHENIIA V ZVUKOVOM POTOKE]
V. V. VYSHINSKII and E. N. KUZNETSOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 3, 1986, p. 110-114. In Russian. refs
Wave, friction, and total drag calculations are presented for the nose sections of parabolic bodies of revolution for sonic velocities of the incoming flow at Re (0.5-18)x10 to the 6th and aspect ratios of 2-6. The calculations were carried out for both stationary and varying positions of the boundary-layer laminar-turbulent transition point. The region of Reynolds numbers and aspect ratios for which the optimal shape should be determined with allowance for friction drag and transition point position is determined. V.L.

A88-50050
EFFECT OF THE BOUNDARIES OF THE TEST SECTION OF A WIND TUNNEL WITH RIGID SIDE WALLS AND PERFORATED HORIZONTAL WALLS ON FLOW OVER A WING OF FINITE ASPECT RATIO [VLIIANIE GRANITS RABOCHEI CHASTI AERODINAMICHESKOI TRUBY S ZHESTKIMI BOKOVYMI I PERFORIROVANNYMI GORIZONTAL'NYMI STENKAMI NA OBTEKANIE KRYLA KONECHNOGO RAZMAKHA]
A. V. SEMENOV and O. K. SEMENOVA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 3, 1986, p. 121-125. In Russian. refs
The effect of the test section boundaries of a wind tunnel of rectangular cross section with perforated horizontal walls and rigid side walls on incompressible flow over a finite aspect ratio wing is investigated analytically. The problem is solved in a linear formulation using the method of successive mapping of singularities simulating the effect of a single wall. Results are compared with those obtained by other methods. The optimal value of the wall permeability parameter is determined. V.L.

A88-50060
A METHOD FOR CALCULATING THE AERODYNAMIC INTERFERENCE OF WING AND POWERPLANT ELEMENTS WITH JETS [METOD RASCHETA AERODINAMICHESKOI INTERFERENTSII ELEMENTOV KRYLA I DVIGATEL'NOI USTANOVKI SO STRUIAMI]
V. I. BABKIN and L. N. TEPERINA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 4, 1986, p. 64-68. In Russian. refs
The method of discrete vortices is extended to the analysis of the interaction of wing and powerplant components with jets. The wing, powerplant, and jet surfaces are modeled by vortex layers which are replaced, in a numerical implementation, by discrete vortex systems. Examples of aerodynamic load calculations for aircraft elements are presented, and the results are compared with experimental data. V.L.

A88-50062
BOUNDARY LAYER CONTROL THROUGH THE INTRODUCTION OF ARTIFICIAL PERTURBATIONS [UPRAVLENIE SOSTOIANIEM POGRANICHNOGO SLOIA PUTEM VVEDENIIA ISKUSSTVENNYKH VOZMUSHCHENII]
A. A. PILIPENKO and G. K. SHAPOVALOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 4, 1986, p. 73-78. In Russian. refs
The objective of the experimental study reported here was to investigate the possibility of achieving laminar flow in a boundary layer through the suppression of Tollmien-Schlichting waves by artificial perturbations whose phase is opposite to that of the waves being suppressed. The feasibility of the proposed approach is demonstrated in principle. Results of the experiments, which were carried out on a straight wing in a low-turbulence subsonic wind tunnel, are presented. V.L.

A88-50064
TRANSITION VISUALIZATION IN A BOUNDARY LAYER USING SUBLIMABLE COATINGS [VIZUALIZATSIIA PEREKHODA V POGRANICHNOM SLOE SUBLIMIRUIUSHCHIMISIA POKRYTIIAMI]

B. IU. ZANIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 4, 1986, p. 84-88. In Russian.

A technique is described whereby the laminar-turbulent transition in a boundary layer is visualized by means of sublimable coatings. Results of visualization studies of the laminar-turbulent transition in a wing during flight and on a model in a wind tunnel are reported. The possibility of using this method for visualizing various types of flows is demonstrated. V.L.

A88-50070

SHOCKLESS ENTRY OF FLOW ONTO THE LEADING EDGE OF A WING WITH A DEFLECTABLE TIP [BEZUDARNYI VKHOD POTOKA NA PEREDNIUIU KROMKU KRYLA S OTKLONIAEMYM NOSKOM]

G. G. SUDAKOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 5, 1986, p. 1-7. In Russian. refs

The method of matched asymptotic expansions is used to determine the angle of deflection of a wing tip, providing for the shockless entry of flow onto the wing leading edge. Particualr attention is given to the case of a rectangular wing of finite aspect ratio in the presence of flow separation from the wing's lateral edges. B.J.

A88-50071

PROJECTION METHOD FOR CALCULATING SEPARATED IDEAL-FLUID FLOW PAST BODIES [PROEKTSIONNYI METOD RASCHETA KHARAKTERISTIK OTRYVNOGO OBTEKANIIA TEL IDEAL'NOI ZHIDKOST'IU]

A. V. VOEVODIN and G. G. SUDAKOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 5, 1986, p. 8-17. In Russian. refs

A numerical method is proposed for calculating separated flow past wings of low aspect ratio and their combinations with the fuselage. The proposed method makes it possible to calculate separated flow past wing-fuselage systems of arbitrary cross section. The computation is stable with respect to short-wave perturbations, which makes it unnecessary to introduce a special regularization procedure. B.J.

A88-50072

UNSTEADY PROCESSES CONNECTED WITH THE LOCATION OF REGIONS OF THE 'EXPLOSION' OF VORTICES FORMED IN THE VICINITY OF THE LEADING EDGES OF A DELTA WING [NESTATSIONARNYE IAVLENIIA V POLOZHENII OBLASTEI 'VZRYVA' VIKHREI, OBRAZUIUSHCHIKHSIA V OKRESTNOSTI PEREDNIKH KROMOK TREUGOL'NOGO KRYLA]

M. A. GOLOVKIN, V. P. GORBAN', A. A. EFREMOV, and E. V. SIMUSEVA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 5, 1986, p. 18-27. In Russian. refs

Flow visualization of a delta wing with a leading-edge sweep angle of 70 deg is used to investigate unsteady processes connected with the location of regions of the breakdown (explosion) of vortices near the wing leading edges. It is shown that, for a number of unsteady regimes, there are observed very significant differences in the displacement laws of vortex-breakdown regions along the wing with changes in the attack and slip angles as compared with the location of these regions in the case of steady flow for the same angles. B.J.

A88-50074

DEVELOPMENT OF A 'LASER KNIFE' METHOD FOR THE FLOW VISUALIZATION IN SUPERSONIC WIND TUNNELS [RAZVITIE METODA 'LAZERNOGO NOZHA' DLIA VIZUALIZATSII POTOKA V SVERKHZVUKOVYKH AERODINAMICHESKIKH TRUBAKH]

A. I. MAKSIMOV and A. A. PAVLOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 5, 1986, p. 39-50. In Russian. refs

The paper describes a laser-knife technique for flow visualization in supersonic wind tunnels with a closed working part with a pressure chamber and operating with pure dry air. The quantity of light-scattering particles necessary for flow visualization is formed through condensation of additional moisture introduced in the compressed-air delivery channel. Results obtained using this laser technique for a delta wing are found to agree well with oil-soot and pneumometric measurements. B.J.

A88-50075

SUBSONIC FLOW PAST A THIN AIRFOIL IN A CHANNEL WITH MIXED JET AND POROUS BOUNDARIES [DOZVUKOVOE OBTEKANIE TONKOGO PROFILIA V KANALE SO SMESHANNYMI STRUINYMI I PERFORIROVANNYMI GRANITSAMI]

A. V. PILIUGIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 5, 1986, p. 51-60. In Russian.

Linear subsonic theory is used to investigate the flow past a thin airfoil in a channel with mixed jet and porous boundaries. The airfoil is located at the beginning of the jet boundary, asymmetrically with respect to the channel axis and it has a separation zone modeled by the Kirchhoff scheme. The problem is solved in connection with the determination of the value of flow deceleration at the channel axis before the airfoil, which represents a composite problem involving model/support interaction in a wind tunnel. B.J.

A88-50083

JUSTIFICATION OF THE RELATIONSHIP PI=RHO DELTA (DOUBLE ASTERISK)2(INFINITY) V-SQUARED(INFINITY) IN THE MODEL FOR THE GENERATION OF CIRCULATION AT A WING OF INFINITE SPAN WITH A SHARP TRAILING EDGE [OBOSNOVANIE SOOTNOSHENIIA PI=RHO DELTA/DOUBLE ASTERISK/2/INFINITY/ V-SQUARED/INFINITY/, PRIMENIAEMOGO V MODELI PROISKHOZHDENIIA TSIRKULIATSII U KRYLA BESKONECHNOGO RAZMAKHA S OSTROI ZADNEI KROMKOI]

G. I. TAGANOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 5, 1986, p. 120-124. In Russian.

The paper offers a final variant of the proof of the validity of the relationship for the suction force, used in the model for the generation of circulation at a wing of infinite span with a sharp trailing edge. The proposed method relies on the use of an energy approach, instead of the previously used force approach. B.J.

A88-50085

CALCULATION OF THE UNSTEADY AERODYNAMIC CHARACTERISTICS OF AN AIRFOIL WITH AN AILERON IN TRANSONIC FLOW [K RASCHETU NESTATSIONARNYKH AERODINAMICHESKIKH KHARAKTERISTIK PROFILIA S ELERONOM V TRANSZVUKOVOM POTOKE]

IU. P. NUSHTAEV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 5, 1986, p. 129-133. In Russian. refs

A small-perturbation method is used to calculate the aerodynamic characteristics of an airfoil in the transonic flow of an ideal gas in a wide range of Strouhal numbers. It is shown that the Strouhal number and the freestream Mach number have a significant effect on aerodynamic damping. B.J.

A88-50088

APPLICATION OF PROJECTION METHODS IN WING THEORY [PRIMENENIE PROEKTSIONNYKH METODOV V TEORII KRYLA]

A. V. VOEVODIN and G. G. SUDAKOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 6, 1986, p. 1-9. In Russian. refs

The application of projection methods in wing theory is examined using the example of two-dimensional incompressible flow past bodies. Particular attention is given to the application of the Galerkin-Petrov projection method in conjunction with the boundary element method. An appropriate choice of basis functions makes it possible to obtain consistently applicable solutions which converge rapidly according to the number of elements. B.J.

A88-50090

A MODIFICATION OF THE METHOD OF EQUIVALENT CONES [OB ODNOI MODIFIKATSII METODA EKVIVALENTNYKH KONUSOV]

A. I. SARANTSEV and V. F. SIAGAEV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 6, 1986, p. 16-22. In Russian. refs

The paper proposes a modification of the local method of equivalent cones which can be used to calculate pressure on an object in supersonic flow. This method is used to develop a FORTRAN program for calculating the aerodynamic characteristics of supersonic flight vehicles. The program can be used in the initial stage of the design of such vehicles. B.J.

A88-50094

DRAG OF A MODEL BODY IN THE CASE OF IDEAL-FLUID FLOW IN A CHANNEL WITH POROUS WALLS [O SOPROTIVLENII MODELI PRI OBTEKANII IDEAL'NOI ZHIDKOST'IU V KANALE S PRONITSAEMYMI STENKAMI]

V. M. NEILAND TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 6, 1986, p. 48-53. In Russian. refs

The method of matched asymptotic expansions is used to solve the induction problem for porous walls having different porosities at the inlet and outlet. It is shown that an airfoil at angle of attack in a two-dimensional flow acquires a drag similar to the inductive drag of a wing of finite span. B.J.

A88-50099

FEATURES OF THE STATIC HYSTERESIS OF THE AERODYNAMIC CHARACTERISTICS OF A RECTANGULAR WING [OSOBENNOSTI FORMIROVANIIA STATICHESKOGO GISTEREZISA AERODINAMICHESKIKH KHARAKTERISTIK PRIAMOUGOL'NOGO KRYLA]

E. A. KARAVAEV, IU. A. PRUDNIKOV, and E. A. CHASOVNIKOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 6, 1986, p. 95-98. In Russian.

Aerodynamic-hysteresis characteristics are examined for the steady flow past a NACA-0012-profile rectangular wing with an aspect ratio of 5. It is shown that static hysteresis on this wing is produced only in the case of laminar flow on the upper surface and the leading edge of the wing. B.J.

A88-50103

MATHEMATICAL MODEL OF A SENSOR FOR DETERMINING MACH NUMBER AND FLOW VELOCITY DIRECTION [MATEMATICHESKAIA MODEL' PRIEMNIKA DLIA OPREDELENIIA CHISLA MAKHA I NAPRAVLENIIA SKOROSTI POTOKA]

I. D. VERSHININ, A. N. KOVALENKO, and S. A. NEBURCHILOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 6, 1986, p. 116-121. In Russian.

The paper examines the development of an algorithm for determining the Mach number and the velocity direction of a three-dimensional flow according to pressures measured on the surface of an axisymmetric sensor. Detailed consideration is given to a conical sensor intended for the measurement of flow parameters at Mach numbers ranging from 1.5 to 4. B.J.

A88-50326*# United Technologies Research Center, East Hartford, Conn.

ANALYSIS OF CROSSOVER BETWEEN LOCAL AND MASSIVE SEPARATION ON AIRFOILS

MARK BARNETT (United Technologies Research Center, East Hartford, CT) AIAA Journal (ISSN 0001-1452), vol. 26, May 1988, p. 513-521. Previously cited in issue 18, p. 2805, Accession no. A87-42355. refs

(Contract NAS1-16585)

A88-50580*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

EFFECT OF LARGE AMPLITUDE PITCHING MOTIONS ON THE UNSTEADY AERODYNAMIC CHARACTERISTICS OF FLAT-PLATE WINGS

JAY M. BRANDON and GAUTAM H. SHAH (NASA, Langley Research Center, Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 35-45. refs

(AIAA PAPER 88-4331)

Large-amplitude unsteady motion effects on the aerodynamic force and stability characteristics of flat-plate wings were investigated in a wind tunnel for the cases of two delta wings with respective leading edge sweeps of 70 and 45 deg, and a rectangular wing whose aspect ratio was equal to that of the 70-deg delta wing. Attention was given to the effects of reduced frequency and mean angle of attack. It is found that lags in vortex burst location and separation/reattachment of flow on the upper surface of the wing produced large overshoots and hysteresis loops in normal force and pitching moment coefficients that were a strong function of mean oscillation angle and reduced frequency. O.C.

A88-50582#

NUMERICAL SIMULATION OF THREE-DIMENSIONAL LIFTING FLOWS BY A VORTEX PANEL METHOD

DEAN T. MOOK (Virginia Polytechnic Institute and State University, Blacksburg, VA) and CURTIS P. MRACEK IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 55-62. refs

(Contract AF-AFOSR-85-0158)

(AIAA PAPER 88-4336)

A three-dimensional panel method has been developed to simulate incompressible, potential flow. Lifting and non-lifting, steady and unsteady flows can be treated. The method uses triangular panels of linearly varying vortex sheets (more precisely linearly varying jumps in tangential velocity across the surface) to model the surface of the body. The strengths of the vortex sheets are determined by minimizing the flow throuhg the body subject to constraints. The method predicts continuous velocity and pressure fields on the lifting surface. In the present paper, single lifting surfaces and multi-body combinations have been investigated with this technique. There is close agreement between the present results and available analytical solutions and experimental data for both steady and unsteady flows. Thick lifting bodies have not been investigated, but the method does not preclude their analysis. The method was designed for low aspect ratios, high angles of attack and vorticity-dominated flow, but it can be used for high aspect ratios and low angles of attack with equal ease. Author

A88-50583#

EFFECT OF MOVING SURFACES ON THE AIRFOIL BOUNDARY-LAYER CONTROL

F. MOKHTARIAN, V. J. MODI, and T. YOKOMIZO (British Columbia, University, Vancouver, Canada) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 63-71. refs

(AIAA PAPER 88-4337)

Flow visualizations have been undertaken as part of an experimental program exploring moving-surface boundary layer control, in the case of a Joukowsky airfoil that incorporates rotating cylinders at its leading and trailing surfaces. Substantial increases in lift and delays in stall are obtained; these performance improvements are generally correlated with an increase in the ratio of cylinder surface speed to the freestream velocity. This benefit is found to progressively decrease and becomes negligible at a ratio value greater than 4. The flow visualizations qualitatively illustrate the complex character of the flow. O.C.

A88-50584*# Bihrle Applied Research, Inc., Jericho, N. Y.

MEASUREMENTS OF PRESSURES ON THE TAIL AND AFT FUSELAGE OF AN AIRPLANE MODEL DURING ROTARY MOTIONS AT SPIN ATTITUDES

RANDY S. HULTBERG (Bihrle Applied Research, Inc., Jericho, NY), JAMES S. BOWMAN, JR. (NASA, Langley Research Center, Hampton, VA), and COLIN A. MARTIN (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN,

Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 72-82. refs
(AIAA PAPER 88-4338)

The NASA-Langley Spin Tunnel was used to determine the empennage and aft fuselage surfaces of an aircraft model while it was rotated at spinning-event attitudes, in order to ascertain stern flow conditions and the effects of horizontal tail, as well as the wings, on the vertical tail. A substantial horizontal tail influence is noted on both sides of the vertical tail; the removal of the horizontal tail was found to change the propelling or damping moment characteristics of the vertical tail. The wing was also found to have a large influence on the magnitude of the pressures measured on both the empennage and the aft-fuselage areas. O.C.

A88-50586#

AERODYNAMIC DESIGN OF A VARIABLE-BEND VEHICLE

G. F. POLANSKY and W. H. RUTLEDGE (Sandia National Laboratories, Albuquerque, NM) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 94-102. refs
(Contract DE-AC04-76DP-00789)
(AIAA PAPER 88-4340)

An examination is made of the use of variable bending as a means of control in supersonic and hypersonic maneuvering vehicles, with a view to the amelioration of the large hinge moments that have thus far prevented their realization. A procedure is devised for the efficient design of a variable-bend geometry vehicle for a given set of system constraints, giving attention to the selection of vehicle parameters which will generate the minimum hinge moments for trimmed flight. O.C.

A88-50595*# Air Force Flight Test Center, Edwards AFB, Calif.

ANGLE OF ATTACK ESTIMATION USING AN INERTIAL REFERENCE PLATFORM

JOSEPH E. ZEIS, JR. (USAF, Edwards AFB, CA), HEATHER H. LAMBERT (NASA, Flight Research Center, Edwards, CA), ROBERT A. CALICO, and DANIEL GLEASON (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 180-190. refs
(AIAA PAPER 88-4351)

This paper presents the mathematical development and flight test results of an angle of attack estimation system based on inertial navigation system inputs. The estimator uses these inputs to determine the coefficient of lift required at any instant inflight. Angle of attack is then modeled through a regression analysis based on coefficient of lift, altitude and Mach. Overall correlation of the estimator as tested was generally within 0.5 degrees through 17 degrees angle of attack on an F-15A aircraft. A robustness analysis indicates that the system can be used adequately in maneuvering flight. Author

A88-50597#

PREDICTION OF PLANFORM MODIFICATION EFFECTS AT HIGH ANGLES OF ATTACK

M. G. NAGATI (Wichita State University, KS) and B. RASHIDIAN IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 217-222. refs
(Contract DOT-FA03-86-R-60039)
(AIAA PAPER 88-4353)

A method is presented for the estimation of the effects of wing planform modifications on its aerodynamic forces using the popular panel methods, to assist in the preliminary concept design of spin-resistant aircraft. The pressure distributions are obtained by applying changes to the boundary conditions at the panel control points to simulate separated boundary layer flow. The changes in normal velocity vectors are computed, based on two-dimensional airfoil data beyond the onset of separation. Results for angles of attack up to 27 deg are in agreement with the experiment. Author

A88-50598#

OVERALL FORCES AND MOMENTS ON WING-BODIES AT HIGH INCIDENCE

G. A. JOHNSON (British Aerospace, PLC, Bristol, England) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 223-232. Research supported by the British Aerospace, PLC and SERC. refs
(AIAA PAPER 88-4354)

Modern fighter aircraft and missiles maneuver at high incidence. At these incidences the slender forebodies of such vehicles generate asymmetric flow patterns. This paper studies the influence of these patterns on downstream lifting surfaces by examining the overall forces and moments obtained from low-speed wind tunnel tests. A limited amount of pressure measurement was also performed to give estimates of the local, normal and side force coefficients at certain axial positions. Correlations are made between the key features of the overall forces and moments and the flow just ahead of the lifting surfaces, as obtained by the smoke-wire flow visualization technique. This shows that the sign and magnitude of both the overall side force and rolling moment can be dramatically affected by the flow field just ahead of the lifting surfaces, particularly at the onset of flow asymmetry and at the shedding of the first forebody vortex. Author

A88-50599#

IMPROVED CURVE FITTING TECHNIQUES OF FREQUENCY DOMAIN GENERALIZED AERODYNAMIC FORCES

V. JAMES SALLEE (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 233-243. refs
(AIAA PAPER 88-4355)

Presented are methods for forming a stable, continuous, s-plane representation of the generalized aerodynamic forces which are known only at discrete values of reduced frequency. Problems encountered are achieving stable, low-order representations while accurately matching the known values. The problem formulation and the solution used in ADAM1 are examined first. The improved methods are then presented. These methods include: determining independent denominators for each row; determining an optimal denominator based on the weighted/normalized generalized aerodynamic forces; determining the degree of difficulty of the curve fit for each generalized aerodynamic force together with its weighting factor. Example results of the methods are given. These methods are currently being used in the latest Air Force Flight Dynamics Laboratory aeroservoelastic analysis code, ADAM 2.02. Author

A88-50604*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A COMPUTATIONAL ANALYSIS OF UNDER-EXPANDED JETS IN THE HYPERSONIC REGIME

ANDREW T. HSU and MENG-SING LIOU (NASA, Lewis Research Center, Cleveland, OH) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 300-306. refs
(AIAA PAPER 88-4361)

Underexpanded axisymmetric jets are studied numerically using a full Navier-Stokes solver. Emphasis has been given to supersonic and hypersonic jets in supersonic and hypersonic ambient flows, a phehomenon previously being overlooked for the most part. The present work demonstrates that the shear layers and shock patterns in a jet plume can be captured without complicated viscous/inviscid and subsonic/supersonic coupling schemes. In addition, a supersonic pressure relief effect has been identified for underexpanded jets in supersonic ambient flows. While it is well known that an underexpanded jet in a quiescent ambience (or subsonic ambience) contains multiple shock cells, the present study shows that because of the supersonic pressure relief effect, an underexpanded jet in a supersonic or hypersonic ambience contains only one major shock cell. Author

A88-50605#
A NUMERICAL METHOD FOR UNSTEADY TRANSONIC FLOW ABOUT LOW-ASPECT-RATIO WINGS
J. B. ZHANG (China Aerodynamics and Development Centre, Sichuan, People's Republic of China) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 307-313. refs
(AIAA PAPER 88-4362)

A numerical method is presented for predicting steady and unsteady transonic aerodynamic flow about thin wings of general planforms. A special designed coordinate transformation is employed in the method. The numerical procedure solves the unsteady transonic modified three-dimensional small perturbation equation by time accurate alternating direction implicit finite difference algorithm. Numerical results are presented for an F-5 fighter wing and compared with experimental date and those by other methods for subsonic and transonic flight conditions. Present method is proved to be successful and rapid. Author

A88-50610#
THE VARIOUS SOURCES OF WING ROCK
L. E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 371-384. refs
(AIAA PAPER 88-4370)

Limit cycle oscillations in roll of advanced aircraft can result from three different fluid mechanical flow processes. The so-called slender wing rock is caused by asymmetric vortex shedding from highly swept wing leading edges. A completely different flow mechanism causes wing rock for aircraft with moderately swept leading edges. In this case the causative mechanism is dynamic airfoil stall. Finally, if the aircraft has a slender forebody, the rocking motion can be generated by asymmetric body vortices from the nose, which interact with a non-axisymmetric aft body, e.g. due to the presence of wing or tail surfaces. The present paper describes the nonsteady fluid dynamic processes generating the different types of wing rock. Author

A88-50615#
AERODYNAMIC DESIGN CONSIDERATIONS FOR A FREE-FLYING DUCTED PROPELLER
ROBERT J. WEIR (Sandia National Laboratories, Albuquerque, NM) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 420-431. refs
(Contract DE-AC04-76DP-00789)
(AIAA PAPER 88-4377)

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

A88-50618#
EFFECT OF WING VERTICAL POSITION ON LIFT FOR SUPERSONIC DELTA WING MISSILE CONFIGURATIONS
A. A. JENN (McDonnell Douglas Astronautics Co., Saint Louis, MO) and H. F. NELSON (Missouri-Rolla, University, Rolla) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 447-454. Research supported by the McDonnell Douglas Astronautics Co. refs
(AIAA PAPER 88-4381)

The effect of wing vertical position on lift is investigated for supersonic missiles with cylindrical bodies and delta wings. Wing locations above and below the body centerline are considered over a range of Mach number, angle of attack, and aspect ratio. A finite difference Euler code, SWINT, is used to compute the wing lift. The lift forces are presented in terms of a measure of the wing-body interference due to body upwash. The SWINT interference values for wings located on the missile centerline compare favorably with existing results from theoretical and experimental sources. SWINT results for wings located off the missile centerline indicate that wing lift decreases symmetrically as the wing is moved above or below the centerline. A simple model based on upwash theory is developed which agrees well with the interference values predicted by SWINT. Empirical formulas for calculating the interference values as a function of wing span and vertical position are presented for easy use in preliminary design. Author

A88-50619#
EXPERIMENTAL AND COMPUTATIONAL INVESTIGATION FOR TWO-DIMENSIONAL CHARACTERISTICS OF FLAT PLATE WINGS
RYUJIRO KUROSAKI, EIICHI NAKANO (Mitsubishi Electric Corp., Kamakura, Japan), and KAZUHIRO KUMASAKA (Mitsubishi Space Software, Corp., Kamakura, Japan) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 455-468. refs
(AIAA PAPER 88-4382)

Wind tunnel tests for three types of flat plate wings for missiles are conducted at Mach numbers of 0.5, 0.8 and 2.0. Prior to the tests, verification of the Two-Dimensional performance of the trisonic wind tunnel used is made using a conventional wing model (NACA 0012). At the same time, in order to confirm the applicability of a two-dimensional Navier-Stokes code to flat plate wings, computations are made and compared with the experiments. The section lift coefficient and section pressure drag coefficient differ among the different types of wings, except for the former, in the supersonic region. The computational results prove the applicability of numerical simulations to flat-plate wings. Author

A88-50777
WING GEOMETRY: METHODS AND ALGORITHMS FOR DESIGNING LIFTING SURFACES [GEOMETRIIA KRYLA: METODY I ALGORITMY PROEKTIROVANIIA NESUSHCHIKH POVERKHNOSTEI]
IURII VASIL'EVICH DAVYDOV and VIKTOR ALEKSANDROVIC ZLYGAREV Moscow, Izdatel'stvo Mashinostroenie, 1987, 136 p. In Russian. refs

Problems pertaining to the geometric simulation of aircraft wings are addressed. Methods for the mathematical description of planar contours and surfaces and for the calculation of geometric characteristics are presented. The formulation of algorithms for the solution of these tasks and the design of automated systems for their implementation are discussed. K.K.

A88-50779#
NUMERICAL INVESTIGATION OF A MACH 3.5 AXISYMMETRIC INLET WITH MULTIPLE BLEED ZONES
K. W. ABRAHAMSON (General Dynamics Corp., Convair Div., San Diego, CA) AIAA, Applied Aerodynamics Conference, 6th, Williamsburg, VA, June 6-8, 1988. 8 p. refs
(AIAA PAPER 88-2588)

The axisymmetric, compressible, Navier-Stokes equations were numerically solved for the flow through a Mach 3.5 axisymmetric inlet with multiple bleed zones. Solutions are presented for flows computed at both on- and off-design bleed mass flow rates. The turbulence model of Baldwin and Lomax (1978) and the bleed boundary condition of Abrahamson and Brower (1988) are evaluated by comparison of the computational results against experimental data. The present results indicate that the Baldwin-Lomax turbulence model is inadequate for simulating flows with successive shock wave boundary layer interactions and bleed. The bleed boundary condition was unable to reproduce the experimentally measured mass flow rates, which suggests that the boundary condition be reformulated based on local freestream total pressure rather than local wall total pressure. Author

A88-50905#
DESIGN OF A SUPERCRITICAL AIRFOIL
Z. Y. ZHANG, X. T. YANG (Northwestern Polytechnical University, Xian, People's Republic of China), and B. LASCHKA (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 1, p. 67-70) Journal of Aircraft (ISSN 0021-8669), vol. 25, June 1988, p. 503-506. Research supported by Chinese Aeronautical Establishment, DFVLR, and Technische Universitaet Braunschweig. Previously cited in issue 24, p. 3529, Accession no. A86-48982. refs

A88-50906#
OSCILLATING WINGS AND BODIES WITH FLEXURE IN SUPERSONIC FLOW
D. D. LIU, P. GARCIA-FOGEDA (Arizona State University, Tempe), and P. C. CHEN (ICAS, Congress, 15th, London, England, Sept. 7-12, 1986, Proceedings. Volume 2, p. 1270-1284) Journal of Aircraft (ISSN 0021-8669), vol. 25, June 1988, p. 507-514. Army-supported research. Previously cited in issue 24, p. 3533, Accession no. A86-49108. refs

A88-50908#
LIFT OF DELTA WINGS WITH LEADING-EDGE BLOWING
D. A. TAVELLA (Stanford University, CA) Journal of Aircraft (ISSN 0021-8669), vol. 25, June 1988, p. 522-524. Previously cited in issue 23, p. 3385, Accession no. A86-47691. refs

A88-50912#
COMPUTATION OF TRANSONIC AERODYNAMICALLY COMPENSATING PILOT TUBE
SHIJUN LUO (Northwestern Polytechnical University, Xian, People's Republic of China) and YUN BAO Journal of Aircraft (ISSN 0021-8669), vol. 25, June 1988, p. 544-547. Previously cited in issue 21, p. 3340, Accession no. A87-49112. refs

A88-50913#
AIRFOIL DYNAMIC STALL AT CONSTANT PITCH RATE AND HIGH REYNOLDS NUMBER
PETER F. LORBER and FRANKLIN O. CARTA (United Technologies Research Center, East Hartford, CT) Journal of Aircraft (ISSN 0021-8669), vol. 25, June 1988, p. 548-556. Previously cited in issue 18, p. 2807, Accession no. A87-42391. refs
(Contract F49620-84-C-0082)

A88-50916#
OPSGER - COMPUTER CODE FOR MULTICONSTRAINT WING OPTIMIZATION
S. C. GUPTA (Institute of Armament Technology, Pune, India) Journal of Aircraft (ISSN 0021-8669), vol. 25, June 1988, p. 572-574.

The OPSGER code for aerodynamic optimization can handle linearized flows, and several combinations of constraints can be specified for it. The code is applicable to advanced aircraft design aerodynamics applications, as presently demonstrated for the case of a low aspect ratio, flat-plate delta wing. Results are presented for the lift-alone constraint; drag reduction as high as 67 percent is feasible in the incompressible flow regime. O.C.

A88-51153* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
TRANSONIC SEPARATED FLOW PREDICTION BASED ON A MATHEMATICALLY SIMPLE, NONEQUILIBRIUM TURBULENCE CLOSURE MODEL
D. A. JOHNSON and L. S. KING (NASA, Ames Research Center, Moffett Field, CA) IN: Turbulent shear-layer/shock-wave interactions. Springer-Verlag, Berlin and New York, 1986, p. 27-37. Previously announced in STAR as N86-13676. refs

A mathematically simple, turbulence closure model designed to treat transonic airfoil flows even with massive separation is described. Numerical solutions of the Reynolds-averaged, Navier-Stokes equations obtained with this closure model are shown to agree well with experiments over a broad range of test conditions. Author

A88-51156
APPLICATION OF INTERACTING BOUNDARY-LAYER THEORY IN THE ANALYSIS OF TRANSONIC SHOCK INDUCED SEPARATION
DAVID E. EDWARDS, JAMES E. CARTER (United Technologies Research Center, East Hartford, CT), and DAVID L. WHITFIELD (Mississippi State University, Mississippi State) IN: Turbulent shear-layer/shock-wave interactions. Springer-Verlag, Berlin and New York, 1986, p. 79-91. refs
(Contract N00014-81-C-0381)

This paper presents results of an analysis of transonic-shock-induced separation by an interacting-boundary-layer-theory (IBLT) method which uses a stream function-vorticity representation of the inviscid flow and either a finite difference or integral representation of the boundary-layer equations. In this method, the viscous equations are coupled to the inviscid equations using either Carter's (1979) semiinverse method or the Edwards and Carter (1985) (or Veldman, 1979) quasi-simultaneous method. The accuracy of this approach was verified using the experimental data of Om (1982), demonstrating that the IBLT is capable of accurately resolving many of the details of the transonic shock-induced separated flow. I.S.

A88-51157
THE SHOCK-WAVE/TURBULENT BOUNDARY-LAYER INTERACTION ON CURVED SURFACE AT TRANSONIC SPEED
X. LIU and L. C. SQUIRE (Cambridge University, England) IN: Turbulent shear-layer/shock-wave interactions. Springer-Verlag, Berlin and New York, 1986, p. 93-104. refs

Detailed experimental measurements have been made of the shock-wave/turbulent boundary-layer interaction on curved surface at transonic speed. The flow field is calculated by a wide range of numerical methods including two boundary-layer methods, two shock/boundary-layer interaction methods and one Euler-solver inviscid method. Author

A88-51158
CALCULATION OF TWO-DIMENSIONAL TURBULENT SHOCK/BOUNDARY-LAYER INTERACTION AT CURVED SURFACES WITH SUCTION AND BLOWING
R. BOHNING and J. ZIEREP (Karlsruhe, Universitaet, Federal Republic of Germany) IN: Turbulent shear-layer/shock-wave interactions. Springer-Verlag, Berlin and New York, 1986, p. 105-112. refs

The interaction between a weak normal shock and a two-dimensional compressible turbulent boundary layer at a curved wall was investigated using an analytical interference model developed by embedding the local interference model in different global numerical solutions of the outer flow field coupled with boundary layer procedures of Dargel and Jakob (1984). A typical example of the calculated pressure distribution for different wall distances is presented. It is emphasized that the analytical interference model can be used for the support of numerical global methods for calculating the flow over transonic airfoils. I.S.

A88-51159
IMPROVEMENT OF TRANSONIC AIRFOIL PERFORMANCE THROUGH PASSIVE SHOCK/BOUNDARY-LAYER INTERACTION CONTROL
P. THIEDE (Messerschmitt-Boelkow-Blohm GmbH, Bremen, Federal Republic of Germany) and P. KROGMANN (DFVLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) IN: Turbulent shear-layer/shock-wave interactions. Springer-Verlag, Berlin and New York, 1986, p. 113-123. refs

The effect of passive control of the shock/boundary-layer interaction (SBLI) on the performance of transonic airfoil was investigated in experiments carried out in the DFVLR 1 m x 1 m transonic wind tunnel with a supercritical airfoil designed to have a relatively small shock shifting with Mach number. The effectiveness of the different SBLI control methods on the airfoil performance was evaluated using pressure distribution, boundary-layer, and wake measurements and schlieren optic observations. It was found that, as the result of passilve SBLI control, wave and shock-induced viscous drag are drastically reduced and the onset of shock-induced separation is delayed, resulting in substantial improvements of transonic airfoil performance at off-design conditions. I.S.

A88-51165
A 'PREVIEW' OF THREE-DIMENSIONAL SHOCK-WAVE/TURBULENT BOUNDARY-LAYER INTERACTIONS
ALEXANDER J. SMITS and SEYMOUR M. BOGDONOFF (Princeton University, NJ) IN: Turbulent shear-layer/shock-wave interactions. Springer-Verlag, Berlin and New York, 1986, p. 191-202. USAF-supported research. refs

This paper presents a critical assessment of current understanding of three-dimensional shock wave/turbulent boundary-layer interactions. Special attention is given to the computational work of three-dimensional flows, emphasizing that, in some cases, the agreement with experiment is better than in calculations of two-dimensional flows. Two classes of shock wave/turbulent boundary-layer interactions are discussed, the 'weak' and the 'strong' interactions, defining the conditions for the interaction to be considered weak or strong. It is emphasized that, in case of strong interactions, the flow cannot be calculated using existing turbulence models; the turbulence is severely distorted, the flow is unsteady, and there exists strong coupling between the mean and turbulent fields, such as in the interaction produced at Mach 3 by a swept wedge at high angles of attack and angles of sweep less than 20 deg. Problems encountered in strong interactions are examined, and recommendations for their study are given. I.S.

A88-51166* Pennsylvania State Univ., University Park.
ON THE INCEPTION LENGTHS OF SWEPT SHOCK-WAVE/TURBULENT BOUNDARY-LAYER INTERACTIONS
G. S. SETTLES (Pennsylvania State University, University Park) IN: Turbulent shear-layer/shock-wave interactions. Springer-Verlag, Berlin and New York, 1986, p. 203-213. USAF-NASA-supported research. refs

Experimental data are shown for the inception lengths of swept compression corner-generated and fin-generated shock/boundary layer interactions at Mach 2.95. These results are found to correlate on the basis of three different flow regimes. The inception lengths of these flows are dominated by a singularity at the cylindrical/conical boundary for swept corners and by an elongation due to shock wave sweepback for fin interactions. Similarity rules for both Re(delta)and shock generator geometry effects on inception lengths are demonstrated. Author

A88-51167
EXPERIMENTAL STUDY OF THE BOUNDARY-LAYER SEPARATION CONDITIONS THROUGH A SHOCK-WAVE ON AIRFOIL AND SWEPT WING
A. MIGNOSI, J. B. DOR, and A. SERAUDIE (ONERA, Departement d'Aerothermodynamique, Toulouse, France) IN: Turbulent shear-layer/shock-wave interactions. Springer-Verlag, Berlin and New York, 1986, p. 215-231. refs

The experimental studies presented in this paper were obtained in T2 wind tunnel on two models equipped with LC 100 D profiles: (1) an airfoil with a large chord (C = 400 mm) placed near the lower wall of the test section, and (2) a swept wing (C = 100 mm; phi = 30 deg and phi = 45 deg). Pressure measurements, boundary layer probings, and wall visualizations around the separation conditions of the turbulent boundary layer interaction with the shock wave have been done. The turbulent boundary layer separation occurs when the upstream local Mach number, normal to the shock, reaches approximately 1.3. Author

A88-51168
A MODEL OF THE FLOW OVER SWEPT WINGS WITH SHOCK INDUCED SEPARATION
J. L. FULKER and P. R. ASHILL (Royal Aircraft Establishment, Bedford, England) IN: Turbulent shear-layer/shock-wave interactions. Springer-Verlag, Berlin and New York, 1986, p. 233-245. refs

A new flow model is proposed for describing quasi two-dimensional flows with shock-induced separation on wings of modest sweep. Correlations of the main features of the flow model over a wide range of Reynolds number have been deduced from wind-tunnel tests on wings and aerofoils. These correlations have successfully been used as a basis for simulating 'full-scale' flows over wings in the wind tunnel. Author

A88-51169
SEPARATION AHEAD OF BLUNT FINS IN SUPERSONIC TURBULENT BOUNDARY-LAYERS
N. SAIDA (Aoyama Gakuin University, Tokyo, Japan) IN: Turbulent shear-layer/shock-wave interactions. Springer-Verlag, Berlin and New York, 1986, p. 247-258. refs

An experimental study of the three-dimensional shock wave/turbulent boundary layer interaction induced by a blunt fin was made mainly at Mach 2.48. The effects of leading edge shape and angle of attack were studied. Surface pressure measurements, and flow visualizations were made. The results show that, on the test surface near the fin, the structure of the vortex in the reverse flow region depends strongly on the leading edge shape, but it does not affect the flow near the separation point. Furthermore, the effects of the angle of attack appear downstream of the plateau region especially on the windward side. Author

A88-51171
NUMERICAL EXPERIMENT WITH INVISCID VORTEX-STRETCHED FLOW AROUND A CRANKED DELTA WING - TRANSONIC SPEED
ARTHUR RIZZI (Flygtekniska Forsoksanstalten, Bromma, Sweden), CHARLES J. PURCELL, and J. THOMAS MCMURRAY (ETA Systems, Inc., Saint Paul, MN) IN: Turbulent shear-layer/shock-wave interactions. Springer-Verlag, Berlin and New York, 1986, p. 283-298.

A numerical method that solves the Euler equations for compressible flow is used to study vortex stretching. The particular case simulated is transonic flow M-infinity = 0.9, alpha = 10 deg around the twisted and cambered cranked-and-cropped TKF delta wing of MBB. This geometry induces multiple leading-edge vortices in a straining velocity field that brings about flow instabilities, but the result is a state of statistical equilibrium. The discretization contains over 600,000 cells and offers sufficient degrees of freedom in the solution to exhibit the onset of chaotic vortex flow that could well lead to turbulence. The simulated results are compared with wind-tunnel measurements. Author

A88-51172
SHOCK/BOUNDARY-LAYER INTERACTION MODEL FOR THREE-DIMENSIONAL TRANSONIC FLOW CALCULATIONS
J. D. MCLEAN and T. K. MATOI (Boeing Commercial Airplane Co., Seattle, WA) IN: Turbulent shear-layer/shock-wave

interactions. Springer-Verlag, Berlin and New York, 1986, p. 311-321. refs

A computer model of three-dimensional shock/boundary-layer interaction is proposed for studying viscous transonic flow. Two programs using a modified three-dimensional finite-difference boundary layer method are described. One program calculates wing-body and wing-body-strut-nacelle flows using a transonic full-potential method for the inviscid flow, and the other determines nacelle-center-body flows using a Euler equation method. The model provides a general improvement over previous methods, and it is shown to be capable of predicting the onset of shock-induced separation (provided that the onset is not preceded by significant trailing-edge separation). R.R.

A88-51173

AEROTHERMAL PROBLEMS ASSOCIATED WITH VISCOUS/INVISCID INTERACTION OVER HYPERSONIC FLIGHT VEHICLES

MICHAEL S. HOLDEN (Calspan/UB Research Center, Buffalo, NY) IN: Turbulent shear-layer/shock-wave interactions. Springer-Verlag, Berlin and New York, 1986, p. 323-338. refs

Aerothermal problems associated with viscous/inviscid shock-wave/turbulent-boundary-layer interactions over hypersonic vehicles are discussed, with application to the design of systems such as the transatmospheric vehicle and the OTV. Topics considered include interacting flows over transitional nose shapes, hypersonic interacting flows over two-dimensional and three-dimensional compression surfaces, swept wedge and skewed shock/boundary-layer interactions, and corner interactions. It is pointed out that turbulence models must adequately describe the generation of turbulence at the base of the boundary layer as separation occurs, along with its restructuring as the boundary layer undergoes radical thinning through the strong reattachment compression process. R.R.

A88-51175

REDUCTION OF LOW FREQUENCY BUFFET FROM A BLUFF BODY AT TRANSONIC SPEEDS

D. G. MABEY and P. LEE (Royal Aircraft Establishment, Bedford, England) IN: Turbulent shear-layer/shock-wave interactions. Springer-Verlag, Berlin and New York, 1986, p. 359-370. refs

Wind tunnel tests on an experimental aircraft fitted with a bluff fairing close to the nose have been performed in order to investigate the severe buffeting noted at transonic speeds. The phenomena was found to be due to alternate low-frequency shock oscillations between the port and starboard sides of the fairing which caused time-dependent pressure variations with a significant phase difference between the two sides of the fairing. It is shown that connecting both sides of the fairing (where the mean pressures were the same) by a number of 'buffet breather' tubes stabilizes the position of the shock-induced separation and reduces the level of low-frequency pressure fluctuations. R.R.

A88-51176*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

TURBULENCE ALTERATION DUE TO SHOCK MOTION

M. Y. HUSSAINI (NASA, Langley Research Center, Institute for Computer Applications in Science and Engineering, Hampton, VA), F. COLLIER (Virginia Polytechnic Institute and State University, Blacksburg), and D. M. BUSHNELL (NASA, Langley Research Center, Hampton, VA) IN: Turbulent shear-layer/shock-wave interactions. Springer-Verlag, Berlin and New York, 1986, p. 371-381. refs
(Contract NAS1-17170)

Physical and computational models are provided for three cases of shock motion-turbulence interaction: (1) the production of velocity fluctuations due to shock oscillations; (2) eddy alteration due to transient eddy shocklets; and (3) eddy production due to transient shock-entropy spottiness interactions. Shock motions are shown to be efficient in converting mean flow energy into fluctuation energy, and high-frequency induced shock motions produce intense vorticity fields from the incident mean flow. The effects of transient eddy shocklets created by subsonic eddy motion in a supersonic stream are discussed in detail. R.R.

A88-51177

PROPERTIES OF WALL PRESSURE FLUCTUATIONS IN A SEPARATED FLOW OVER A COMPRESSION RAMP

J. P. DUSSAUGE (Aix-Marseille II, Universite, Marseille, France), K. C. MUCK, and J. ANDREOPOULOS (Princeton University, NJ) IN: Turbulent shear-layer/shock-wave interactions. Springer-Verlag, Berlin and New York, 1986, p. 383-392. refs
(Contract AF-AFOSR-85-0126; F49620-84-C-0086)

An experimental study of the unsteadiness of a shock/boundary layer interaction is presented. The interaction is produced by a 24 deg compression ramp at Mach number 2.84. Multi-channel measurements of wall pressure fluctuations are performed. It is found that the shock has significant large scale 'rippling'; the shock induced fluctuations produce a maximum in the space time correlation for negative time delay, indicating a strong modification of transport properties in the interaction. At last, the analysis of frequency measurements suggests that shock oscillation could be triggered by the bursting mechanism in the incoming boundary layer. Author

A88-51179* Grumman Aerospace Corp., Bethpage, N.Y.

AN OVERVIEW OF SOME INVESTIGATIONS OF PRESSURE AND THERMAL DISTRIBUTIONS INDUCED BY TRAILING EDGE CONTROLS ON HYPERSONIC AIRCRAFT

LOUIS G. KAUFMAN, II (Grumman Corp., Bethpage, NY) and CHARLES B. JOHNSON (NASA, Langley Research Center, Hampton, VA) IN: Turbulent shear-layer/shock-wave interactions. Springer-Verlag, Berlin and New York, 1986, p. 407-418. refs

Detailed surface heat transfer and pressure distributions have been obtained in three-dimensional shock-wave boundary-layer interactions flow regions. The data described were obtained on fundamental shapes: planar wings with trailing edge flaps or spoilers and planar or cylindrical center bodies, representative of the aft portion of hypersonic aircraft. An overview of the work is presented; details of the projects are available in many reports in the open literature. Analytic, empiric methods are advanced for predicting the extent of separation and the increased heat transfer and pressure loads in three-dimensional separated flow regions. Author

A88-51184

PASSIVE CONTROL OF SHOCK-BOUNDARY LAYER INTERACTION

S. RAGHUNATHAN (Belfast, Queen's University, Northern Ireland) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 25, no. 3, 1988, p. 271-296. SERC-supported research. refs

Passive control shock-boundary layer studies, both theoretical and experimental, are reviewed in this paper. The first paper in this area was published in 1983. Since then there have been program of research in U.S.A., Germany and U.K. to understand the concept of passive shock wave boundary layer control and to predict the effect of such a control on the aerodynamic forces on an aerofoil. This review shows that the application of passive control in transonic flow can reduce drag, increase lift and reduce unsteady pressures on an aerofoil. Author

A88-51362

BOUNDARY ELEMENT TECHNIQUES: APPLICATIONS IN FLUID FLOW AND COMPUTATIONAL ASPECTS

C. A. BREBBIA, ED. (Wessex Institute of Technology, Southampton, England) and W. S. VENTURINI, ED. (Sao Paulo, Universidade, Sao Carlos, Brazil) Southampton, England and Billerica, MA, Computational Mechanics Publications, 1987, 258 p. For individual items see A88-51363 to A88-51371.

Various papers on the applications of boundary element methods (BEMs) to fluid flow and computation are presented. The topics addressed include: boundary element (BE) solution of viscous flow problems; BEs for mixed-convection flow problems; solution of steady, incompressible, two-dimensional Navier-Stokes equations using integral representations; calculation of transonic flow about airfoils by a field panel method; three-dimensional analysis of supersonic flows around arbitrary bodies using boundary collocation method; aerodynamic study of a delta wing with sideslip and high angles of attack. Also discussed are: the PROCAT system for cathodic protection design; programing BEs in ADA; potential problems involving axisymmetric geometry and arbitrary boundary conditions by the BEM; BE improved integration technique using spline functions; application of the radon transform in the boundary integral equation method; the variational formulation of the BEM; potential problems solved by an analytical integration scheme. C.D.

A88-51365

COMPARING IMPROVED 1ST ORDER PANEL METHOD RESULTS WITH WIND-TUNNEL MEASUREMENTS FOR A COMPLETE AIRPLANE CONFIGURATION

F. L. GALVAO (Instituto de Pesquisas Espaciais, Sao Jose dos Campos, Brazil) IN: Boundary element techniques: Applications in fluid flow and computational aspects. Southampton, England and Billerica, MA, Computational Mechanics Publications, 1987, p. 47-60. refs

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 at the ONERA's Modane wind-tunnel. It is shown that for subcritical Mach numbers and attached flow angles of attack, a fair agreement can be found between computed and measured pressure values and also that wind-tunnel and nacelle internal flows can be correctly simulated. Author

A88-51366

CALCULATION OF TRANSONIC FLOW ABOUT AIRFOILS BY A FIELD PANEL METHOD

R. S. RIBEIRO (Empresa Brasileira de Aeronautica, S.A., Sao Jose dos Campos, Brazil) and P. A. O. SOVIERO (Instituto Tecnologico de Aeronautica, Sao Jose dos Campos, Brazil) IN: Boundary element techniques: Applications in fluid flow and computational aspects. Southampton, England and Billerica, MA, Computational Mechanics Publications, 1987, p. 61-74. refs

A transonic field panel method is developed to solve the small disturbances equation for lifting and nonlifting symmetric airfoils in both the subcritical and supercritical domain. Tests are performed to apply the finite-difference concept to the derivatives involved in the source term of the Poisson equation. The results suggest that this representation can improve the stability and convergence rate of the method. For supercritical flows, the concepts of artificial viscosity and upwind differences are used, with better results being achieved with the former. Lifting flows can be represented with good agreement for small angles of incidence, but for supercritical flows instability can occur for grids which are too coarse or too refined, depending on the flow conditions at infinity. C.D.

A88-51368

AERODYNAMIC STUDY OF A DELTA WING WITH SIDESLIP AND HIGH ANGLES OF ATTACK

P. A. O. SOVIERO, R. M. GIRARDI (Instituto Tecnologico de Aeronautica, Sao Jose dos Campos, Brazil), and R. S. RIBEIRO (Empresa Brasileira de Aeronautica, S.A., Sao Jose dos Campos, Brazil) IN: Boundary element techniques: Applications in fluid flow and computational aspects. Southampton, England and Billerica, MA, Computational Mechanics Publications, 1987, p. 89-99. refs

The flow past the delta-wing with sideslip is analyzed through an extension of the method of Soviero and Girardi (1986) in order to include the effects of sideslip. Normal force and rolling moment coefficients are shown as well as pressure distributions in the upper and lower parts of the wing and shapes of the vortex sheet for several sideslip angles. Comparisons with experimental results demonstrate the usefulness of the method. C.D.

A88-51425*# Analytical Services and Materials, Inc., Hampton, Va.

BOUNDARY LAYER CROSSFLOW STABILIZATION OF HIGH SUBSONIC SPEED LFC TRANSPORT AIRPLANES

W. PFENNINGER and CHANDRA S. VEMURU (Analytical Services and Materials, Inc., Hampton, VA) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 31 p. refs
(Contract NAS1-18235)
(AIAA PAPER 88-0275)

With a view to the elaboration of the design of Mach 0.83 and 0.97 cruise-speed long-range aircraft employing LFC, a study is conducted of the laminar flow characteristics of supercritical airfoils of blunt leading-edge X88 type, for the case of lightly loaded wings that dispense with leading-edge flaps for low-speed operations. The boundary layer crossflow in the front acceleration zone of these airfoils' upper surface is optimally stabilized by suction in the upstream portion of the zone, yielding a crossflow that is neutrally stable. O.C.

A88-51752

REPRESENTATION OF SWEEP EFFECTS ON DYNAMIC STALL

J. G. LEISHMAN (Maryland, University, College Park) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 15 p. Army-supported research. refs

A practical method is presented to evaluate the effects of swept flow on airfoil dynamic stall. The method is included within the formulation of a general two-dimensional unsteady aerodynamic model for predicting the sectional lift, pitching moment and drag in routine helicopter rotor airloads and performance analyses. The procedure has also been extended, in a preliminary manner, to account for time dependent sweep effects. It has been concluded from the present study that the introduction of a swept (radial) component primarily affects the local development of trailing edge flow separation on the airfoil; the subsequent modifications to the unsteady lift, pitching moment and drag hysteresis loops appear as a consequence. Justification of the modeling is conducted with experimental dynamic stall data on a NACA 0012 airfoil oscillating in pitch at a Mach number of 0.4 with a steady sweep angle of 30 deg. Excellent correlations were obtained with the test data and provide increased confidence in the validity of the unsteady aerodynamic model for the helicopter rotor environment. Author

A88-51753

EXPERIMENTAL AND NUMERICAL AERODYNAMIC STUDY OF ROTORS AND PROPELLERS OPERATING IN SEVERAL FLIGHT CONDITIONS

DANIEL FAVIER, CHRISTIAN MARESCA, MARCELLIN NSI MBA, and CLAUDE BARBI (Aix-Marseille II, Universite, Marseille, France) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 18 p. refs
(Contract DRET-85-115; DRET-87-095)

The aerodynamics of rotors and propellers operating under various conditions of hover, axial, and forward flight is investigated experimentally and numerically. For each flight configuration, an attempt is made to improve the prediction efficiency of computational models based on the forward wake analysis method. In the hovering rotor case, an equilibrium procedure based on a prescribed blade circulation model is shown to circumvent the problem of the collective pitch angle change to achieve the convergence of the solution. In the axial flight regime, a complete equilibrium procedure on all vortex filaments shed from the blade is derived. Some comparisons between calculations and experimental data are presented for the forward flight regime. V.L.

A88-51755

EMERGING ROLE OF FIRST-PRINCIPLES BASED COMPUTATIONAL AERODYNAMICS FOR ROTORCRAFT APPLICATIONS

R. D. JANAKIRAM, A. A. HASSAN, B. CHARLES (McDonnell Douglas Helicopter Co., Mesa, AZ), and L. N. SANKAR (Georgia Institute of Technology, Atlanta) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 21 p. refs

The computational aerodynamic techniques currently used in rotorcraft flow field analyses are briefly reviewed with emphasis on nonlinear first-principles based methods. The methods discussed include linear lifting surface/panel techniques, and nonlinear potential flow, Euler, and Navier-Stokes flow solvers. The discussion covers applications of these methods in airload prediction, details of the flow field on advancing rotor blades, and steady and unsteady rotor airfoil characteristics, including dynamic stall, two-dimensional blade-vortex interactions, and fuselage-induced upwash at the rotor blade. A comparative evaluation of the methods is made in terms of accuracy and computer resource requirements. V.L.

A88-51756

CALCULATION OF UNSTEADY ROTOR BLADE LOADS AND BLADE/FUSELAGE INTERFERENCE

DAVID R. CLARK and BRIAN MASKEW (Analytical Methods, Inc., Redmond, WA) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 13 p. Research supported by Analytical Methods, Inc. refs

(Contract DAAL03-87-C-0011)

The paper reviews the background to the calculation of unsteady rotor and fuselage loads and presents results from an analysis of a typical helicopter configuration made using a panel method operated in a time-stepping mode. The method models the fuselage and blades using surface singularities and the shed and trailing wakes with doublet lattice sheets. Unsteady local pressures and component forces are presented and the ability of the analysis to determine dynamic phenomena such as fulselage/blade-passage events and blade/vortex interactions is demonstrated. Author

A88-51757

ROTOR-AIRFRAME AERODYNAMIC INTERACTION PHENOMENA

SHIUH-GUANG LIOU, NARAYANAN M. KOMERATH, HOWARD M. MCMAHON (Georgia Institute of Technology, Atlanta), and ALBERT G. BRAND IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 10 p. refs

(Contract DAAG29-82-K-0084)

The aerodynamic interactions between a two-bladed rotor and a cylindrical airframe in low-speed forward flight are investigated experimentally in a wind tunnel with a view to providing a physical interpretation of the interaction phenomena and validating prediction methods. Time-averaged airframe surface pressure distributions and periodic surface pressure fluctuations are presented for advance ratios of 0.075, 0.1, 0.15, and 0.2. The data show large excursions in mean airframe surface pressure caused by the effects of rotor wake and hub. High levels of periodic fluctuations occur about the mean values due to blade passage and also to vortex interactions above and with the airframe. V.L.

A88-51758* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

PREDICTION OF TIME-DEPENDENT FUSELAGE PRESSURES IN THE WAKE OF A HELICOPTER ROTOR

JOHN D. BERRY (NASA, Langley Research Center; U.S. Army, Aerostructures Directorate, Hampton, VA) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 7 p. refs

A method is described for the analysis of the unsteady, incompressible potential flow associated with a helicopter. The fuselage, rotor, and rotor wake are considered together in forward flight. This method is particularly useful in low advance ratio flight due to the contribution of the deformed wake to the airloads imposed on the fuselage. The rotor geometry is prescribed and the unsteady wake geometry is computed from the local flow perturbation velocities. The fuselage is modeled as a non-lifting body of source panels and the rotor and its wake are modeled as a full vortex lattice. The rotor geometry is arbitrary and several rotor blades can be represented. The unsteady airloads are computed in the presence of the deformed rotor wake by a time-stepping technique. The wake is started impulsively from rest, allowing a natural convection of the wake with time. Author

A88-51760* Continuum Dynamics, Inc., Princeton, N. J.

COMPUTATIONAL ANALYSIS OF HOVER PERFORMANCE USING A NEW FREE WAKE METHOD

TODD R. QUACKENBUSH, DANIEL A. WACHSPRESS (Continuum Dynamics, Inc., Princeton, NJ), and DONALD B. BLISS (Duke University, Durham, NC) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 15 p. refs

(Contract NAS2-12148)

The development of EHPIC (Evaluation of Hover Performance using Influence Coefficients), a hover performance analysis code incorporating a new free wake analysis method based on the use of influence coefficients, is discussed. The technical principles underlying the EHPIC code are examined with emphasis on the extension of single-filament wake models to a multi-bladed multifilament wake suitable for realistic hover performance predictions. The coupling of the wake model to a lifting surface loads analysis is described, and sample problems are solved to demonstrate the robustness of the method. V.L.

A88-51761

HELICOPTER FREE WAKE IMPLEMENTATION ON ADVANCED COMPUTER ARCHITECTURES

T. ALAN EGOLF (United Technologies Research Center, East Hartford, CT) and J. P. MASSAR (Thinking Machines Corp., Cambridge, MA) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 12 p. refs

New computer architectures have significantly reduced the cost of computing and now allow the removal of many of the previous simplifying and limiting assumptions regarding the prediction of helicopter rotor wake geometries. These architectures range from new serial processor workstations to a massively parallel computer and are compared in terms of relative speed and cost effectiveness for the inviscid prediction of the distortion of the complete helicopter rotor wake. Implementation of a complete free wake method on the Cray 2 and the CM-2 massively parallel computer is described. Author

A88-51762

EXPERIMENTAL STUDY OF VORTEX AND WAKE FLOWS PAST HELICOPTER ROTOR BLADE TIPS AT M=0.6

O. IMINE, L. SALLES, J. F. MARCILLAT (Aix-Marseille II, Universite, Marseille, France), and P. CERONI (ONERA, Chatillon-sous-Bagneux, France) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 16 p. refs

A specific experimental study has been devoted to the study of the flow past helicopter rotor-blade tips. Semispan wings were placed in a high-speed wind tunnel (M = 0.6) to simulate actual blade tips from the point of view of compressibility effects. The tests concerned were aerodynamic characteristics (lift, drag, and pitching moment) with respect to root incidence angle, limiting flow at the two-surface wall, tip vortices, and wake flow (using a laser light sheet), and velocity-component measurements (from which flowfield circulation was deduced). A swept-back tapered wing was found to improve aerodynamic performance, although it generated a pair of contrarotating vortices that intermingled downstream about one chord of coexistence. An original simple method of circulation determination was used to provide spanwise distribution and so to characterize blade tips under the best conditions. Author

A88-51774* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

SOME ROTORCRAFT APPLICATIONS OF COMPUTATIONAL FLUID DYNAMICS

W. J. MCCROSKEY (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 24 p. Previously announced in STAR as N88-24601. refs

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

A88-51775

FLOW FIELD PREDICTION FOR HELICOPTER ROTOR WITH ADVANCED BLADE TIP SHAPES USING CFD TECHNIQUES

M. COSTES, A. DESOPPER, P. CERONI, and P. LAFON (ONERA, Chatillon-sous-Bagneux, France) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 14 p. refs

The computational methods used at the Aerodynamics Department of ONERA for rotor flows predictions are presented. They are finite difference methods solving the Full Potential equation (FP3D code) and the Transonic Small Disturbances equation (TSD code); the computation is performed on an isolated blade. For lifting cases, the wake is modeled by an angle of attack approach. Two wake models are used for a rotor in forward flight: the simple Drees model and a prescribed wake model, called METAR, developed by Aerospatiale. Nonlifting and lifting computations for rotors at high speed forward flight are compared with experimental data obtained in the ONERA S2Ch wind tunnel on a model rotor equipped with very rigid blades. The accuracy of a small disturbance assumption and the influence of the wake model are discussed. Author

A88-51776

EULER SOLUTIONS FOR STEADY FLOW OF A HELICOPTER ROTOR

JOHANN HERTEL, EWALD KRAEMER, and SIEGFRIED WAGNER (Muenchen, Universitaet der Bundeswehr, Neubiberg, Federal Republic of Germany) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 15 p. BMFT-supported research. refs

An Euler procedure for the calculation of steady transonic rotor flow is presented. The procedure uses a closed computational domain enclosing the near wake and the helical vortex. This approach avoids the usage of an external wake model. The Euler solver is based on a code using a characteristic flux averaging method and does not need any explicit artificial viscosity terms. The discretization of the flow field is carried out in two different ways concerning the grid structures and the size of the computational domain. Calculations were performed for multi-bladed rotors and the results are compared with available experimental data. Author

A88-51777

ROTOR PLANE VELOCITIES INDUCED BY A HELICOPTER FUSELAGE

JULIETTE RYAN, GREGOIRE FALEMPIN, and THIEN HIELP LE (ONERA, Chatillon-sous-Bagneux, France) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 9 p. refs

This paper deals with a low cost methodology to compute the 3-D incompressible, inviscid and steady flow around a bluff body such as a helicopter fuselage. The external velocity field is used to deduce the perturbation of the flow field at the rotor disk represented by local angle of attack distributions. Results obtained with such a method are presented for three rotor planes with a helicopter fuselage at a zero degree angle of attack. Computations are done without and with separated flow at the rear part of a body. Author

A88-51781

A NEW APPROACH FOR FLOW FIELD AND AIRLOADS PREDICTION OF HOVERING ROTORS

WUJIANG LOU and SHICUN WANG (Nanjing Aeronautical Institute, People's Republic of China) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 9 p. refs

The concept of constraint wake analysis is proposed whereby the wake analysis is performed under the limitation of some specified constraints imposed on the wake. This concept, combined with lifting line theory, is implemented for hovering rotors. The CWAHR (Constraint Wake Analysis for Hovering Rotors) is applicable to cases where tip vortices have the predominant influence and is capable of extending the prescribed wake to advanced rotor geometries. A correlation study demonstrates good agreement with data from other sources. V.L.

A88-51785

PASSIVE TRANSONIC DRAG REDUCTION OF SUPERCRITICAL AND HELICOPTER ROTOR AIRFOILS

HENRY T. NAGAMATSU (Rensselaer Polytechnic Institute, Troy, NY) and TODD W. TRILLING IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 13 p. refs

(Contract DAAG29-82-K-0093)

Passive shock wave/boundary layer control for three airfoil models with porous surfaces was investigated in a transonic wind tunnel. Schlieren photgraphs for both solid and porous surfaces were taken, and the photographs revealed that the normal shock wave changed to a lambda shock wave over the porous surface. The static pressure distributions over the models and the wake impact pressure data were used to calculate the flow Mach number over the airfoils and the profile drag of the airfoils, respectively. Over the porous surface, the Mach number decreases from a supersonic flow to nearly sonic velocity ahead of the terminating normal shock wave, thus minimizing the boundary layer separation. In addition, the lambda shock wave also minimizes the entropy losses through the shock wave. Both of these effects tend to decrease the transonic drag. Introducing porous surfaces on the modes resulted in drag reductions ranging from 25 to 46 percent at transonic Mach numbers. Author

A88-51877

COMPUTATION OF ASYMMETRIC FLOWS AROUND PROFILES BY COUPLING THE BOUNDARY-LAYER AND POTENTIAL EQUATIONS [BERECHNUNG DER ASYMMETRISCHEN PROFILUMSTROEMUNG DURCH KOPPLUNG VON GRENZSCHICHT- UND POTENTIALGLEICHUNGEN]

F. ARNOLD, E. LUTUM, and F. THIELE (Berlin, Technische Universitaet, Federal Republic of Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Stuttgart, Federal Republic of Germany, Apr. 13-17, 1987) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 68, no. 5, 1988, p. T 277-T 279. In German. refs

A numerical technique for computing the turbulent incompressible flow around a profile is described and demonstrated, with a focus on the treatment of the wake. The defect formulation of Le Balleur (1981) and the semiinverse iterative procedure of Carter (1979) are used to couple and solve the boundary-layer and potential equations. Numerical results for a flat plate with no longitudinal pressure gradient and for an NLR7301 wing profile are presented in graphs and shown to be in good agreement with published experimental data. T.K.

A88-51880

NUMERICAL SIMULATION OF COMPRESSIBLE VISCOUS CASCADE FLOWS [NUMERISCHE SIMULATION KOMPRESSIBLER, REIBUNGSBEHAFTETER GITTERSTROEMUNGEN]

K. DORTMANN (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Stuttgart, Federal Republic of Germany, Apr. 13-17, 1987) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 68, no. 5, 1988, p. T 293-T 295. In German.

The interactions between compression shocks, boundary layers, separation zones, and unsteady wakes in the viscous compressible laminar flow in a two-dimensional symmetric cascade of NACA 0012 blades are investigated by means of numerical simulations. The solution method employed for the Navier-Stokes equations in the thin-layer approximation is outlined, and typical results for subcritical and critical inlet flows are presented graphically. Particular attention is given to the expansion of the unsteady wake in the critical cases. T.K.

A88-51882

EFFICIENT COMPUTATION OF UNSTEADY POTENTIAL FLOWS AROUND ENGINES, FUSELAGES, AND RING WINGS [EFFIZIENTE BERECHNUNG INSTATIONAERER POTENTIALSTROEMUNGEN UM TRIEBWERKE, RUEMPFE UND RINGFLUEGEL]

E. KATZER (DFVLR, Institut fuer Aeroelastik, Federal Republic of Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Stuttgart, Federal Republic of Germany, Apr. 13-17, 1987) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 68, no. 5, 1988, p. T 304, T 305. In German. refs

Numerical procedures for steady and unsteady inviscid incompressible potential flows around bodies of rotation and thin ring wings are briefly reviewed, summarizing the report of Katzer (1987). Particular attention is given to the Fourier expansion of the flow and the Kutta conditions and time-stepping schemes. Results on the harmonic flapping vibration of a thin ring wing are presented in graphs. T.K.

A88-51884

THE OPTIMUM-OPTIMORUM SHAPE OF THE INTEGRATED WING-FUSELAGE CONFIGURATION IN SUPERSONIC FLOW

ADRIANA NASTASE (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Stuttgart, Federal Republic of Germany, Apr. 13-17, 1987) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 68, no. 5, 1988, p. T 324-T 327.

The analytical procedures developed by Nastase (1969, 1970, 1980, and 1986) are applied to optimize the shape of thin and thick symmetric integrated delta wings and wing-fuselage configurations. The derivation of the governing equations is explained in detail, and the results are presented graphically. The optimized integrated wing is shown to have reduced drag and high lift and is recommended as a base design for future space shuttles or supersonic transport aircraft. T.K.

A88-51885

DETERMINATION OF THE INTENSITY OF LEADING EDGE VORTICES ON WING-FUSELAGE CONFIGURATION AT HIGHER ANGLE OF ATTACK, IN SUPERSONIC FLOW

ADRIANA NASTASE and DEMETER FALIAGAS (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Stuttgart, Federal Republic of Germany, Apr. 13-17, 1987) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 68, no. 5, 1988, p. T 327-T 330.

The effect of the freestream Mach number and the angle of attack on the flow over a conical-fuselage/wedge-delta-wing configuration is investigated analytically, with a focus on the pressure-coefficient (Cp) distribution and the intensity of leading-edge vortices. The solutions obtained by Nastase (1969, 1979, and 1987) for the boundary-value problems of the axial disturbance velocities are applied, and the potential and boundary-layer solutions are matched at several points. Numerical results are presented in extensive graphs and shown to be in good general agreement with published experimental data. Discrepancies in Cp on lateral holes near the leading edge are attributed to the effects of leading-edge vortices, which become more intense with increasing angle of attack and lower freestream Mach number. T.K.

A88-51886

UNSTEADY LAVAL-NOZZLE FLOWS [INSTATIONAERE LAVALDUESENSTROEMUNGEN]

FRANK OBERMEIER (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, Federal Republic of Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Stuttgart, Federal Republic of Germany, Apr. 13-17, 1987) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 68, no. 5, 1988, p. T 330-T 332. In German.

The unsteady homentropic isoenergetic transonic flow of an inviscid ideal gas through a Laval nozzle is investigated analytically, with a focus on the behavior of weak disturbance waves which arise in the subsonic flow region behind the primary shock. The pressures at the nozzle inlet and outlet are selected so that the flow is accelerated to supersonic velocity at the narrowest point, forming a weak shock slightly downstream; small additional pressure disturbances are then introduced into the subsonic region. A solution procedure based on the generalized method of distorted coordinates (Handke, 1986) is applied to the case of LF disturbances, and expressions are obtained for the dependence of the disturbance effects on their frequency and intensity. T.K.

A88-51887

UNSTEADY FLOW IN A LAVAL NOZZLE OF TIME-DEPENDENT CROSS SECTION [INSTATIONAERE STROEMUNG IN EINER LAVALDUESE MIT ZEITABHAENGIGEM QUERSCHNITT]

M. REIN, G. GRABITZ, and G. E. A. MEIER (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, Federal Republic of Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Stuttgart, Federal Republic of Germany, Apr. 13-17, 1987) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 68, no. 5, 1988, p. T 339, T 340. In German.

The effects of steadily increasing or decreasing the cross section of the diverging part of a Laval nozzle on the transonic nozzle flow are investigated by means of numerical computations. The case considered is that of constant chamber/outlet pressure ratio, when the primary shock wave is nearly vertical and the flow is essentially one-dimensional; the equations of mass, impulse, and entropy conservation for an ideal gas are solved using the method of characteristics. Results for three different nozzle opening or closing rates are presented in graphs and discussed in detail. Particular attention is given to the upstream-propagating shock which appears when the nozzle is opened rapidly. T.K.

A88-51889
FLOW CURVATURE EFFECTS ON A ROTATING AIRFOIL
A. ZERVOS (Athens, University, Greece) and R. ROUCOUS (Paris VI, Universite, France) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Stuttgart, Federal Republic of Germany, Apr. 13-17, 1987) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 68, no. 5, 1988, p. T 365-T 368.

The pressure distribution, lift, and drag forces on an airfoil in two-dimensional translational motion through an incompressible ideal fluid are determined analytically and compared with those for an airfoil in rotational motion. The solution method is based on the approach of Couchet (1976), and numerical results for a NACA 0012 airfoil are presented in graphs and briefly characterized. Significant differences in the aerodynamic parameters are noted between translational and rotational motion, and the generation of new experimental data sets for standard airfoils in rotation is recommended. T.K.

A88-51938#
FORWARD SWEEP - A FAVOURABLE CONCEPT FOR A LAMINAR FLOW WING
G. REDEKER and G. WICHMANN (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 12 p. refs
(AIAA PAPER 88-4418)

In view of the preclusion of laminar flow's establishment on swept wings at high Re numbers, beyond a critical sweep angle at which the crossflow instability and attachment line transition lead to fully turbulent boundary layers, theoretical and experimental investigations have been conducted on finite-sweep wings. It is found that, due to three-dimensional displacement effects, an effective increase of wing sweep is required for a backward-swept wing while an effective decrease of sweep is recommended for forward-swept cases. For a laminar-flow wing, the reduction in sweep in the case of forward sweep more directly leads to a stable boundary layer than the backward-swept case. O.C.

A88-51939#
SWEEP EFFECTS ON LOW REYNOLDS NUMBER STALL HYSTERESIS
J. F. MARCHMAN, III, Y. K. CHANG (Virginia Polytechnic Institute and State University, Blacksburg), and R. D. ROBINSON AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 12 p. refs
(AIAA PAPER 88-4419)

Wind tunnel experiments were conducted to investigate the effects of sweep on the aerodynamic behavior of wings with a Wortmann FX-63-137-ESM airfoil section over the range of chord Reynolds number from 100,000 to 250,000. Wings of fifteen and thirty degrees aft sweep and one (fifteen degree) forward swept wing were tested. Force measurements, pressure distributions and flow visualization studies were compared. It was found that aft sweep reduces the size of the low Reynolds number stall hysteresis loop but at least 30 degrees sweep is needed to eliminate hysteresis. The study also showed that stall hysteresis was eliminated with 15 degrees of forward sweep; however, the maximum lift coefficient was greatly reduced compared to the aft sweep cases. Flow visualization showed complex separation patterns over the swept wings. Author

A88-51969#
LIFT DEFICIENCY FUNCTIONS FOR ASPECT RATIO 6, 12 AND 18 ROTOR BLADES AT ADVANCE RATIOS OF 0 TO 0.4
ROBERT L. MILLIKEN and ROBERT E. DUFFY (Rensselaer Polytechnic Institute, Troy, NY) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 12 p. Army-supported research. refs
(AIAA PAPER 88-4494)

Lift deficiency functions for rotors in forward flight have been determined using a pulse transfer technique. This technique is shown to be successful in obtaining the frequency response of airfoils (Theodorsen functions) and wings (Reissner functions). The pulse transfer technique uses discrete vortex filament modeling to represent the time history of the shed vorticity after an airfoil, wing, or rotor is subjected to a pulse type disturbance in either angle of attack or heave. The lift response is determined and fast Fourier transforms (FFT) are used to invert the pulse response and obtain the frequency response. Lift deficiency functions for rotors having blade aspect ratios of 6, 12, and 18 at advance ratios of 0, 0.2, and 0.4 are presented. Author

A88-52012
A POTENTIAL THEORY FOR THE STEADY SEPARATED FLOW ABOUT AN AEROFOIL SECTION
TRAN-CONG TON (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) Ingenieur-Archiv (ISSN 0020-1154), vol. 58, no. 4, 1988, p. 285-294. refs

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

A88-52028
SELECTION OF AN OPTIMAL SHAPE FOR A SUPERSONIC FLIGHT VEHICLE [O VYBORE OPTIMAL'NOI FORMY SVERKHZVUKOVOGO LETATEL'NOGO APPARATA]
G. I. MAIKAPAR TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 1, 1987, p. 18-27. In Russian. refs

By considering a wave rider, treated as a schematized flight vehicle, the wave drag of a flight vehicle with specified lifting force and volume is determined under various constraints. The minimum-drag shape is shown to be dependent on several dimensionless parameters, and it is shown that the contour of the leading edge has a particularly strong effect on wave drag for a specified length. For specified lift, volume, length and width, the leading edge shape is a trapeze tending to a straight wedge with increasing dimensionless volume and decreasing lift. V.L.

A88-52035
CALCULATION OF TRANSONIC FLOW PAST A FUSELAGE-WING COMBINATION WITH ALLOWANCE FOR THE WING STRUCTURE ELASTICITY [RASCHET OKOLOZVUKOVOGO OBTEKANIIA KOMBINATSII KRYLO-FIUZELIAZH S UCHETOM VLIIANIIA UPRUGOSTI KONSTRUKTSII KRYLA]
V. I. SAVITSKII TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 1, 1987, p. 81-89. In Russian. refs

By using the method of influence coefficient in the context of the transonic theory of small perturbations and the method of sequential relaxation, an iteration method is developed for considering the effect of wing structure elasticity on transonic flow past a fuselage-wing configuration. The convergence of the iteration procedure is investigated, and the optimal parameters of the procedure are determined. Results of calculations of the static aeroelasticity of the wing based on the method proposed here are presented. V.L.

A88-52037
EFFECT OF THE ASPECT RATIO ON TRANSONIC FLOW PAST RECTANGULAR WINGS [VLIIANIE UDLINENIIA NA OBTEKANIE PRIAMOUGOL'NYKH KRYL'EV PRI OKOLOZVUKOVYKH SKOROSTIAKH]
N. A. VLADIMIROVA and IA. M. SEREBRIISKII TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 1, 1987, p. 98-105. In Russian.

The effect of the aspect ratio on transonic flow past rectangular wings is calculated by a method based on the numerical solution of a full three-dimensional equation for the velocity potential. At supercritical regimes, flow past rectangular wings of finite aspect ratio is shown to be essentially three-dimensional. As a result, the plane section hypothesis is not satisfied even for wings of a sufficiently large aspect ratio. The difference between flow past a rectangular wing section and that past an infinite-span wing is significant and depends largely on the aspect ratio, lift coefficient, and profile shape. V.L.

A88-52038
USING A SOLUTION TO THE INVERSE PROBLEM FOR AERODYNAMIC SURFACE DESIGN [ISPOL'ZOVANIE RESHENIIA OBRATNOI ZADACHI DLIA PROEKTIROVANIIA AERODINAMICHESKOI POVERKHNOSTI]
L. A. POTAPOVA, IU. N. SVIRIDENKO, and L. L. TEPERIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 1, 1987, p. 106-109. In Russian.

A method for solving the problem of the aerodynamic design of a lifting surface, with a specified pressure profile and a fixed wing planform, is proposed which allows for the effect of the fuselage, powerplant, and other components on the wing profile shapes. In the design problem for part of a wing, the specified pressure distribution represents a boundary condition for determining profile shapes for the surface being designed. The geometry of the remaining part of the wing and other components is assumed to be known and remains unchanged in the process of the solution. V.L.

A88-52041
CONSIDERATION OF THE EFFECT OF A PROPELLER JET ON PRESSURE DISTRIBUTION ALONG THE TUNNEL WALL [UCHET VLIIANIIA STRUI VINTA NA RASPREDELENIE DAVLENIIA VDOL' STENKI TRUBY]
V. I. BABKIN and IU. A. GORELOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 1, 1987, p. 121-125. In Russian.

The testing of models with working propellers in a wind tunnel with nonperforated walls gives rise to an additional static pressure field at the tunnel wall. Here, the principal factors affecting the additional pressure are determined in relation to the relative propeller and tunnel dimensions, loading coefficient, and free-stream Mach number. Particular attention is given to the effect of air compressibility. V.L.

A88-52043
APPLICABILITY OF THE BEAM TORSION THEORY TO THE ANALYSIS OF A TRAPEZOIDAL WING [O PRIMENIMOSTI TEORII KRUCHENIIA BRUS'EV K RASCHETU TRAPETSIEVIDNOGO KRYLA]
V. S. VOITYSHEN and V. M. FROLOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 1, 1987, p. 134-139. In Russian.

The paper is concerned with the problem of determining the equivalent torsional stiffness of a trapezoidal wing based on the plate theory. A comparison is made between simplified and exact solutions for various load types and wing mounting methods, and it is shown that the approximate formula can be used for determining the effective stiffness of the wing at its mid-span. The dimensions of the regions near the wing root and tip are determined where the approximate formula produces a significant error; the factors affecting this value are identified. Exact formulas are presented for calculating the torsional deformations of the wing under the effect of a distributed torque and a torque concentrated at the wing tip. V.L.

A88-52045
FLOW IN A LOCAL SUPERSONIC FLOW IN THE PRESENCE OF A TRANSONIC FLOW AROUND A WING PROFILE [O TECHENII V MESTNOI SVERKHZVUKOVOI ZONE PRI OKOLOZVUKOVOM OBTEKANII KRYLOVOGO PROFILIA]
V. A. PAN'ZHENSKII and A. S. PETROV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 2, 1987, p. 1-8. In Russian. refs

This paper presents analytical relationships describing the velocity field in the local supersonic zone of a wing profile in the presence of the transonic flow of an ideal compressible gas around that wing section. The equations are validated by a comparison with available experimental and numerical data, and the results of the derived relationships are used to calculate the wave drag on the wing. I.S.

A88-52046
NUMERICAL ALGORITHM FOR CALCULATING SUPERSONIC INVISCID FLOW AROUND WING-BODY COMBINATIONS [CHISLENNYI ALGORITM RASCHETA SVERKHZVUKOVOGO NEVIAZKOGO OBTEKANIIA KOMBINATSII KRYLA S KORPUSOM]
IU. I. LOBANOVSKII TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 2, 1987, p. 9-19. In Russian. refs

This paper presents a technique for developing a numerical algorithm based on Euler equations, which can be used to calculate flow fields and integral aerodynamic characteristics for a basic glider design of ultrasonic and supersonic flight vehicles. The solutions obtained here are compared with available experimental data and with numerical results obtained by others. I.S.

A88-52047
ANALYSIS OF SINGULARITIES IN THE SOLUTION OF THE PROBLEM OF HYPERSONIC FLOW AROUND A LOW-ASPECT-RATIO DELTA WING [ANALIZ OSOBENNOSTEI V RESHENII ZADACHI GIPERZVUKOVOGO OBTEKANIIA TREUGOL'NOGO KRYLA MALOGO UDLINENIIA]
A. I. GOLUBINSKII and V. N. GOLUBKIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 2, 1987, p. 20-29. In Russian. refs

The solutions obtained by Golubinskii and Golubkin (1976) and Golubkin (1977) for the problem of hypersonic flow around a flat low-aspect-ratio delta wing contain singularities such as concentrated forces and breaks in the shock wave and in stream surfaces on a series of singular lines (sections). This paper analyzes the reasons of these singularities. It is shown that, in the field of continuous flow behind the bow shock, there exist narrow regions with elevated pressure and increased gradients of some characteristics. Under these conditions, these narrow regions are transformed into the peculiar sections. I.S.

A88-52056
LIFT-DRAG RATIO AND BALANCE OF A WING WITH BLUNT EDGES IN HYPERSONIC FLOW [AERODINAMICHESKOE KACHESTVO I BALANSIROVKA KRYLA S ZATUPLENNYMI KROMKAMI V GIPERZVUKOVOM POTOKE]
V. S. NIKOLAEV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 2, 1987, p. 104-111. In Russian.

This paper presents an analysis of the aerodynamic characteristics of a wing in a hypersonic flow, investigating the effects of the degree of the lower-surface camber, the degree of bluntness, the design form, and the position of the mass center. Simple formulas are proposed for calculating the optimal balanced angle of attack and the position of the mass center needed for the optimal balance. I.S.

A88-52060
ANGULAR-MOTION DYNAMICS OF A FLIGHT-VEHICLE IN THE PRESENCE OF AERODYNAMIC HYSTERESIS OF THE MOMENT CHARACTERISTICS [DINAMIKA UGLOVOGO DVIZHENIIA LETATEL'NOGO APPARATA PRI NALICHII AERODINAMICHESKOGO GISTEREZISA MOMENTNOI KHARAKTERISTIKI]
S. S. BOGODISTOV and V. G. SITNIKOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 2, 1987, p. 130-142. In Russian. refs

This paper considers the angular-motion dynamics of a flight vehicle (FV) in the angle-of-attack plane in the presence of aerodynamic hysteresis of the moment characteristics. The FV motion is described by a second-order dynamic system with a 'linear' approximation of the hysteresis loop. The results of the analysis can be used for evaluating qualitatively different motion types which can occur during planar vibrations of a FV that are characterized by aerodynamic hysteresis. The types of motion corresponding to structural stability of the system are derived. I.S.

A88-52062
THE FLOW PAST A STRAIGHT WING UNDER STATIONARY AND QUASI-STATIONARY EXTERNAL CONDITIONS [OBTEKANIE PRIAMOGO KRYLA PRI STATSIONARNYKH I KVAZISTATSIONARNYKH VNESHNIKH USLOVIIAKH]
M. A. GOLOVKIN, V. P. GORBAN', E. V. SIMUSEVA, and A. N. STRATONOVICH TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 3, 1987, p. 1-12. In Russian.

The aerodynamics of rectangular wings with an aspect ratio of 5 is studied at a Reynolds number of 0.6 x 10 to the 6th over a wide range of angles of attack. Included are weight measurements and flow visualization at the wing surfaces. At large angles of attack, in the absence of slip, substantial roll and yaw moments can arise due to the asymmetric structure of the flow relative the wing's plane of symmetry. K.K.

A88-52065
A METHOD FOR CALCULATING THE FLOW PAST INTERFERING BODIES AT SUPERSONIC VELOCITIES [METOD RASCHETA OBTEKANIIA INTERFERIRUIUSHCHIKH TEL PRI SVERKHZVUKOVYKH SKOROSTIAKH]
V. V. KOVALENKO and A. N. KRAVTSOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 3, 1987, p. 31-38. In Russian. refs

A method is developed for the calculation of the supersonic flow past aircraft elements with allowance for aerodynamic interference. The calculations are carried out within the framework of a model using a set of Euler equations together with the second-order MacCormack two-step scheme in which the bow shocks are explicitly identified. The use of the present method to identify internal gasdynamic discontinuities is demonstrated. K.K.

A88-52073
THE EXPERIMENTAL INVESTIGATION OF VORTICES SHED FROM A WING STRAKE [EKSPERIMENTAL'NOE ISSLEDOVANIE VIKHREI, SKHODIASHCHIKH S NAPLYVA KRYLA]
V. A. PESETSKII TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 3, 1987, p. 114-119. In Russian. refs

The results of experimental investigations of the velocity field in a vortex shed from a strake are presented for wings with low and medium aspect ratios. The measurements were carried out with a laser-Doppler velocimeter in a wind tunnel at small subsonic velocities. Consideration is given to vortex breakdown as well as to the effect of the rounding-off of the leading edge of the strake on the vortex velocity field. K.K.

A88-52078
SEVERAL FEATURES OF WALL FLOW IN THE WING-FUSELAGE JUNCTION REGION [NEKOTORYE OSOBENNOSTI PRISTENNOGO TECHENIIA V OBLASTI SOPRIAZHENIIA KRYLA I FIUZELIAZHA]
V. I. KORNILOV and A. M. KHARITONOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 4, 1987, p. 1-9. In Russian. refs

Results are presented from experimental studies of incompressible wallow in the wing-fuselage junction region during subsonic flow across a schematized aircraft configuration at zero angle of attack. It is shown that the flow in this region has a complex spatial pattern with a dual-vortex structure and local zones, characterized by the separated flow and flow unsteadiness in the narrow regions adjacent to the line of the wing and fuselage junction. R.B.

A88-52079
NUMERICAL STUDY OF VISCOUS SWIRLING FLOWS [CHISLENNOE ISSLEDOVANIE VIAZKIKH ZAKRUCHENNYKH POTOKOV]
A. M. GAIFULLIN and V. F. MOLCHANOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 4, 1987, p. 10-16. In Russian. refs

A method for the numerical analysis of the motion of viscous fluid in a swirling steady axisymmetric flow is presented. Examples are introduced, calculating this motion in the presence of recirculating regions near the central line of the vortex. The study is useful in understanding the anomaly known as a 'vortex explosion,' which sometimes occurs during subsonic flow along a wing in a vortex line. R.B.

A88-52083
CALCULATION OF SUPERSONIC FLOW PAST A PITOT-STATIC TUBE [RASCHET SVERKHZVUKOVOGO OBTEKANIIA PRIEMNIKA VOZDUSHNOGO DAVLENIIA]
A. P. BAZZHIN, G. G. NERSESOV, and I. I. SHITIKOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 4, 1987, p. 43-49. In Russian.

Results of a numerical calculation of the flow past a pitot-static tube are presented. The calculations are made for the freestream Mach number range of 2 to 4 at zero angle of attack. The distribution of gasdynamic characteristics along the tube surface is presented. It is shown that changes in the front part of the pitot-static tube influence the distribution of static pressure. R.B.

A88-52096
EFFECT OF THE OFF-DESIGN WORK OF THE NOSE AIR INTAKE ON FLOW PAST A FINITE-SPAN WING [VLIIANIE NERASCHETNOI RABOTY LOBOVOGO VOZDUKHOZABORNIKA NA OBTEKANIE KRYLA KONECHNOGO RAZMAKHA]
V. M. SHURYGIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 5, 1987, p. 11-16. In Russian. refs

A linear theory is presented to account for the effect of the off-design work of the nose air intake (in the case of relatively thin nacelles) on flow past a finite-span wing at subsonic velocities of the incoming flow. Analytical results based on the theory proposed here are found to be in good agreement with wind tunnel test results obtained for a flow velocity of 40 m/s. V.L.

A88-52097
CALCULATION OF THE POSITION AND INTENSITY OF BOW SHOCKS ON DELTA WINGS BY THE METHOD OF DEFORMED COORDINATES [RASCHET POLOZHENIIA I INTENSIVNOSTI GOLOVNYKH SKACHKOV UPLOTNENIIA NA TREUGOL'NYKH KRYL'IAKH METODOM DEFORMIROVANNYKH KOORDINAT]
T. M. PRITULO TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 5, 1987, p. 17-27. In Russian.

The method of deformed coordinates is used to calculate the position and intensity of weak bow shocks separating flow regions with and without perturbations in the case of supersonic flow past delta wings. The intensity of the bow shocks is on the order of the squared angle of attack of the wing. The solution is obtained using the additional potential method. The analytical approach developed here is sufficiently general and suitable for wings with both supersonic and subsonic edges. V.L.

N88-27158*# United Technologies Research Center, East Hartford, Conn.
AEROELASTIC MODELING OF ROTOR BLADES WITH SPANWISE VARIABLE ELASTIC AXIS OFFSET: CLASSIC ISSUES REVISITED AND NEW FORMULATIONS
RICHARD L. BIELAWA *In* NASA, Ames Research Center, Integrated Technology Rotor Methodology Assessment Workshop p 217-228 Jun. 1988
Avail: NTIS HC A17/MF A01 CSCL 01A

In response to a systematic methodology assessment program directed to the aeroelastic stability of hingeless helicopter rotor blades, improved basic aeroelastic reformulations and new formulations relating to structural sweep were achieved. Correlational results are presented showing the substantially improved performance of the G400 aeroelastic analysis incorporating these new formulations. The formulations pertain partly to sundry solutions to classic problem areas, relating to dynamic inflow with vortex-ring state operation and basic blade kinematics, but mostly to improved physical modeling of elastic axis offset (structural sweep) in the presence of nonlinear structural twist. Specific issues addressed are an alternate modeling of the delta EI torsional excitation due to compound bending using a force integration approach, and the detailed kinematic representation of an elastically deflected point mass of a beam with both structural sweep and nonlinear twist. Author

N88-27159*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
COMPARISON OF EXPERIMENTAL ROTOR DAMPING DATA-REDUCTION TECHNIQUES
WILLIAM WARMBRODT *In its* Integrated Technology Rotor Methodology Assessment Workshop p 231-248 Jun. 1988
Avail: NTIS HC A17/MF A01 CSCL 01A

The ability of existing data reduction techniques to determine frequency and damping from transient time-history records was evaluated. Analog data records representative of small-scale helicopter aeroelastic stability tests were analyzed. The data records were selected to provide information on the accuracy of reduced frequency and decay coefficients as a function of modal damping level, modal frequency, number of modes present in the time history record, proximity to other modes with different frequencies, steady offset in time history, and signal-to-noise ratio. The study utilized the results from each of the major U.S. helicopter manufacturers, the U.S. Army Aeroflightdynamics Directorate, and NASA Ames Research Center using their inhouse data reduction and analysis techniques. Consequently, the accuracy of different data analysis techniques and the manner in which they were implemented were also evaluated. It was found that modal frequencies can be accurately determined even in the presence of significant random and periodic noise. Identified decay coefficients do, however, show considerable variation, particularly for highly damped modes. The manner in which the data are reduced and the role of the data analyst was shown to be important. Although several different damping determination methods were used, no clear trends were evident for the observed differences between the individual analysis techniques. It is concluded that the data reduction of modal-damping characteristics from transient time histories results in a range of damping values. Author

N88-27166# National Aeronautical Establishment, Ottawa (Ontario).
ANALYSIS OF EXPERIMENTAL DATA FOR CAST 10-2/DOA2 SUPERCRITICAL AIRFOIL AT HIGH REYNOLDS NUMBERS
Y. Y. CHAN Jan. 1988 69 p
(AD-A192827; NAE-AN-49; NRC-28595) Avail: NTIS HC A04/MF A01 CSCL 20D

Experimental data obtained in the NAE Two Dimensional Test Facility for CAST 10-2/DOA2 supercritical airfoil have been analyzed for the effects of Reynolds number, transition fixing and Mach number. The data were obtained for Reynolds numbers from 6 to 30 million and Mach numbers from 0.3 to 0.8 with fixed and free transitions. The analysis indicates that the aerodynamic parameters of the airfoil depend strongly on Reynolds number and transition fixing. Above Reynolds number 10 million the trends of dependency on Reynolds number with free or fixed transition can be established. For lower Reynolds number, the long stretch of laminar boundary layer over the airfoil alters the flow characteristics significantly and the data do not follow the trends for high Reynolds numbers. GRA

N88-27168*# West Virginia Univ., Morgantown. Dept. of Mechanical and Aerospace Engineering.
THEORETICAL-NUMERICAL STUDY OF FEASIBILITY OF USE OF WINGLETS ON LOW ASPECT RATION WINGS AT SUBSONIC AND TRANSONIC MACH NUMBERS AT REDUCE DRAG Contractor Report, Jan. 1986 - Aug. 1987
JOHN M. KUHLMAN, PAUL LIAW, and MICHAEL J. CERNEY Washington NASA Aug. 1988 87 p
(Contract NAG1-625)
(NASA-CR-4174; NAS 1.26:4174) Avail: NTIS HC A05/MF A01 CSCL 01A

A numerical design study was conducted to assess the drag reduction potential of winglets installed on a series of low aspect ratio wings at a design point of M=0.8, C sub L=0.3. Wing-winglet and wing-alone design geometries were obtained for wings of aspect ratios between 1.75 and 2.67, having leading edge sweep angles between 45 and 60 deg. Winglet length was fixed at 15% of wing semispan. To assess the relative performance between wing-winglet and wing-alone configurations, the PPW nonlinear extended small disturbance potential flow code was utilized. This model has proven to yield plausible transonic flow field simulations for the series of low aspect ratio configurations selected. Predicted decreases in pressure drag coefficient for the wing-winglet configurations relative to the corresponding wing-alone planform are about 15% at the design point. Predicted decreases in wing-winglet total drag coefficient are about 12%, relative to the corresponding wing-alone design. Longer winglets (25% of the wing semispan) yielded decreases in the pressure drag of up to 22% and total drag of up to 16.4%. These predicted drag coefficient reductions are comparable to reductions already demonstrated by actual winglet designs installed on higher aspect ratio transport type aircraft. Author

N88-27169# Institut Franco-Allemand de Recherches, St. Louis (France).
THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF A VORTEX DRAG BEHIND A WING PROFILE WITH SPOILER [THEORETISCHE UND EXPERIMENTELLE UNTERSUCHUNG DER WIRBELSTRASSE HINTER EINEM TRAGFLUEGELPROFIL MIT SPOILER]
WOLFGANG CZICHOWSKY, BERNARD-CHARLES JAEGGY, GERMAIN KOERBER, and PAUL MEYER 1987 48 p In GEORGIAN
(ISL-PU-309/87; ETN-88-92736) Avail: NTIS HC A03/MF A01

A flow model behind a wing profile was studied in a subsonic wind tunnel. Laser anemometry and smoke are used for velocity components measurements and visualization of the vortex zone for two or three interference surfaces. Two analytical methods developed for the investigation of the vortex behavior are described. Numerical solutions for multivortex equations of motion and for Navier-Stokes equations are presented. ESA

N88-27170# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction de l'Aerodynamique.
FLOW AROUND A DELTA WING WITH OR WITHOUT A CANARD CONTROL SURFACE (PHI BA = 60 DEG). PART 1: HYDRODYNAMIC VISUALIZATION IN PERMANENT REGIME [ECOULEMENT AUTOUR D'UNE AILE DELTA SANS OU AVEC PLAN CANARD (PHI BA=60 DEG). VISUALISATIONS HYDRODYNAMIQUES EN REGIME PERMANENT]
H. WERLE Nov. 1987 31 p In FRENCH
(ONERA-RT-10/2891-AN-101-A-PT-1; ETN-88-92749) Avail: NTIS HC A03/MF A01

The flow visualizations obtained in the hydrodynamics tunnel for a 60 deg wing and the same wing in canard configuration with a forebody control surface are presented. The results are a complement of data presented for 75 deg delta wings. The start of vortices in a steady flow condition is considerably reduced when using the canard configuration. ESA

N88-27171# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Hauptabteilung Windkanaele.
WIND TUNNEL TESTS OF THE INFLUENCE OF AIRFOIL-THICKNESS ON NORMAL FORCE AND PITCHING MOMENT OF TWO SLENDER WINGS AT TRANSONIC AND SUPERSONIC MACH NUMBERS
HELMUT ESCH Nov. 1987 168 p In GERMAN; ENGLISH summary
(DFVLR-FB-88-17; ISSN-0171-1342; ETN-88-92935) Avail: NTIS HC A08/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Federal Republic of Germany, 67.50 deutsche marks

Force measurements at subsonic, transonic, and supersonic Mach numbers were conducted to determine the infuence of airfoil thickness and shape on normal force and pitching moment of slender wings. Both wings, a rectangular and a clipped delta wing, had hexagonal wing sections. In addition to the variation of wing thickness, different angles of the wedge-like edges and rounded edges were investigated. The tests were performed in the trisonic wind tunnel at Mach numbers between 0.5 and 4. In supersonic flow the angle of attack varied from -10 to 90 deg, but was often limited to a lower value because of model blockage. ESA

N88-27173*# Ohio State Univ., Columbus. Aeronautical and Astronautical Research Lab.
AN EXPERIMENTAL STUDY OF THE EFFECT OF PITCH RATE ON DELTA WING AERODYNAMICS AND STABILITY Final Report, 1 Apr. 1986 - 30 Jun. 1988
M. B. BRAGG Aug. 1988 55 p
(Contract NAG1-641)
(NASA-CR-183159; NAS 1.26:183159) Avail: NTIS HC A04/MF A01 CSCL 01A

The final report for the research conducted under this grant (NAG1-641) are contained in the two documents attached as Apendices A and B. The first is the presentation made to NASA Langley personnel on 10 December, 1987, which gave a brief analysis of the experiments. The second is a copy of an AIAA paper given in June 1988, which describes in detail the test setup, data acquisition and reduction, and results obtained. Author

N88-28032# AMF, Inc., White Plains, N.Y.
STUDY OF THREE-DIMENSIONAL TRANSONIC FLOW SEPARATIONS Final Report, 1 Jul. 1981 - 30 Nov. 1987
F. K. OWEN, G. M. ORNGARD, T. K. MCDEVITT, and T. A. AMBUR Apr. 1988 252 p Original contains color illustrations
(Contract DAAG29-81-C-0028)
(AD-A193018; ARO-17903.2-GS) Avail: NTIS HC A12/MF A01 CSCL 19J

An extensive wind tunnel study of flows with transonic swept separation zones and shock-boundary layer interactions on realistic stationary and spinning projectile test models was conducted in the NASA Ames 6-by-6 ft supersonic wind tunnel. These studies provide a detailed data base to assess the potential effects of symmetric and asymmetric three-dimensional transonic flow separations on projectile performance. A three-component laser velocimeter system, laser vapor screen, model balance and static and dynamic surface pressure gages were used to conduct detailed non-intrusive wind tunnel test measurements. This instrumentation was used to determine model forces and moments, surface pressure distributions and to explore the time-averaged and turbulent characteristics of the attached viscous and coiled free shear layers over ranges of angle of attack and transonic freestream Mach number. Flow field and aerodynamic static and dynamic surface pressure measurements were obtained on a stationary projectile model and normal and Magnus force and flow field measurements were made on a geometrically similar spinning model. A comparison of the two sets of three-dimensional lee side flow field surveys shows that model spin produces significant changes in vortex position and strength which accounts for the measured destabilizing aerodynamic effects in the transonic test regime. GRA

N88-28033*# Texas A&M Univ., College Station. Dept. of Aerospace Engineering.
DEVELOPMENT OF DIRECT-INVERSE 3-D METHODS FOR APPLIED TRANSONIC AERODYNAMIC WING DESIGN AND ANALYSIS Semiannual Progress Report, 1 Jan. - 30 Jun. 1988
LELAND A. CARLSON Aug. 1988 7 p
(Contract NAG1-619)
(NASA-CR-183127; NAS 1.26:183127; TAMU-5373-88-02) Avail: NTIS HC A02/MF A01 CSCL 01A

Since the project is rapidly nearing conclusion, the status of the tasks outlined in the original proposal are briefly outlined. These tasks include: viscous interation and wake curvature effects; code optimization and design methodology studies; methods for the design of isolated regions; program improvement efforts; and validation, testing, and documentation. B.G.

N88-28035 Cornell Univ., Ithaca, N.Y.
TRANSONIC BLADE-VORTEX INTERACTIONS Ph.D. Thesis
ANASTASIOS SOTIRIOS LYRINTZIS 1988 147 p
Avail: Univ. Microfilms Order No. DA8804590

Mid-field and far-field noise generated by transonic blade-vortex interactions (BVI), typical of helicopter main rotor noise was studied. The VTRAN2 small disturbance, two-dimensional, transonic flow code, which includes convected vorticity, is used to compute near-field and far-field information. The different coordinate systems used for following the generated waves are discussed. Helpful scaling is also introduced. Because of mesh limitations this information is restricted to the mid-field and does not give the desired far-field and three-dimensional information. A method of extending the solutions to the far-field in three dimensions is developed based on Kirchhoff's solution to the linear flow outside a surface S enclosing the nonlinear near field. A spherically symmetric partial sine wave is first used as a test case for the method. The effects of mesh size, wave thickness, analytical or numerical formulation of the normal and time derivatives and the inclusion of the tip surfaces are studied. The edge term in Farassat's formulation is also discussed and its computational importance was evaluated. Spherical wave results for a C mesh were also obtained. Then the Kirchhoff method was applied for calculation of BVI waves. Some results for three-dimensional interactions with oblique and curved vortices are also obtained and discussed. Application of the Kirchhoff method to other acoustic problems was also discussed and some simple cases were illustrated. Dissert. Abstr.

N88-28036*# Kansas Univ. Center for Research, Inc., Lawrence.
VSAERO ANALYSIS OF TIP PLANFORMS FOR THE FREE-TIP ROTOR
D. M. MARTIN and P. E. FORTIN Jun. 1988 125 p
(Contract NCC2-175)
(NASA-CR-177487; NAS 1.26:177487) Avail: NTIS HC A06/MF A01 CSCL 01A

The results of a numerical analysis of two interacting lifting surfaces separated in the spanwise direction by a narrow gap are presented. The configuration consists of a semispan wing with the last 32 percent of the span structurally separated from the inboard section. The angle of attack of the outboard section is set independently from that of the inboard section. In the present study, the three-dimensional panel code VSAERO is used to perform the analysis. Computed values of tip surface lift and pitching moment coefficients are correlated with experimental data to determine the proper approach to model the gap region between the surfaces. Pitching moment data for various tip planforms are also presented to show how the variation of tip pitching moment with angle of attack may be increased easily in incompressible flow. Calculated three-dimensional characteristics in compressible flow at Mach numbers of 0.5 and 0.7 are presented for new tip planform designs. An analysis of sectional aerodynamic center shift as a function of Mach number is also included for a representative tip planform. It is also shown that the induced drag of the tip surface is reduced for negative incidence angles relative to the inboard section. The results indicate that this local drag reduction overcomes the associated increase in wing induced drag at high wing lift coefficients. Author

N88-28037*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
EULER EQUATION COMPUTATIONS FOR THE FLOW OVER A HOVERING HELICOPTER ROTOR
THOMAS WESLEY ROBERTS Aug. 1988 245 p
(Contract NAG2-275)
(NASA-CR-177493; NAS 1.26:177493) Avail: NTIS HC A11/MF A01 CSCL 01A

A numerical solution technique is developed for computing the flow field around an isolated helicopter rotor in hover. The flow is governed by the compressible Euler equations which are integrated using a finite volume approach. The Euler equations are coupled to a free wake model of the rotary wing vortical wake. This wake model is incorporated into the finite volume solver using a prescribed flow, or perturbation, technique which eliminates the numerical diffusion of vorticity due to the artificial viscosity of the scheme. The work is divided into three major parts: (1) comparisons of Euler solutions to experimental data for the flow around isolated wings show good agreement with the surface pressures, but poor agreement with the vortical wake structure; (2) the perturbation method is developed and used to compute the interaction of a streamwise vortex with a semispan wing. The rapid diffusion of the vortex when only the basic Euler solver is used is illustrated, and excellent agreement with experimental section lift coefficients is demonstrated when using the perturbation approach; and (3) the free wake solution technique is described and the coupling of the wake to the Euler solver for an isolated rotor is presented. Comparisons with experimental blade load data for several cases show good agreement, with discrepancies largely attributable to the neglect of viscous effects. The computed wake geometries agree less well with experiment, the primary difference being that too rapid a wake contraction is predicted for all the cases. Author

N88-28038*# Connecticut Univ., Storrs.
DUAL ADAPTIVE CONTROL: DESIGN PRINCIPLES AND APPLICATIONS Final Contractor Report
PURUSOTTAM MOOKERJEE Aug. 1988 120 p
(Contract NAG2-213; NAG2-318)
(NASA-CR-177485; NAS 1.26:177485) Avail: NTIS HC A06/MF A01 CSCL 01A

The design of an actively adaptive dual controller based on an approximation of the stochastic dynamic programming equation for a multi-step horizon is presented. A dual controller that can enhance identification of the system while controlling it at the same time is derived for multi-dimensional problems. This dual controller uses sensitivity functions of the expected future cost with respect to the parameter uncertainties. A passively adaptive cautious controller and the actively adaptive dual controller are examined. In many instances, the cautious controller is seen to turn off while the latter avoids the turn-off of the control and the slow convergence of the parameter estimates, characteristic of the cautious controller. The algorithms have been applied to a multi-variable static model which represents a simplified linear version of the relationship between the vibration output and the higher harmonic control input for a helicopter. Monte Carlo comparisons based on parametric and nonparametric statistical analysis indicate the superiority of the dual controller over the baseline controller. Author

N88-28041*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
INVESTIGATION OF OSCILLATING CASCADE AERODYNAMICS BY AN EXPERIMENTAL INFLUENCE COEFFICIENT TECHNIQUE
DANIEL H. BUFFUM and SANFORD FLEETER (Purdue Univ., West Lafayette, Ind.) Jul. 1988 25 p Presented at the 24th Joint Propulsion Conference, Boston, Mass., 11-13 Jul. 1988; sponsored in part by AIAA, ASME, SAE and ASEE
(NASA-TM-101313; E-4308; NAS 1.15:101313; AIAA-88-2815) Avail: NTIS HC A03/MF A01 CSCL 01A

Fundamental experiments are performed in the NASA Lewis Transonic Oscillating Cascade Facility to investigate the torsion mode unsteady aerodynamics of a biconvex airfoil cascade at realistic values of the reduced frequency for all interblade phase angles at a specified mean flow condition. In particular, an unsteady aerodynamic influence coefficient technique is developed and utilized in which only one airfoil in the cascade is oscillated at a time and the resulting airfoil surface unsteady pressure distribution measured on one dynamically instrumented airfoil. The unsteady aerodynamics of an equivalent cascade with all airfoils oscillating at a specified interblade phase angle are then determined through a vector summation of these data. These influence coefficient determined oscillation cascade data are correlated with data obtained in this cascade with all airfoils oscillating at several interblade phase angle values. The influence coefficients are then utilized to determine the unsteady aerodynamics of the cascade for all interblade phase angles, with these unique data subsequently correlated with predictions from a linearized unsteady cascade model. Author

N88-28042*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THREE-DIMENSIONAL ZONAL GRIDS ABOUT ARBITRARY SHAPES BY POISSON'S EQUATION
REESE L. SORENSON Aug. 1988 13 p
(NASA-TM-101018; A-88258; NAS 1.15:101018) Avail: NTIS HC A03/MF A01 CSCL 01A

A method for generating 3-D finite difference grids about or within arbitrary shapes is presented. The 3-D Poisson equations are solved numerically, with values for the inhomogeneous terms found automatically by the algorithm. Those inhomogeneous terms have the effect near boundaries of reducing cell skewness and imposing arbitrary cell height. The method allows the region of interest to be divided into zones (blocks), allowing the method to be applicable to almost any physical domain. A FORTRAN program called 3DGRAPE has been written to implement the algorithm. Lastly, a method for redistributing grid points along lines normal to boundaries will be described. Author

N88-28044# Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
WIND TUNNEL INVESTIGATION OF WING AND CONTROL PANEL LOADS AT TRANSONIC AND SUPERSONIC SPEEDS ON SOME SCHEMATIC CRUCIFORM MISSILE CONFIGURATIONS
SVEN ERIK GUDMUNDSON and LARS TORNGREN Jul. 1986 317 p
(Contract FMV-F-K-82223-74-001-07-001; FMV-F-K-82223-75-007-07-001)
(FFA-TN-1986-43-SUPPL-1; ETN-88-92699) Avail: NTIS HC A14/MF A01

Tables and graphs of wind tunnel test data for cruciform missiles are presented. ESA

N88-28045# Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
RUNGE-KUTTA FINITE-VOLUME SIMULATION OF LAMINAR TRANSONIC FLOW OVER THE ONERA M6 WING USING THE NAVIER-STOKES EQUATIONS
BERNHARD MULLER and ARTHUR RIZZI 15 Sep. 1987 46 p
(Contract FFA-STU-AU-2519)
(FFA-TN-1987-06; ETN-88-92804) Avail: NTIS HC A03/MF A01

A 3-D Navier-Stokes solver was developed to simulate laminar compressible flow over quadrilateral wings. The finite volume technique is employed for spatial discretization with a variant for the viscous fluxes. An explicit three-stage Runge-Kutta scheme is used for time integration. Local time steps are determined from a linear stability condition derived for finite difference and finite volume discretizations of the Navier-Stokes equations. The code is applied to compute laminar transonic flow over the ONERA M6 wing. For the subcritical flow case the computed surface pressure distribution is in satisfactory agreement with experimental data and a thin-layer solution. On the lower side of the wing, similar agreement with experimental and Euler results is found for the supercritical flow case. The resolution of the suction peaks and compression regions on the upper surface, however, requires finer meshes. Moreover, a turbulence model should be implemented. ESA

N88-28047*# United Technologies Research Center, East Hartford, Conn.
PROGRAM USER'S MANUAL FOR AN UNSTEADY HELICOPTER ROTOR-FUSELAGE AERODYNAMIC ANALYSIS
PETER F. LORBER Aug. 1988 107 p
(Contract NAS1-17469)
(NASA-CR-181701; NAS 1.26:181701; UTRC-R88-956977-14) Avail: NTIS HC A06/MF A01 CSCL 01A

The Rotor-Fuselage Analysis is a method of calculating the

aerodynamic reaction between a helicopter rotor and fuselage. This manual describes the structure and operation of the computer programs that make up the Rotor-Fuselage Analysis, programs which prepare the input and programs which display the output.
Author

03

AIR TRANSPORTATION AND SAFETY

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

A88-49275
CANARD-CONFIGURED AIRPLANES REQUIRE NEW RULES
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 8, Aug. 1988, p. 42-46.

The elevator surfaces of canard-configured aircraft can be located on the forward airfoil, or the main wing, or both; maneuvers which had previously correlated control input with aircraft response accordingly require new definition, and FAR rules applicable to flight loads have to be modified accordingly. The FAA proposes to change 'up elevator', 'download on horizontal tail', and 'airplane nose-up' references so that aft movement of the pitch control would be associated with aircraft nose-up pitching, and forward movement with nose-down. O.C.

A88-50901
PASSENGER PROTECTION TECHNOLOGY IN AIRCRAFT ACCIDENT FIRES
NEVILLE BIRCH (Rolls-Royce, PLC, Derby, England) Aldershot, England, Gower Technical Press, 1988, 160 p. refs

Techniques for protecting passengers from the effects of fire in otherwise survivable aircraft accidents are evaluated, and specific recommendations involving the expansion of current ground-based fire-fighting capabilities are presented. Chapters are devoted to the origin and characteristics of aircraft fires, heat, smoke and toxic gases, factors affecting evacuation, the internal cabin fire, evacuation-chute protection, smoke hoods, and aircraft security. Diagrams, graphs, and tables of numerical data are provided.
T.K.

A88-50902*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
RESEARCH ON AIRCRAFT/VORTEX-WAKE INTERACTIONS TO DETERMINE ACCEPTABLE LEVEL OF WAKE INTENSITY
VERNON J. ROSSOW and BRUCE E. TINLING (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 25, June 1988, p. 481-492. refs

An evaluation of the literature on large aircraft wake-vortex encounters in flight and in flight simulators has furnished an estimate of the level to which the vortex-induced rolling moments must be reduced in order to be perceived as nonhazardous at a 2-n.mi. separation distance. The criteria are based on the ratio of the vortex-induced acceleration in roll to the aileron-induced roll acceleration. A wake is acceptably alleviated if the ratio of vortex-to-aileron rolling moments is less than about 0.5. When a satisfactory alleviation scheme is identified, the alleviated vortex structure should be inserted into a simulator to ascertain whether the maximum bank angles induced are within tolerable limits.
O.C.

A88-50910*# Massachusetts Inst. of Tech., Cambridge.
IN-FLIGHT MEASUREMENT OF AIRFOIL ICING USING AN ARRAY OF ULTRASONIC TRANSDUCERS
R. JOHN HANSMAN, JR., MARK S. KIRBY (MIT, Cambridge, MA), ROBERT C. MCKNIGHT (NASA, Lewis Research Center, Cleveland, OH), and ROBERT L. HUMES (Calspan Corp., Arnold Air Force Station, TN) Journal of Aircraft (ISSN 0021-8669), vol. 25, June 1988, p. 531-537. FAA-supported research. Previously cited in issue 08, p. 1047, Accession no. A87-22464. refs
(Contract NGL-22-009-640; NAG3-666)

N88-27176# Kernforschungsanlage, Juelich (West Germany). Inst. fuer Nukleare Sicherheitsforschung.
IMPROVED PROCEDURE FOR IMPACT PROBABILITY COMPUTATION OF AIRCRAFT CRASH BASED ON BALFANZ MODEL [VERBESSERTE VERFAHREN ZUR BERECHNUNG DER TREFFERWAHRSCHEINLICHKEIT DURCH ABSTUERZENDE FLUGZEUGE NACH DEM BALFANZ-MODELL]
WILFRIED HENNINGS Jan. 1988 26 p In GERMAN
(JUEL-SPEZ-425; ISSN-0343-7639; ETN-88-92961) Avail: NTIS HC A03/MF A01

A mathematical model for impact probability of military aircraft crash accident is improved by Balfanz-model considering the crash angle statistical evaluation. The model is extended for cylindrical and parallelepiped buildings in dependance of shadow surface.
ESA

N88-28023# National Transportation Safety Board, Washington, D. C.
THE ROLE PLAYED BY FDRS IN UNDERSTANDING THE WINDSHEAR PHENOMENON
DENNIS R. GROSSI *In* DFVLR, Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems p 451-472 Jan. 1988
Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

Wind shear accidents are reviewed, and the utility of flight data recorders (FDR) in investigating them is discussed. The Dec. 17, 1973, Iberia Air Lines, DC-10-30 crash at Boston, Massachusetts, became the first U.S. accident where wind shear could be positively identified as a cause of a large airplane accident. The 96-parameter digital flight data recorder provided investigators their first real glimpse at the windshear phenomenon. Since then there have been at least 18 accidents in the U.S. involving windshear, culminating with the August 1985 Delta L-1011 accident at Dallas-Fort Worth Airport. It is suggested that data on wind shear accidents is one of the major contributions of FDR to aviation safety. ESA

N88-28024# Technische Hochschule, Aachen (West Germany). Inst. fuer Luft und Raumfahrt.
THE PNEUMATIC WIND SHEAR SENSOR: A TOOL FOR METEOROLOGICAL INVESTIGATIONS AND FLIGHT MANAGEMENT
H. NELLES, S. ZHU, and R. W. STAUFENBIEL *In* DFVLR, Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems p 473-500 Jan. 1988
Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

A simple and reliable pneumatic device for measuring wind shear (PWSS) was developed. It delivers the local change in horizontal wind speed with the height by measuring the difference of total pressure between two probes positioned in different heights. It can also be used to measure the change in horizontal wind speed along the flight path. The PWSS was used to investigate special meteorological phenomena, in particular nocturnal low lewel jets and the associated turbulence. The wind shear measuring device is applicable as wind shear indicator or as an additional sensor for an autopilot. The effectiveness of PWSS, as support for an autopilot during instrument landing system approach, is shown in a simulation program that uses local wind shear information as an additional input. ESA

N88-28030# Vibro-Meter S.A., Fribourg (Switzerland).
NEW ICE DETECTION SYSTEM
M. LUSTENBERGER *In* DFVLR, Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems p 619-638 Jan. 1988

Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

A concept for detecting ice on aircraft, based on a vibrating diaphragm was developed. Ice accretion on the surface increases the diaphragm stiffness causing the natural frequency to increase sharply. The diaphragm is forced into oscillation by a piezoelectric material, which is also responsible for reading the frequency. The conditioning electronics measures the change in frequency, which is proportional to the accreted ice thickness. Flight and ice tunnel tests confirm the measurement principle for a variety of icing conditions. ESA

N88-28049# Rolls-Royce Ltd., Derby (England).
THE DESIGN AND TESTING OF AERO ENGINES TO MINIMISE HAZARD FROM BIRDS
A. B. WASSELL 14 Oct. 1987 16 p Presented at the RAeS Symposium on Bird Hazards in Aviation, United Kingdom, 14 Oct. 1987
(PNR90436; ETN-88-92671) Avail: NTIS HC A03/MF A01

Why and how the present civil engine airworthiness requirements relating to bird hazards were developed are illustrated. The impact this has on the design and testing of aero-engines, and the major remaining unknowns are discussed. ESA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A88-49721
NEW EUROPEAN-COVERAGE LORAN C RECEIVER [NOUVEAU RECEPTEUR LORAN C A COUVERTURE EUROPEENNE]
CHRISTIAN LAMIRAUX Navigation (Paris) (ISSN 0028-1530), vol. 36, July 1988, p. 301-315. In French.

The operation of the LRX 322 cross chain receiver, for establishing a geographic position based on the data from three or four stations operating in two independent chains, is described and receiver results are presented. The receiver uses a linear hard-limited method for signal acquisition. While achieving the performance guidelines of 50-m repeatability and 400-m geodetic precision on the earth, the LRX 322 extends Loran C coverage to regions north and south of Europe and increases the precision of hyperbolic cross-checking in numerous cases. Use of the semicircular mode requires a position precision of only 8 nmi. It is noted that the receiver does not require the use of dual-rate transmitters. R.R.

A88-49722
THE MIXED HYPERBOLIC MODE - A NEW MEANS OF EXTENDING LORAN C COVERAGE [LE MODE HYPERBOLIQUE MIXTE - UN MOYEN ORIGINAL D'ETENDRE LA COUVERTURE LORAN C]
GERARD RUARO (Techniphone, Le Puy-Sainte-Reparade, France) Navigation (Paris) (ISSN 0028-1530), vol. 36, July 1988, p. 316-323. In French.

Following a review of the main Loran C processing principles, a mixed hyperbolic mode for extending Loran C coverage in Europe is described. The present method treats the signals from three stations, two of which belong to the same chain. A position line is formed from the two chained stations, and another position line is formed from two stations of different chains. The method extends Loran C coverage with respect to either the simple or crossed hyperbolic modes while avoiding the constraints of the circular mode. The method is, however, very sensitive to deviations in the time synchronization of the Loran transmitters, and a method for measuring this deviation is proposed. Application of the new mode to the French chain GRI 8940 is discussed. R.R.

A88-49725
USSR - FUTURE USE OF SPACE AND TERRESTRIAL RADIONAVIGATION SYSTEMS [U.R.S.S. - UTILISATION FUTURE DES SYSTEMES DE RADIONAVIGATION TERRESTRES ET SPATIAUX]
G. MOSKVIN (Ministry of Merchant Marine, Moscow, USSR) and V. SOROCHINSKII (Tsentral'nyi Nauchno-Issledovatel'skii Institut Morskogo Flota, Leningrad, USSR) (Royal Institute of Navigation, Colloquium on Radionav 2000: A European Dimension, London, England, Mar. 22-24, 1988) Navigation (Paris) (ISSN 0028-1530), vol. 36, July 1988, p. 370-375. In French.

Soviet ships engaged in international voyages are navigated using both Soviet navigation systems (Chaika and Tsikada) and foreign systems (Decca, Loran C, and Transit). The low-frequency phase modulation system Chaika is similar to Loran C. The Tsikada system consists of four to five satellites in quasi-circular orbit. Hybridization of the systems is considered. It is noted that present limitations either in coverage or in position-fixing accuracy and availability may be overcome by using the future Navstar and Glonass systems. R.R.

A88-50179*# Rice Univ., Houston, Tex.
PENETRATION LANDING GUIDANCE TRAJECTORIES IN THE PRESENCE OF WINDSHEAR
A. MIELE, T. WANG (Rice University, Houston, TX), and W. W. MELVIN (Delta Air Lines, Inc., Atlanta, GA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 152-170. Research supported by Boeing Commercial Airplane Co. and Air Line Pilots Association. refs
(Contract NAG1-516)
(AIAA PAPER 88-4069)

Flight trajectory guidance in the presence of windshear is considered with reference to flight in a vertical plane. Both horizontal shear and the presence of a downdraft are assumed. The optimal trajectory is first determined by minimizing a performance index which is subject to touchdown constraints, under the assumption of control via angle of attack and power setting. It is shown that the coupling relation between the angle of attack and the power setting can be ignored. A guidance scheme is constructed in which the angle of attack is determined by the windshear intensity, the absolute path inclination, and the glide slope angle, while the power setting is determined by the windshear intensity and the velocity. Particular attention is given to low-altitude penetration landing. R.R.

A88-50279*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
OBSTACLE-AVOIDANCE AUTOMATIC GUIDANCE - A CONCEPT-DEVELOPMENT STUDY
VICTOR H. L. CHENG (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1142-1152. refs
(AIAA PAPER 88-4189)

This paper studies the notion of obstacle-avoidance guidance, and investigates the issues in automating this function by considering helicopter nap-of-the-earth (NOE) flight as an example. In particular, it considers a hierarchy of guidance components, including mission planning and obstacle avoidance. Based on this hierarchical breakdown, the functional requirements of obstacle-avoidance guidance are identified. An effort in developing automatic guidance algorithms to meet these requirements is presented, along with the necesssary simulation tools for evaluation of these algorithms. Author

A88-50459
MILLIMETER-WAVE COMMUNICATIONS - AIR-TO-AIR APPLICATIONS
ERIC N. BARNHART (Georgia Institute of Technology, Atlanta) IN: Millimeter wave technology IV and radio frequency power

sources; Proceedings of the Meeting, Orlando, FL, May 21, 22, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 94-98. refs

The performance of millimeter-wave (MMW) communications techniques for air-to-air applications is reviewed. The anti-jam (AJ) and low-probability-of-intercept (LPI) performance of a communications system resulting from the attenuative characteristics of the atmosphere in the 50-60 GHz band are characterized. The objective of the communications system design is to avoid traditional AJ and LPI techniques such as spread-spectrum modulation and narrow-beam antennas, resulting in a simple system with a robust and secure communications capability. Author

A88-50767
SYSTEMS FOR THE ADAPTIVE CONTROL OF AIRCRAFT [SISTEMY ADAPTIVNOGO UPRAVLENIIA LETATEL'NYMI APPARATAMI]
ANATOLII SEMENOVICH NOVOSELOV, VITALII EVGEN'EVICH BOLNOKIN, PETR IVANOVICH CHINAEV, and ARTUR NIKOLAEVICH IUR'EV Moscow, Izdatel'stvo Mashinostroenie, 1987, 280 p. In Russian. refs

Problems pertaining to the development of adaptive systems for the remote control of aircraft are considered. These include the adaptive selection of a control variant when the entire task is changed, an adaptive change in course, and the adaptation of individual subsystems and components. K.K.

A88-50961
USE OF AN EXTERNAL CASCADED KALMAN FILTER TO IMPROVE THE PERFORMANCE OF A GLOBAL POSITIONING SYSTEM (GPS) INERTIAL NAVIGATOR
F. H. SCHLEE, N. F. TODA, M. A. ISLAM, and C. J. STANDISH (IBM, Federal Systems Div., Owego, NY) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 345-350. refs

The accuracy of in-air Inertial Navigation System (INS) alignment has been analyzed for several methods of GPS/INS integration. It is found that an external filter which operates on the outputs of the GPS receiver achieves a faster alignment than the GPS receiver alone. Steady-state accuracy is not significantly improved by the use of the external filter. The data rate of this external filter should be one update per second, which is the same as the GPS receiver's update rate and is the fastest that the external filter could be updated. In-air alignment of a second INS can be performed as a transfer alignment. In this procedure, the INS, which is integrated with the GPS, transfers its alignment to the second INS using an external filter. The performance of this external filter is analyzed and it is found that for a medium-accuracy INS, and also for a low-accuracy attitude heading reference system (AHRS), the fastest update rate provides the best alignment response. I.E.

A88-50976
TERRAIN MASKING AND THREAT AVOIDANCE USING LAND MASS DATA
A. WEIMANN, D. SCHEIBE, and P. SCHROEDER (ESG Elektronik-System-Gesellschaft mbH, Munich, Federal Republic of Germany) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 540-545. Research supported by the Bundesamt fuer Wehrtechnik und Beschaffung; Bundesministerium der Verteidigung.
(Contract BMVG-T/R426/D0019/62487; BMVG-T/R426/E0022/E2478; BMVG-E/F15G/F0144/85333; BMVG-E/L31N/G0538/G5117)

Digital land mass data applied for flight guidance are of increasing importance. Using this three-dimensional terrain information, three-dimensional flight paths can be calculated onboard the aircraft to maximize terrain masking and minimize threat exposure. The navigation aspect, terrain data presentation, flight path calculation and a system concept are discussed. I.E.

A88-51377* Ohio Univ., Athens.
SOLE MEANS NAVIGATION THROUGH HYBRID LORAN-C AND GPS
FRANK VAN GRAAS (Ohio University, Athens) Navigation (ISSN 0028-1522), vol. 35, Summer 1988, p. 147-160. FAA-NASA-supported research. refs

A minimum of four GPS range measurements or two Loran-C time differences are normally required for a position solution for en route navigation, area navigation, and nonprecision approaches. This paper describes a new technique that hybridizes GPS and Loran-C used in the pseudorange mode to process efficiently all available navigation information. Emphasis is placed on combined GPS and Loran-C timing, both for the ground/space facilities and the user. The hybrid system has the potential to solve the GPS and Loran-C integrity problems; more range measurements are available than are required for the navigation solution. Author

A88-51382
CHOOSING THE BEST SOLUTION TO THE GPS INTEGRITY AND COVERAGE ISSUES
T. R. DAMIANI (Rockwell International Corp., Seal Beach, CA) and N. B. HEMESATH (Rockwell International Corp., Cedar Rapids, IA) Navigation (ISSN 0028-1522), vol. 35, Summer 1988, p. 217-237. refs

Studies providing possible solutions to ensure that the GPS can quickly notify out-of-tolerance conditions (integrity) and provide adequate coverage during satellite failures (coverage) are reviewed. Approaches to the integrity issue include implementation of ground-based monitor stations to evaluate GPS signals and processing of redundant data within the GPS receiver to detect anomalies and autonomously provide warning. Answers to the problem of coverage include expansion of the DOD constellation to 24 semisynchronous satellites, augmentation by dedicated geosynchronous GPS satellites, and addition of a civil GPS payload on existing geosynchronous civil weather satellites. The operational, institutional, economic, and international concerns of the proposed solutions and the criteria for choosing a system are discussed. R.B.

A88-51383
NEW CONCEPT FOR INDEPENDENT GPS INTEGRITY MONITORING
YOUNG C. LEE (Mitre Corp., McLean, VA) Navigation (ISSN 0028-1522), vol. 35, Summer 1988, p. 239-254. refs

Monitoring of the GPS signals-in-space status for integrity, with a fast response time, is essential if the system is to be used by civil aviation for nonprecision approach guidance. One alternative for providing such a monitoring function is to employ an independent monitoring system with a few ground-based signal monitors to cover a region and a satellite-based integrity broadcast channel to provide real-time GPS signal status. This paper introduces a new decision concept for accepting or rejecting a GPS signal for navigation in the independent monitoring system. Performance of the new concept is evaluated in terms of the probability of alarms against position error protection level, which are two important parameters for any integrity method. Author

A88-51384
AUTONOMOUS GPS INTEGRITY MONITORING USING THE PSEUDORANGE RESIDUAL
BRADFORD W. PARKINSON and PENINA AXELRAD (Stanford University, CA) Navigation (ISSN 0028-1522), vol. 35, Summer 1988, p. 255-274. refs

A method for autonomous GPS satellite failure detection and isolation (D/I) is presented. The test statistic for the D/I algorithm is the range residual parameter for six or more satellites in view. Nominal carrier-aided pseudorange measurement errors are modeled as Gaussian random variables with a mean in the range of -5 m to +5 m and standard deviation of 0.4 m. Monte Carlo simulations are conducted, applying the algorithm to measurement sets containing a biased measurement. In the presence of a 100 m biased measurement, successful detection was achieved 99.9 percent of the time, and succssful D/I was achieved 72.2 percent of the time. R.B.

A88-51385
HIGH-ACCURACY KINEMATIC POSITIONING BY GPS-INS
R. V. C. WONG, K. P. SCHWARZ, and M. E. CANNON (Calgary, University, Canada) Navigation (ISSN 0028-1522), vol. 35, Summer 1988, p. 275-287. refs

The possibility of eliminating the effect of cycle slips over short intervals by integrating differential GPS measurements with an INS is discussed. A Kalman filter-smoother which integrates differential range and phase measurements with data from an INS has been developed. The optimal backward smoother improves the filter estimates for periods of poor geometry and multiple cycle slips. Results from tests of the package show that submeter kinematic positioning accuracies and cm/s velocity accuracies are achievable with an integrated GPS-INS. R.B.

A88-51467
DIGITAL TELEMETRY SYSTEM FOR REAL-TIME ANALYSIS OF AIRBUS A320 FLIGHT TEST RESULTS
YVES NEGRE and DENIS LAFOURCADE (Aerospatiale, Toulouse, France) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 19-1 to 19-9.

A 1500 MHz waveband high data flow digital telemetry system has been developed to provide a tool capable of permitting real-time analysis of aircraft text flight results during the development and certification period. In this paper, the airborne flight test installation and general ground analysis facilities are described. The telemetry component is emphasized, with special stress on the ground analysis aspect. The general test analysis philosophy, the organization of the resulting work, the station installation, associated graphic facilities and computer hardware, and the universality of the basic and application software are addressed. C.D.

A88-51507
MEASUREMENT OF AIRCRAFT DETECTABILITY USING SIMULATED INFRA RED (IR) SURVEILLANCE EQUIPMENT
P. A. W. DAVIES, P. L. PHILLIPS, and S. D. SEARLE (British Aerospace, PLC, Sowerby Research Centre, Bristol, England) IN: Passive infrared systems and technology; Proceedings of the Meeting, The Hague, Netherlands, Mar. 31-Apr. 1, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 73-78.

An image processing computer is used to simulate the viewing of an aircraft by an observer using standard IR surveillance equipment. The technique enables specific and controlled target/background signatures based on either theoretical or practical measurements to be used in human factor experiments to measure aircraft detectability. Author

A88-51701
INSTITUTE OF NAVIGATION, NATIONAL TECHNICAL MEETING, SANTA BARBARA, CA, JAN. 26-29, 1988, PROCEEDINGS
Meeting sponsored by ION, Bell Aerospace Textron, Canadian Marconi Co., et al. Washington, DC, Institute of Navigation, 1988, 315 p. For individual items see A88-51702 to A88-51727.

Various papers on navigation are presented. The topics addressed include: progress toward Loran IFR avionics systems, use of a single-channel GPS receiver in a dynamic environment, fault-tolerant technology concept for radio navigation systems, common Kalman filter: fault-tolerant navigation for next-generation aircraft, validating the airborne and ground-based components of a differential GPS system, navigation system integrity monitoring using redundant measurements, SCIRAS sensor, inertial grade fiber gyros, the GPS users integration guide, interactive and operational tactical mission planning, and current and near-term trends in GPS receiver technology. Also discussed are: problems and solutions for GPS use beyond the 12-hour orbit, feasibility of using GPS measurements for OMV attitude update, performance measures of receiver-autonomous GPS integrity monitoring, receiver clock stability as aid in the GPS integrity problem, integrity monitoring of the GPS using a barometric altimeter, integrity and the NATO standardization agreement, software-centered signal model for the microwave landing system, microwave landing system ground and flight inspection alignment procedures, helicopter application of MLS, and cross-rate synchronization of Loran-C using GPS. C.D.

A88-51705#
COMMON KALMAN FILTER - FAULT-TOLERANT NAVIGATION FOR NEXT GENERATION AIRCRAFT
PETER V. W. LOOMIS (TAU Corp., Los Gatos, CA), NEAL CARLSON (Integrity Systems, Inc., Winchester, MA), and MICHAEL P. BERARDUCCI (USAF, Avionics Laboratory, Wright-Patterson AFB, OH) IN: Institute of Navigation, National Technical Meeting, Santa Barbara, CA, Jan. 26-29, 1988, Proceedings. Washington, DC, Institute of Navigation, 1988, p. 38-45. refs
(Contract F33615-86-C-1047)

The Common Kalman Filter (CKF), an ongoing USAF Avionics Laboratory program to develop, simulate, and evaluate computational techniques and software architectures that will enhance the robustness and reliability of integrated navigation systems for the next generation of military aircraft, is addressed. The CKF design, which is nearing maturity and is currently entering a computer simulation test cycle, is described. Approaches to sensor information requirements definition, local sensor integration/filtering, master filter modeling, automatic fault detection/isolation, and system reconfiguration are discussed. Failure modes which will be the basis for the evaluation of CKF failure response in subsequent simulations are described. C.D.

A88-51706*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
VALIDATING THE AIRBORNE AND GROUND BASED COMPONENTS OF A DIFFERENTIAL GPS SYSTEM
F. G. EDWARDS, D. M. HEGARTY (NASA, Ames Research Center, Moffett Field, CA), R. N. TURNER, F. VAN GRAAS, and S. SHARMA (Ohio University, Athens) IN: Institute of Navigation, National Technical Meeting, Santa Barbara, CA, Jan. 26-29, 1988, Proceedings. Washington, DC, Institute of Navigation, 1988, p. 46-56. refs

A differential GPS mechanization of an external data link concept under development at NASA Ames Research Center is discussed. The system is intended to evaluate the use of differential GPS to support helicopter approach operation. Analytical techniques for static testing and evaluation of the system hardware and software performance in real time are described. Several techniques that have been used to detect and rectify a specific problem encountered during the tests are dicussed. An example of flight test results using the validated system is provided. C.D.

A88-51712#
CRITERIA FOR MILITARY CERTIFICATION OF GPS FOR SOLE MEANS AIR NAVIGATION
EDWARD C. RISH, GARY L. NOSEWORTHY (Synetics Corp., Wakefield, MA), GEORGE LOWENSTEIN, and PETER P. FISCHER (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: Institute of Navigation, National Technical Meeting, Santa Barbara, CA, Jan. 26-29, 1988, Proceedings. Washington, DC, Institute of Navigation, 1988, p. 130-137. refs

Data from existing standards are utilized in this report to characterize the current approaches to operational standards and requirements for aircraft navigating in the National Aerospace System environment. Specific operational requirements regarding accuracy, waypoints, course selection and path computation, maneuvering, coordinate systems, annunciation of navigation modes, and equipment certification are examined. Expected GPS system integrity requirements are discussed, and GPS military certification is addressed. C.D.

A88-51717#
IMPACT OF AUTOMATIC DEPENDENT SURVEILLANCE AND NAVIGATION SYSTEM ACCURACY ON COLLISION RISK ON INTERSECTING TRACKS
H. JAMES ROME (Lowell, University, MA) and RUDOLPH KALAFUS (DOT, Transportation Systems Center, Cambridge, MA) IN: Institute of Navigation, National Technical Meeting, Santa Barbara, CA, Jan. 26-29, 1988, Proceedings. Washington, DC, Institute of Navigation, 1988, p. 213-222. FAA-supported research. refs

An analytic model for evaluation of collision risk on intersecting tracks based on geometry, flow rates, and distribution of the errors in navigation and reporting is discussed. The concept of capacity of a track intersection is developed and utilized as a primary measure of effectiveness in evaluating the effects of an Automatic Dependent Surveillance System (ADS) and the navigation errors on ADS system performance. Numerical trade-off studies were carried out to demonstrate the usefulness of the model. Author

A88-51723#
A SOFTWARE CENTERED SIGNAL MODEL FOR THE MICROWAVE LANDING SYSTEM
D. VICKERS (Ohio University, Athens) IN: Institute of Navigation, National Technical Meeting, Santa Barbara, CA, Jan. 26-29, 1988, Proceedings. Washington, DC, Institute of Navigation, 1988, p. 264-268. FAA-supported research. refs

A model of the MLS signal-in-space is being developed for use as input to aircraft computer simulations supporting integration of MLS signals with autopilots and flight management systems. The signal model makes it possible to estimate guidance accuracy and quality, and provides sampled signal outputs, appropriate flags, and deviation display outputs. The model tabulates primary equipment and propagation error sources as a function of azimuth and elevation angles and the range coordinates. Errors from various sources are summed, filtered, and delivered to the aircraft simulation at rates scaled to the actual signal-in-space. It is suggested that the model may be used as the navigation signal input to simulations to certify aircraft for operations including straight-in centerline approach paths to a specified decision height, precision arc navigation within the MLS coverage volume to centerline intercept, fully automatic landing and roll-out to conditions of zero visibility, and missed-approach operations. R.B.

A88-51724#
MICROWAVE LANDING SYSTEM - GROUND AND FLIGHT INSPECTION ALIGNMENT PROCEDURES
ALFRED R. LOPEZ (Hazeltine Corp., Commack, NY) IN: Institute of Navigation, National Technical Meeting, Santa Barbara, CA, Jan. 26-29, 1988, Proceedings. Washington, DC, Institute of Navigation, 1988, p. 269-273.

Over the past years several Microwave Landing Systems (MLS) have been installed, ground checked, flight inspected and commissioned. Some of the experience gained during these installations is reviewed. Fundamental differences exist between ILS and MLS which impact ground and flight inspection procedures. The ILS glideslope antenna incorporates the ground to form the glidepath; the MLS elevation antenna is essentially insensitive to the ground reflection. The ILS localizer antenna requires control of the ground reflecting surface; the MLS azimuth antenna utilizes a sharp bottom-side cutoff radiation pattern which substantially reduces the sensitivity to the ground reflection. It is believed that the MLS insensitivity to ground reflection will ultimately allow simpler inspection procedures which attach more reliance on less expensive ground inspection procedures as opposed to flight inspection procedures. Author

A88-51725#
HELICOPTER APPLICATIONS OF MLS
BARRY R. BILLMANN, MICHAEL AUSSERER, and SCOTT SHOLLENBERGER (FAA, Technical Center, Atlantic City, NJ) IN: Institute of Navigation, National Technical Meeting, Santa Barbara, CA, Jan. 26-29, 1988, Proceedings. Washington, DC, Institute of Navigation, 1988, p. 274-278. refs

Flight tests evaluating the use of MLS for helicopter applications are discussed. In tests to determine the optimal course width, the best performance was obtained with an azimuth course width of 3.5 tp 3.75 deg and an elevation course width 1/3 of the elevation approach angle. Tests of deceleration requirements, glidepath angle limitations on decision height, MLS navigation accuracy, and heliport terminal instrument approach procedures are examined. Also, equipment siting, critical area protection, heliport MLS flight inspection, and the future uses of MLS for heliports are considered. R.B.

A88-51912*# Lockheed Missiles and Space Co., Palo Alto, Calif.
INVESTIGATION OF AIRBORNE LIDAR FOR AVOIDANCE OF WINDSHEAR HAZARDS
RUSSELL TARG (Lockheed Missiles and Space Co., Inc., Research and Development Div., Palo Alto, CA) and ROLAND L. BOWLES (NASA, Langley Research Center, Hampton, VA) AIAA, NASA, and AFWAL, Conference on Sensors and Measurements Techniques for Aeronautical Applications, Atlanta, GA, Sept. 7-9, 1988. 10 p. refs
(AIAA PAPER 88-4658)

The present generalized windshear hazard index is formulated in terms of wind conditions at the given aircraft position and of remotely-sensed information obtained along the extended flight path. Overall system functional requirements are addressed by comparing microwave Doppler radar, Doppler lidar, and IR radiometry candidate techniques, giving attention to airborne CO2 and Ho:YAG lidar windshear-detection systems; these furnish pilots with data on the line-of-sight component of windshear threats over as much as 1-3 km, for a warning time of 15-45 sec. While the technology for a 10.6-micron, CO2 laser-based lidar is available, additional development is required for 2-micron, Ho:YAG laser-based systems. O.C.

N88-28026# Eurocontrol Agency, Brussels (Belgium).
THE EXPLOITATION OF AIRCRAFT INTEGRATED MONITORING SYSTEM (AIMS) DATA IN HEIGHT-KEEPING STUDIES FOR AIRCRAFT OPERATING ABOVE FL 290
M. E. COX *In* DFVLR, Proceedings of the 14th Symposium in Aircraft Integrated Monitoring Systems p 527-545 Jan. 1988
Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

Studies of aircraft height-keeping performance undertaken to determine the feasibility of reducing the vertical separation minima employed above FL 290 to 1000 ft are described. The types of data that can be used in determining components of the total height-keeping error are shown. It is shown how aircraft integrated monitoring system provides a unique source of data for this study; specimen results are included. ESA

N88-28050# American Electronics, Inc., Lanham, Md.
ANALYSIS OF ATCRBS (AIR TRAFFIC CONTROL RADAR BEACON SYSTEM), MODE SELECT (MODE S) IN COMBAT OPERATIONS Final Report
J. J. BERNER Oct. 1987 42 p
(Contract DAAB07-87M-P011)
(AD-A193140; AMELEX-86-0030) Avail: NTIS HC A03/MF A01 CSCL 17G

This study was prepared for the Combat Identification/Electronic Warfare Division, Fort Monmouth, New Jersey, under the direction of the Army Combat Identification Systems Program Office. Its purpose is to review the impact the implementation of the Air Traffic Control Radar Beacon System (ATCRBS) Mode S will have on Army combat operations. As part of the National Airspace Plan, the Federal Aviation Administration will update all major components of the existing air traffic control system. One of the new major system components of the ATC system is the Mode S Beacon Interrogator System, a combined secondary surveillance radar and ground-air-ground data link system which will be capable of providing the aircraft surveillance and communications necessary to support air traffic control automation in the dense traffic environment expected in the future. GRA

N88-28053# Royal Signals and Radar Establishment, Malvern (England).
THE AVOIDANCE OF COLLISIONS FOR NEWTONIAN BODIES WITH HIDDEN VARIABLES
B. D. BRAMSON Oct. 1987 12 p
(RSRE-87013; BR104725; ETN-88-92663) Avail: NTIS HC A03/MF A01

The collision avoidance of a pair of uniformly moving bodies is considered in three dimensions. The relative motion of the bodies yields an expression relating the time to closest approach, the minimum range, the current range, and its rate of change, other variables being unobservable. A Boolean relation that is satisfied whenever the minimum range and time to closest approach simultaneously fall below given thresholds is proposed. The relation is studied in particular with regard to the issue of false and premature alarms. An airborne collision avoidance system is a possible application. ESA

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AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A88-49502
MATRICES OF POSSIBLE SOLUTIONS FOR COMPUTERIZING AIRCRAFT DESIGN WITH ALLOWANCE FOR SERVICE REQUIREMENTS [MATRITSY VOZMOZHNYKH RESHENII DLIA AVTOMATIZATSII PROEKTIROVANIIA SAMOLETA S UCHETOM EKSPLUATATSIONNYKH TREBOVANII]
L. L. ANTSELIOVICH Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1988, p. 7-11. In Russian. refs

A method for formalizing information on aircraft design solutions is proposed which makes it possible to improve the reliability, safety, and longevity of aircraft. The method helps select optimal design alternatives during the interactive computer-aided design process. The general design of a high-speed maneuverable aircraft is examined as an example. V.L.

A88-49653
DYNAMICS OF HELICOPTER ROTOR BLADES
P. J. MAGARI, L. A. SHULTZ, and V. R. MURTHY (Syracuse University, NY) Computers and Structures (ISSN 0045-7949), vol. 29, no. 5, 1988, p. 763-776. refs

A rotating blade finite element with coupled bending, torsion and axial stretching degrees-of-freedom is developed. APL is used for symbolic manipulations required for the development of the element. The element is implemented in MSC/NASTRAN to generate the numerical results. The results are compared with the experimental and other published numerical results and are found to be accurate. There are several immediate potential applications. The implementation of the element in the existing finite element software greatly enhances their utility for helicopter applications. Author

A88-49922#
PRELIMINARY RESEARCH ON WAVE AND FREQUENCY SPECTRUM ANALYSIS OF DYNAMIC PERFORMANCE PARAMETERS FOR EJECTION POWER
WUMIN GANG (Flight Test Research Center, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, June 1988, p. B241-B247. In Chinese, with abstract in English.

The purpose of this study was to investigate the transfer function of the ejection power of a pilot escape system. The simulation tests were conducted by using a linear mechanical vibration system, and the data measured were processed by the method of wave and frequency spectrum analysis of the digital signal. A preliminary analysis of the processed test data is briefly described in this paper. It shows that the processed results agree with the ejection power performance and dummy model. The computational equations and method selected are reasonable and practicable. Author

A88-49925#
ESTABLISHMENT OF CLIMBING PROGRAM BASED ON THE ATMOSPHERIC TEMPERATURE FEATURES OF CHINA
XUECHU CHEN and SHAOKANG SUN (Air Force PR China, Institute of Engineering, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, June 1988, p. B272-B276. In Chinese, with abstract in English. refs

The establishment of a climbing program based on the atmospheric temperature features of China is recommended in this paper. It is established by the method of dynamic programming in conjuction with simple and easy control. It has been verified in flight tests that, as four kinds of fighters and the Trident 2E transport plane climb to 10,000 m (in contrast to the original program in the flight manuals), the new program saves about 1 min in climbing time and 5 percent in fuel consumption, so that both range and endurance have been improved. Author

A88-49999
F-16N SUPERSONIC ADVERSARY AIRCRAFT EVALUATION
T. PENNINGTON and R. KOTARBA (U.S. Navy, Strike Aircraft Test Directorate, Patuxent River, MD) Cockpit (ISSN 0742-1508), April-June 1988, p. 4-14.

The F-16 fighter, which has been chosen by the USN to serve as its training squadrons' Supersonic Adversary Aircraft, exhibits a deep stall phenomenon at center-of-gravity positions aft to 36 percent mean aerodynamic chord that is not recoverable by means of full aerodynamic control deflection. Departures can occur during cross-control and roll-pull maneuvers which could result in aircraft overstress; departures can also result from nonoptimum recovery techniques at nose-high/low airspeed flight, which may lead to dynamic deep stall entry. The deep stall phenomenon is very disorienting, and could result in excessive time and altitude required for recovery. Strict adherence to the onset of the low speed warning as a minimum airspeed limit will constitute a suitable airspeed margin that will allow the F-16N to be safely operated. O.C.

A88-50042
STATISTICAL LINEARIZATION OF THE DAMPING CHARACTERISTICS OF LANDING GEAR [STATISTICHESKAIA LINEARIZATSIIA KHARAKTERISTIK AMORTIZATSII SHASSI]
IU. A. STUCHALKIN and S. I. FLEROV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 3, 1986, p. 71-78. In Russian.

Some aspects of the statistical linearization of the force characteristics of landing gear damping associated with specific types of nonlinearity inherent to the damping force components are examined. Procedures for the correction of linearization results are proposed which make it possible to compensate for errors resulting from distortions of the normal stochastic oscillatory process in the essentially nonlinear damping stages. V.L.

A88-50044
EXPERIMENTAL STUDIES OF PRESSURE DISTRIBUTION ON A WING WITH END PLATES AT TRANSONIC VELOCITIES [EKSPERIMENTAL'NYE ISSLEDOVANIIA RASPREDELENIIA DAVLENIIA NA KRYLE S KONTSEVYMI SHAIBAMI PRI OKOLOZVUKOVYKH SKOROSTIAKH]
N. A. CHICHEROV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 3, 1986, p. 90-94. In Russian.

Pressure distribution on a half-wing with an upper one-sided end plate is investigated experimentally for different end plate angles in the Mach range 0.5-0.9 at angles of attack of -2 to 15 deg. It is shown that, in calculating the strength of wings with end plates at large angles of attack, it should be remembered that particularly high increments in loads associated with end plates are observed in the angle of attack range 8-10 deg. Plots of pressure and force distributions are presented. V.L.

A88-50069
SELECTION OF THE CHARACTERISTICS OF LANDING GEAR [O VYBORE KHARAKTERISTIK POSADOCHNYKH USTROISTV]
L. I. KISELEV and N. A. PAVLOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 4, 1986, p. 109-115. In Russian.

An analysis is made of the motion of an elastic body represented by a set of elastically coupled loads in the presence of an external moment of limited magnitude. With a two-mass model used as an example, the limited nature of the dynamic bending moment is demonstrated, and a coupling function is introduced which relates the dynamic bending moment to the characteristics of damping devices limiting the magnitude of the external moment. V.L.

A88-50096
ROLLING OF AN ELASTIC PNEUMATIC TIRE WITH SPIN [KACHENIE UPRUGOI PNEVMATICHESKOI SHINY S PROSKAL'ZYVANIEM]
E. I. LAR'KIN and E. V. IAGOL'NITSKII TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 6, 1986, p. 69-77. In Russian.

An improved string model is used to obtain the equations of the rolling motion of an elastic tire, taking small transverse oscillations of the wheel and tire spinning into account. The stationary motion of the wheel with allowance for the slippage angle is analyzed, and the frequency characteristics of the moving tire are calculated. B.J.

A88-50254#
RELAXATION OSCILLATIONS IN AIRCRAFT CRUISE-DASH OPTIMIZATION
UDAY J. SHANKAR (General Electric Co., Astro Space Div., Princeton, NJ), EUGENE M. CLIFF (Virginia Polytechnic Institute and State University, Blacksburg), and HENRY J. KELLEY IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 906-916. DARPA-supported research. refs
(Contract F08635-86-K-0390; F49620-87-C-0116)
(AIAA PAPER 88-4161)

Periodic solutions in energy approximation are sought for aircraft optimal cruise-dash problems. The cost functional is a weighted sum of the time taken and the fuel used averaged over one cycle. It is known from previous work that in energy-state approximation, relaxed-steady-state controls may give lower costs than steady-state operation. However, such a 'chattering' control is not implementable. In this study, improved approximations are sought via averaging methods. In one formulation, the 'fast' dynamics (path-angle/altitude/throttle/lift-coefficient) is modeled in terms of periodic solutions in a boundary-layer-like motion which does not die out, but moves along with the progression of the 'slow' state, energy. This is shown not to help the situation. A better approximation in terms of relaxation oscillations is proposed. Unlike earlier models, the energy is allowed to vary. However, the net change in energy per cycle is zero. Fast, constant-energy climbs and descents and slow energy transitions are 'spliced' together in zeroth order approximation to obtain appropriate periodic solutions. The range of energy values is determined as part of the problem. This technique is shown to produce a more practical solution. Author

A88-50255#
AIRCRAFT CRUISE-DASH OPTIMIZATION - PERIODIC VERSUS STEADY-STATE SOLUTIONS
UDAY J. SHANKAR (General Electric Co., Astro Space Div., Princeton, NJ), EUGENE M. CLIFF (Virginia Polytechnic Institute and State University, Blacksburg, VA), and HENRY J. KELLEY IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 917-927. refs
(AIAA PAPER 88-4162)

This paper conducts a comparative study of periodic and steady-state solutions for aircraft cruise-dash optimization. The solutions employ the point-mass model. The cost functional is the average of a weighted sum of the fuel-used and the time-taken. Previous work on cruise has determined that the steady-state solution fails a Jacobi-type test, conducted in frequency domain. Periodic solutions that use lesser fuel have been obtained for the same problem. The periodic solutions have been shown to be locally optimal. Similar analysis is carried out for the cruise-dash problems that have non-zero weights on the time taken. As the weight on the time is increased, the difference in the costs between periodic and steady-state solutions becomes less and less. For all values for the weight on the time above a certain value, the steady-state solutions are locally optimal. The structure of the periodic solutions becomes intricate. The periodic solutions seem to 'approach' the steady-state solution as the weight on time is increased. Author

A88-50327#
ANALYSIS OF THE ACOUSTIC PLANFORM METHOD FOR ROTOR NOISE PREDICTION
VALANA L. WELLS (Arizona State University, Tempe) AIAA Journal (ISSN 0001-1452), vol. 26, May 1988, p. 522, 523. refs

This study analyzes the acoustic planform method as an alternative to using the equation of Ffowcs Williams and Hawkings for predicting transonic and supersonic rotor noise. The studied method avoids the singularity encountered when the noise source travels towards the observer at sonic velocity. It introduces the necessity for computing acoustic planforms and integrating over them. Results are presented for a rotating, rectangular, monopole surface with supersonic tip velocity. These computations show a decrease in peak acoustic pressure as the tip speed increases beyond a critical supersonic Mach number. The results provide an explanation for some experimental data and some guidelines for proceeding on to the prediction of actual rotor noise. Author

A88-50592#
RECENT RESULTS IN THE IDENTIFICATION OF HIGH ANGLE-OF-ATTACK F/TF-18 AERODYNAMICS
ROBERT A. HESS (Systems Control Technology, Inc., Lexington Park, MD), WILLIAM MCNAMARA, and MARK FRANKO (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 153-160. refs
(AIAA PAPER 88-4348)

With the increasing complexity of today's high performance aircraft, there exists a strong need to provide accurate aircraft simulations. The Navy, through efforts conducted at the Naval Air Test Center (NAVAIRTESTCEN), is developing the most accurate F/A-18A and B aerodynamic models possible. Flight data collected from both the single seat (F/A-18A) and two seat (TF-18A or F/A-18B) fighter-escort (FE) configurations has been analyzed using modern parameter identification (PID) methodologies. The goal of this analysis has been to validate and improve the NAVAIRTESTCEN F-18 aerodynamic simulation database using modern systems identification techniques. Presented in this paper is a description of the NAVAIRTESTCEN F/A-18A and B simulations, a brief discussion of the flight test and data analysis methods used, a sample of the results obtained and conclusions drawn from this work. Author

A88-50593#
FREQUENCY DOMAIN IDENTIFICATION OF REMOTELY-PILOTED HELICOPTER DYNAMICS USING FREQUENCY-SWEEP AND SCHROEDER-PHASED TEST SIGNALS
P. YOUNG and R. J. PATTON (York, University, England) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 161-169. Research supported by the Royal Aircraft Establishment and SERC. refs
(AIAA PAPER 88-4349)

The validity of applying frequency domain identification

techniques to structural estimation of aircraft systems is to be investigated using data from a remotely piloted helicopter. A simulation study of the closed-loop identification of the scaled helicopter using decoupled longitudinal and lateral linear models of the aircraft, with noise, is described. Input signals are applied to excite the system modes. Frequency response estimates are obtained by spectral analysis and the coherence function is evaluated to indicate their likely accuracy. The transfer function coefficients are obtained by a nonlinear least-squares curve-fitting technique. With prior knowledge of the system order the advantages of using a low peak-factor harmonic test signal for identification instead of the more usual frequency sweeps are demonstrated.
Author

A88-50609*# Cornell Univ., Ithaca, N.Y.
PERFORMANCE LIMITS FOR OPTIMAL MICROBURST ENCOUNTER
MARK L. PSIAKI (Cornell University, Ithaca, NY) and ROBERT F. STENGEL (Princeton University, NJ) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 358-370. FAA-supported research. refs
(Contract NGL-31-001-252)
(AIAA PAPER 88-4367)

An effort has been made to ascertain the envelope-edges for uneventful aircraft penetrations of microburst windshears on the basis of optimal aircraft control strategies. Over 1100 such trajectories have been computed for contemporary airliners and general aviation aircraft, in the case of idealized microbursts, using a successive quadratic program trajectory optimization algorithm able to directly handle inequality constraints. Variations of optimal performance with microburst type, intensity, length scale, and location, define performance limits; these limits fall into short, intermediate, and long microburst length scale regimes. The ability to safely transit a microburst also varies strongly with microburst location.
O.C.

A88-50613*# Massachusetts Inst. of Tech., Cambridge.
FLIGHT TESTING A HIGHLY FLEXIBLE AIRCRAFT - CASE STUDY ON THE MIT LIGHT EAGLE
S. H. ZERWECKH, A. H. VON FLOTOW (MIT, Cambridge, MA), and J. E. MURRAY (NASA, Flight Research Center, Edwards, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 405-414. refs
(AIAA PAPER 88-4375)

This paper describes the techniques developed for a flight test program of a human powered aircraft, the application of these techniques in the winter of 1987/88 and the results of the flight testing. A system of sensors, signal conditioning and data recording equipment was developed and installed in the aircraft. Flight test maneuvers which do not exceed the aircraft's limited capability were developed and refined in an iterative sequence of test flights. The test procedures were adjusted to yield maximum data quality from the point of view of estimating lateral and longitudinal stability derivatives. Structural flexibility and unsteady aerodynamics are modeled in an ad hoc manner, capturing the effects observed during the test flights. A model with flexibility-extended equations of motion is presented. Results of maneuvers that were flown are compared with the predictions of that model and analyzed. Finally the results of the flight test program are examined critically, especially with respect to future applications, and suggestions are made in order to improve maneuvers for parameter estimation of very flexible aircraft.
Author

A88-50614#
EVALUATION OF A NEW SUPERSONIC FLUTTER PREDICTION TOOL
MARK FRENCH (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 415-419.
(AIAA PAPER 88-4376)

As the supersonic flight envelopes of aircraft continue to expand, being able to perform accurate supersonic flutter analyses becomes more of a concern. Although a number of very good subsonic flutter analysis programs are available, results of some supersonic flutter prediction programs have been greeted with some skepticism. The Air Force has sponsored the development of a new multidisciplinary design and analysis program called ASTROS (Automated Structural Optimization System) which includes a new unsteady supersonic aerodynamic analysis package called the Constant Pressure Method (CPM). ASTROS uses a finite element structural package in combination with both subsonic and supersonic unsteady aerodynamic analysis packages to perform flutter analyses. The unique feature of ASTROS is an optimization package which allows the user to perform structural optimization using a variety of different constraints, including flutter and aeroelastic constraints. Since the first version of the production code is complete, it is helpful to present data which demonstrates some of the supersonic flutter analysis capabilities of the system.
Author

A88-50839* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
VIBRATORY RESPONSE OF A STIFFENED, FLOOR EQUIPPED, COMPOSITE CYLINDER
FERDINAND W. GROSVELD (NASA, Langley Research Center; Bionetics Corp., Hampton, VA) and TODD B. BEYER (NASA, Langley Research Center, Hampton, VA) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 812-819. refs
(Contract NAS1-16978)

A structural modal analysis has been performed on a composite, filament wound cylindrical shell with floor, using a Computer Aided Test (CAT) system. The twelve foot (3.66 m) long shell is five and one half feet (1.68 m) in diameter and includes a half inch thick plywood floor attached to the shell 69 degrees from the vertical centerline through the bottom of the shell. The shell is composed of carbon fibers embedded in an epoxy resin. The cylinder is supported by two heavy, rigid endcaps simulating simply supported end conditions. Modal frequencies of the shell and floor have been extracted by measuring the frequency response functions from impulse excitation by an impact hammer. Reasonable agreement is obtained between the measured structural modal frequencies and mode shapes and analytical results from a computerized prediction model. The effects of floor location, fiber orientation, and skin thickness on the resonance frequencies of the shell and floor have been predicted for a stiffened and unstiffened cylinder.
Author

A88-50911#
EFFICIENT SIZING OF A CARGO ROTORCRAFT
WILFRIED H. MEIER and JOHN R. OLSON (United Technologies Corp., Stratford, CT) Journal of Aircraft (ISSN 0021-8669), vol. 25, June 1988, p. 538-543. Previously cited in issue 05, p. 584, Accession no. A87-17918. refs

A88-50917#
PRELIMINARY WEIGHT ESTIMATION OF CONVENTIONAL AND JOINED WINGS USING EQUIVALENT BEAM MODELS
PRABHAT HAJELA (Florida, University, Gainesville) and JAHAU LEWIS CHEN (National Cheng Kung University, Tainan, Republic of China) Journal of Aircraft (ISSN 0021-8669), vol. 25, June 1988, p. 574-576. refs

An efficient approach to obtaining optimum weight estimates of conventional and joined wing structures and is based on representing the detailed FEM models of the structure by means of equivalent beam models. The latter are considered more efficient in an optimization environment that requires repetitive analysis of several candidate designs. A joined wing design is obtained by replacing the horizontal tail in a conventional airplane with a forward-swept wing that is joined to the front wing at the tip or at an intermediate-span station. O.C.

A88-51008
ELECTRONICS ON THE EJECTION SEAT
SIMON HELLYER and CLIVE SHERHOD (GEC Avionics, Ltd., Instrument Systems Div., Rochester, England) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1988, p. 874-880. Research supported by the Ministry of Defence Procurement Executive.

The objective of the escape system is to eject the crewman from the aircraft, decelerate the seat, and get the crewman onto a fully open parachute without causing injurious loads. The ejection process is summarized and common difficulties that may occur with current seats are identified. Improvements using electronic circuitry to enhance the performance of the standard ejection sent are specified along with additional improvements that can be made through a revision of the overall ejection system concept, in particular, by integration of the seat sequencer to the aircraft avionics. I.E.

A88-51185
VARIABLE WING CAMBER FOR TRANSPORT AIRCRAFT
J. SZODRUCH and R. HILBIG (Messerschmitt-Boelkow-Blohm GmbH, Bremen, Federal Republic of Germany) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 25, no. 3, 1988, p. 297-328. refs

The long-term increasing fuel prices and their relatively large share in the Direct Operating Costs on the one hand, and the continuously changing market requirements with respect to payload, range etc. on the other hand, are a challenge for aeronautical research and aircraft design, respectively. At present the aircraft manufacturers' solution is the development of an increasing number of variants and derivatives, although this is not always the most economical way to solve the problem. Thus it is desirable to find technologies which not only provide potentials for performance improvements but also increase the operational flexibility for new aircraft designs. The variable wing camber concept described in this paper represents a promising contribution to this target. In detail the discussion concentrates on basic phenomena, various wind tunnel results with wings of different camber, wing design philosophy, systems requirements and finally the benefits of new wing concept. Author

A88-51330#
SOME CONSIDERATIONS FOR INTEGRATING AEROELASTICITY IN CAE
M. H. LOVE, R. T. MILBURN, and W. A. ROGERS (General Dynamics Corp., Fort Worth, TX) ASME, Winter Annual Meeting, Boston, MA, Dec. 13-18, 1987. 10 p. refs
(ASME PAPER 87-WA/AERO-10)

This paper discusses the process of testing the sensitivity of aircraft design to specific aeroelastic phenomena, such as flutter, control surface effectiveness, divergence, and lift-induced drag. The results of the incorporation of these parameters into the design process by means of formal optimization and analysis integration are presented. It is shown that the role that aeroelasticity will play in the design of future aircraft is a function of vehicle type and mission. I.S.

A88-51398
A330/A340 - THE AIRBUS FAMILY GROWS AND GROWS
Air International (ISSN 0306-5634), vol. 35, Sept. 1988, p. 122-125, 128-131, 134.

An account is given of the design features, performance capabilities, and commercial prospects for the four-engined A340-300 (large capacity) and A340-200 (intermediate capacity) airliners, and the two-engined A-330 airliner. The A330 uses the same wing, empennage, systems and cockpit as the A340 variants, as well as the same basic fuselage, with a length that is intermediate between the two A340s. The 31,200-lb static thrust CFM56-5C2 engine is assumed as the basis of propulsion for these aircraft. The A340 and A330 programs were launched simultaneously in May 1987; as of September 1988, there are 71 firm orders and 37 options for the A340, and 12 firm orders and 29 options for the A330. O.C.

A88-51399
GREEN LIGHT FOR EFA
Air International (ISSN 0306-5634), vol. 35, Sept. 1988, p. 147-152, 154, 155.

The full-scale development of the European Fighter Aircraft (EFA) began in May 1988. An account is presently given of both the development history and design features of this single-seat, twin-engined canard configuration aircraft, whose construction will involve the participation of German, British, Italian, and Spanish manufacturers; the air forces of these four countries will collectively take delivery of 800 EFAs. The basic configuration is optimized for the air-to-air combat role, with ground attack relegated to a secondary role. The chin-inlet used by the configuration ensures alpha-insensitive airflow; the airframe makes extensive use of CFRP and Al-Li alloys. O.C.

A88-51426
1987 REPORT TO THE AEROSPACE PROFESSION; SOCIETY OF EXPERIMENTAL TEST PILOTS, SYMPOSIUM, 31ST, BEVERLY HILLS, CA, SEPT. 23-26, 1987, PROCEEDINGS
Symposium sponsored by the Society of Experimental Test Pilots. Lancaster, CA, Society of Experimental Test Pilots, 1987, 312 p. For individual items see A88-51427 to A88-51442.

The present conference discusses propfan test assessment, A320 airliner development and flight test results, the B7J7's FBW control system development, cockpit design concepts for nap-of-the-earth helicopters, the F-15 adaptive engine control system's flight test results, and the nature of 'skunk works' prototyping. Also discussed are initial flight test results for the F-15E, the F-14's yaw vane technology demonstration program, flight tests of the Rafale fighter, a flight test report for the EAP fighter prototype, the Lavi fighter flight test program, flight research with the MIT Daedalus prototype, a history of the X-15 program, the challenge posed by X-30 flight testing, and the circumnavigational flight strategy of the Voyager. O.C.

A88-51428
MD-11 STATUS REPORT
JOHN I. MILLER (Douglas Aircraft Co., Long Beach, CA) IN: 1987 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 31st, Beverly Hills, CA, Sept. 23-26, 1987, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1987, p. 13-32.

The MD-11 derivative of the DC-10 will include among its certification tasks the validation of a full-time Longitudinal Stability Augmentation System by which the pilot is kept in the loop, and retains that ability to override the envelope-protection that is provided by the system, if required. A six-CRT cockpit has been designed for two-pilot crew operation without workload increase, by automating the duties of the flight engineer in not only normal but abnormal and even emergency operations. Attention is presently given to both system controller development results and the form taken by such configurational features as winglets, an advanced-technology horizontal tail, and the two candidate engines. O.C.

A88-51431
MBB HELICOPTER FLIGHT TEST AND SIMULATION ACTIVITIES
HELMUT RUECKERT and ANDREW WARNER (Messerschmitt-Boelkow-Blohm GmbH, Munich, Federal Republic of Germany) IN: 1987 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 31st, Beverly Hills, CA, Sept. 23-26, 1987, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1987, p. 76-94.

This paper describes several of the recent activities carried out at the MBB helicopter flight test facility which is co-located with MBB headquarters at Ottobrunn on the southern outskirts of Munich. Apart from the development of the existing BO 105 and BK117 helicopters, flight and simulator testing is carried out to examine new concepts which are to be integrated into future aircraft such as the PAH II attack helicopter and the NH 90 medium transport helicopter. Author

A88-51432
COCKPIT CONCEPTS FOR NAP OF THE EARTH HELICOPTERS
NICHOLAS D. LAPPOS (United Technologies Corp., Sikorsky Aircraft, Stratford, CT) IN: 1987 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 31st, Beverly Hills, CA, Sept. 23-26, 1987, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1987, p. 95-113.

An account is given of a helicopter nap-of-the-earth (NOE)-flying-oriented cockpit-design concept predicated on (1) 'artificially intelligent' processing for screening and preparing information; (2) advanced control laws which reduce flight path control pilot workloads; and (3) advanced input/output methods that reduce crew cognitive burdens. The NOE control systems evaluated to date share some common properties, such as high stability, docile handling qualities, and some degree of heading and ground velocity hold. With 'AI-assistant' technology, the NOE hover/low speed control laws can be rapidly changed through a scheme that 'folds in' tactical data and pilot requests. O.C.

A88-51435
F-15E INITIAL FLIGHT TEST RESULTS
STEPHEN D. STOWE (USAF, Edwards AFB, CA) and GARY JENNINGS (McDonnell Douglas Corp., Saint Louis, MO) IN: 1987 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 31st, Beverly Hills, CA, Sept. 23-26, 1987, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1987, p. 171-186. refs

The F-15E Dual-Role Fighter's initial flight test results indicate a reduction in directional stability due to the LANTIRN pod installation. The two-seat aircraft's highly 'missionized' cockpits allow the crew to use a range of weapons that encompasses the GBU-15, the Maverick missile, laser-guided bombs, and nuclear stores; automatic terrain following for all-weather/night penetration missions is also incorporated. The APG-70 multimode radar possesses Doppler high-resolution mapping for target search and cueing. The Automatic Flight Control Set is based on a triplex digital flight control computer. O.C.

A88-51436
F-14A YAW VANE TECHNOLOGY DEMONSTRATION PROGRAM
JEFFREY W. SAPPINGTON and ROBERT L. THOMPSON (U.S. Navy, Strike Aircraft Test Directorate, Patuxent River, MD) IN: 1987 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 31st, Beverly Hills, CA, Sept. 23-26, 1987, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1987, p. 187-200.

As short-range fighter engagements drift to lower speeds, and medium range/beyond visual range combat occurs at faster speeds, it will become imperative to develop advanced flight control and propulsion/aerodynamic control-blending schemes. An account is presently given of the F-14A's Yaw Vane Technology Demonstration Program, which has evaluated the use of thrust-vectoring vanes to deflect engine exhaust gases on a horizontal plane, to generate yawing motion. Attention was given to the yaw vane device's mechanical and thermal characteristics, its contribution to aircraft performance and handling qualities, and its utility in combat maneuvering. O.C.

A88-51437
FLIGHT TESTING THE RAFALE
GUY MITAUX-MAUROUARD (Avions Marcel Dassault Breguet Aviation, Vaucresson, France) IN: 1987 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 31st, Beverly Hills, CA, Sept. 23-26, 1987, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1987, p. 201-223.

The Rafale A next-generation fighter technology demonstration aircraft has completed 155 flight test sorties during its first 12 months of operation. The tests were concerned with such diverse high-technology features of the design as an electronic flight control system (EFCS), a highly reclined ejection seat for the pilot, engine air intake behavior during in-flight restarts and high-alpha maneuvering, flight envelope extension, and both air force and navy evaluation for specific combat capabilities. Attention was given to the flying quality results of the EFCS's software. O.C.

A88-51438
EAP FLIGHT TEST REPORT
PETER ORME (British Aerospace, PLC, London, England) IN: 1987 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 31st, Beverly Hills, CA, Sept. 23-26, 1987, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1987, p. 224-235.

The EAP next-generation fighter technology integration testbed aircraft has been subjected to a series of flight tests that emphasized high-alpha maneuvering and general handling qualities, while noting the effects of the incorporated configurational and component features on both overall performance and pilot workload. The unstable, delta-canard configuration yielded excellent turning performance at both subsonic and supersonic speeds; a digital, full-authority quadruplex FBW FCS allowed scheduling of control surface movement for optimum performance as a function of alpha, Mach number, and altitude. O.C.

A88-51450
SOCIETY OF FLIGHT TEST ENGINEERS, ANNUAL SYMPOSIUM, 18TH, AMSTERDAM, NETHERLANDS, SEPT. 28-OCT. 2, 1987, PROCEEDINGS
Symposium organized by the Netherlands Association of Aeronautical Engineers; Sponsored by the Society of Flight Test Engineers. Lancaster, CA, Society of Flight Test Engineers, 1987, 372 p. For individual items see A88-51451 to A88-51486.

Various papers on flight testing are presented. Among the subjects considered are: new techniques in flight testing, update on rotorcraft icing technology, computational fluid dynamics in flight test, identification of aerodynamic coefficients by means of measured flight loads, identification of the DLC-flap system of the research aircraft ATTAS, modeling V/STOL takeoff performance, data acquisition system for the Fokker 100 test aircraft, airborne data monitoring system, image processing as a tool in flight test evaluation, application of video as navigation system test instrumentation. Also discussed are: electrooptical flight deflection measurement system, flight test of the Advanced Electromechanical Actuation System, electromagnetic compatibility and the flight test engineer, UDF flight test program, NATO E-3A production acceptance testing, certification flight tests of the Conair/Fokker F-27 Firefighter, Fokker-50 and Fokker-100 flight test program, U.S. Air Force Flight Test Center, inertial measurement of airfield performance, instrumentation for ULM and hang-glider flight tests, the Aeritalia solution for flight test data acquisition and processing, terrain-following subsystem testing and development of maneuver loads spectrum for F-7 aircraft. C.D.

A88-51453
TEST PLANNING FOR THE SHORT TAKEOFF AND LANDING/MANEUVER TECHNOLOGY DEMONSTRATOR (STOL/MTD)
PAUL W. KIRSTEN (USAF, Flight Test Center, Edwards AFB, CA) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 3-1 to 3-9.

The STOL/MTD is a highly modified F-15 incorporating four new technologies: integrated flight and propulsion controls, thrust vectoring and reversing engine nozzles, advanced pilot/vehicle interface, and soft/rough field landing gear. In addition, the configuration includes a canard to enhance lift and maneuverability. The flight test program is designed to evaluate and demonstrate these four technologies singularly and in combination in 100 flights spanning no more than 13 months. Because of this ambitious schedule, an innovative approach to flight testing is being planned. A four-element flow chart has been developed which defines parallel flow paths of takeoff, landing rollout, approach and touchdown, and up-and-away flight testing segments. Parallel segments allow testing of different disciplines to be alternated throughout the program, thereby minimizing down-time due to data analyses and turnaround. Testing in each segment is oriented toward a limited number of specific program goals defined by the original contract. Success criteria have been established for major steps in the testing process which will be used to define when it is acceptable to proceed to the next step. Minimum emphasis will be placed on optimization of design. Author

A88-51454
NEW TECHNIQUES IN FLIGHT TESTING
BYRON BILLINGSLEY (Boeing Commercial Airplane Co., Seattle, WA) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 4-1 to 4-6.

Improvements being made in aircraft testing techniques to meet new requirements for faster data availability are discussed. New data acquisition systems and advances in the use and calibration of sensors are examined. Progress made in real time data monitoring and in data analysis techniques are considered. C.D.

A88-51457
COMPUTATIONAL FLUID DYNAMICS IN FLIGHT TEST
E. G. HERNANDEZ and J. G. CANCLINI (USAF, Wright-Patterson AFB, OH) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 8-1 to 8-9. refs

This paper discusses the computational aerodynamic capability currently being established at the 4950th Test Wing, Wright Patterson AFB, Ohio. This capability will improve aircraft modification and flight testing. The five simulation levels of computational fluid dynamics (CFD) are first discussed. Next, the benefits CFD can provide to flight testing are addressed. The hardware and software used in the Test Wing's Computational Aerodynamics Workstation (CAW) is described. The paper then details how CFD analysis was used to identify pitot-static impact pressure errors and shock wave formation on EC-18B aircraft. Finally, plans are presented detailing how the Test Wing will take advantage of future improvements in CFD software, hardware, computers, and communications. Author

A88-51459
ON THE IDENTIFICATION OF AERODYNAMIC COEFFICIENTS BY MEANS OF MEASURED FLIGHT LOADS
M. SCHMUECKER (Messerschmitt-Boelkow-Blohm GmbH, Bremen, Federal Republic of Germany) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 11-1 to 11-10. refs

An appropriate method for measuring component loads during a flight test is described. Appropriate installation for the method is summarized, and the instrumentation is discussed, including on-line limit warning, load verification, data verification, and identification of load-determining parameters and of main aerodynamic coefficients. Operational loads monitoring is addressed. C.D.

A88-51460
IDENTIFICATION OF THE DLC-FLAP SYSTEM OF THE RESEARCH AIRCRAFT ATTAS
D. ROHLF and W. MOENNICH (DFVLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 12-1 to 12-8. refs

The Direct Lift Control (DLC) flap system of the Advanced Technologies Testing Aircraft System (ATTAS) research aircraft is discussed. The determination of a simplified equivalent model of the DLC-flap actuator system and the estimation of the aerodynamic DLC flap efficiency at three different landing flap positions are examined. A simplified equivalent model for the actuator system is proposed in two phases, considering a linear system in the frequency domain and a nonlinear system in the time domain. The maximum likelihood method is used for system identification in both cases. C.D.

A88-51461* San Jose State Univ., Calif.
DETERMINATION OF ROTOR DERIVATIVES AND ROTOR HUB FORCE AND MOMENT DERIVATIVES FROM FLIGHT MEASUREMENTS WITH THE RSRA COMPOUND HELICOPTER
JI C. WANG (San Jose State University, CA) and PETER D. TALBOT (NASA, Ames Research Center, Moffett Field, CA) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 13-1 to 13-17. refs
(Contract NCC2-267)

A case study of the application of an integrated rotorcraft identification method to the linear modeling of rotor system dynamics and rotor hub loads is presented. Applying the method to flight data obtained from the RSRA compound helicopter, the rotor derivatives in the rotor state dynamic equation are identified along with blade equivalent damping and spring periodic coefficients. A rigid blade flapping equation of motion can be derived from the identified rotor state equation. It is shown that the concept of rotor hub load derivatives is useful for small maneuvering loads. The hub load derivatives can be used to relate the hub dynamic load to rotor/fuselage motion and applied inputs. C.D.

A88-51462
APPLICATION OF COMPLEMENTARY PARAMETER IDENTIFICATION TECHNIQUES TO FLIGHT TEST DATA OF A TRANSPORT AIRCRAFT
B. KRAG (DFVLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany), M. LABARRERE (ONERA, Centre d'Etudes et de Recherches de Toulouse, France), G. W. FOSTER (Royal Aircraft Establishment, Bedford, England), and J. H. BREEMAN (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 14-1 to 14-12. refs

This paper reports the experience which was gained from the application of several different Parameter Identification techniques to the same set of flight test data. These PI-techniques and the corresponding approaches are explained and a selection of the results of the identification is presented. It is shown that differences in the results can be attributed to the different models employed and the ways in which the results of the preceding Flight Path Reconstruction were considered by the analysts. Author

A88-51463
DETERMINATION OF THE MATHEMATICAL MODEL FOR THE NEW DUTCH GOVERNMENT CIVIL AVIATION FLYING SCHOOL FLIGHT SIMULATOR
J. A. MULDER, M. BAARSPUL (Delft, Technische Hogeschool, Netherlands), J. H. BREEMAN, A. M. H. NIEUWPOORT (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands), J. P. T. VERBRAAK (Rijksluchtvaartschool, Eelde, Netherlands) et al. IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 15-1 to 15-10. refs

In the spring of 1986 the Dutch Government Civil Aviation Flying School (RLS) decided to purchase an FAA Phase II flight simulator for the Cessna Citation 500 business jet, used in the final part of civil aviation pilot training. The objective was to transfer part of the type-training from the aircraft to the simulator, enabling the RLS to reduce its fleet from six to three aircraft. For the Citation 500, which was developed in the late sixties, no adequate mathematical model and data package were available. Therefore, the National Aerospace Laboratory (NLR) and the Faculty of Aerospace Engineering of Delft University of Technology (DUT) were selected to execute a flight test program, identify mathematical models of aerodynamic forces and moments, engine performance characteristics, flight control system and landing gear and to evaluate the models with off-line and pilot-in-the-loop-real-time simulations. In the paper the emphasis is on the flight test program, the high accuracy flight test measurement system and the system identification techniques applied to synthesize the mathematical models. Author

A88-51464
MODELLING V/STOL TAKE-OFF PERFORMANCE
K. R. NIPPRESS (Aeroplane and Armament Experimental Establishment, Salisbury, England) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 16-1 to 16-8.

An attempt to derive a mathematical model of a V/STOL attack aircraft for takeoff and ship launch phases is described. The reasons for modeling the performance rather than relying on a purely empirical approach are discussed, and the parameter identification process is outlined from the viewpoint of a practicing flight engineer. The use of the least squares regression technique is found to be a useful tool which enables the efficient matching of the model response to flight data, resulting in the production of an 'optimum' model. The model derived by the matching process could be used successfully to predict aircraft performance during takeoff and launch maneuvers and to investigate the effects of varying parameters on performance. C.D.

A88-51471
FLIGHT TEST OF THE ADVANCED ELECTROMECHANICAL ACTUATION SYSTEM
WILLIAM J. NORTON (USAF, Wright-Patterson AFB, OH) and GRAHAM BRADBURY (Sundstrand Corp., Rockford, IL) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 23-1 to 23-12. USAF-sponsored research.

An electromechnical aileron actuator was tested on a C-141 aircraft to demonstrate in flight for the first time the feasibility of driving a primary flight control surface with such a device. The aircraft modification included replacing a single hydromechanical actuator with the test item and adding test instrumentation. The testing consisted of a ground checkout phase followed by an airborne phase including airworthiness and roll performance trials. Important lessons were learned for future efforts of this kind, including installation and maintenance factors and performance characteristics. Except for minor deviations, the electromechanical actuator duplicated the operation of the hydraulic unit. The success of the project stands as a major milestone toward the goal of achieving an all electric airplane. Author

A88-51472
ELECTROMAGNETIC COMPATIBILITY AND THE FLIGHT TEST ENGINEER
M. B. REDMAN (Aerospace and Armament Experimental Establishment, Boscombe Down, England) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 24-1 to 24-5.

The aspects of flight testing of engine control systems and flight control systems are discussed, with special consideration given to methods used to produce both subjective and qualitative data on the behavior of the aircraft during exposure to RF electromagnetic energy in a controlled flight test program. Criteria for flight testing are examined together with activities involved in flight planning, flight test assessment, and post-flight analysis. Special attention is given to the evaluation of the effects of EMI and its mechanisms. I.S.

A88-51476
CERTIFICATION FLIGHT TESTS OF THE CONAIR/FOKKER F-27 FIREFIGHTER
J. C. T. MARTIN (Transport Canada, Ottawa) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 29-1 to 29-6.

This paper includes a brief discussion of the development of firefighting aircraft in Canada and Conair's conversion of the Fokker F-27 civil transport aircraft to the F-27 Firefighter. The Transport Canada certification flight tests are described with emphasis on the specialized controllability and performance tests. Author

A88-51477
THE FOKKER-50 AND FOKKER-100 FLIGHT TEST PROGRAM
J. VAN TWISK (Fokker Aircraft, Schiphol, Netherlands) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 30-1 to 30-8.

Flight test results for the Fokker-50 and Fokker-100 programs are presented, and differences in the progress between the two programs are pointed out. Due to added-on system changes, such as the introduction of electronic flight instruments, adoption of the dark cockpit philosophy, and replacement of the pneumatic system by a hydraulic system, the F-50 program was delayed and incomplete, and only limited test results were obtained. The F-100 program, though delayed, was completed, and the F-100 tests demonstrated excellant flight behavior. R.R.

A88-51479
INERTIAL MEASUREMENT OF AIRFIELD PERFORMANCE
MARTIN E. ESHELBY (Cranfield Institute of Technology, England) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 33-1 to 33-7.

This paper discusses the practical aspects of using inertial data to reconstruct the flight path of an aircraft for the purpose of assessing airfield performance. Examples of a take-off and a landing measured by inertial techniques and by kinetheodolite are compared and show that the inertial technique is potentially capable of providing evidence of airfield performance of a standard similar to the kinetheodolite. In addition to the flight path data, attitude and velocity data are produced which provides positive evidence of performance events and piloting techniques. Recommendations are made for further development of the technique. Author

A88-51480
METHOD FOR THE DETERMINATION AND OPTIMIZATION OF VECTORED THRUST TAKEOFF PERFORMANCE
J. F. CALVERT (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 34-1 to 34-10.

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

A88-51481
MILITARY AIRCRAFT TESTING TECHNIQUES FOR SUB-STANDARD RUNWAY OPERATIONS
C. J. BRAIN (Aeroplane and Armament Experimental Establishment, Boscombe Down, England) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 35-1 to 35-5.

The specialized techniques necessary to conduct safe efficient trials of military aircraft operations from critical substandard runway surfaces are discussed, based upon results obtained covering operations in a wide range of cases including grass runways, aluminum matting ruways, and simulated bomb-damaged-runway repairs. Topics reviewed include trials planning, the identification of critical areas, computer simulation modelling, instrumentation transducers, and flight testing. Also considered are computer simulation validation and the application of validated computer models to provide accurate operational data. General applications of the techniques are pointed out, such as the management of integrated flight test and computer simulation clearance programs. R.R.

A88-51484
TERRAIN FOLLOWING SUBSYSTEM TESTING FROM SIMULATION TO RESULTS
D. R. STROUP and J. N. T. ABANERO (USAF, Edwards AFB, CA) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 38-1 to 38-11. refs

The flight test methodology used during the evaluation of the automatic terrain following/terrain avoidance subsystem of the F/FB-111 aircraft is described, with special attention given to the test procedures, data processing, and data analysis. The roles of simulations and statistical techniques used to determine performance repeatability and deviations during tests are discussed. The results of 96 flight test missions, including more than 700 test runs over terrain segments ranging from flat to mountainous (with set clearances as low as 200 feet above ground level) are summarized. The techniques and the methodology developed during the F/FB-111 flight tests is currently being applied to the B-1B and F-15E flight test programs. I.S.

A88-51486
DEVELOPMENT OF MANEUVER LOADS SPECTRUM FOR F-7 AIRCRAFT
SHUNQI HUANG (China Flight Test Research Center, Xian, People's Republic of China) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 41-1 to 41-4.

This paper describes an approach for obtaining a maneuver loads spectrum for F-7 aircraft according to the flight-by-flight method. First, the mission segment spectra are developed based on the mission profiles, and the mission spectra and the compound maneuver spectrum are then derived. The compound maneuver spectrum is compared with those loads spectra of three types of aircraft. The comparison indicates that this spectrum represents the operational status of F-7 aircraft and that this approach is feasible. Author

A88-51498
AEROELASTIC STABILITY OF ROTOR BLADES BY LIFTING SURFACE THEORY AND FINITE ELEMENT METHOD
CHANGQING FU and SHICUN WANG (Nanjing Aeronautical Institute, People's Republic of China) Vertica (ISSN 0360-5450), vol. 12, no. 1-2, 1988, p. 27-37. refs

The finite element formulation based on the principle of minimum potential energy for the spatial discretization of the equations of motion governing rotor blade aeroelastic problems is presented. A numerical lifting surface method based on the velocity potential is used to evaluate the unsteady airloads on a hovering rotor in compressible flow. The blade is divided into a number of equally spaced elements. Instead of the Hermite polynomials in helicopter dynamics new polynomials are used to define the shape functions so as to reduce both the computer storage and time required. The equations of motion are linearized assuming blade motion to be a small perturbation about the steady deflected shape. The flutter equations of motion are solved in an iterative modification of the conventional V-g method. The formulation is applied to hingeless helicopter rotor blades. Numerical results show a sensitivity of the aeroelastic stability boundaries to the unsteady airloads. Author

A88-51499
TIME-DOMAIN UNSTEADY AERODYNAMICS OF ROTORS WITH COMPLEX WAKE CONFIGURATIONS
WAYNE JOHNSON (Johnson Aeronautics, Palo Alto, CA) Vertica (ISSN 0360-5450), vol. 12, no. 1-2, 1988, p. 83-100. refs

A theory for thime-domain unsteady aerodynamics of rotary wings is developed and illustrated. The method is suitable for calculating the aeroelastic behavior of wings with complex wake configurations. The principal assumption is the existence of an incompressible wake of concentrated vorticity. The wing theory must be formulated in terms of the wake-induced downwash. Then the wake theory gives a linearized relation between the downwash and the wing bound circulation, in terms of the impulse response obtained directly in the time domain. This approach makes it possible to treat general wake configurations, including distorted wake geometry, rolled up tip vortices, multiple blades, and time-varying geometry. The impulse response can be related to the influence coefficients of a nonlinear wake model, allowing direct use of existing sophisticated wake models. Implementation of the wake theory, including model order reduction, is discussed. Examples are presented of the impulse response for elementary rotor configurations, and a computational example is given for a helicopter rotor in forward flight. Author

A88-51754* Boeing Helicopter Co., Philadelphia, Pa.
DEVELOPMENT OF AN ADVANCED HIGH-SPEED ROTOR - FINAL RESULTS FROM THE ADVANCED FLIGHT RESEARCH ROTOR PROGRAM
MARK JENKS (Boeing Helicopter Co., Philadelphia, PA) and LEONARD HASLIM (NASA, Ames Research Center, Moffett Field, CA) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 17 p. refs

The final results of the Advanced Flight Research Rotor (AFRR) study, a NASA sponsored research program, are summarized. First, the results of the initial phase of the AFRR program, consisting of the definition of a conventional rotor with planform and prescribed twist distributions, are briefly reviewed. The mechanism of the calculated performance benefit is then explained, and a detailed analysis of the prescribed twist distribution is presented. Recommendations are made on the practical means of approximating the prescribed twist on the actual rotor. V.L.

A88-51759
THE INFLUENCE OF INTERACTIONAL AERODYNAMICS IN ROTOR/FUSELAGE COUPLED RESPONSE
OMRI RAND (Maryland, University, College Park) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 12 p. refs

The paper presents a model which enables the exploration of the influence of rotor/fuselage interactional aerodynamics on the coupled vibratory response. The model is based on harmonic representation of the involved parameters and the overall solution is achieved by rotor/body iterations and harmonic balance. Rotor loads calculations are based on unsteady strip theory. Wake is represented by an improved vortex rings model. The modeling of the fuselage aerodynamic influence consists of a superposition of the influence of free stream velocity, fuselage yaw angle, rotor downwash and other contributions. The rotor and fuselage structural/dynamic behavior is based on beam models. The blade structural model includes elastic and rigid flapping motions. The fuselage model consists of vertical elastic and rigid body heaving and pitching motions. Rotor/fuselage coupling includes hub loads and reactions, in addition to unsteady induced loads over the fuselage surface. The model provides insight to the problem and improves the understanding of the interactional effects and their relative importance. Author

A88-51763* Maryland Univ., College Park.
AIR RESONANCE OF AN ADVANCED BEARINGLESS ROTOR IN FORWARD FLIGHT
JINSEOK JANG and INDERJIT CHOPRA (Maryland, University, College Park) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 9 p. refs
(Contract NAG2-409; DAAG29-83-K-0002)

The air resonance of an advanced bearingless rotor in forward flight is investigated using a finite element formulation in space and time. The flexbeam, the torque tube, and the outboard blade are modeled as individual elastic beams, and the formulation includes five rigid body degrees of motion. It is shown that a large increase in stability is achieved by increased negative pitch-lag coupling arising from the vertical offset of the cuff restraint pin. It is also shown that body inertia has a significant effect on stability. V.L.

A88-51764* Kaman Aerospace Corp., Bloomfield, Conn.
EFFICIENT ASSEMBLY OF FINITE-ELEMENT SUBSYSTEMS WITH LARGE RELATIVE ROTATIONS
JON-SHEN FUH, BRAHMANANDA PANDA (Kaman Aerospace Corp., Bloomfield, CT), and DAVID A. PETERS (Georgia Institute of Technology, Atlanta) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 14 p. refs
(Contract NAS2-12340)

A finite element approach is presented for the modeling of rotorcraft undergoing elastic deformation in addition to large rigid body motion with respect to inertial space, with particular attention given to the coupling of the rotor and fuselage subsystems subject to large relative rotations. The component synthesis technique used here allows the coupling of rotors to the fuselage for different rotorcraft configurations. The formulation is general and applicable to any rotorcraft vibration, aeroelasticity, and dynamics problem. V.L.

A88-51765* California Univ., Los Angeles.
INFLUENCE OF TIME DOMAIN UNSTEADY AERODYNAMICS ON COUPLED FLAP-LAG-TORSIONAL AEROELASTIC STABILITY AND RESPONSE OF ROTOR BLADES
P. P. FRIEDMANN and L. H. ROBINSON (California, University, Los Angeles) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 11 p. refs
(Contract NAG2-209; NAG2-477)

This paper describes the incorporation of finite-state, time-domain aerodynamics in a flag-lag-torsional aeroelastic stability and response analysis in forward flight. Improvements to a previous formulation are introduced which eliminate spurious singularities. The methodology for solving the aeroelastic stability and response problems with augmented states, in the time domain, is presented using an implicit formulation. Results describing the aeroelastic behavior of soft and stiff in-plane hingeless rotor blades, in forward flight, are presented to illustrate the sensitivity of both the stability and response problems to time domain unsteady aerodynamics. Author

A88-51766* Analytical Services and Materials, Inc., Hampton, Va.
MINIMUM WEIGHT DESIGN OF RECTANGULAR AND TAPERED HELICOPTER ROTOR BLADES WITH FREQUENCY CONSTRAINTS
ADITI CHATTOPADHYAY (Analytical Services and Materials, Inc., Hampton, VA) and JOANNE L. WALSH (NASA, Langley Research Center, Hampton, VA) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 13 p. Previously announced in STAR as N88-19465. refs

The minimum weight design of a helicopter rotor blade subject to constraints on coupled flap-lag natural frequencies has been studied. A constraint has also been imposed on the minimum value of the autorotational inertia of the blade in order to ensure that it has sufficient inertia to aurorotate in the case of engine failure. The program CAMRAD is used for the blade modal analysis and CONMIN is used for the optimization. In addition, a linear approximation analysis involving Taylor series expansion has been used to reduce the analysis effort. The procedure contains a sensitivity analysis which consists of analytical derivatives of the objective function and the autorotational inertia constraint and central finite difference derivatives of the frequency constraints. Optimum designs have been obtained for both rectangular and tapered blades. Design variables include taper ratio, segment weights, and box beam dimensions. It is shown that even when starting with an acceptable baseline design, a significant amount of weight reduction is possible while satisfying all the constraints for both rectangular and tapered blades. Author

A88-51767
EXPERIMENTAL VERIFICATION OF OPTIMIZED HELICOPTER DRIVESHAFT DESIGNS
ROBERT F. KRAUS, MARK S. DARLOW, WILLIAM P. CONLEY, and PATRICIA L. JONES (Rensselaer Polytechnic Institute, Troy, NY) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 6 p. refs
(Contract DAAG29-82-K-0093)

An analytical and experimental program to investigate the rotordynamic behavior of supercritical, aluminum and composite driveshafts for helicopter applications is in progress. Weight optimized results for a helicopter drive system are presented with either a single mid-span bearing or none at all. As a consequence, the flexural rigidity of these shafts is small, and multiple critical speeds occur between rest and the operating speed. Uncertainties in the ability to manufacture, balance, and operate supercritical composite shafts motivates the experimental program to study their dynamic performance. All experiments are conducted at model scale. Test shafts include composite shafts braided using carbon fiber and epoxy resin, and an aluminum power transmission shaft. The benefits of this research are: (1) the fewer support bearings used, and the lighter shaft in the drive system, the less that the system weighs; and (2) as the number of components decreases, the maintenance costs also decrease and the system reliability increases. Author

A88-51768* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ADVANCEMENTS IN FREQUENCY-DOMAIN METHODS FOR ROTORCRAFT SYSTEM IDENTIFICATION
MARK B. TISCHLER (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 18 p. refs

A new method for frequency-domain identification of rotorcraft dynamics is presented. Nonparametric frequency-response identification and parametric tranfer-function modeling methods are extended to allow the extraction of state-space (stability and control derivative) representations. An interactive computer program DERIVID is described for the iterative solution of the multi-input/multi-output frequency-response matching approach used in the identification. Theoretical accuracy methods are used to determine the appropriate model structure and degree-of-confidence in the identified parameters. The method is applied to XV-15 tilt-rotor aircraft data in hover. Bare-airframe stability and control derivatives for the lateral/directional dynamics are shown to compare favorably with models previously obtained using time-domain identification methods and the XV-15 simulation program. Author

A88-51769
SOME BASIC ISSUES IN HELICOPTER SYSTEM IDENTIFICATION
P. M. FITZSIMONS, D. TEARE, J. V. R. PRASAD, D. P. SCHRAGE, and B. H. TONGUE (Georgia Institute of Technology, Atlanta) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 10 p. refs
(Contract DAAL03-86-K-0160)

Significant advancement has been made in the field of aircraft state estimation and parameter identification for fixed wing aircraft over the last two decades. By comparison, the progress for rotary wing aircraft has been relatively slow due to important issues and problems which need to be resolved. A highly coupled, high order system which is basically unstable summarizes some of the important issues and problems. Other issues, which are more basic, deal with the type of input used to excite the system, length of the signal used, consistency checks, and the handling of errors. This paper will address some of the basic issues in helicopter system identification using simulated and flight test data for the UH-60A Black Hawk helicopter. Author

A88-51782
BLADE VIBRATION REDUCTION USING MINIMIZED ROTOR HUB FORCES APPROACH
FU-SHANG WEI and ROBERT JONES (Kaman Aerospace Corp., Bloomfield, CT) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 9 p. refs

Blade vibration reduction, via optimal trailing edge servo flap reflex angle, has been successfully analyzed on a pitch horn rotor. The existing SH-2F helicopter rotor system and blade properties are used in the analysis. The rotor control spring rate is modified to have a feathering frequency of 4.2/rev for a metal blade and 3.7/rev for a composite blade. The trailing edge flap is treated as an adaptively controlled reflex angle at 75 percent radius of the main rotor. Three different airfoils and ballast weight configurations are investigated to assess their influence on vibration levels. The trailing edge flap angle has shown significant effects on blade airloads distribution and vibration levels. The total 4/rev vertical hub shears in the fixed system can be reduced by 78 percent, as compared to the baseline values. Also, the total blade vibratory bending moments along the radial direction are reduced by up to 54 percent. From the analytical results, this approach can be used in rotor development flight tests to reduce blade bending moments and fuselage vibration. Author

A88-51783* Princeton Univ., N. J.
A LINEARIZED MODEL OF HELICOPTER DYNAMICS INCLUDING CORRELATION WITH FLIGHT TEST
H. C. CURTISS (Princeton University, NJ) and XIN ZHAO IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 14 p. refs
(Contract NAG2-244)

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

A88-51786
ROTARY WING TEST TECHNOLOGY; PROCEEDINGS OF THE NATIONAL SPECIALISTS' MEETING, BRIDGEPORT, CT, MAR. 15, 16, 1988
Meeting sponsored by AHS. Alexandria, VA, American Helicopter Society, 1988, 261 p. For individual items see A88-51787 to A88-51812.

The conference presents papers on CAFTA-Bell's V-22 flight test data processing and analysis system, a fixed base data system, the use of real-time data analysis techniques on the V-22 Osprey program, SPATE as a noncontact NDI tool, a pilot survey method of helicopter mission spectra development, and Navy helicopter structural demonstrations. Other topics include US Navy vibration analysis evaluation for helicopter gearboxes, bench test demonstration of a main rotor damper isolation system, and aerial combat testing of the AH-64A Apache. Consideration is also given to damage tolerance testing of the S-76 composite tail rotor spar, measurement of tooth root stress due to dynamic gear response, and ACAP airframe crashworthiness demonstration. K.K.

A88-51787
CFTA - BELL'S V-22 FLIGHT TEST DATA PROCESSING AND ANALYSIS SYSTEM
RANDALL C. SMITH (Bell Helicopter Textron, Fort Worth, TX) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. I-1 to I-9.

Bell Helicopter-Textron is nearing completion on the development of a new flight test data processing and analysis system called CAFTA (Computer Aided Flight Test Analysis). This system will support Bell's portion of the V-22 tilt rotor Full Scale Development (FSD) test program. CAFTA will also connect with Boeing Helicopter's new data system and with the Naval Air Test Center (NATC)'s system via telephone data link. Together, these three data systems will comprise the total V-22 data processing and analysis system. This paper describes the overall capabilities and architecture of CAFTA and discusses how it will be used to support the V-22 flight test program. The interface between Bell's CAFTA, Boeing Helicopter's data system and the NATC system is also presented. Author

A88-51789
THE USE OF REAL TIME DATA ANALYSIS TECHNIQUES ON THE V-22 OSPREY PROGRAM
PHILIP J. DUNFORD and CLARENCE HUTCHINSON (Boeing Helicopters, Philadelphia, PA) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. I-16 to I-26.

The advantages of using real-time data systems and analysis are studied from a budgetary standpoint and a technical position. Examples of some of the programs being prepared for use on the V-22 program are provided. Real-time data processing provides the following advantages: (1) testing efficiency is improved, (2) manpower and schedule requirements are reduced, and (3) testing is expedited in the region of critical limits without compromising flight safety. Factors affecting the productive flight rate are discussed as well as the tools available for real-time predictions, and the use of real-time application programs. The ATLAS data system is described in detail. K.K.

A88-51791
DEVELOPMENT OF QUALIFICATION CRITERIA FOR FLIGHT TESTS OF THE RSRA/X-WING COMPOSITE MAIN ROTOR BLADE
ANDREW F. CRISCUOLO, STANLEY J. MAGDA, and WILLIAM C. BOYCE (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. II-7 to II-13.

The overall test methodology, damage detection techniques, and failure criteria development options for complex composite structures such as the X-wing main rotor blade are discussed. The static tests conducted on the RSRA/X-wing main rotor blades revealed that there can be a variability in the manufacturing of large complex composite structures. It is noted that ultrasonic inspection cannot always detect poor bond adhesion. Conventional damage detection techniques can be significantly aided through the monitoring of acoustic emission signals. K.K.

A88-51792
QUALIFICATION AND FLEET INTRODUCTION OF THE AH-1T FLIGHT LOADS AND USAGE MONITOR
CARL G. SCHAEFER, JR. (U.S. Navy, Naval Air Systems Command, Washington, DC) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. II-14 to II-19.

A survey has been conducted to collect a sizable database for the evaluation of the current attack helicopter usage spectrum. The survey includes the design and installation of an instrumentation system that monitors flight environmental loads and the operational mission usage of eight fleet Marine AH-1T (TOW) attack helicopters. The technical and operational evaluation of a flight data recorder for the AH-1T helicopter is described. This flight test effort is discussed together with some of the problems encountered, and the introduction of the system into the fleet. K.K.

A88-51793
MULTI-NATIONAL CIVIL TYPE CERTIFICATION OF THE S-76A HELICOPTER WITH TURBOMECA ARRIEL 1S ENGINES
ROBERT E. WARREN and KEVIN T. OHRENBERGER (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. III-1 to III-6.

The paper discusses the combined effort on the part of two major manufacturers, three civil airworthiness authorities, and four engineering and flight test organizations to achieve French, British, and FAA approval of the S-76A which was modified to install Arriel 1S engines. The advantages of the FAA's Certification Directorate system are demonstrated. Among the reasons why the S-76A/Arriel 1S project was such a cost-effective joint venture are the following: (1) up-front certification planning and discussion with the FAA-NE and FAA-Rotorcraft Directorate and the French DGAC, and (2) the CAA's decision to approve the TM modifications under the certification policy between the U.K. and France. K.K.

A88-51794
A REVIEW OF THE U.S. ARMY'S FIRST DYNAMIC COMPONENTS 'SURVEILLANCE' PROGRAM
JAMES KIERAS, FRED M. HERNANDEZ (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT), and ROBERT W. ARDEN (U.S. Army, Aviation Systems Command, Saint Louis, MO) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. III-7 to III-14.

Phase I of the Black Hawk surveillance program is discussed in detail. Particular attention is given to start-up, component selection and control, and testing (residual strength tests, functional tests, and fatigue tests). The surveillance main rotor shaft results indicated that the shaft retirement time for the recently disclosed dimple mode should have been lower. Nonetheless, the program facilitated a better technical understanding of the low cycle fatigue characteristics of the spindle; it led to a change to methodology designed to enhance the safety for all model aircraft. K.K.

A88-51795
PILOT SURVEY METHOD OF HELICOPTER MISSION SPECTRA DEVELOPMENT
JEFFREY H. SCHNEIDER (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) and JACOB BAR-ON (Israel Air Force, Tel Aviv, Israel) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. III-15 to III-23.

A novel approach to the derivation of a composite usage spectrum based on pilot surveys is presented. Three different methods were considered for deriving the composite mission spectrum: (1) worst case methodology, (2) weighted average methodology, and (3) seventy percent methodology. It is noted that choosing a methodology is a trade-off between safety of flight and maintenance costs. K.K.

A88-51796
NAVY HELICOPTER STRUCTURAL DEMONSTRATIONS
HERMAN G. KOLWEY and WILLIAM A. ALISON (U.S Navy, Naval Air Test Center, Patuxent River, MD) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. III-24 to III-30. refs

The US Navy's process for conducting structural demonstrations on helicopter flight vehicles is described. It is based on the demonstration specification MIL-D-23222 and its appropriate addendum. Test experiences from past demonstration programs are discussed, including SH-60B and SH-2F composite rotor blade demonstrations. K.K.

A88-51798
BENCH TEST DEMONSTRATION OF A MAIN ROTOR DAMPER ISOLATION SYSTEM
GREGG J. AMBROSE (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. IV-9 to IV-15.

The bench test methods and technical rationale used to qualify a main rotor damper isolation system are described. Dampers unprotected by an isolation valve provide as little as 26 percent of the energy dissipation capacity originally available from the damper. The quantity of fluid trapped by the isolation valve was found to be affected by the leakage rate experienced by the hydraulic system. However, isolation valve operation and structure were not influenced by environmental effects such as vibration, temperature, and pressure extremes. K.K.

A88-51799
STRUCTURAL SUBSTANTIATION OF FAN IMPELLERS ACCOUNTING FOR INSTALLATION EFFECTS
PAUL D. WATSON (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. IV-16 to IV-24.

Developmental test experience with H-53E and S-76A cooling fan impellers has shown that significant reliability improvements can be achieved when installation effects are accounted for during structural substantiation. This paper presents examples of aerodynamic and structural transmitted excitation of impellers as influenced by blower installation. Tests were developed to determine the damaging blowere response, evaluate effectiveness of design improvements and obtain material properties. In-flight and bench stress surveys are presented as well as experimental modal analysis including holographic interferometry. Design modifications resulting in significant stress reductions were achieved by reducing blower backpressure and incorporation of an isolation system. Both modifications were successful in reducing excitation. The advantages and pitfalls of system testing to identify failure modes are emphasized. Author

A88-51801
CH-46E/AV-8B MINIMUM SEPARATION DISTANCE TEST
JERRY P. HIGMAN (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. IV-34 to IV-42.

A minimum separation distance test was carried out between a CH-46E and an AV-8B to determine the susceptibility of the helicopter to the Harrier's exhaust flow as a function of separation distance. The vibratory and angular rate response of the helicopter was measured and evaluated to determine whether the vibration amplitudes remain within limits and to detect possible resonant conditions. For the conditions tested, the vibratory response of the helicopter was dynamically stable; it did not experience any resonant conditions and remained within US Navy vibration tolerances for the separation distances tested. Moreover, hot gas ingestion into the engines did not cause the turbine inlet temperature to exceed the operational temperature limits. K.K.

A88-51802
HELICOPTER TOW PERFORMANCE MODELLING USING NON-TOW TEST DATA
ROBERT H. BOWES (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. V-9 to V-15.

A simple force model was used to estimate rotor thrust during steady helicopter towing operations. The estimated thrust required has been combined with hover and high and low airspeed power required models and with performance data taken during U.S. Navy development flight under non-tow conditions to predict towing maps (interrelation of gross weight, tow cable tension, aircraft pitch attitude, and engine power/torque required). Limited tow data are currently available for comparison but correlation of available data and estimation values is considered good. Fallouts of the modelling efforts have been methods of estimating low airspeed power required during non-tow flight and a proposed simplified method of obtaining level flight power required in 'up and away' conditions. This paper addresses the performance models used, test data correlation with the models, methods for estimating tow performance for zero and non-zero airspeed flight, and a modified mathematical model of level flight power required for use in conducting performance tests. Author

A88-51803
FLIGHT TEST OF AN ADVANCED ROTOR SYSTEM FOR FUTURE COMBAT HELICOPTER APPLICATIONS
KENNETH G. MCENTIRE, HARLAN W. FRIEDMAN, and JON P. ROGERS (Bell Helicopter Textron, Fort Worth, TX) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. V-16 to V-23.

The requirements for future military rotorcraft to perform more demanding missions such as air to air combat dictate the need for advanced rotor systems. This paper discusses the results of flight testing an advanced light rotorcraft (ALR) main rotor blade. It also describes the design and manufacturing aspects of the prototype blades, which allowed the blades to be delivered for testing at half the cost and in 30 percent less time than is customary for a set of prototype main rotor blades. Author

A88-51804
STRUCTURAL 'LESSONS LEARNED' FROM FLIGHT TESTS OF SIKORSKY HELICOPTERS IN AIR COMBAT ROLES
J. R. LAMB and T. N. TRAINER (United Technologies Corp., Sikorsky Development Flight Center, West Palm Beach, FL) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. V-24 to V-30. refs

Flight test programs designed to investigate the effects of evasive maneuver training and air combat maneuvering on the CH-53D, CH-53E, UH-60A, and AUH-76A helicopters are described. Particular attention is given to the structural implications of combat maneuvering. Areas of structural interest are main rotor control loads associated with high-speed high 'g' level maneuvering, control loads associated with high-power climb maneuvers, tail rotor loads associated with uncoordinated flight and high roll rate maneuvers, and airframe loads associated with air combat maneuvering. The climbing spiral turn maneuver generated some of the highest main and tail rotor loads observed during the flight test programs. K.K.

A88-51805
DAMAGE TOLERANCE TESTING OF THE S-76 COMPOSITE TAIL ROTOR SPAR
W. GEOFFREY ANDREW (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. VI-1 to VI-8.

The composite tail rotor spar used on the Sikorsky S-76 helicopter has successfully completed a fail-safe (damage tolerant) substantiation based on whirl testing of a rotor whith detectable spar cracks. This is the first example of replacement (retirement time eliminated) based on a fail-safe demonstration whirl test. Inspections developed during the over 1700 equivalent propagation flight hours are a 500-hour partial disassembly phase inspection and a 25-hour 'audible' crack inspection (audible clicking noises when the blade is deflected by hand). These inspections have a minimum operator impact and provide a substantial margin of safety for the crack propagation rates observed in the whirl test. The details of the test methodology are discussed as well as pertinent test results. The relative merits of the fail-safe and safe life methods are compared for components of this type. Author

A88-51806
PREDICTION OF STRESSES IN A HELICOPTER TRANSMISSION OUTPUT SHAFT - CORRELATION OF FINITE ELEMENT RESULTS WITH LABORATORY TEST RESULTS
LYNDON LAMBORN, JEFFREY BUNCH, and DARRYL SZARKA (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. VI-9 to VI-13.

A finite element model of a helicopter transmission output shaft was constructed using NASTRAN CQUAD 4 and CBEAM elements. The model consisted of the output shaft and the output ring gear. The model was developed to assess the consequences of manufacturing defects in the upper flange of the output shaft. An experimental program was also conducted to measure the loads applied to the output shaft. The experiments were conducted on an oputput shaft that had strain gage rosettes attached and which had been reassembled into a transmission housing. By measuring the loads on a shaft which was in an assembled transmission, the loads which were measured on the ouput shaft reflected an accurate transfer of loads from the input. When the results of the NASTRAN model were compared with the experimentally measured loads, the correlation was within 7.5 percent for the maximum stresses. Author

A88-51808
ACAP AIRFRAME CRASHWORTHINESS DEMONSTRATION
J. PHILIP PERSCHBACHER (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) and NED CHASE (U.S. Army, Aviation Applied Technology Directorate, Saint Louis, MO) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. VI-20 to VI-34.

The airframe crash test of the US Army/Sikorsky Advanced

Composite Airframe Program (ACAP) is described. The use of the analytical KRASH program in determining the test parameters is demonstrated. The ACAP airframe demonstrated survivable crashworthiness characteristics during a 39 fps 10 deg pitch 10 deg roll crash, and the KRASH 85 model adequately predicted the crash results. It is believed that additional instrumentation/measurement devices are required to measure composite airframe deflections because of the structure's springback characteristics. K.K.

A88-51810

HELICOPTER MANEUVERING PERFORMANCE FLIGHT TESTS USING AN INS BASED DATA ACQUISITION SYSTEM

J. J. MCCUE, L. E. SCOTT, and T. E. ARCHER IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, 36 p. refs

The U.S. Naval Test Pilot School has been conducting an ongoing study of helicopter maneuvering performance utilizing aircraft assigned to the school. Specific areas of interest have included the development of acceptable test techniques and data analyses, and the accurate determination of airspeed during low airspeed maneuvers. This paper discusses the utilization of a Litton LTN-72 Inertial Navigation System installed in a UH-60A Black Hawk helicopter to quantify helicopter maneuvering performance. Tests included level flight acceleration runs, sustained turning performance, Rylands technique maneuvers and wind-down turns. Test techniques and data analysis are discussed and sample data are presented. Author

A88-51811

ANALYSIS AND TESTING OF COMPOSITE AIRCRAFT FRAMES FOR INTERLAMINAR TENSION FAILURE

GERALD E. MABSON and E. PERCIVAL NEALL, III (Boeing Helicopters, Philadelphia, PA) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, 10 p. refs

Three analysis methods are presented for calculating stresses and strains in curved composite material laminates. These methods are:(1) a simple isotropic approach, (2) and exact closed form solution, and (3) a finite element analysis. A parameter study, based on these analyses, indicated important effects to consider in design. Test data is presented based on coupons cut from V-22 Osprey airframe fuselage frames. Author

A88-51812

DITCHING AND FLOTATION TESTS ON A 1/12-SCALE MODEL V-22 OSPREY

HARRY MUTTER (Boeing Helicopters, Philadelphia, PA) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, 5 p. refs

A 1/12 Froude-scaled model of the V-22 Osprey aircraft was tested in the ditching and flotation test tanks at the British Hovercraft Corporation Ltd., Isle of Wight, U.K. facility, during November and December 1986 and April and May 1987. This cooperative program between Bell Boeing and NAVAIR demonstrated that the V-22 aircraft design incorporates sufficient inherent flotation capability to permit safe personnel egress following an emergency water landing in design specification sea state conditions without the aid of supplemental flotation devices. The model scaled the aircraft flotation volumes, mass, inertia, emergency egress openings and selected aircraft structural breakaway strengths. The model rotors were powered to simulate lift during the ditching tests but were unpowered during the flotation and stability tests. Belly skin pressures and fuselage accelerations were measured during selected ditching tests. Author

A88-51928#

FIRST STEP TOWARD INTEGRATING THE DESIGN PROCESS

BONNIE L. ANDERSON (Douglas Aircraft Co., Long Beach, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 6 p. Research supported by McDonnell Douglas Corp. refs

(AIAA PAPER 88-4403)

A configuration-design methodology has been developed which reduces the time required for both design-definition and its subsequent iteration by means of a CAD-based parametric definition system. The interactive computer graphics employed allow design engineers to create and iterate their designs through the automation of repetitive tasks. In addition, a partially automated method analyzes standard geometry on the basis of completed designs. Both overall configurational arrangement and major component details are substantially more quickly generated for conventional, airliner-type aircraft. O.C.

A88-51937*# Pennsylvania State Univ., University Park.

FIGURES OF MERIT FOR AIRFOIL/AIRCRAFT DESIGN INTEGRATION

MARK D. MAUGHMER (Pennsylvania State University, University Park) and DAN M. SOMERS (NASA, Langley Research Center, Hampton, VA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 9 p. refs

(AIAA PAPER 88-4416)

Because the airfoil can so strongly impact other aspects of an aircraft configuration, it is important that the airfoil design process be integrated with that of the aircraft to achieve the best possible performance of a new flight vehicle. To aid in preliminary design efforts, several aerodynamic figures of merit are presented which facilitate the matching of the airfoil performance characteristics to those of the aircraft. These figures of merit are fairly general and can assist the airfoil design process for flight vehicles designed for maximum endurance, range, or ceiling. Although specifically applicable to vehicles for which the wing area is sized by some required minimum airspeed, the discussion is pertinent to all airfoil/aircraft matching situations and points the way for developing similar figures of merit to aid the airfoil/aircraft design process for any flight vehicle. Author

A88-51940#

PREDICTION OF UNSTEADY AERODYNAMIC ROTOR-AIRFRAME

NARAYANAN M. KOMERATH, HOWARD M. MCMAHON (Georgia Institute of Technology, Atlanta), and DIMITRI N. MAVRIS AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 12 p. refs

(Contract DAAG29-82-K-0084)

(AIAA PAPER 88-4420)

A numerical code has been developed for the prediction of unsteady aerodynamic rotor-airframe interactions in forward flight. This method is based on the extension and coupling of a lifting line/free wake rotor analysis and a source/doublet panel fuselage analysis. Coupling was achieved by iterating on the disturbance velocities induced by the airframe at the rotor inflow plane, and the effect of the rotor and wake on the airframe. Newly discovered flow features such as the energy addition in the wake, and the blade passage effect were modeled and included in the analysis. Results from this new code were validated against data obtained in the Georgia Tech 2.13 x 2.74 meter wind tunnel for a two bladed teetering rotor mounted over a cylindrical body with a hemispherical nose. Comparisons between predictions and experimental data are shown for instantaneous and time-averaged pressure distributions on the surface of the airframe and flow velocity distributions in the wake. The good correlations achieved between predicted and measured results indicate that the dominant physical flow phenomena in this case have been successfully accounted for by the computation, and can be predicted well through simple potential flow methods. Author

A88-51942*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

OPTIMIZATION OF HELICOPTER AIRFRAME STRUCTURES FOR VIBRATION REDUCTION CONSIDERATIONS, FORMULATIONS AND APPLICATIONS

T. SREEKANTA MURTHY (NASA, Langley Research Center; PRC

Kentron, Inc., Hampton, VA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 15 p. refs
(AIAA PAPER 88-4422)

Several key issues involved in the application of formal optimization technique to helicopter airframe structures for vibration reduction are addressed. Considerations which are important in the optimization of real airframe structures are discussed. Considerations necessary to establish relevant set of design variables, constraints and objectives which are appropriate to conceptual, preliminary, detailed design, ground and flight test phases of airframe design are discussed. A methodology is suggested for optimization of airframes in various phases of design. Optimization formulations that are unique to helicopter airframes are described and expressions for vibration related functions are derived. Using a recently developed computer code, the optimization of a Bell AH-1G helicopter airframe is demonstrated. Author

A88-51943#
APPLICATIONS OF LESSONS LEARNED TO THE STRUCTURAL INTEGRITY OF C-130 AND C-5 AIRCRAFT
H. J. SINGLETARY (Lockheed Aeronautical Systems Co., Marietta, GA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 7 p.
(AIAA PAPER 88-4424)

An account is given of the range of corrosion-prevention and corrosion-control practices that have been developed in order to enhance the structural integrity of C-130 and C-5 airlifters in such matters as materials-selection, design configuration, moisture drainage, accessibility of structural elements for inspection and maintenance, protective coatings, sealing materials, and structural assembly methods. Attention is given to the specific care that must be given to piano-hinge attachments, fiberglass-reinforced composites, Mg alloys, and spot-welded skin panels. O.C.

A88-51946*# Purdue Univ., West Lafayette, Ind.
APPLICATION OF FUZZY THEORIES TO FORMULATION OF MULTI-OBJECTIVE DESIGN PROBLEMS
A. K. DHINGRA, S. S. RAO (Purdue University, West Lafayette, IN), and H. MIURA (NASA, Ames Research Center, Moffett Field, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 10 p. refs
(Contract NCA2-223)
(AIAA PAPER 88-4430)

Much of the decision making in real world takes place in an environment in which the goals, the constraints, and the consequences of possible actions are not known precisely. In order to deal with imprecision quantitatively, the tools of fuzzy set theory can by used. This paper demonstrates the effectiveness of fuzzy theories in the formulation and solution of two types of helicopter design problems involving multiple objectives. The first problem deals with the determination of optimal flight parameters to accomplish a specified mission in the presence of three competing objectives. The second problem addresses the optimal design of the main rotor of a helicopter involving eight objective functions. A method of solving these multi-objective problems using nonlinear programming techniques is presented. Results obtained using fuzzy formulation are compared with those obtained using crisp optimization techniques. The outlined procedures are expected to be useful in situations where doubt arises about the exactness of permissible values, degree of credibility, and correctness of statements and judgements. Author

A88-51955#
MATERIALS IMPROVEMENTS IN THE C-5B AIRCRAFT
GUY E. KNOWLES, JR. (Lockheed Aeronautical Systems Co., Marietta, GA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 10 p.
(AIAA PAPER 88-4445)

Modifications made to the C-5 design in the course of producing its C-5B variant encompass changes in materials aimed at improving corrosion resistance, utilization, and durability, as well as reducing maintenance costs. These changes involve the incorporation of different structural materials, adhesively bonded structures, sealing systems, protective surface finishes, and reduced flammability and toxicity potentials. Composite materials have been used where cost, redesign opportunity, tooling constraints, etc., permitted the replacement of metallic elements. O.C.

A88-51961*# Boeing Commercial Airplane Co., Seattle, Wash.
SONIC BOOM LOUDNESS STUDY AND AIRPLANE CONFIGURATION DEVELOPMENT
JESSICA G. BROWN and GEORGE T. HAGLUND (Boeing Commercial Airplane Co., Seattle, WA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 13 p. refs
(Contract NAS1-18377)
(AIAA PAPER 88-4467)

Sonic boom wave form parameters as related to loudness were investigated analytically. The parameters studied include rise time, duration, maximum overpressure and initial overpressure. The design criteria of a 72 dBA for corridors and 65 dBA for unconstrained flight were chosen based on a review of human response testing. The 72 dBA criterion suggests that 1.0 psf shock waves may be acceptable. On that basis, acceptable low sonic boom wave forms were explored with respect to cruise conditions, aerodynamic lifting length requirements and configuration design at M 1.5 and M 2.4. An M 2.4 baseline arrow wing configuration was studied as a possible vehicle for M 1.5 cruise overland. Modifications made to approach the low boom wave form included a slightly longer forebody, staggered nacelles, a lifting arrow wing horizontal tail, and carefully tailored lift and volume elements. The same wave form criteria applied for M 2.4 cruise results in a low boom configuration that has significant weight, length and balance penalties. Further detailed design work is required to reach the target wave form and resultant loudness level for overland cruise at M 1.5. These results so far suggest that a properly designed M 2.4 overwater configuration may be capable of M 1.5 overland operation with sonic boom noise characteristcs that meet the criterion. Author

A88-51962*# Planning Research Corp., Hampton, Va.
THE INFLUENCE OF SUBSONIC MISSION SEGMENTS ON THE USE OF VARIABLE-SWEEP WINGS FOR HIGH SPEED CIVIL TRANSPORT CONFIGURATIONS
GLENN L. MARTIN, FRED L. BEISSNER, JR., CHRISTOPHER S. DOMACK, and E. WILLIAM SHIELDS (Planning Research Corp., Hampton, VA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 9 p.
(Contract NAS1-18000)
(AIAA PAPER 88-4470)

A Mach-3.0, 250-passenger, 6500-n. mi. range SST configuration's alternative use of fixed-planform or variable-sweep wings is presently evaluated, with a view to effects on aerodynamics, mission performance, and sizing. After preliminary design, the fixed and variable-wing configurations were resized to perform missions incorporating subsonic cruise segments of as much as 4000 n. mi.; the effect of subsonic segment length on design gross weight and block time was then ascertained. Due to the reduced supersonic efficiency of the variable-sweep aircraft, over one-half of the 6500-n. mi. mission would have to be flown subsonically for its sizing to reach a lower ramp weight than that of its fixed-geometry counterpart. O.C.

A88-51964#
EFFECTIVE INTEGRATION OF SUPPORTABILITY DESIGN CRITERIA INTO COMPUTER AIDED DESIGN FOR THE CONCEPTUAL DESIGN PHASE
ALBERT H. KEMP (McDonnell Aircraft Co., Saint Louis, MO) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 9 p.
(AIAA PAPER 88-4473)

Several design parameters and characteristics such as wing planform, aspect ratio, chord thickness ratio, internal fuel volume, and fuel splits are discussed. The translation of these characteristics into specific supportability measures of merit is demonstrated. Several engineering tools currently embedded in CAD (i.e., the finite element model and the fuel mass properties program) are described. It is suggested that fighter aircraft density and equipment arrangement/location are the two major design characteristics having the greatest impact on supportability. K.K.

A88-51966#
A SPECIAL MISSION V/STOL TRANSPORT AIRCRAFT STUDY
GORDON ROSENTHAL, NORRIS J. KRONE, JR. (Maryland, University Research Foundation, Greenbelt), and RICHARD A. CARNS (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 10 p. refs
(AIAA PAPER 88-4477)

A preliminary conceptual design study was undertaken to establish the feasibility of a Special Mission V/STOL Transport Aircraft that operates over a comparatively long range at low altitude and hovers upon reaching a targeted area. Out of twelve concepts initially considered, four were selected for more detailed examination. A fixed cargo compartment size was selected based on the XC-142A. Data on advanced propulsion system performance was based on the best available data in open publication. A payload of 12,000 lb appears practicable at a gross vehicle weight of about 90,000 lb for operations at Mach 0.6 at low altitude, with a mission radius of 1,000 n.m. and a hover time of 10 minutes. Of the various concepts examined, Tilt-Wing configurations appear to be the most promising. Author

A88-51970*# California Univ., Davis.
DESIGN AND EVALUATION OF A COCKPIT DISPLAY FOR HOVERING FLIGHT
RONALD A. HESS (California, University, Davis) and PETER JAMES GORDER AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 11 p. refs
(Contract NCC2-383)
(AIAA PAPER 88-4495)

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

A88-51976#
IMPROVED METHOD OF ANALYZING TAKEOFF PERFORMANCE DATA
REUBEN M. CHANDRASEKHARAN (Gulfstream Aerospace Corp., Savannah, GA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 5 p.
(AIAA PAPER 88-4509)

A method of analyzing takeoff data has been developed for the rotation and airborne phases of the takeoff. The new procedure uses a flight-derived variation of non-dimensional parameters (instead of time intervals that are normally used), in the reduction and expansion of takeoff data. This allows test data to be corrected for speed deviations and reduces the amount of scatter in the results. The analysis also provided insights that enabled the takeoff technique to be optimized, which resulted in a significant improvement in takeoff distance for the Gulfstream-IV airplane. Author

A88-52091
THE STUDY OF THE INTERFERENCE BETWEEN LIFTING SURFACES ON AN AIRCRAFT MODEL IN THE CANARD CONFIGURATIONS WITH SWEPTFORWARD WING AT LOW SUBSONIC SPEEDS [ISSLEDOVANIE INTERFERENTSII MEZHDU NESUSHCHIMI POVERKHNOSTIAMI NA MODELI SAMOLETA V SKHEME 'UTKA' S KRYLOM OBRATNOI STRELOVIDNOSTI PRI MALYKH DOZVUKOVYKH SKOROSTIAKH]
E. P. VIZEL' and A. E. GONCHAR TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 4, 1987, p. 103-106. In Russian.

Results are presented from the study of the mutual influence of the lifting elements in a canard configuration model with sweptforward wings at low subsonic speeds. The total interference of the lifting elements is determined and the range of attack angles with positive and negative interference is identified. R.B.

A88-52120
A SPECIALIZED THIN-SKIN FINITE ELEMENT ALLOWING FOR SUPERCRITICAL ELASTIC DEFORMATIONS [SPETSIALIZIROVANNYI KONECHNYI ELEMENT TONKOI OBSHIVKI, UCHITYVAIUSHCHII UPRUGIE ZAKRITICHESKIE DEFORMATSII]
N. S. POGODINA, G. I. SIDOROIV, and V. D. CHUBAN' TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 6, 1987, p. 74-83. In Russian. refs

A specialized finite element modeling a plane rectangular cell of thin wing and fuselage skins or rib, frame, and spar walls, bounded by stiff reinforcing elements on four sides, is proposed for the finite element calculation of the stress-strain state of aircraft under loads inducing a local elastic stability loss. The Ritz method is used to obtain a function of the nonlinear supercritical deformation of such a cell under combined loading by compression-tension and shear. Test results are presented and compared with some known data on cell deformation. V.L.

N88-27155*# Army Aerostructures Directorate, Hampton, Va.
A COMPARISON OF THEORY AND FLIGHT TEST OF THE BO 105/BMR IN HOVER AND FORWARD FLIGHT
PAUL H. MIRICK *In* NASA, Ames Research Center, Integrated Technology Rotor Methodology Assessment Workshop p 103-115 Jun. 1988
Avail: NTIS HC A17/MF A01 CSCL 01C

Four cases were selected for comparison with theoretical predictions using stability data obtained during the flight test of the Bearingless Main Rotor (BMR) on a Messerschmidt-Boelkkow-Blohm BO 105 helicopter. The four cases selected from the flight test included two ground resonance cases and two air resonance cases. The BMR used four modified BO 105 blades attached to a bearingless hub. The hub consisted of dual fiberglass C-channel beams attached to the hub center at 0.0238R and attached to the blade root at 0.25R with blade pitch control provided by a torque tube. Analyses from Bell Helicopter Textron, Boeing Vertol, and Sikorsky Aircraft were compared with the data and the correlation ranged from very poor-to-poor to poor-to-fair. Author

N88-27182*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONCEPT DEVELOPMENT OF A MACH 3.0 HIGH-SPEED CIVIL TRANSPORT
A. WARNER ROBINS, SAMUEL M. DOLLYHIGH, FRED L. BEISSNER, JR., KARL GEISELHART, GLENN L. MARTIN, E. W. SHIELDS, E. E. SWANSON (PRC Kentron, Inc., Hampton, Va.), PETER G. COEN, and SHELBY J. MORRIS, JR. 1988 50 p
(NASA-TM-4058; L-16445; NAS 1.15:4058) Avail: NTIS HC A03/MF A01 CSCL 01C

A baseline concept for a Mach 3.0 high-speed civil transport concept was developed as part of a national program with the goal that concepts and technologies be developed which will enable an effective long-range high-speed civil transport system. The Mach 3.0 concept reported represents an aggressive application of advanced technology to achieve the design goals. The level of technology is generally considered to be that which could have a demonstrated availability date of 1995 to 2000. The results indicate that aircraft are technically feasible that could carry 250 passengers at Mach 3.0 cruise for a 6500 nautical mile range at a size, weight and performance level that allows it to fit into the existing world airport structure. The details of the configuration development, aerodynamic design, propulsion system design and integration, mass properties, mission performance, and sizing are presented. Author

N88-27184# Air Command and Staff Coll., Maxwell AFB, Ala.
PILOT REPORT: AFTI (ADVANCED FIGHTER TECHNOLOGY INTEGRATION) F-111
SCOTT E. PARKS Apr. 1988 23 p
(AD-A192937; ACSC-88-2050) Avail: NTIS HC A03/MF A01 CSCL 01C

The Advanced Fighter Technology Integration (AFTI) F-111 research program is designed to evaluate a new wing design called the Mission Adaptive Wing (MAW). The MAW has the ability to continuously change it's shape in flight. This article provides a non-technical overview of the program with emphasis on the flight test and future uses of the wing on bomber, transport, and fighter aircraft. GRA

N88-27185# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
DESIGN MANUAL FOR IMPACT DAMAGE TOLERANT AIRCRAFT STRUCTURE, ADDENDUM
M. J. JACOBSON (Northrop Corp., Hawthorne, Calif.) Mar. 1988 36 p
(AGARD-AG-238-ADD; ISBN-92-835-0443-7) Avail: NTIS HC A03/MF A01

In 1981 the Structures and Materials Panel of AGARD published a design manual for Impact Damage Tolerant Aircraft Structures (AG 238). Since that date, there have been significant advances in design to resist impact damage. The Panel has therefore considered it appropriate to record this information in an addendum to the AGARDograph. This Addendum has been prepared at the request of the USAF for presentation to the Structures and Materials Panel of AGARD. Author

N88-27186# Lear Siegler, Inc., Grand Rapids, Mich.
ELECTRICAL LOAD AND POWER SOURCE CAPACITY REPORT FOR THE C-130 AIRCRAFT SELF CONTAINED NAVIGATION SYSTEM (SCNS): LSI MODEL 6216A, 6216B, 6216C, REVISION
JAMES M. SCHIEFFER 28 Aug. 1987 20 p
(Contract F09603-85-C-1224)
(AD-A193079; GRR-6216-011-REV) Avail: NTIS HC A03/MF A01 CSCL 17G

This report presents the electrical load analysis for the installation of the Self Contained Navigation System (SCNS) Class V Modification into the C-130 aircraft. It contains the delta load requirements by incorporation of the SCNS equipment, the load requirements of the SCNS equipment and the load requirements of removed aircraft equipment. GRA

N88-27187# Defence Research Establishment Suffield, Ralston (Alberta).
IN-FLIGHT LOAD MEASUREMENTS OF THE ROBOT-X CANARDS
S. G. PENZES Feb. 1988 41 p
(AD-A193428; DRES-SM-1191) Avail: NTIS HC A03/MF A01 CSCL 01A

The strain gauge system implemented in one of the Robot-X canards is described. The system is designed to measure lift, drag and torque. The description includes design considerations, calibration procedures and data reduction techniques. Data are presented from an early Robot-X flight test. GRA

N88-27188# Sandia National Labs., Albuquerque, N. Mex.
AIRBORNE REMOTE OPERATED DEVICE
H. D. ARLOWE 1988 14 p Presented at the 15th AUVS Annual Technical Symposium, San Diego, Calif., 6 Jun. 1988
(Contract DE-AC04-76DP-00789)
(DE88-010324; SAND-88-0519C; CONF-880689-2) Avail: NTIS HC A03/MF A01

Sandia National Laboratories has recently delivered ten ducted fan airborne reconnaissance vehicles to the U.S. Marine Corps for training and evaluation. This Airborne Remote Operated Device (AROD) concept centers on a ducted fan lifting technique that uses on-board attitude sensors and a stabilization computer to minimize the operator training requirements. These vehicles have been flown under a variety of conditions for over twelve hours. Video tapes of various flights and on-board camera views will be shown. This paper will cover the design, construction, testing, and operator training. Component reliability will be discussed as well as payload options., performance, and possible future program directors such as size, weight, communications, navigation, and operator aids. The paper will conclude that the concept of the AROD vehicle has been well demonstrated and is ready for use in solving problems of noise, communications, navigation, and integration into military tactical structures. DOE

N88-27190# Stuttgart Univ. (West Germany). Inst. fuer Mechanik.
CONTRIBUTION TO THE NUMERICAL SOLUTION OF AIRPLANE SPIN MOTION Ph.D. Thesis [BEITRAG ZUR NUMERISCHEN SIMULATION DER TRUDELBEWEGUNG VON FLUGZEUGEN]
MANFRED BUBECK 1987 159 p In GERMAN
(ETN-88-92368) Avail: NTIS HC A08/MF A01

Procedures for the numerical modeling of airplane spin phenomena with related aerodynamic considerations are presented. All six degrees of freedom are conserved during the motion and modeling of flow is performed by a computational procedure for 2D wakes. Spinning tests on light airplanes show that the pressure for a given domain and moment is constant. Wake pressure is a function of the general structure of the airplane and is submitted to the reaction of the single airplane components. ESA

N88-27191# Institut Franco-Allemand de Recherches, St. Louis (France).
A NUMERICAL SIMULATION OF SIDE FORCE EFFECTS BY AERODYNAMIC FLIGHT TRAJECTORY CORRECTION [NUMERISCHE SIMULATION DES EINFLUSSES VON SEITENKRAEFTEN BEI AERODYNAMISCHER FLUGBAHNKORREKTUR]
TH. MERKEL and V. FLECK 30 Jun. 1987 27 p In GERMAN Presented at the Seminar Aussenballistik an der Bundesakademie fuer Wehrverwaltung und Wehrtechnik, Mannheim, Fed. Republic of Germany, 26 May 1987
(ISL-CO-211/87; ETN-88-92738) Avail: NTIS HC A03/MF A01

Flight trajectory correction is performed by numerical simulation by a computer program for nonrotational symmetry projectiles with six degrees of freedom. Results indicate that several small corrections are more favorable than a large one. Transversal or side forces effects perpendicular to the correction surface are the most important disturbance factors. ESA

N88-27192# Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avions.
SUPERSONIC TRANSPORT/HYPERSONIC TRANSPORT (SST/HST) DEVELOPMENT
D. COLLARD and P. PICQ 12 Feb. 1988 53 p Presented at the IAAAC Meeting, Stockholm, Sweden, Sep. 1987
(SNIAS-881-111-101; ETN-88-92842) Avail: NTIS HC A04/MF A01

The development of the Concorde is reviewed, and the advantages and pitfalls associated with the introduction of a radically new type of transportation such as hypersonic aircraft are discussed. The design of the year 2000 aircraft is outlined. Commercial and technical feasibility are analyzed. ESA

N88-27193# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AGARD STANDARD AEROELASTIC CONFIGURATIONS FOR DYNAMIC RESPONSE. 1: WING 445.6
E. CARSON YATES, JR. (National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.) Jul. 1988 82 p Presented at the 61st Meeting of the Structures and Materials Panel at Oberammergau, Fed. Republic of Germany, 8-13 Sep. 1985
(AGARD-R-765; ISBN-92-835-0463-1) Avail: NTIS HC A05/MF A01 CSCL 01C

This report contains experimental flutter data for the AGARD 3-D swept tapered standard configuration Wing 445.6, along with related descriptive data of the model properties required for comparative flutter calculations. As part of a cooperative AGARD-SMP program, guided by the Sub-Committee on Aeroelasticity, this standard configuration may serve as a common basis for comparison of calculated and measured aeroelastic behavior. These comparisons will promote a better understanding of the assumptions, approximations and limitations underlying the various aerodynamic methods applied, thus pointing the way to further improvements. Author

N88-28056# Air Command and Staff Coll., Maxwell AFB, Ala.
PROPOSAL FOR A NEW AGGRESSOR AIRCRAFT
CRAIG W. NAAS Apr. 1988 39 p
(AD-A194311; ACSC-88-1945) Avail: NTIS HC A03/MF A01 CSCL 01C

The F-5 aircraft is no longer capable of simulating the adversary threat. Therefore, a replacement aggressor aircraft must be found. This project examines the threat presenting the most difficult challenge in the air combat arena and then compares the threat to possible replacement aggressor aircraft. Analysis of the adversary has determined the MIG-29 to be the most difficult challenge in the air combat arena. Comparison of the possible replacement aircraft has shown the F-18 Hornet to be the single best choice to simulate the MIG-29 Fulcrum and replace the F-5. This study proposes the F-18 Hornet be chosen as the new aggressor aircraft. GRA

N88-28057# Air Command and Staff Coll., Maxwell AFB, Ala.
THE IMPACT OF INCREASED AIRCRAFT RELIABILITY ON MAINTENANCE FACILITY DESIGN
GEORGE E. WALROND Apr. 1988 50 p
(AD-A194395; ACSC-88-2705) Avail: NTIS HC A03/MF A01 CSCL 01C

This report investigates how the increase in future fighter aircraft weapons systems reliability may impact the design of maintenance facilities. It investigates the technologies that will be incorporated in the Advanced Tactical Fighter (ATF) to determine if they will increase this aircraft's reliability. The paper briefly discusses the likelihood of a fighter being built that is capable of operating out of a very austere base. The report found that the intermediate level maintenance avionics and engine shops will be reduced in size and they could be eliminated. GRA

N88-28058*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A SIMPLE, ANALYTIC 3-DIMENSIONAL DOWNBURST MODEL BASED ON BOUNDARY LAYER STAGNATION FLOW
ROSA M. OSEGUERA and ROLAND L. BOWLES Jul. 1988 18 p
(NASA-TM-100632; NAS 1.15:100632) Avail: NTIS HC A03/MF A01 CSCL 01C

A simple downburst model is developed for use in batch and real-time piloted simulation studies of guidance strategies for terminal area transport aircraft operations in wind shear conditions. The model represents an axisymmetric stagnation point flow, based on velocity profiles from the Terminal Area Simulation System (TASS) model developed by Proctor and satisfies the mass continuity equation in cylindrical coordinates. Altitude dependence, including boundary layer effects near the ground, closely matches real-world measurements, as do the increase, peak, and decay of outflow and downflow with increasing distance from the downburst center. Equations for horizontal and vertical winds were derived, and found to be infinitely differentiable, with no singular points existent in the flow field. In addition, a simple relationship exists among the ratio of maximum horizontal to vertical velocities, the downdraft radius, depth of outflow, and altitude of maximum outflow. In use, a microburst can be modeled by specifying four characteristic parameters, velocity components in the x, y and z directions, and the corresponding nine partial derivatives are obtained easily from the velocity equations. Author

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AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A88-50275*# Technion - Israel Inst. of Tech., Haifa.
ADAPTIVE SUPPRESSION OF BIODYNAMIC INTERFERENCE IN HELMET MOUNTED AND HEAD DOWN DISPLAYS
SHMUEL J. MERHAV (Technion - Israel Institute of Technology, Haifa) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1106-1116. refs
(Contract NAGW-1013; NAGW-1128)
(AIAA PAPER 88-4185)

This paper addresses errors caused by vibrations or turbulence in airborne helmet teleoperation, helmet mounted, and head down displays. A preliminary study is presented which indicates that these errors can be significantly suppressed by adaptive filtering. A modified version of the LMS adaptive noise suppression algorithm facilitates the separation of the voluntary large head movements from the vibration-induced small nonvoluntary head movements. Computer simulations demonstrate the potential of the approach in suppressing both aiming errors and apparent display blurring. Author

A88-50936
A PROPOSED LOCAL AREA NETWORK FOR NEXT-GENERATION AVIONIC SYSTEMS
MARC D. COHN (Northrop Corp., Advanced Systems Div., Pico Rivera, CA) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 90-98. refs

The Fiber-optic Data Distribution Network (FDDN) is described that has been proposed to meet the data communication demands for advanced aircraft avionics. Performance, fault-tolerance, and versatility are primary objectives of the FDDN approach. The ultimate goal is to offer aircraft designers a powerful interprocessor communications capability for next-generation avionic platforms. A brief examination of the data communication requirements for distributed, real-time avionic systems is presented, followed by the rationale for selection of a network. The functional description of the FDDN is provided, and the development status is summarized. I.E.

A88-50944
A GENERIC GROUND COLLISION AVOIDANCE SYSTEM FOR TACTICAL AIRCRAFT
RICHARD C. LEBORNE (Cubic Corp., Defense Systems Div., San Diego, CA) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 184-190.
(Contract F04606-84-G-0008)

A novel approach was developed and tested to solve the controlled-flight-into-terrain (CFIT) accidents problem. This approach yielded a sensor flexible and highly dynamic system. A basic overview of Ground Collision Avoidance System (GCAS) is presented with a discussion of possible error sources and their effect on the system. A description of the methods used to validate the GCAS is given. The generic GCAS was tested using the Tactical Aircrew Combat Training System (TACTS)/Air Combat Maneuvering Instrumentation (ACMI) system. Utilization of the TACTS/ACMI system avoided the need for costly aircraft modifications during development while providing a test bed diverse in tactical aircraft types. I.E.

A88-50947

ENHANCED NAVIGATION AND DISPLAYS FROM PASSIVE TERRAIN REFERENCED AVIONICS

PETER J. BENNETT (Ferranti Defence Systems, Ltd., Edinburgh, Scotland) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 209-216.

An integrated all-weather mission system has been evolved that enhances the capability for covert high-speed low-level penetration at night and in adverse weather conditions. The system, called PENETRATE, is a passive enhanced-navigation and terrain-referenced avionics system that uses a single mass digital data store housing a three-dimensional model of the terrain including cultural details and tactical intelligence information. The system is designed to provide aircrew with extremely accurate navigation coupled with head-up and head-down display options and enhancements which can be tailored to the outside visibility. The design philosophy and architecture of this integrated covert mission system together with details of the PENETRATE demonstration system are discussed. I.E.

A88-50956

A LASER ANEMOMETER REFERENCE FOR AIR DATA CALIBRATION

JACQUES MANDLE (Crouzet, S.A., Division Aerospatial, Valence, France) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 300-308. refs

The proposed airborne laser velocimeter ALEV-3 is discussed. The instrument is intended to be able to solve a large number of reference problems for air data, angle of attack, and sideslip measurement during aircraft flight tests. The use of this type of instrument is expected to reduce the time and cost of this phase of new aircraft programs. After a brief summary of calibration tool requirements, the prototype equipment is described together with its applicability for flight tests. I.E.

A88-50957

AN INTEGRATED PROBE/SENSOR DESIGN FOR FUTURE DISTRIBUTED AIR DATA SYSTEM APPLICATIONS

DONALD F. MULKINS (Garrett Corp., Tucson, AZ) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 309-316.

An IPS (integrated probe/sensor) transducer is described that has been designed as a single absolute-pressure transducer to measure, compute, and digitally output the pressure sensed by its attached probe. For the intended commercial flight test application, the IPS will be attached to a pitot probe. The transducer will also be connected to the aircraft's static pressure crosstie tubing, both ends of which are connected to flush static ports, for aircraft static-pressure measurement. The IPS transducer has been designed to interface with other avionic systems through an ARINC 429 serial digital data bus. I.E.

A88-51029#

MODULAR AVIONICS: ITS IMPACTS ON COMMUNICATION, NAVIGATION, AND IDENTIFICATION (CNI)

ROBERT L. HARRIS (USAF, Avionics Laboratory, Wright-Patterson AFB, OH) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1164-1169. refs

The impact of modular integrated avionics on radio communication, navigation, and identification (CNI) systems is discussed from several viewpoints: (1) system design, (2) specifications, (3) cost, (4) market effects, and (5) supportability. It is concluded that system designs, market practices, and maintenance and support will appreciably change, resulting in enhanced mission effectiveness at optimum costs to the US Dept. of Defense. I.E.

A88-51043#

A SYSTEM STATUS MONITOR FOR THE NATIONAL AERO-SPACE PLANE

JAMES M. BAUMANN and CHARLES R. BISBEE, III (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1487-1494. refs

A study was undertaken to develop a model for an in-flight diagnostic system that could be applied to the National Aero-Space plane, and to implement a computer program to demonstrate the feasibility of that model as a basis for a system status monitor. The model developed features a double-hierarchy structure, one for the aircraft functions to be diagnosed, and another for the diagnostic functions to be performed. The hierarchical nature of both the system knowledge and the functions that use the knowledge allow decomposition of the diagnostic task into relatively independent and manageable parts. I.E.

A88-51056

FALCON EYE FORWARD-LOOKING INFRARED (FLIR) SYSTEM

DAN ROCK, JOHN REDUS, LYALE MARR, MARK GOHLKE, and DOUG HARTNETT (Texas Instruments, Inc., Dallas) IN: Infrared sensors and sensor fusion; Proceedings of the Meeting, Orlando, FL, May 19-21, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 38-45.

Texas Instruments has completed the development of a new, cost-effective family of FLIR systems named 'Falcon Eye' for current and future fighter aircraft. Falcon Eye is based on advanced detector technology in a system concept that merges the FLIR function of a navigation pod and many of the functions of a targeting pod within a conformal sensor package. This new FLIR packaging concept will virtually eliminate the drag penalty associated with externally mounted FLIR systems. Author

A88-51064

DESIGN AND TEST OF THE AIRBORNE VISIBLE/INFRARED IMAGING SPECTROMETER (AVIRIS) FOCAL PLANE ASSEMBLIES

R. MICHAEL DAVIS and CURTISS A. NIBLACK (Cincinnati Electronics Corp., OH) IN: Infrared sensors and sensor fusion; Proceedings of the Meeting, Orlando, FL, May 19-21, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 142-146. refs

The airborne visible/IR imaging spectrometer (AVIRIS) developed by the JPL for NASA is an optomechanical scanner that employs line arrays of detectors to image 224 continuous spectral bands from 0.4 to 2.4 microns. The availability of multiplexed arrays has made the interface from 224 detector elements to acquired data feasible. The AVIRIS focal plane consits of four line arrays, one of Si and three of InSb. The three arrays are each 64 elements long and sized to 200-micron squares. Each line array is bonded to ceramic substrates. O.C.

A88-51468

IMAGE PROCESSING AS A TOOL IN FLIGHT TEST EVALUATION

JAN UHLIN and ANDERS KALLDAHL (Saab-Scania, AB, Linkoping, Sweden) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 20-1 to 20-6. refs

In the past ordinary film cameras have been used for the Head-Up-Display. Evaluation of these films is expensive and very time-consuming. Now the film cameras are exchanged for videocameras of CCD-type, that requires new techniques and equipment on ground for evaluation, digital image processing. The demands on an image processing system for HUD-evaluation are quite specific. This paper describes these demands. With a computerized ground station it is possible to speed up and automize the evaluation procedure, a method for that is described. This specific method is a modern pyramid-based displacement field algorithm which can be extended to give subpixel resolution. Methods to estimate three-dimensional motion parameters of a rigid body from projections are also presented, both exact and various forms of approximate approaches are considered.

Author

A88-51469

AN APPLICATION OF VIDEO AS NAVIGATION SYSTEM TEST INSTRUMENTATION

DAVID GIBBINGS (Westland Helicopters, Ltd., Yeovil, England) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 21-1 to 21-5.

A video system suitable for recording aircraft position operating over land in visual contact with the ground which is applicable to most low-speed aircraft and helicopters is proposed. The system uses a miniature video camera directed vertically downwards, and the installation includes a gyro-stabilized vertical datum, digital presentation of the instrumentation timebase, a video recorder, and an audio channel to record intercom. The components of the system and the work carried out to demonstrate achievable accuracy are discussed. The analysis and interpretation process is covered and some of the lessons learned from the existing demonstrator are included. An engineered version capable of easy installation is proposed, and a number of secondary applications for the system are discussed. C.D.

A88-51470*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, Calif.

ELECTRO-OPTICAL FLIGHT DEFLECTION MEASUREMENT SYSTEM

V. MICHAEL DEANGELIS (NASA, Flight Research Center, Edwards, CA) and ROBERT FODALE (Grumman Aerospace Corp., Bethpage, NY) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 22-1 to 22-14.

This paper describes an electrooptical flight-deflection measurement system (FDMS) developed for use on highly-maneuverable-aircraft-technology (HiMAT) RPV flight research program. The FDMS provides in-flight measurements of the aircraft structural deflections and magnetic-tape recordings for automated data processing. The capabilities and limitations, requirements for installation on an aircraft, analytical considerations, and typical flight data acquired from the HiMAT research program are examined. The flight data indicate that the background light is the major obstacle to acquiring high-quality data and that the relationship between the target displacement and the output of the FDMS is nonlinear; however, the nonlinear effects can be minimized with judicious planning of the installation of the FDMS on the aircraft. Excellent flight deflection data were obtained from both the HiMAT and X-29 A flight research program with very little data lost as a result of encounters with severe background light. I.S.

A88-51522

FLIGHT EVALUATION TRIALS OF A HETERODYNE CO2 LASER RADAR

BERNARD STEPHAN and PHILIPPE METIVIER (Societe Francaise d'Equipements pour la Navigation Aerienne, Velizy-Villacoublay, France) IN: Active infrared systems and technology; Proceedings of the Meeting, The Hague, Netherlands, Apr. 2, 3, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 110-118. refs

A compact engineering model of a FM-CW lidar for combat aircraft terrain-following/avoidance has been subjected to helicopter flight evaluation trials. Altimetric data for the overflown terrain were processed to create 10 x 10 km altimetric maps that are centered on the aircraft and divided into 40 sq m elementary cells. Results are presented from two different analyses of the altimetric files: visual correlations between three-dimensional projections, and the standard deviation between lidar and radio altimeter profiles. O.C.

A88-51809

ONBOARD 1553 MUX BUS RECORDING TECHNIQUES

CHARLES R. KIRKPATRICK (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, 14 p.

A synopsis of past and current status in the field of MUX bus recording is presented. It is believed that MUX bus traffic will continue to be an important source of test and evaluation data. Areas of particular interest to MUX bus traffic for the future include fly by wire technology, artificial intelligence, unmanned vehicle development, remote communications with onboard systems during testing and field operations, and enhanced diagnostics for maintenance of fielded air and ground vehicles. K.K.

A88-51908*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

A DISCUSSION OF SOME PROPOSED MEASUREMENT TECHNIQUES FOR HYPERSONIC FLIGHT AND INSTRUMENTATION RESEARCH EXPERIMENTS

R. F. HELLBAUM and H. DOUGLAS GARNER (NASA, Langley Research Center, Hampton, VA) AIAA, NASA, and AFWAL, Conference on Sensors and Measurements Techniques for Aeronautical Applications, Atlanta, GA, Sept. 7-9, 1988. 11 p. refs

(AIAA PAPER 88-4651A)

Sensors, instrumentation, and test techniques proposed for the Hypersonic Flight Instrumentation and Research Experiment are discussed. The project is concerned with Mach 4 to 16 flight at pressure altitudes of 50,000 to 150,000 feet. The developmental instrumentation for the program includes angle-of-attack sensors, transition sensors, skin-friction sensors, particle sensors, species-concentration sensors, and temperature and heat flux sensors. Support instrumentation (required to monitor basic flight parameters and to supply data from which the performance of the developmental instruments may be evaluated) considered include surface pressure sensors, inertial instrumentation, magnetic attitude sensors, and signal conditioning and data transmission instrumentation. R.R.

A88-51910*# Massachusetts Inst. of Tech., Cambridge.

ULTRASONIC TECHNIQUES FOR AIRCRAFT ICE ACCRETION MEASUREMENT

R. JOHN HANSMAN, JR., MARK S. KIRBY (MIT, Cambridge, MA), and FRED LICHTENFELTS (Simmonds Precision Products, Inc., Aircraft Systems Div., Vergennes, VT) AIAA, NASA, and AFWAL, Conference on Sensors and Measurements Techniques for Aeronautical Applications, Atlanta, GA, Sept. 7-9, 1988. 12 p. FAA-supported research.

(Contract NGL-22-009-640; NAG3-666)

(AIAA PAPER 88-4656)

Ultrasonic pulse-echo measurements of ice growth on cylinders and airfoils exposed to both artificial (icing wind tunnel) and natural (flight) icing conditions are presented. An accuracy of + or - 0.5 mm is achieved with the present method. The ultrasonic signal characteristics associated with each of the two types of icing regimes identified, wet and dry ice growth, are discussed. Heat transfer coefficients are found to be higher in the wind tunnel environment than in flight. Results for ice growth on airfoils have also been obtained using an array of ultrasonic transducers. Icing profiles obtained during flight are compared with mechanical and stereo image measurements. R.R.

A88-51911*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

AIRBORNE DOPPLER RADAR DETECTION OF LOW ALTITUDE WINDSHEAR

E. M. BRACALENTE, C. L. BRITT, and W. R. JONES (NASA, Langley Research Center, Hampton, VA) AIAA, NASA, and AFWAL, Conference on Sensors and Measurements Techniques for Aeronautical Applications, Atlanta, GA, Sept. 7-9, 1988. 13 p. refs

(AIAA PAPER 88-4657)

NASA and the FAA, as part of a joint research effort aimed at the development of airborne sensor technology for low altitude windshear detection during aircraft takeoffs and landings, are giving attention to the potential usefulness of a microwave Doppler radar operating at X-band or above. A preliminary feasibility study was conducted with a microburst/clutter/radar simulation program. It is found that, using bin-to-bin automatic gain control, clutter filtering, limited detection range, and suitable antenna tilt, the windshear generated from a high-moisture microburst can be detected with 10-65 sec of warning time. O.C.

A88-51913#

AIRBORNE PASSIVE INFRARED SYSTEM FOR THE ADVANCE WARNING OF LOW-LEVEL WINDSHEAR AND CLEAR AIR TURBULENCE - 1988 IN-SERVICE AND THEORETICAL WORK

H. PATRICK ADAMSON (Turbulence Prediction Systems, Boulder, CO) AIAA, NASA, and AFWAL, Conference on Sensors and Measurements Techniques for Aeronautical Applications, Atlanta, GA, Sept. 7-9, 1988. 7 p. refs

(AIAA PAPER 88-4659)

Flight tests, laboratory research, and computer simulations have indicated that a microprocessor-based passive IR system will be able to furnish adequate advance warning of both high-altitude clear air turbulence and low-level wind shear. An evaluation of the effectiveness of such a system by a commercial airline will begin in September, 1988, and will continue for up to 12 months, leading to FAA certification. The system will then become available for installation aboard airliners in the later months of 1989. O.C.

A88-51932*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

FAULT-TOLERANT CLOCK SYNCHRONIZATION TECHNIQUES FOR AVIONICS SYSTEMS

RICKY W. BUTLER (NASA, Langley Research Center, Hampton, VA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 10 p. refs

(AIAA PAPER 88-4408)

This paper examines six provably correct fault-tolerant clock synchronization algorithms. These algorithms are all presented in the same notation to enable easier comprehension and comparison. The advantages and disadvantages of the different techniques are examined and issues related to the implementation of these algorithms are discussed. The paper argues for the use of such algorithms in life-critical applications. Author

A88-51949*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

FLIGHT DEMONSTRATION OF REDUNDANCY MANAGEMENT ALGORITHMS FOR A SKEWED ARRAY OF INERTIAL SENSORS

F. R. MORRELL (NASA, Langley Research Center, Hampton, VA), M. L. BAILEY (Planning Research Corp., Hampton, VA), and P. R. MOTYKA (Charles Stark Draper Laboratory, Inc., Cambridge, MA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 10 p. refs

(AIAA PAPER 88-4434)

Flight test results for two fault-tolerance algorithms developed for a redundant strapdown inertial measurement unit consisting of four 2-DOF gyros and accelerometers mounted on the faces of a semioctahedron are presented. Although both algorithms provided timely detection and isolation of flight control level failures, the generalized likelihood test algorithm provided more timely detection and isolation of low-level sensor failures than the edge vector test algorithm. The generalized likelihood test produced a false isolation for the case of a dual low-level failure applied to the sensitive axes of an accelerometer. Both of the algorithms were shown to provide dual fail-operational performance for the skewed array of inertial sensors. R.R.

A88-51952#

747-400 FLIGHT DISPLAYS DEVELOPMENT

MICHAEL L. KONICKE (Boeing Co., Seattle, WA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 8 p. refs

(AIAA PAPER 88-4439)

The Boeing 747-400 Flight Deck was designed to accommodate an Electronic Flight Instrument System (EFIS) that uses two 8-in-square cathode ray tubes (CRT) arranged in a side-by-side manner for primary flight data and navigation data. This paper summarizes the Primary Flight Display (PFD) development prior to flight testing, which consisted of a series of simulator evaluations of candidate PFD formats by pilots. PFD format descriptions are presented for each iteration in the design process, among with appropriate conclusions. The usable display area on the CRT; the shape, design, and location of the individual instruments; and the relationship between individual instruments were all shown to have a significant impact on the utility of the PFD format. A PFD format that uses vertical tape instruments for airspeed and altitude was found to offer the best overall flying utility. Author

N88-27196*# Lockheed Aeronautical Systems Co., Marietta, Ga.

AN EVALUATION OF FLIGHT PATH FORMATS HEAD-UP AND HEAD-DOWN Final Report

GEORGE A. SEXTON, LAURA E. MOODY, JOANNE EVANS, and KENNETH E. WILLIAMS Washington NASA 1988 123 p

(Contract NAS1-18029)

(NASA-CR-4176; LG87ER0154; NAS 1.26:4176) Avail: NTIS HC A06/MF A01 CSCL 01D

Flight path primary flight display formats were incorporated on head-up and head-down electronic displays and integrated into an Advanced Concepts Flight Simulator. Objective and subjective data were collected while ten airline pilots evaluated the formats by flying an approach and landing task under various ceiling, visibility and wind conditions. Deviations from referenced/commanded airspeed, horizontal track, vertical track and touchdown point were smaller using the head-up display (HUD) format than the head-down display (HDD) format, but not significantly smaller. Subjectively, the pilots overwhelmingly preferred (1) flight path formats over attitude formats used in current aircraft, and (2) the head-up presentation over the head-down, primarily because it eliminated the head-down to head-up transition during low visibility landing approaches. This report describes the simulator, the flight displays, the format evaluation, and the results of the objective and subjective data. Author

N88-28002# British Airways, Heathrow (England).

ENGINE CONDITION MONITORING CIVIL REQUIREMENTS: A BRITISH AIRWAYS VIEW

A. W. TICHBON *In* DFVLR, Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems p 9-26 Jan. 1988 Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

Engine condition monitoring activities are reviewed. The size and complexity in handling the turbine engine operation together with the magnitude of costs involved are presented. Monitoring techniques are listed. Monitoring oil wetted components, gas path analysis, and vibration trending are discussed. Areas where efforts should be concentrated to improve the overall effectiveness of engine condition monitoring are indicated. ESA

N88-28003# Societe de Fabrication d'Instruments de Mesure, Massy (France).
FROM TURBOPROP AIRCRAFT TO MULTI-ENGINED JET AIRCRAFT AIRCRAFT INTEGRATED MONITORING SYSTEMS (AIMS)
L. HANUS *In* DFVLR, Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems p 27-49 Jan. 1988
Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

The evolution of the hardware and the software of aircraft integrated monitoring systems (AIMS) from turboprop aircraft like the ATR 42 to the next generation of multijet engined aircraft like B 747-400, MD 11, and A 340 is reviewed. The AIMS on B 737-300 are outlined. ESA

N88-28006# GEC Avionics Ltd., Rochester (England). Powerplant Systems Div.
AIRCRAFT COMPONENT HEALTH MONITORING: AN EFFECTIVE APPROACH
C. W. HUMPHRIS *In* DFVLR, Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems p 99-117 Jan. 1988
Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

It is argued that intelligent LCD instruments provide a low cost, reliable, and user friendly mechanism for the implementation of an aircraft engine health monitoring strategy. On board maintenance systems such as the maintenance data panel provide an efficient single point access to all aircraft data and can provide an extensive, integrated health monitoring capability. Both types of system are supported by comprehensive ground support capability. Based on totally proven technology, the units are designed to provide maximum benefit at minimum investment. From units of this type, more complex systems can be developed as user confidence and experience grows. This growth will assist in the wider acceptance of on-condition maintenance policies by the certification authorities. ESA

N88-28009# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
ONBOARD LIFE MONITORING SYSTEM (OLMOS), HARDWARE EQUIPMENT ONBOARD AND ON GROUND
U. SCHULZ *In* DFVLR, Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems p 155-179 Jan. 1988
Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

The Onboard Life Monitoring System (OLMOS) of a military aircraft is described. It gathers and processes onboard stress relevant data to determine life cycles of the engines and structure. It monitors limit exceedance and events and stores the results onboard in nonvolatile stores. The onboard functions were implemented into the data acquisition unit of the existing crash recorder system. The logistic and technical evaluation of the data are implemented into the OLMOS Ground Station (OGS) that has a data link to the central logistic system of the Air Force by means of a hand held terminal, the onboard collected data are displayed and transferred to the OGS. ESA

N88-28013# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).
A SOLUTION TO IMPROVE A MILITARY AIRCRAFT'S ONBOARD-CHECKOUT-AND-MONITORING-SYSTEM (OCAMS)
J. WURSTER *In* DFVLR, Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems p 253-270 Jan. 1988
Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

Ways to improve postflight maintenance aspects of aircraft onboard checkout and monitoring systems are discussed. Equipment improvements, and centralized fault evaluation are considered. Introduction of improvements in dedicated steps is suggested. ESA

N88-28014# Japan Air Lines Co. Ltd., Tokyo.
JAPAN AIR LINE'S AIRCRAFT INTEGRATED MONITORING SYSTEM (AIMS) ACTIVITIES
F. NAGAMATSU *In* DFVLR, Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems p 271-288 Jan. 1988
Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

The airborne and ground systems of a civil aviation aircraft integrated monitoring system are presented. The B767 aircraft takeoff, landing, and turbulence reports, and the B747/DC10 aircraft systems are described. The ground based mainframe computer and its flight operations monitoring, engine monitoring, and cruise performance monitoring programs are introduced. The data recovery analysis system is presented. ESA

N88-28016# Messerschmitt-Boelkow-Blohm G.m.b.H., Hamburg (West Germany).
PROPOSAL FOR THE ON-BOARD PART OF A FUTURE AIRCRAFT INTEGRATED MONITORING SYSTEM
HELMUT KALBE *In* DFVLR, Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems p 317-337 Jan. 1988
Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

The necessity to improve maintenance systems in future aircraft is discussed and the weak points in existing fault detection and monitoring are indicated. The requirements for the on-board part of a maintenance system are evaluated and a proposal for a maintenance and recording system is introduced. The special repercussions on the system architecture if a new high speed bidirectional data bus is used are considered. ESA

N88-28020# British Airways, Heathrow (England).
THE INTELLIGENT QAR AND ITS COST EFFECTIVE ROLE IN NEW GENERATION AIMS
C. MURFET and A. F. BOND *In* DFVLR, Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems p 389-409 Jan. 1988
Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

The utility of carrying a quick access recorder (QAR) on airliners is discussed. Despite the general trend away from the use of a QAR, British Airways decided to retain a high level of data recording on their Boeing 747-400 fleet. This decision was taken in the context of a commitment to incident analysis and with an understanding of the extent by which the capability of a modern QAR surpasses that of its predecessor. The combination of an intelligent recorder and a high quality industry standard cartridge offers a cost effective solution to high integrity data storage. ESA

N88-28021# Sundstrand Data Control, Inc., Redmond, Wash.
THE SUNDSTRAND B747-400 DATA MANAGEMENT UNIT
ROBERT J. OWEN *In* DFVLR, Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems p 411-431 Jan. 1988
Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

The Aircraft Condition Monitoring System (ACMS) for the B747-400 aircraft is described. Advances in the acquisition and analysis of operational and maintenance related data onboard aircraft are discussed. The ACMS is based on the data management unit that acquires data from many of the other major avionic systems on the aircraft. The data are then processed in real time for both routine and abnormal situations in accordance with numerous user defined algorithms, and the results are stored in solid state memory. The resulting data are available on the multipurpose control and display unit cockpit printer or can be transferred to the ground station either via ACARS or a micro-floppy disk. ESA

N88-28028# National Aerospace Lab., Amsterdam (Netherlands).
INTERFACE TECHNIQUES AND SYSTEMS FOR STANDARD AIRCRAFT DATA BUSES

PETER J. MAUNDERS *In* DFVLR, Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems p 563-588 Jan. 1988
Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

For flight testing of the Fokker 50 and Fokker 100 aircraft, a flight-test instrumentation systems (MRVS) for the acquisition, presentation, recording, and processing of measured parameter data was developed. To connect standard avionics systems with MRVS, special interface systems were developed for ARINC, IRIG-PCM, and IRIG-B data streams. The MRVS and the interface techniques and systems are outlined. Though applied here in flight-test equipment, these techniques have much broader applications. ESA

N88-28029# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany).
TEST AND CALIBRATION SYSTEM FOR MONITORING THE ADVANCED TECHNOLOGIES TESTING AIRCRAFT SYSTEM (ATTAS) DATA ACQUISITION SYSTEM
M. F. KEVENOGLU and H.-J. KLEWE *In its* Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems p 589-617 Jan. 1988
Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

The Advanced Technologies Testing Aircraft System for flight testing and inflight simulation is presented. It is equipped with a versatile, highly accurate data acquisition system. The Built-In-Test Equipment constituted by the sensors and a part of the signal conditioning system serves together with the Test And Calibration System for monitoring the data acquisition system, permitting fast computer-controlled functional checks (pre and postflight) of the data acquisition system and related sensors. ESA

N88-28060# Crew Systems Consultants, Yellow Springs, Ohio.
IMPROVEMENT OF HEAD-UP DISPLAY STANDARDS. VOLUME 4: HEAD-UP DISPLAY DYNAMICS FLIGHT TESTS Final Report, 1 Oct. 1984 - 15 Jun. 1987
RICHARD L. NEWMAN and RANDALL E. BAILEY Sep. 1987 87 p
(Contract F33615-85-C-3602)
(AD-A193617; TR-87-12-VOL-4; AFWAL-TR-87-3055-VOL-4)
Avail: NTIS HC A05/MF A01 CSCL 25C

An in-flight investigation of the effect of head up display (HUD) symbol control laws has been conducted using a variable stability T-33 aircraft. The results indicate that HUD delays (pure time delays) of the order to of 140 msec in up-and-away flight have little effect on flying qualities. Sampling at intervals of 100 msec (10 hz) has a marked effect and degrades Cooper-Harper pilot ratings from a rating of 2 (good with negligible deficiencies) to a rating of 6 (very objectionable but with tolerable deficiencies). For the power approach case, the delays of up to 230 msec have negligible effect. In the power approach case, sampling at 10 hz had no effect. GRA

N88-28061*# Douglas Aircraft Co., Inc., Long Beach, Calif.
SYSTEM STATUS DISPLAY EVALUATION Final Report
LELAND G. SUMMERS Washington Sep. 1988 78 p
(Contract NAS1-18028)
(NASA-CR-4181; NAS 1.26:4181; MDC-K0653) Avail: NTIS HC A05/MF A01 CSCL 01D

The System Status Display is an electronic display system which provides the crew with an enhanced capability for monitoring and managing the aircraft systems. A flight simulation in a fixed base cockpit simulator was used to evaluate alternative design concepts for this display system. The alternative concepts included pictorial versus alphanumeric text formats, multifunction versus dedicated controls, and integration of the procedures with the system status information versus paper checklists. Twelve pilots manually flew approach patterns with the different concepts. System malfunctions occurred which required the pilots to respond to the alert by reconfiguring the system. The pictorial display, the multifunction control interfaces collocated with the system display, and the procedures integrated with the status information all had shorter event processing times and lower subjective workloads. 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.

A88-49473
A METHOD FOR ANALYZING NATURAL VIBRATIONS OF TURBINE BLADES, BASED ON A THREE-DIMENSIONAL MODEL [METOD ANALIZA SOBSTVENNYKH KOLEBANII LOPATOK TURBOMASHIN NA OSNOVE TREKHMERNOI MODELI]
IU. S. VOROB'EV, Z. V. SAPELKINA, and A. I. SHEPEL' (AN USSR, Institut Problem Mashinostroeniia, Kharkov, Ukrainian SSR) Problemy Prochnosti (ISSN 0556-171X), June 1988, p. 81-86. In Russian. refs

This paper describes a method for the analysis of natural vibrations in complex-shape turbine blades. The method is developed on the basis of a three-dimensional model, with the three-dimensional continuum approximated by means of curvilinear hexahedral elements of the Serendip family; the problem of natural vibrations is reduced to the solution of the generalized eigenvalue problem. The validity of the method was tested experimentally on a turbine blade with an elongated foot and a fir-tree root. I.S.

A88-49474
CALCULATIONS OF NATURAL VIBRATION FREQUENCIES FOR GAS-TURBINE-ENGINE ROTORS ON THE BASIS OF A METHOD OF WAVE-DYNAMICAL STIFFNESSES AND COMPLIANCES [RASCHET SOBSTVENNYKH CHASTOT KOLEBANII RABOCHIKH KOLES GTD NA OSNOVE METODA VOLNOVYKH DINAMICHESKIKH ZHESTKOSTEI U PODATLIVOSTEI]
A. I. ERMAKOV, V. P. IVANOV, and V. A. FROLOV (Kuibyshevskii Aviatsionnyi Institut, Kuibyshev; Moskovskii Institut Inzhenerov Grazhdanskoi Aviatsii, Moscow, USSR) Problemy Prochnosti (ISSN 0556-171X), June 1988, p. 90-95. In Russian. refs

This paper describes a method, based on the wave-dynamical stiffness method of Ivanov (1983), for calculating natural frequencies for gas-turbine rotors. In this procedure, the structures of rotors are separated into standard ring components and, after the numerical integration of the respective systems of differential equations of vibrations, the elastoinertial characteristics of the standard components are determined. The elastoinertial characteristics of the whole rotor are found by coupling the standard components. The comparison of calculated and experimental results showed a divergence of 4-12 percent. I.S.

A88-49507
CALCULATION OF THE MEAN MASS TEMPERATURE OF THE GAS IN THE COMBUSTION ZONE OF THE COMBUSTION CHAMBER OF A GAS TURBINE ENGINE [RASCHET SREDNEMASSOVOI TEMPERATURY GAZA V ZONE GORENIIA KAMERY SGORANIIA GTD]
S. G. DEMENKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1988, p. 25-29. In Russian. refs

A simple analytical method for calculating the mean mass temperature of a gas in a combustion chamber is proposed which uses an empirical expression relating the composition of the combustion products to the excess air and completeness-of-combustion coefficients. It is shown that the approach proposed here can be used at the stage of preliminary design calculations in CAD systems for gas turbine engine design. V.L.

A88-49508
THE PROBLEM OF JET NOISE REDUCTION IN THE NEAR ACOUSTIC FIELD OF A GAS TURBINE ENGINE [PROBLEMA SNIZHENIIA SHUMA REAKTIVNOI STRUI GTD V BLIZHNEM ZVUKOVOM POLE]
I. S. ZAGUZOV, E. V. VLASOV, and K. V. KAKHOVSKII Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1988, p. 29-33. In Russian.

The paper is concerned with the problem of reducing jet noise in aircraft gas turbine engines which constitutes a source of high-intensity low-frequency acoustic loads on the fuselage surface of passenger aircraft and, consequently, noise inside the cabin. A tubular jet noise suppressor is examined as a possible way of solving this problem. The efficiency of this approach is illustrated by test results. V.L.

A88-49509
AN ANALYTICAL STUDY OF THE FLOW RATE CHARACTERISTICS OF MULTISTAGE FAN-SPOOL TURBINES OF BYPASS ENGINES [RASCHETNOE ISSLEDOVANIE RASKHODNYKH KHARAKTERISTIK MNOGOSTUPENCHATYKH TURBIN VENTILIATOROV TRDD]
M. M. KAMOTSKAIA, B. I. MAMAEV, and T. A. SANDIMIROVA Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1988, p. 33-36. In Russian.

Results of an analytical study are presented for two multistage (2 and 3 stages, respectively) fan-spool turbines, which are commonly used in turbofan engines with bypass ratios of 1.5-4.5. It is shown that, in turbines with subsonic ratios, the opening of the blade rims has only a slight effect on the efficiency, while flow swirling at the exit is prevented through the correction of the last rim. Changes in design load distribution over the stages play only a minor role from the standpoint of the possibility of increasing the normalized gas flow rate. V.L.

A88-49511
A STUDY OF THE EFFECT OF STEPWISE VELOCITY AND TEMPERATURE PROFILE INHOMOGENEITIES IN THE INITIAL CROSS SECTION OF A JET ON ITS ACOUSTIC CHARACTERISTICS [ISSLEDOVANIE VLIIANIIA STUPENCHATOI NERAVNOMERNOSTI PROFILEI SKOROSTI I TEMPERATURY V NACHAL'NOM SECHENII STRUI NA EE AKUSTICHESKIE KHARAKTERISTIKI]
S. IU. KRASHENINNIKOV and M. N. TOLSTOSHEEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1988, p. 39-43. In Russian.

The effect of the gasdynamic and geometrical parameters of a bypass nonisothermal jet with velocity and temperature profile inhomogeneities on its acoustic characteristics is investigated experimentally, with gas temperature in the internal and external flow varying from 273 to 773 K and the full pressure at the nozzle inlet varying from 1.2 to 1.9 kg/sq cm. It is shown that the acoustic power of a bypass jet (with both normal and reversed velocity profiles) can be calculated from the parameters of the initial cross section of an equivalent jet whose area, flow rate, and full impulse are the same as those of the bypass jet. V.L.

A88-49514
INTERNAL EFFICIENCY OF TURBOFAN ENGINES [O VNUTRENNEM KOEFFITSIENTE POLEZNOGO DEISTVIIA DVUKHKONTURNYKH TURBOREAKTIVNYKH DVIGATELEI]
N. I. MELIK-PASHAEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1988, p. 51-54. In Russian.

Although the internal (effective) efficiency is not used directly in calculating the processes and performance characteristics of turbofan engines, it is commonly used in the theory of turbofan engines for the qualitative analysis of energy conversion inside the engine. Here, it is shown that the dependence of the internal efficiency of bypass engines can be represented as a function of the parameters of the core and bypass circuits. V.L.

A88-49518
SELECTION OF THE EFFICIENT DIMENSIONALITY AND WORKING PROCESS PARAMETERS OF A UNIFIED BYPASS ENGINE FOR A CLASS OF SUBSONIC AIRCRAFT [VYBOR RATSIONAL'NOI RAZMERNOSTI I PARAMETROV RABOCHEGO PROTSESSA UNIFITSIROVANNOGO TRDD DLIA SEMEISTVA DOZVUKOVYKH SAMOLETOV]
E. D. STEN'KIN, V. S. KUZ'MICHEV, M. A. MOROZOV, and O. M. ZHUKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1988, p. 67-71. In Russian.

A concept is described which provides an approach to the selection of the efficient dimensionality and working process parameters of a unified gas turbine engine for a class of aircraft. The approach is based on the analysis of the effect of bypass engine dimensionality on the efficiency of the aircraft. The approach is illustrated by a specific example involving the Tu-154 commercial aircraft. V.L.

A88-49520
THE STRUCTURE-ADEQUACY PRINCIPLE IN THE METHODOLOGY FOR THE DESIGN AND FINAL ADJUSTMENT OF AIRCRAFT ENGINES [O PRINTSIPE ADEKVATNOSTI STROENIIA V METODOLOGII PROEKTIROVANIIA I DOVODKI AVIATSIONNYKH DVIGATELEI]
B. D. FISHBEIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1988, p. 75-79. In Russian. refs

Specific applications of the structure-adequacy principle are examined. Particular attention is given to the role of this principle in the realization of various types of design, including the design of the mathematical model of engine working process and the organizational design in connection with the development of a gas-turbine engine. B.J.

A88-49522
EFFECT OF NOZZLE TYPE ON THE CHARACTERISTICS OF A DIFFUSER WITH TANGENTIAL INJECTION [VLIIANIE TIPA SOPLOVOGO BLOKA NA KHARAKTERISTIKI DIFFUZORA S TANGENTSIAL'NYM VDUVOM]
I. V. BABCHENKO and N. A. SHUSHIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1988, p. 82-84. In Russian.

The starting and operating pressure ratios of channels with a conventional mononozzle and a cellular nozzle unit with injection along the narrow sides of the supersonic diffusor were investigated in a wind tunnel. It is shown that the channel with the mononozzle performs better than the channel with the cellular nozzle unit in the range of intense injection in long diffusors. B.J.

A88-49531
TEMPERATURE STATE OF A TURBOFAN BLADE IN AN EXHAUST-GAS FLOW [TEMPERATURNOE SOSTOIANIE LOPASTI VINTOVENTILIATORA V POTOKE VYKHLOPNYKH GAZOV]
V. S. PETROVSKII and V. I. KRICHAKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1988, p. 103-105. In Russian.

The heat-conduction problem is investigated for a turbofan blade with a heat-protecting coating in an exhaust-gas flow. The results make it possible to choose the optimal combination of methods to protect the blade from overheating. B.J.

A88-49793
EFFECT OF PRIMARY JET EXCITATION ON THE PERFORMANCE OF AN EJECTOR
M. A. BADRI NARAYANAN (Indian Institute of Science, Bangalore, India) Indian Institute of Science, Journal (ISSN 0019-4964), vol. 67, Mar.-Apr. 1987, p. 109-114. Research supported by the Ministry of Defence of India. refs

Experiments were conducted on an ejector with its plane primary jet excited by a small oscillating flap placed in the potential core region. Excitation did increase the spread of the jet as well as local mixing inside a straight rectangular ejector duct; however, there was negligible improvement in the induced mass flow as well as in thrust. On the other hand, with a diffuser attached to the rectangular duct, there was significant enhancement in ejector thrust on account of the improvement in the quality of the flow in the diffuser due to jet excitation. Author

A88-49912#

THE THEORETICAL ANALYSIS OF THE MISTUNED BLADE ROTOR FOR CONTROLLING FLUTTER

ZHAOHONG SONG and TAO SONG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, May 1988, p. A260-A266. In Chinese, with abstract in English. refs

The equation of motion which governs the aeroelastic behavior of the mistuned blade rotor in which the blade is modeled as a two degree-of-freedom vibrational body is formulated. The stabilities of the tuned and alternate mistuned blade rotors are studied. The influential factors that cause the mistuned blade rotor to be more stable than the tuned one are analyzed. Author

A88-49923#

INVESTIGATION OF MEASURING AND TESTING TECHNIQUES FOR EVALUATING STABLE OPERATING MARGIN OF TWIN-SPOOL TURBOJET ENGINE

YUEGENG WU and QISHENG YUN (Liyang Machinery Co., People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, June 1988, p. B248-B258. In Chinese, with abstract in English. refs

In this paper an experimental technique for forced surge based on water injection into the main combustion chamber is introduced, and a reliable method for testing the actual stable operating margin of the compressor system in the twin-spool turbojet engine is demonstrated. A simple and practical data-treatment method for evaluating the stable operating margin of compressors is recommended. Author

A88-49976

RUB IN HIGH PERFORMANCE TURBOMACHINERY, MODELING, SOLUTION METHODOLOGY AND SIGNATURE ANALYSIS

F. K. CHOY, J. PADOVAN, and W. H. LI (Akron, University, OH) Mechanical Systems and Signal Processing (ISSN 0888-3270), vol. 2, April 1988, p. 113-133. refs

This paper presents an analytical modeling and signature analysis procedure which enables the simulation of the nonlinear dynamical characteristics associated with rotor-blade-seal-casing rub interactions in high performance rotating equipment. The overall methodology includes the handling of the onset, transient and steady responses as well as defining their concomitant signatures. Based on the methodologies developed, special attention will be given to analyzing the onset, transient and steady phases of rub bounce events. Attention will also be given to determine the most likely sites to locate sensors so as to enable the proper experimental evaluation of rub events and their associated severity levels. Author

A88-49998

NEAR NET SHAPE MANUFACTURE OF AERO ENGINE COMPONENTS

D. DRIVER (Rolls-Royce, PLC, Derby, England) Metals and Materials (ISSN 0266-7185), vol. 4, Aug. 1988, p. 493-497. refs

An account is given of state-of-the-art aircraft gas turbine engine component manufacturing methods that encompass casting and forging to near-net shape with such materials as Ti-6Al-4V, RR58 aluminum alloy, alloy steels, and Ni-based superalloys. The components in question are turbofan blades, compressor and turbine rotor disks, and compressor and turbine blades. Attention is given to blade forging and investment casting methods, the cores that must be incorporated into turbine blade castings for the formation of cooling passages, and thermal treatments used in producing polycrystalline, directionally solidified, and single-crystal turbine blades. O.C.

A88-50052

THRUST EFFICIENCY OF AN EJECTOR WITH A SUPERSONIC NOZZLE [TIAGOVAIA EFFEKTIVNOST' EZHEKTORA SO SVERKHZVUKOVYM SOPLOM]

N. V. SAMOILOVA and E. A. SHUMILKINA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 3, 1986, p. 133-137. In Russian. refs

Estimated performance characteristics are presented for an ejector thrust augmentor equipped with a supersonic nozzle, and a comparison is made with the characteristics of a converging-nozzle ejector thrust augmentor. Over the practically important range of critical nozzle cross sections and pressure ratios, the use of a supersonic nozzle is shown to provide a gain in thrust of up to 10 percent. V.L.

A88-50102

OPTIMALITY CONDITIONS AND CHARACTERISTICS OF A DIFFUSERLESS GAS EJECTOR DURING THE EJECTION OF A MIXTURE INTO A SUBMERGED SPACE [USLOVIIA OPTIMAL'NOSTI I KHARAKTERISTIKI GAZOVOGO EZHEKTORA BEZ DIFFUZORA PRI VYKHLOPE SMESI V ZATOPLENNOE PROSTRANSTVO]

IU. K. ARKADOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 6, 1986, p. 111-115. In Russian.

Optimality conditions for small degrees of compression are examined for a compact diffuserless gas ejector, in which the mixture is ejected from the mixing chamber directly into a submerged space (e.g., into an aircraft emergency life-raft). Analytical expressions for the optimality conditions are obtained, and used to calculate the characteristics of an optimal ejector and to determine its geometry. B.J.

A88-50104

CORRECTION OF THE DESIGN SHAPE OF SCIMITAR-PLANFORM BLADES BY THE FINITE ELEMENT METHOD [KORREKTSIIA STAPEL'NOI FORMY SABLEVIDNOI LOPASTI METODOM KONECHNYKH ELEMENTOV]

V. P. AGAPOV and V. A. KOROTKOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 6, 1986, p. 122-126. In Russian. refs

The shape correction problem is considered for turbofan blades. Using the finite element method, the correction is based on the condition that the sum bending moments from the action of static centrifugal and aerodynamic loads are equal to zero. The proposed approach is applied to the shape correction of a scimitar-planform carbon-plastic blade. B.J.

A88-50144

PROBABILISTIC ESTIMATION OF THE EXHAUSTION OF GAS-TURBINE-ENGINE DISK SERVICE LIFE UNDER LOW-CYCLE FATIGUE [VEROIATNOSTNAIA OTSENKA ISCHERPANIIA RABOTOSPOSOBNOSTI DISKOV GTD PRI MALOTSIKLOVOI USTALOSTI]

T. V. BALEPINA Problemy Prochnosti (ISSN 0556-171X), July 1988, p. 40-43. In Russian.

This paper describes a procedure for estimating the service-life of gas-turbine disks under low-cycle fatigue. The approximation procedure is based on a method for random-argument function linearization and the Manson formula to express the relationship between the disk strain and its service life. An example is presented for calculating the probability of service-life exhaustion of a turbine disk and the probability of its cracking from a set number of service cycles of the gas-turbine engine. I.S.

A88-50778

OPERATION PROCESSES IN THE COOLED PERFORATED-BLADE TURBINES OF GAS TURBINE ENGINES [RABOCHIE PROTSESSY V OKHLAZHDAEMYKH TURBINAKH GAZOTURBINNYKH DVIGATELEI S PERFORIROVANNYMI LOPATKAMI]

EVGENII NIKOLAEVICH BOGOMOLOV Moscow, Izdatel'stvo Mashinostroenie, 1987, 160 p. In Russian. refs

Methods are presented for calculating the principal parameters of the perforated-blade cooling systems of gas turbines with convective-film cooling (e.g., gas screen efficiency, heat conductivity of the perforated wall, and optimality of the injection system). An exergic method is proposed for selecting the parameters of systems for feeding the coolant to the turbine blades. The thermodynamic and aerodynamic characteristics of processes in turbines with coolant injection through perforations are examined V.L.

A88-50784*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

A NUMERICAL STUDY OF MIXING ENHANCEMENT IN SUPERSONIC REACTING FLOW FIELDS

J. PHILIP DRUMMOND and H. S. MUKUNDA (NASA, Langley Research Center, Hampton, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 19 p. refs

(AIAA PAPER 88-3260)

NASA Langley has intensively investigated the components of ramjet and scramjet systems for endoatmospheric, airbreathing hypersonic propulsion; attention is presently given to the optimization of scramjet combustor fuel-air mixing and reaction characteristics. A supersonic, spatially developing and reacting mixing layer has been found to serve as an excellent physical model for the mixing and reaction process. Attention is presently given to techniques that have been applied to the enhancement of the mixing processes and the overall combustion efficiency of the mixing layer. A fuel injector configuration has been computationally designed which significantly increases mixing and reaction rates. O.C.

A88-50785*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

TWO-DIMENSIONAL VISCOUS FLOW COMPUTATIONS OF HYPERSONIC SCRAMJET NOZZLE FLOWFIELDS AT DESIGN AND OFF-DESIGN CONDITIONS

G. J. HARLOFF, H. T. LAI, and E. S. NELSON (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 12 p. Previously announced in STAR as N88-25459. refs

(Contract NAS3-25266)

(AIAA PAPER 88-3280)

The PARC2D code has been selected to analyze the flowfields of a representative hypersonic scramjet nozzle over a range of flight conditions from Mach 3 to 20. The flowfields, wall pressures, wall skin friction values, heat transfer values and overall nozzle performance are presented. Author

A88-50813

DYNAMIC CHARACTERISTIC CALCULATION AND ANALYSIS OF TWIN-ROTOR ENGINE

BAO LIN HONG (Changcheng Institute of Metrology and Measurement, Beijing, People's Republic of China) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 502-508.

In this paper, the critical speeds and unbalance responses of the squeeze film damped twin-rotor system of an aircraft gas turbine engine are computed using the simplified transfer method. The simplified transfer matrix method is found to be readily programmed for multirotor system calculations. The computer program for this method can be easily applied to the rotor having rigid supports. Author

A88-51049

JET ENGINE DIAGNOSTICS AND TRENDING: ROADMAP FOR THE FUTURE

TIMOTHY G. JELLISON, RONALD L. DE HOFF (Systems Control Technology, Inc., Palo Alto, CA), and CHARLES B. SUEHS (USAF, Air Logistics Center, San Antonio, TX) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1536-1540.

A standard for US Air Force engine diagnostics and trending has been developed and fielded. The Comprehensive Engine Management System increment IV (CEMS IV) will be enhanced and fielded under the functional umbrella of the Core Automated Maintenance System. The methodology by which CEMS IV supports the philosophy of on-condition maintenance is discussed. The operational implementation of portable decision support tools within the CEMS IV network is highlighted. Necessary development steps are presented for the successful implementation of CEMS IV across all jet engines in the US Air Force inventory. I.E.

A88-51427

PROPFAN TEST ASSESSMENT

FRANK D. HADDEN (Lockheed-Georgia Co., Marietta) IN: 1987 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 31st, Beverly Hills, CA, Sept. 23-26, 1987, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1987, p. 3-12.

The purpose of the NASA-sponsored Propfan Test Assessment Program was to validate the structural integrity of propfan blades, evaluate associated cabin noise and vibration, and investigate near- and far-field noise; an effort was also made to acquire an extensive, systematic experimental data base for the validation of recently developed propfan-design and acoustic characteristics-prediction methods. The program involved the creation of a propulsion system that mated a 6000-hp Model 501-M78 turboprop engine to an SR-7L propfan, as well as the redesign, modification, and instrumentation of the G II testbed aircraft. O.C.

A88-51433* National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, Calif.

HIDEC F-15 ADAPTIVE ENGINE CONTROL SYSTEM FLIGHT TEST RESULTS

JAMES W. SMOLKA (NASA, Flight Research Center, Edwards, CA) IN: 1987 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 31st, Beverly Hills, CA, Sept. 23-26, 1987, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1987, p. 114-137.

NASA-Ames' Highly Integrated Digital Electronic Control (HIDEC) flight test program aims to develop fully integrated airframe, propulsion, and flight control systems. The HIDEC F-15 adaptive engine control system flight test program has demonstrated that significant performance improvements are obtainable through the retention of stall-free engine operation throughout the aircraft flight and maneuver envelopes. The greatest thrust increase was projected for the medium-to-high altitude flight regime at subsonic speed which is of such importance to air combat. Adaptive engine control systems such as the HIDEC F-15's can be used to upgrade the performance of existing aircraft without resort to expensive reengining programs. O.C.

A88-51456

THE APPLICATION OF PROPULSION ANALYSIS TECHNIQUES TO FLYING QUALITIES AND PERFORMANCE TESTING OF TURBINE-PROPELLER AIRCRAFT

ART PUGLIESE (Grumman Corp., Aircraft Systems Div., Calverton, NY) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 7-1 to 7-11.

This paper discusses and illustrates relationships between aircraft aerodynamic characteristics and propeller power variations as well as installation effects. Various test and analysis techniques required to manage the impacts of these factors are defined. Examples of the potential magnitudes of the various effects are given. Multiengine aircraft considerations are addressed. C.D.

A88-51473

FLIGHT TESTING THE UDF ENGINE

STEVE H. HOLT (General Electric Co., Mojave, CA) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 25-1 to 25-7.

This paper discusses the features of the unducted fan (UDF) engine together with the procedures employed in the flight testing of its 'proof of concept demonstrator', and the results of the flight tests. The UDF engine was shown to permit cruise speeds in excess of Mach 0.8 with fuel consumption from 30 to 70 percent less than conventional turbofans. The test results confirmed the model tests and analytical procedures used to predict performance and acoustical characteristics. Control laws were tested and developed, providing smooth positive engine control throughout the flight envelope. The data obtained can be used to develop design criteria for fan blade frequency responses. I.S.

A88-51474
FLIGHT TEST RESEARCH ON THE STATIC CHARACTERISTICS OF AFTERBURNER FUEL CONTROL SYSTEM FOR TURBOJET ENGINES
LIYI TAO, ZHANPING CHEN (Flight Test Research Center, People's Republic of China), SIQI FAN, and CHIHUA WU (Northwestern Polytechnical University, Xian, People's Republic of China) (Journal of Aerospace Power, vol. 2, Jan. 1987, p. 65-68, 93, 94) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 26-1 to 26-6. Translation. Previously cited in issue 16, p. 2452, Accession no. A87-37844.

A88-51800
TEST EVALUATION OF UH-60A ENGINE DRIVESHAFT DYNAMICS
C. WINSLOW (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. IV-25 to IV-33.

Tests conducted to evaluate the effects of system variables on H-60 engine driveshaft system behavior are described. Installed shaft balance, shaft angular alignment, transmitted torque, and fastener payload were among the variables studied. The results indicated that system response was minimal over the operating range regardless of transmitted torque. However, system unbalance, and unbalance induced by a lack of fastener preload, excited a latent rigid body driveshaft response. K.K.

A88-51929#
AIRCRAFT SYNTHESIS WITH PROPULSION INSTALLATION EFFECTS
C. A. WIDDISION, E. S. SCHREFFLER, and C. W. HOSKING (Boeing Co., Seattle, WA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 8 p.
(Contract F33615-83-C-2347)
(AIAA PAPER 88-4404)

The Propulsion/Weapon System Interaction Model computer program for rapid evaluation of a wide variety of aircraft configurations, in any desired mission application, is structured to allow the user to select from a library of existing generic configurations and propulsion systems. In addition to assessing the propulsion/airframe interaction of different types of engine installations, a flexible mission definition procedure is used which allows the calculation of virtually any mission profile. The propulsion-airframe interactions encompass the effects of inlet losses, nozzle gross thrust, and aft-body drag, on the net thrust of the propulsion system. O.C.

A88-52117
STUDIES AIMED AT INCREASING THE EFFICIENCY OF SOUND-ABSORBING STRUCTURES IN THE DUCT OF AN AIRCRAFT ENGINE [ISSLEDOVANIIA PO POVYSHENIIU EFFEKTIVNOSTI ZVUKOPOGLOSHCHAIUSHCHIKH KONSTRUKTSII V KANALE AVIATSIONNOGO DVIGATELIA]
A. F. SOBOLEV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 6, 1987, p. 41-50. In Russian. refs

Approximation formulas are obtained which make it possible to determine the direction of the maximum radiation of a given mode relative to the duct axis for various ratios between flow velocities inside and outside the duct. Two characteristics cases are considered: (1) continuous transition from flow inside the duct to external flow and (2) the presence of a tangential discontinuity between the jet issuing from the duct and the coflow. The possibility of increasing noise attenuation in the duct by optimizing the attenuation of the principal modes is investigated experimentally. V.L.

N88-27199# Institut National des Sciences Appliquees, Lyon (France). Lab. de Mecanique des Structures.
PREDICTION OF THE AEROELASTIC BEHAVIOR OF TUNED BLADES. APPLICATION TO AIRCRAFT ENGINES Ph.D. Thesis [PREVISION DU COMPORTEMENT AEROELASTIQUE DES AUBAGES ACCORDES. APPLICATION AUX MOTEURS D'AVIONS]
BENOIT VINCENT 1987 155 p In FRENCH Sponsored by SNECMA, France and the Ministere de la Recherche et de la Technologie, Paris, France
(ISAL-87-0046; ETN-88-92757) Avail: NTIS HC A08/MF A01

A method of analysis based on the study of the behavior of the tuned engine blades after investigation of resonant frequencies and dumping in the presence of fluid is proposed. The model presented, in Lagrange coordinates, allows the calculation of complex coefficient differential equation systems. The solution leads to the stability diagnostic. The results obtained in the two described examples show the predominant role played by the fluid. Mechanical and aerodynamic coupling analysis must be done over the whole length of the structure. ESA

N88-27200*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL DETERMINATION OF AERODYNAMIC DAMPING IN A THREE-STAGE TRANSONIC AXIAL-FLOW COMPRESSOR M.S. Thesis - Case Western Reserve Univ.
FREDERICK A. NEWMAN Aug. 1988 113 p
(NASA-TM-100953; E-4267; NAS 1.15:100953) Avail: NTIS HC A06/MF A01 CSCL 21E

Rotor blade aerodynamic damping is experimentally determined in a three-stage transonic axial flow compressor having design aerodynamic performance goals of 4.5:1 pressure ratio and 65.5 lbm/sec weight flow. The combined damping associated with each mode is determined by a least squares fit of a single degree of freedom system transfer function to the nonsynchronous portion of the rotor blade strain gauge output power spectra. The combined damping consists of aerodynamic and structural and mechanical damping. The aerodynamic damping varies linearly with the inlet total pressure for a given equivalent speed, equivalent mass flow, and pressure ratio while structural and mechanical damping are assumed to be constant. The combined damping is determined at three inlet total pressure levels to obtain the aerodynamic damping. The third stage rotor blade aerodynamic damping is presented and discussed for 70, 80, 90, and 100 percent design equivalent speed. The compressor overall performance and experimental Campbell diagrams for the third stage rotor blade row are also presented. Author

N88-28005# Stewart Hughes Ltd., Southhampton (England).
RECENT ADVANCES IN ENGINE HEALTH MANAGEMENT
K. PIPE *In* DFVLR, Proceedings of the 14th Symposium on Aircraft Integrated Monitoring Systems p 73-97 Jan. 1988
Avail: NTIS HC A99/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Fed. Republic of Germany 160 Deutsche marks

The problem of extracting an accurate prognosis for the data available in aircraft engine health management, and establishing a practical management system for the types of monitoring system required to support the analysis techniques are reviewed. Computer and statistical techniques for solving these problems are outlined.

The use of representational models in pattern matching approaches is emphasized. The advantages of using an expert system to fully exploit all the monitoring information available are underlined. The need to translate data into a form meaningful to maintenance and plant engineers is stressed. ESA

N88-28063# Allied-Signal Aerospace Co., Phoenix, Ariz. Engine Div.

JTDE 1 XTE34 MATERIALS RESEARCH AND DEVELOPMENT REPORT

A. GRAHAM 15 Jan. 1988 28 p
(Contract F33657-83-C-2004)
(AD-A194268; REPT-21-6519) Avail: NTIS HC A03/MF A01 CSCL 13I

This report describes the materials research and development efforts conducted in support of the Joint Technology Demonstrator Engine (JTDE) Flowpath Test and Assessment (FTA) Program. The impeller run in the JTDE XTE34 was fabricated from the titanium alloy Ti 6-2-4-6. This component was originally intended to be a hollow, dual alloy impeller, which was needed to meet the design life goals for this engine. The dual alloy impeller concept used a creep resistant titanium alloy (Ti-5Al-6Sn-2Zr-1Mo + Si) for the backface and a high tensile and fatigue strength titanium alloy (Ti-6Al-2Sn-4Zr-2Mo + Si) for the hub and blades (Figure 1). In addition, internal cavities were generated during the fabrication sequence that significantly reduced the impeller weight and bore stresses. Additional GED-funded, materials R and D effort focused primarily on the HP compressor impeller, which had experienced a HCF failure in ATEGG testing, and on the LP turbine stator. Engine testing demonstrated that all materials behaved as intended and no material flaws or HCF initiation sites were found in any of the components examined after the XTE34 test programs. GRA

N88-28064# Rolls-Royce Ltd., Derby (England).

COMPASS GROUND BASED ENGINE MONITORING PROGRAM FOR GENERAL APPLICATION

M. J. BARWELL 6 Oct. 1987 13 p Presented at the SAE Aerotech 87 Conference, 6 Oct. 1987 Previously announced in IAA as A88-30755
(PNR90420; ETN-88-92667) Avail: NTIS HC A03/MF A01

The COMPASS engine monitoring program, consisting of diagnostic routines particular to a given engine manufacturer, and host services of input/output interfacing, and utility functions including, for example, smoothing and trending, alert generation, fleet averaging, compression, data storage, and data plotting is described. In civil operation the host is applicable to any gas turbine engine, and is also suitable for aircraft performance monitoring. The benefits of a common host to an airline are the need to provide only one set of interfaces and of having only one operating procedure to learn and maintain. The use of the host could be extended to cover military, marine and industrial gas turbine engine monitoring or indeed any industrial or non gas turbine operation requiring data to be processed, either on line or in batch mode, with output evaluated through a smoothing/trending routine and alerts generated and output displayed as appropriate. ESA

N88-28066# Rolls-Royce Ltd., Derby (England).

APPLICATIONS OF FATIGUE ANALYSES: AIRCRAFT ENGINES

A. C. PICKARD, M. A. HICKS, and R. H. JEAL 29 Jun. 1987 27 p Presented at Fatigue 87, Charlottesville, Va., 29 Jun. - 3 Jul. 1987
(PNR90439; ETN-88-92674) Avail: NTIS HC A03/MF A01

Approaches to ensure the safety and reliability of aircraft engine components subject to cyclically varying loading systems are reviewed. Traditional fatigue crack initiation life approaches are compared with database, damage tolerant, and retirement for cause methods. The importance of testing full scale components under representative conditions is emphasized. The requirement for this test evidence is discussed from a total life viewpoint, where it is essential that the life prediction is based on material with the correct standard of surface finish and with a sufficient volume of material subjected to representative stressing conditions. Validation requirements for fracture mechanics based crack propagation life prediction methods are also discussed. Examples are given of the correlation of full scale component behavior with life predictions to demonstrate the validity and limitations of the current approaches. Potential improvements in life prediction methods are discussed. ESA

N88-28067# Rolls-Royce Ltd., Derby (England). Advanced Civil Projects.

TRENDS IN CIVIL AIRCRAFT PROPULSION

J. H. R. SADLER 1 Oct. 1987 27 p Presented at the Institution of Mechanical Engineers Aerospace Technology Conference, Birmingham, United Kingdom, Oct. 1987
(PNR90441; ETN-88-92676) Avail: NTIS HC A03/MF A01

Commercial forces in civil aircraft propulsion systems and how they vary with aircraft size and range are reviewed. Industry responses to these requirements are discussed. ESA

N88-28068# Rolls-Royce Ltd., Derby (England).

FUTURE TRENDS IN AVIATION PROPULSION

D. J. PICKERELL 18 Nov. 1987 13 p Presented at the 1987 Australian Aviation Symposium, Canberra, Australia, 18-20 Nov. 1987
(PNR90443; ETN-88-92677) Avail: NTIS HC A03/MF A01

Development possibilities of aircraft engines are reviewed. Military combat engines thrust/weight ratios twice those of engines in service today are technically possible, and on civil subsonic engines further substantial improvements in fuel efficiency are possible. For the longer term future there is the prospect of a 2nd generation supersonic transport and HOTOL. However, when (or whether) these appear depends on economic and political factors as much as on the technology. ESA

N88-28069# Rolls-Royce Ltd., Derby (England).

RB211 DEVELOPMENTS

D. J. PICKERELL 1 Nov. 1987 16 p Presented at the International Pacific Air and Space Technology Conference, Melbourne, Australia, Nov. 1987
(PNR90444; ETN-88-92678) Avail: NTIS HC A03/MF A01

The growth prospects of long haul civil air transportation in the Pacific basin and the contribution made by the RB211-524 engine in the Boeing 747 are examined. The development of the latest committed version of this engine giving over 60,000lb static thrust is described as well as the design of the proposed 65,000lb static thrust RB211-524L powerplant. The prospects for ultra high bypass ratio cowled turbofans for long haul operation in the next century are reviewed. ESA

N88-28070# Rolls-Royce Ltd., Derby (England).

THE COMPOSITE AEROENGINE

G. E. KIRK 23 Mar. 1988 18 p Presented at the Plastics and Rubber Institute Conference, Liverpool, United Kingdom, 23-26 Mar. 1988
(PNR90451; ETN-88-92682) Avail: NTIS HC A03/MF A01

Aeroengine materials are reviewed. Current aeroengine materials are reaching the limits of their development but composite materials have the potential to meet the increased requirements. The use of resin composites increased, and with improvements could be used more extensively. Metal and ceramics composites are being considered where higher temperature capability is required. ESA

N88-28071# Rolls-Royce Ltd., Derby (England).

A REVIEW OF NON-CONTACTING DISPLACEMENT MEASUREMENT TECHNIQUES USED TO MONITOR THE MOVEMENT OF ROTOR BLADES IN GAS TURBINE AERO ENGINES

P. LOFTUS 15 Oct. 1987 27 p Presented at the Test and Transducer Conference, Oct. 1987
(PNR90457; ETN-88-92687) Avail: NTIS HC A03/MF A01

Techniques to measure the changes in rotor blade geometry which occur during a flight cycle are discussed. They include measurement of blade tip axial position by optical or inductive techniques; measurement of blade tip clearance by optical or capacitive techniques; and measurement of blade untwist and decamber using timing probes. All the techniques involve the use of relatively easily installed casing mounted sensors to monitor the tips of the rotor blades. They can all normally be fitted to standard engine parts using modifications which require only the removal of metal. ESA

N88-28072# Rolls-Royce Ltd., Derby (England). Advanced Research Lab.
HOLOGRAPHIC INTERFEROMETRY FOR FLOW VISUALIZATION STUDIES IN HIGH SPEED FANS
R. J. PARKER 4 Feb. 1988 44 p Presented at the Von Karman Institute for Fluid Dynamics Lecture Series 3 on the Transonic Compressors, Rhode Saint Genese, Belgium, 1-4 Feb. 1988
(PNR90459; ETN-88-92689) Avail: NTIS HC A03/MF A01

Holography was developed as a technique for routine use in the evaluation of fan designs for aero-engines. It is used to investigate aerodynamic and mechanical behavior of the rotating fan. Holographic flow visualization provides clear, three-dimensional images of the transonic flow region between the fan blades. Flow features such as shocks, shock/boundary layer interaction, and over-tip leakage vortices can be observed and measured. Examples of the use of this technique at rotational speeds up to and in excess of 10,000 rpm are given. Holography provides valuable information used to verify and improve numerical modeling of the fan behavior and is successful in evaluating the achievement of design intent. ESA

N88-28074*# Pratt and Whitney Aircraft, East Hartford, Conn.
STRUCTURAL TAILORING OF ADVANCED TURBOPROPS (STAT) Interim Report
KENNETH W. BROWN Aug. 1988 67 p
(Contract NAS3-23941)
(NASA-CR-180861; NAS 1.26:180861; PWA-5967-46) Avail: NTIS HC A04/MF A01 CSCL 21E

This interim report describes the progress achieved in the structural Tailoring of Advanced Turboprops (STAT) program which was developed to perform numerical optimizations on highly swept propfan blades. The optimization procedure seeks to minimize an objective function, defined as either direct operating cost or aeroelastic differences between a blade and its scaled model, by tuning internal and external geometry variables that must satisfy realistic blade design constraints. This report provides a detailed description of the input, optimization procedures, approximate analyses and refined analyses, as well as validation test cases for the STAT program. In addition, conclusions and recommendations are summarized. Author

08

AIRCRAFT STABILITY AND CONTROL

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

A88-49929#
THE CORRECTION PRINCIPLE OF A SPRING BAR AND ITS APPLICATION TO THE MOMENT CONTROL SYSTEM
KUNHUA LIU (Ministry of Aviation Industry, Beijing, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, June 1988, p. B303-B308. In Chinese, with abstract in English.

The way in which a loaded object (e.g., the actuator of an aircraft) affects the dynamic characteristics of a moment control system is studied. The paper presents a correction principle based on the use of a spring bar on the moment control system. By comparing theoretical and experimental data, a basic method for selecting an optimum spring bar is then given. It is necessary to study special design principles to extend the bandwidth of the system. Author

A88-50007
EFFECT OF THE DIMENSIONS OF AIRCRAFT ON ITS FLIGHT DYNAMICS IN A TURBULENT ATMOSPHERE [VLIIANIE RAZMEROV SAMOLETA NA EGO DINAMIKU PRI POLETE V TURBULENTNOI ATMOSFERE]
I. N. TITOVSKII and I. G. KHVOSTOVA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 1, 1986, p. 55-63. In Russian. refs

A method is proposed which makes it possible to determine the statistical characteristics of the increments of forces and moments acting on an aircraft with a large aspect ratio wing flying in a turbulent atmosphere in the case where the scale of turbulence is comparable with the geometrical dimensions of the aircraft. Approximate formulas for estimating the variance of the perturbation forces and moments are obtained which provide good agreement with numerical calculations. V.L.

A88-50009
A STUDY OF ASTATIC RESERVED DIGITAL AIRCRAFT CONTROL SYSTEMS WITH ASYNCHRONOUS COMPUTERS [ISSLEDOVANIE ASTATICHESKIKH REZERVIROVANNYKH TSIFROVYKH SISTEM UPRAVLENIIA SAMOLETA S ASINKHRONNYMI VYCHISLITELIAMI]
P. V. KUSHNIR and IU. F. SHELIUKHIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 1, 1986, p. 82-90. In Russian.

A method for the analysis of reserved digital control systems with asynchronously operating computers is examined which allows the stability analysis to be performed on the basis of the eigenvalues of a specially constructed conversion matrix. The effect of signal control methods on the maximum permissible gain coefficients is demonstrated using an integral control system as an example. Signal mismatch in reserved channels is estimated for the case of stochastic and deterministic effects. V.L.

A88-50056
OPTIMAL CRUISE FLIGHT CONDITIONS OF A NONMANEUVERABLE AIRCRAFT BASED ON THE RANGE CRITERION [OPTIMAL'NYI KREISERSKII REZHIM POLETA NEMANEVRENNOGO SAMOLETA PO KRITERIIU DAL'NOSTI]
V. A. GRIGOR'EV and V. K. SVIATODUKH TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 4, 1986, p. 24-34. In Russian. refs

Necessary conditions for the optimal cruise flight of a nonmaneuverable aircraft are obtained which allow for the effects of air compressibility, airframe elasticity, and balancing relative to the longitudinal moment in the case where the position of the center of mass is the parameter to be optimized and where it depends on the aircraft mass. Using a hypothetical aircraft as an example, the effect of the position of the center of mass on the optimum flight parameters and cruise flight range are estimated. V.L.

A88-50057
APPROXIMATE SYNTHESIS OF AIRCRAFT CONTROL FOR A MINIMUM-TIME CLIMB WITH A SPECIFIED FINAL VELOCITY [PRIBLIZHENNYI SINTEZ UPRAVLENIIA SAMOLETOM DLIA NABORA VYSOTY S ZADANNOI KONECHNOI SKOROST'IU ZA MINIMAL'NOE VREMIA]
N. B. PROKOPETS and A. V. SAVEL'EV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 4, 1986, p. 35-44. In Russian. refs

A simple algorithm is proposed for the approximate synthesis of aircraft control for a minimum-time flight from arbitrary initial conditions to arbitrary final condition with climbing. The algorithm involves program tracking in the H(height)-E(specific energy) plane which, in contrast to similar algorithms for the H-M and H-V planes, does not contain singularities. A procedure is proposed for the synthesis of piecewise-linear programs which compute near-optimum flight trajectories for a wide range of initial and final conditions. V.L.

A88-50079
EFFECT OF CONTROL-SENSITIVITY CHARACTERISTICS ON PILOT EVALUATION OF AIRCRAFT CONTROLLABILITY [VLIIANIE KHARAKTERISTIK CHUVSTVITEL'NOSTI UPRAVLENIIA NA OTSENKU LETCHIKOM UPRAVLIAEMOSTI SAMOLETA]
L. E. ZAICHIK, V. V. RODCHENKO, and P. M. CHERNIAVSKII TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 5, 1986, p. 86-93. In Russian. refs

Based on simulator results and literature data, a criterion is formulated for choosing the sensitivity characteristics of aircraft control. A relationship is obtained which approximately describes the deterioration in pilot evaluation of aircraft handling qualities when the sensitivity characteristics diverge from the optimal ones. B.J.

A88-50080
DIFFERENTIAL METHOD OF THE CONTINUATION OF SOLUTIONS OF SYSTEMS OF FINITE NONLINEAR EQUATIONS WHICH ARE PARAMETER-DEPENDENT [DIFFERENTSIAL'NYI METOD PRODOLZHENIIA RESHENII SISTEM KONECHNYKH NELINEINYKH URAVNENII, ZAVISIASHCHIKH OT PARAMETRA]
M. G. GOMAN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 5, 1986, p. 94-102. In Russian. refs

A system of ordinary differential equations (ODEs) is obtained for the continuation of solutions of systems of finite nonlinear equations with parameter variation. For these ODEs, the unknown single-parameter family of solutions of the finite equations is a stable phase trajectory. A finite-difference algorithm of solution continuation is examined. This approach is applied to the dynamics of the three-dimensional motion of an aircraft. B.J.

A88-50095
METHOD FOR THE EXPERIMENTAL DETERMINATION OF THE FREQUENCY CHARACTERISTICS OF AN ELASTIC FLIGHT VEHICLE WITH A DIGITAL CONTROL SYSTEM [METODY EKSPERIMENTAL'NOGO OPREDELENIIA CHASTOTNYKH KHARAKTERISTIK UPRUGOGO LETATEL'NOGO APPARATA S TSIFROVOI SISTEMOI UPRAVLENIIA]
V. M. KUVSHINOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 6, 1986, p. 54-68. In Russian. refs

Several frequency-analyzer-based techniques for determining the frequency characteristics of flight vehicles with a digital control system in the elastic-vibration frequency range of the structure are examined. Errors due to the finite measurement time are assessed, and simple relationships for choosing the appropriate measurement time are proposed. B.J.

A88-50160
AIAA GUIDANCE, NAVIGATION AND CONTROL CONFERENCE, MINNEAPOLIS, MN, AUG. 15-17, 1988, TECHNICAL PAPERS. PARTS 1 & 2
Conference sponsored by AIAA. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. Pt. 1, 590 p.; pt. 2, 582 p. For individual items see A88-50161 to A88-50279.

Theoretical and applications aspects of aircraft and spacecraft guidance, control, and navigation are examined in reviews and reports of recent investigations. Topics addressed include the optimal nonlinear regulator problem, nonlinear control of a twin-lift helicopter configuration, pole/zero cancellation in flexible space structures, modeling of noncollocated structural control systems, maximum-terminal-velocity descent to a point, test results on spaceborne laser radars, two-controller designs for decentralized systems, and reduction of missile navigation errors by roll programming. Consideration is given to eigenspace methods for symmetric flutter suppression, a quaternion feedback regulator for spacecraft eigenaxis rotations, thrust vectoring and poststall capability in air combat, guidance and control for cooperative tether-mediated orbital rendezvous, a high-accuracy CCD sun sensor, and pilot decisionmaking during low-altitude wind-shear encounters. T.K.

A88-50162#
NONLINEAR CONTROL OF A TWIN-LIFT HELICOPTER CONFIGURATION
P. K. A. MENON, D. P. SCHRAGE, and J. V. R. PRASAD (Georgia Institute of Technology, Atlanta) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 8-14. Army-supported research. refs
(AIAA PAPER 88-4051)

A nonlinear control scheme based on feedback linearization is proposed for the twin-lift helicopter configuration. It is desirable to provide a high degree of stability augmentation for this mission due to a significant increase in the pilot workload. Two control philosophies are explored: the role-assigned control and cooperative control concepts. The controller performance is demonstrated in a nonlinear simulation of the twin-lift system in the transversal plane. Implementation aspects and extension of the present research to the multilift configuration are discussed. Author

A88-50163#
NEAR OPTIMAL FEEDBACK CONTROL FOR NONLINEAR AERODYNAMIC SYSTEMS WITH AN APPLICATION TO THE HIGH-ANGLE-OF-ATTACK WING ROCK PROBLEM
WILLIAM NEFF PATTEN (Iowa, University, Iowa City) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 15-25. refs
(Contract F49620-85-C-0013)
(AIAA PAPER 88-4052)

The analytical derivation of a discrete near-optimal nonlinear feedback controller for aircraft operating at high angles of attack is outlined, and the performance of the controller is demonstrated in numerical simulations. The residual form of the quasi-linearized optimal-control problem is mapped into a minimal-order parameter-dependent algebraic problem via the FEM, and the numerical implementation employs a variable-element mesh to obtain a first-order action to be applied to the aircraft for a short time (with feedback control thereafter). Simulation results for closed-loop control of the unsteady prestall rocking motion of a delta wing at high angle of attack are presented in graphs and briefly characterized. T.K.

A88-50177#
4D-TECS INTEGRATION FOR NASA TCV AIRPLANE
ISAAC KAMINER and PATRICK O'SHAUGHNESSY (Boeing Co., Seattle, WA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 130-140. refs
(AIAA PAPER 88-4067)

Presented here is a design of the four-dimensional mode for an integrated autopilot/autothrottle control system named TECS. This design involves integrating a four-dimensional flight trajectory generator with TECS, creating an outer-loop-time-error control law, and integrating spoilers with TECS to increase the energy bleed-off capacity of the system during descent. The resulting system follows a precomputed four-dimensional profile in cruise, except if there is a large time error when the system is engaged. In such a case, the system generates a speed profile to null out the time error by the top of descent. During descent, the system follows a fixed profile by employing both throttles and spoilers. Author

A88-50178#
A SYSTEM CONCEPT FOR COORDINATED LEADER-FOLLOWER RPV GUIDANCE
MICHAEL J. RUTH (Johns Hopkins University, Laurel, MD) IN:

AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 141-151.
(AIAA PAPER 88-4068)

A detailed RPV simulation is used to study the feasibility of a system concept for the task of regulating follower aircraft position relative to a leader aircraft for the portion of the total mission in which the aircraft navigates to the target area. A decoupled classical control law and a hybrid skid-to-turn/bank-to-turn guidance law have been developed for the task. Positive and stable station-keeping performance is shown throughout a simulated tactical-length mission, demonstrating the viability of the present technical approach. R.R.

A88-50180#
MINIMUM TIME TURNS USING VECTORED THRUST
GARRET L. SCHNEIDER and GEORGE W. WATT (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 171-177. refs
(AIAA PAPER 88-4070)

A steepest-ascent optimization technique is used to determine the optimal controls and trajectories which minimize the time to turn for a high performance aircraft with thrust vectoring capability. No constraints were placed on the angles through which the thrust was vectored in order to determine how much range of thrust vectoring would be exploited if it were available. The determined controls and trajectories are then compared against other methods of turning in minimum time to determine the effects and advantages of thrust vectoring. The results indicate that the use of vectored thrust to supplement the aircraft's lift by directing the thrust into the turn can substantially reduce turning times and increase in-flight maneuverability. The greater the velocity at which the turn is initiated, the larger the range of thrust vectoring capability is used and the greater the reduction in turning time. Author

A88-50185*# Purdue Univ., West Lafayette, Ind.
MODELING, MODEL SIMPLIFICATION AND STABILITY ROBUSTNESS WITH AEROELASTIC VEHICLES
DAVID K. SCHMIDT (Purdue University, West Lafayette, IN) and BRETT NEWMAN IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 210-221. refs
(Contract NAG1-758)
(AIAA PAPER 88-4079)

The linearization and simplification of a nonlinear, literal model for flexible aircraft is highlighted. Areas of model fidelity that are critical if the model is to be used for control system synthesis are developed, and several simplification techniques that can deliver the necessary model fidelity are discussed. These techniques include both numerical and analytical approaches. An analytical approach, based on first-order sensitivity theory is shown to lead not only to excellent numerical results, but also to closed-form analytical expressions for key system dynamic properties such as the pole/zero factors of the vehicle transfer-function matrix. The analytical results are expressed in terms of vehicle mass properties, vibrational characteristics, and rigid-body and aeroelastic stability derivatives, thus leading to the underlying causes for critical dynamic characteristics. Author

A88-50204*# Clemson Univ., S.C.
AN APPLICATION OF EIGENSPACE METHODS TO SYMMETRIC FLUTTER SUPPRESSION
ROBERT E. FENNELL (Clemson University, SC), WILLIAM M. ADAMS, JR. (NASA, Langley Research Center, Hampton, VA), and DAVID M. CHRISTHILF (PRC Kentron, Hampton, VA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 391-399. refs
(Contract N00014-86-K-0693; NAS1-18107)
(AIAA PAPER 88-4099)

An eigenspace assignment approach to the design of parameter insensitive control laws for linear multivariable systems is presented. The control design scheme utilizes constrained optimization techniques to exploit the flexibility in eigenvector assignments to reduce control system sensitivity to changes in system parameters while maintaining performance requirements; it thus provides a systematic approach for choosing values for eigensystem design variables. The methods involve use of the singular value decomposition to provide an exact description of allowable eigenvectors in terms of a minimum number of design parameters. In a design example, the methods are applied to the problem of symmetric flutter suppression in an aeroelastic vehicle. In this example the flutter mode is sensitive to changes in dynamic pressure and eigenspace methods are used to enhance the performance of a stabilizing minimum energy/linear quadratic regulator controller and associated observer. Numerical results indicate that the methods provide feedback control laws that make the stability of the nominal closed loop systems less sensitive to changes in dynamic pressure, while maintaining acceptable control power and robustness constraints. Author

A88-50206*# City Coll. of the City Univ. of New York.
EIGENSTRUCTURE ASSIGNMENT FOR A THRUST-VECTORED HIGH ANGLE-OF-ATTACK AIRCRAFT
KENNETH M. SOBEL (City College, New York) and FREDERICK J. LALLMAN (NASA, Langley Research Center, Hampton, VA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 408-413. refs
(AIAA PAPER 88-4101)

Eigenstructure assignment is utilized to design flight control laws for a thrust-vectored aircraft at several different angles of attack. An interesting characteristic of the aircraft model is that the control distribution matrix is rank-deficient. Also, the effectiveness of the control inputs varies with the angle of attack. A pseudocontrol strategy is used to reduce the control space to two dimensions. After the eigenstructure assignment design is complete, the controller is mapped back to the original five-dimensional control space. The designs are shown to exhibit acceptable multivariable stability margins at the aircraft inputs. Author

A88-50208#
A GRAPHICAL METHOD FOR IMPROVED EIGENSTRUCTURE ASSIGNMENT DESIGN
P. R. SMITH (Royal Aircraft Establishment, Bedford, England) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 421-429. refs
(AIAA PAPER 88-4103)

The method of eigenstructure assignment for the design of control laws using output feedback is reviewed. To allow more effective design a characterization norm is defined, which can be used to provide a graphical illustration of the potential behavior of each mode in the S plane. Use of the method is demonstrated by application to the design of a lateral-directional control law for a nonlinear model of a fast-jet aircraft using appropriate flying qualities criteria. Author

A88-50215#
TWO-TIME-SCALE OUTPUT FEEDBACK DESIGN FOR LONGITUDINAL CONTROL OF AIRPLANES
HASSAN K. KHALIL (Michigan State University, East Lansing) and FU-CHUANG CHEN IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 500-510. refs

(Contract NSF ECS-86-10714)
(AIAA PAPER 88-4112)

A recently developed method for output feedback control of linear two-time-scale systems is applied to longitudinal flight control design. The paper starts by modeling longitudinal dynamics of an airplane into the singularly perturbed form. It is shown that short period and phugoid approximations obtained via the singular perturbation approach are reasonably accurate even for a modern unstable airplane. The sequential design procedure is introduced to design a two-time-scale compensator for a next generation transport airplane by designing the fast compensator first and then designing the slow compensator. The results of fast and slow designs are shown to be reasonably recovered in the full design. Author

A88-50216#
OPTIMAL REGULATORS WITH KESSLER TYPE OF POLE LOCATION WITH APPLICATION TO ROLL AUTOPILOT DESIGN
H. OHTA, M. KAKINUMA (Nagoya University, Japan), and P. N. NIKIFORUK (Saskatchewan, University, Saskatoon, Canada) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 511-518. refs
(Contract NSERC-A-5625; NSERC-A-1080)
(AIAA PAPER 88-4113)

An inverse problem of optimal linear quadratic regulators (LQR) is examined for single-input systems, and the selection of the weighting matrices which achieve a specified pole location is discussed in this paper. In particular, the Kessler polynomial is used as a desirable pole location, and the weighting matrices are derived in an analytical form. Although this pole specification results in the use of some negative weights in the performance index, the existence and uniqueness of the solution are guaranteed by Molinari's (1973) theorem. At the sacrifice of the circle condition, it is shown that some of the deficiencies of the LQR controllers are avoided and that several characteristics which classical controllers provide, but which modern methods cannot, are retained. An application to roll autopilot systems for missiles is given to illustrate and substantiate the proposed method as well as to compare it with the conventional LQR. Author

A88-50217#
A SYNTHESIS OF ROBUST OPTIMAL REGULATORS USING SINGULAR VALUE WITH APPLICATION TO GUST LOAD ALLEVIATION
H. OHTA and A. FUJIMORI (Nagoya University, Japan) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 519-528. Research supported by the Ishida Foundation. refs
(AIAA PAPER 88-4114)

Performance specifications and the stability robustness condition are examined, in order to define magnitude constraints of the loop transfer function singular values used in a synthesis method for multivariable systems' linear optimal regulators. The weighting matrices of the quadratic performance index are selected by the quasi-Newton method; the weights are assumed to be diagonal, leading to a nonsingular matrix in terms of the directional derivatives, and they constitute an optimal regulator that improves system characteristics while maintaining stability. The synthesis method is used to design an aircraft gust alleviation system able to reduce bending moments by 40-80 percent, by comparison with open-loop systems. O.C.

A88-50219#
DESIGN OF DIGITAL MODEL-FOLLOWING FLIGHT-MODE CONTROL SYSTEMS FOR HIGH-PERFORMANCE AIRCRAFT
B. PORTER, A. MANGANAS, and T. MANGANAS (Salford, University, England) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 536-546. refs
(AIAA PAPER 88-4116)

In order to develop a new approach to the design of digital model-following systems that is more direct and more perspicuous than conventional approaches, it is shown that previous results for the design of fast noninteracting digital signal-following systems can be used directly for the design of digital model-following systems. Such model-following systems accordingly incorporate fast-sampling error-actuated digital PID controllers, and the power of the resulting methodology is illustrated by the design of digital model-following flight-mode control systems for the F-16 aircraft. Author

A88-50236#
ANALYSIS AND SIMULATION OF CONTROL DISTRIBUTOR CONCEPT FOR A CONTROL-RECONFIGURABLE AIRCRAFT
CHIEN Y. HUANG (Grumman Aerospace Corp., Bethpage, NY) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 726-735. refs
(AIAA PAPER 88-4139)

Studies of a control reconfiguration scheme based on Control Distributor Concept are presented. The work examines the mechanism behind the approach and discusses its applications and limitations using linear analysis. Modifications to the basic control distributor are described and its performance evaluated using nonlinear simulation of an advanced fighter aircraft. It is concluded that, when used within the constraints, the Control Distributor Concept can play a role in a more encompassing control reconfiguration strategy. Author

A88-50237#
APPLICATION OF EIGENSTRUCTURE ASSIGNMENT TO THE DESIGN OF STOVL FLIGHT CONTROL SYSTEMS
H. P. LEE, H. M. YOUSSEF, and R. P. HANEL (Lockheed Aeronautical Systems Co., Burbank, CA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 736-748. refs
(AIAA PAPER 88-4140)

The application of eigenstructure assignment method to the design of the transition and hover control laws for a Short Takeoff Vertical Landing (STOVL) aircraft is described in this paper. A set of feedback structures for the STOVL flight control system is first selected. Desired eigenvalues and eigenvectors are then chosen to satisfy flying qualities requirements and to decouple appropriate modes of the augmented aircraft. Feedback gains are computed to best approximate the desired eigenvalues and eigenvectors by using the constrained output feedback eigenstructure assignment method. The control law performance is demonstrated by simulations. Author

A88-50238#
DESIGN OF ATTITUDE AND RATE COMMAND SYSTEMS FOR HELICOPTERS USING EIGENSTRUCTURE ASSIGNMENT
WILLIAM L. GARRARD, EICHER LOW, and SCOTT PROUTY (Minnesota, University, Minneapolis) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 749-759. refs
(Contract DAAL03-86-K-0056)
(AIAA PAPER 88-4141)

This paper describes the use of eigenstructure assignment in the direct design of attitude and attitude rate command systems for helicopter flight control. Eigenvalue assignment is used to achieve desired bandwidth based on handling qualities specifications and eigenvector assignment is used to achieve decoupling of lateral, longitudinal, heave and yaw modes and to achieve the desired command response characteristics. Eigenstructure techniques are also used to design a state estimator which gives desired closed loop frequency response. The stability robustness of the control system is evaluated with respect to an error model which includes rotor, actuator, flexure and sensor dynamics and computational and sampling delays in the flight control system. The controlled helicopter is shown to exhibit both good frequency and time response characteristics. Author

A88-50239#
COMPUTER SIMULATION OF PILOT-INDUCED OSCILLATION FOR THE HIGH TECHNOLOGY TEST BED AIRCRAFT
F. B. GREEN (Lockheed Aeronautical Systems Co., Marietta, GA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 760-766.
(AIAA PAPER 88-4142)

The High Technology Test Bed (HTTB) aircraft is an experimental STOL (short takeoff and landing) aircraft which requires a fail-operative DFSC (digital flight control system) plus a pitch rate command/attitude hold augmentation control law to achieve Level 1 flying qualities during a STOL approach and landing. During piloted simulation, a pilot-induced oscillation (PIO) problem was detected which, although infrequent, was severe enough to warrant investigation and correction. This paper examines the operation of this type of pitch augmentation control law, identifies the conditions under which the PIO occurs, synthesizes a correction to correct the problem, and verifies the operation during piloted simulation. In addition to this, a method by which PIO can be reproduced using a digital computer simulation allowing an analytical approach to the problem was developed. Author

A88-50240#
A METHODOLOGY TO GENERATE AN AEROELASTIC MODEL OF A FLEXIBLE AIRCRAFT FOR USE IN CONTROL LAW DESIGN AND ANALYSIS
BRION G. L. RICHARDSON and DON F. KESLER (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 767-776.
(AIAA PAPER 88-4143)

A program has been developed at Northrop which generates a linear state space model of a fully flexible aircraft for use in control system analysis and development. This model is derived from NASTRAN computed data including generalized mass, generalized stiffness, rigid body and elastic modeshapes, and nonsteady aerodynamic force data. This model allows the user to select several options including: type of actuator, identity of flexible modes included in the model, identity of flexible modes residualized in the model, velocity and altitude, type and location of output sensors, and inclusion of alternate rigid body data. Author

A88-50241#
METHODS FOR MODEL REDUCTION
RICHARD DEAN COLGREN (Lockheed Aeronautical Systems Co., Burbank, CA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 777-790. refs
(AIAA PAPER 88-4144)

Three methods for generating reduced order models for control design, including spectral decomposition, simultaneous gradient error reduction, and balancing, are described and compared. The motivations behind each of these methods are considered, and an eighth-order longitudinal model of an Advanced Supersonic Transport with an unstable short period is used to demonstrate each of the methods. Single-input single-output frequency responses are used to demonstrate the characteristics of the results for the methods. It is shown that each method can produce different results for the same problem, and that the selection of the best method depends on the characteristics of the model to be analyzed. C.D.

A88-50256#
A MINIMAL REALIZATION ALGORITHM FOR FLIGHT CONTROL SYSTEMS
CHIN S. HSU (Washington State University, Pullman), GREGORY ROBEL (Boeing Commercial Airplane Co., Seattle, Washington), and D. HOU IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 928-931. refs
(AIAA PAPER 88-4165)

A minimal realization method which is particularly appealing for realizing flight control systems is presented. The computational simplicity of the method is due to the fact that the method works well only for control systems with distinct and/or complex-pair eigenvalues. Many flight control systems satisfy this assumption. Two illustrative numerical examples are included to demonstrate the simplicity and numerical accuracy of the proposed method. C.D.

A88-50272*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COOPERATIVE SYNTHESIS OF CONTROL AND DISPLAY AUGMENTATION FOR A STOL AIRCRAFT IN THE APPROACH AND LANDING TASK
SANJAY GARG (NASA, Lewis Research Center; Sverdrup Technology, Inc., Middleburg Heights, OH) and DAVID K. SCHMIDT (Purdue University, West Lafayette, IN) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1071-1082. Research supported by Honeywell Inc. refs
(Contract NAG4-1; F33615-86-C-3615)
(AIAA PAPER 88-4182)

Application of the Cooperative methodology to synthesize control/display augmentation systems for the piloted longitudinal landing task with a modern, statically-unstable, fighter aircraft is considered. Starting with a control augmentation law which yields augmented vehicle dynamics that meet Level I handling qualities specifications, the effect of time-delay in the Head-up-display is studied using model-based criterion. This evaluation showed that even with 'good' conventional dynamics, a realistic value of display time-delay will cause significant deterioration in pilot workload and piloted-system performance. Application of the Cooperative methodology to control augmentation alone resulted in augmented vehicle dynamics which provide direct control of the flight path from the pilot stick. Analytical evaluation of these dynamics indicates that such dynamics might lead to improved pilot ratings over conventional dynamics, especially in the presence of time-delays in the system. Also, application of the methodology to simultaneous synthesis of control augmentation and flight director laws revealed that it might be advantageous to consider the control/display trade-off in the early design stages. Author

A88-50574#
A DIGITAL ADAPTIVE FLIGHT CONTROL SYSTEM DESIGN FOR AIRCRAFT WITH VARYING STABILITY DERIVATIVES
YUZO SHIMADA, NOBUHIKO KOBAYASHI, and HIROAKI MIYAZAWA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 413, 1988, p. 304-311. In Japanese, with abstract in English. refs

The analytical derivation of an adaptive digital FCS for aircraft with continuously varying stability derivatives is outlined, and the performance of a prototype controller is demonstrated by means of numerical simulations of an advanced jet fighter. Existing controllers for linear time-varying systems are modified by introducing a parameter-adjustment algorithm which synthesizes the input to the aircraft from estimates of the dynamic-pressure power coefficients. The simulation results are presented in graphs, and the proposed controller is found to exhibit good adaptive capabilities. T.K.

A88-50581#

INVESTIGATION OF THE EFFECT OF VARIABLE TAIL DIHEDRAL ON AIRPLANE STABILITY AND CONTROL

JAMES ALLAN KIDD (USAF, Armament Laboratory, Eglin AFB, FL) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 46-54. refs

(AIAA PAPER 88-4335)

A variable-dihedral tail fighter configuration is presently studied to ascertain whether the positioning of stabilators (stabilizers/elevators) in dihedral can maintain sufficient lateral control at high angles-of-attack, while retaining adequate pitching moment authority. Wind tunnel tests were conducted in a subsonic wind tunnel to obtain static force and moment data, and equations of motion were derived for a symmetrically variable dihedral tail design. The stability and controllability of each stabilator dihedral configuration were analyzed with state-space methods. The eigenvalues obtained did not significantly vary with dihedral angle. O.C.

A88-50585#

EFFECT OF WING AND TAIL INTERFERENCES ON THE AUTOROTATIONAL CHARACTERISTICS OF LIGHT AIRPLANE FUSELAGES

BANDU N. PAMADI (Vigyan Research Associates, Inc., Hampton, VA) and ANISUR RAHMAN IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 83-93. refs

(AIAA PAPER 88-4339)

A systematic study was performed of the interference effects on autorotational characteristics of light airplane fuselage models through single degree-of-freedom, free-to-roll tests in a low speed, open jet wind tunnel with various combinations of wing and tail surfaces. The test results show that the interference due to wing is generally damping type. The interference between fuselage and tail surfaces was found to be dependent primarily on the cross sectional shape of the fuselage. The overall effect of wing and tail surfaces was one of damping in nature. For the models with strakes, the autorotational speeds of combined fuselage, wing, and tail configurations displayed similar trends and variations observed on isolated fuselage models. Author

A88-50591#

IDENTIFICATION OF MODERATELY NONLINEAR FLIGHT MECHANICS SYSTEMS WITH ADDITIVE PROCESS AND MEASUREMENT NOISE

RAVINDRA V. JATEGAONKAR and ERMIN PLAETSCHKE (DFVLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 142-152. DFG-supported research. refs

(AIAA PAPER 88-4347)

The parameter estimation problem for dynamic systems with both process and measurement noise from nonlinear model postulates is addressed in this paper. A two step estimation procedure computes explicitly the covariance matrix of residuals and updates the system parameters, the initial conditions, as well as the state noise matrix using the Gauss-Newton optimization method. For the purpose of state estimation in nonlinear systems with process noise, an approximate steady-state filter is used. In each iteration the filter-gain matrix is obtained from the postulated system model linearized at the updated initial conditions. The gradients of the output variables and of the system functions are approximated by finite differences. The proposed approach for nonlinear systems with unknown process and measurement noise covariances is first validated on simulated aircraft response data. It is then applied to estimate from flight test data the aircraft longitudinal derivatives using two models with different degrees of nonlinearities. Advantages and possible limitations of the method are discussed. Author

A88-50600*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

MODELING OF LARGE-AMPLITUDE HIGH-ANGLE-OF-ATTACK MANEUVERS

MARILYN E. OGBURN, LUAT T. NGUYEN (NASA, Langley Research Center, Hampton, VA), and KEITH D. HOFFLER (Vigyan Research Associates, Inc., Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 244-253. refs

(AIAA PAPER 88-4357)

Results from a simulation study to characterize and model rapid, large-amplitude high-angle-of-attack maneuvers of high performance aircraft are summarized. There is concern that conventional aerodynamic math models combining static and small-amplitude demping data may be deficient in properly representing the associated aerodynamics to allow accurate prediction of these types of motion. The objectives of this investigation were: (1) to characterize these maneuvers in order to establish the aerodynamic modeling requirements, (2) to define refinements to address these requirements, and (3) to examine the impact of these refinements on the calculated motions. The results show that accurate modeling of the dynamic terms is vital due to the very high angular rates generated during these maneuvers. It was found that the addition of dynamic terms to include the lateral acceleration derivatives and the rotary aerodynamics can in some cases significantly affect the simulated flight motions. Author

A88-50601*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

LONGITUDINAL LONG-PERIOD DYNAMICS OF AEROSPACE CRAFT

DONALD T. BERRY (NASA, Flight Research Center, Edwards, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 254-264. refs

(AIAA PAPER 88-4358)

Linear analyses are performed to examine the generic aspects of aerospace vehicle longitudinal long-period or trajectory modes of motion. The influence of Mach number, dynamic pressure, thrust-to-drag ratio, and propulsion system thrust laws on the longitudinal trajectory modes is presented in terms of phugoid frequency and damping and height mode stability. The results of these analyses are compared to flying qualities requirements where possible, and potential deficiencies in both the vehicle and the criteria are noted. A preliminary look at possible augmentation schemes to improve potential deficiencies is also presented. Interpretation of the practical consequences of the results is aided by typical time histories. Results indicate that propulsion system characteristics are the dominant influence on the longitudinal long-period flight dynamics of hypersonic aerospace craft. However, straightforward augmentation systems demonstrated the potential to accommodate these influences if the effects are included in the design process. These efforts may be hampered by a lack of design criteria for hypersonic aircraft. Author

A88-50606#

RELATIVE EVALUATION OF MIL-STD 1797 LONGITUDINAL FLYING QUALITIES CRITERIA APPLICABLE TO FLARED LANDING AND APPROACH

J. E. BOOZ (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 314-329. refs

(AIAA PAPER 88-4363)

The intent of this study was to determine which of the short period flying qualities criteria recommended in MIL-STD 1797 provided the best method to predict the handling qualities levels for the approach and flared landing tasks for transport aircraft. The requirements listed in MIL-STD 1797 were applied to a range of dynamic configurations of generic transport aircraft and compared with the associated pilot ratings. Various equivalent system techniques were applied in this study, but none could generate equivalent transfer functions which satisfactorily correlated with the pilot ratings. A much simpler and less time consuming criterion was the transient peak ratio, rise time, effective delay criterion. This technique provided the same results as the 'best' equivalent system match. The gain attenuation and phase rate criterion from the dropback and Nichols chart criterion provided the best correlation with the pilot evaluations in predicting Level 1 and non-Level 1 configurations. Author

A88-50607*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

AN EVALUATION OF AUTOMATIC CONTROL SYSTEM CONCEPTS FOR GENERAL AVIATION AIRPLANES

E. C. STEWART, W. A. RAGSDALE, and A. J. WUNSCHEL (NASA, Langley Research Center, Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 330-343. refs
(AIAA PAPER 88-4364)

A piloted simulation study of automatic longitudinal control systems for general aviation airplanes has been conducted. These automatic control systems were designed to make the simulated airplane easy to fly for a beginning or infrequent pilot. Different control systems are presented and their characteristics are documented. In a conventional airplane control system each cockpit controller commands combinations of both the airspeed and the vertical speed. The best system in the present study decoupled the airspeed and vertical speed responses to cockpit throttle inputs. That is, the cockpit throttle lever commanded only airspeed responses, and the longitudinal wheel position commanded only vertical speed responses. This system significantly reduced the pilot workload throughout an entire mission of the airplane from takeoff to landing. An important feature of the automatic system was that neither changing flap position nor maneuvering in steeply banked turns affected either the airspeed or the vertical speed. All the pilots who flew the control system simulation were favorably impressed with the very low workload and the excellent handling qualities of the simulated airplane. Author

A88-50608#

RESULTS OF A FLIGHT SIMULATOR EXPERIMENT TO ESTABLISH HANDLING QUALITY GUIDELINES FOR THE DESIGN OF FUTURE TRANSPORT AIRCRAFT

J. A. J. VAN ENGELEN (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 344-357. Research supported by the Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart. refs
(AIAA PAPER 88-4365)

Future transport aircraft incorporating electrical fly-by-wire control systems and advanced cockpit display technologies require the investigation of the extent to which existing handling qualities criteria can still be used for the design of both the primary system and its backup. Attention must also be given to guidelines that may be required in order to cover the change introduced when a failure occurs, and the flight control system reverts to a backup system with different characteristics. A moving-base flight simulator has been used to furnish a basis for the formulation of such guidelines, with emphasis on longitudinal handling qualities. O.C.

A88-50611#

ADAPTIVE ROLL CONTROL OF A DYNAMIC WIND TUNNEL MODEL

ANASTASSIOS CHASSIAKOS, PETROS IOANNOU, MICHAEL SAFONOV (Southern California, University, Los Angeles, CA), MARC NUGENT, and DOUG MOORE (Rockwell International Corp., El Segundo, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 385-393. Research supported by Rockwell International Corp.
(AIAA PAPER 88-4373)

The roll control problem of a dynamic wind tunnel model is examined. The analytical full order model consists of a significant number of structural modes and nonlinearities such as surface position and rate limiting. A model reduction technique is used to obtain a reduced order model which approximates the full order one within the frequency range of interest. The reduced order model is used to design three control schemes: two adaptive and one fixed of the proportional plus integral type. All three control schemes are tested on the full order model in the presence of control surface failures and system parameter changes along varying flight conditions. The simulation results demonstrate that the adaptive schemes can easily accommodate failures, parameter variations and other unpredictable changes while maintaining good performance. Author

A88-50612*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

TRANSONIC STABILITY AND CONTROL OF AIRCRAFT USING CFD METHODS

LAM-SON VINH (NASA, Langley Research Center; George Washington University, Hampton, VA), JOHN W. EDWARDS, DAVID A. SEIDEL, and JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 394-404. refs
(AIAA PAPER 88-4374)

Implementation of a capability to calculate longitudinal short-period response in the CAP-TSD (Computational Aeroelasticity Program - Transonic Small Disturbance) finite-difference code is described. The code, developed recently at the NASA Langley Research Center, is capable of solving steady and unsteady flows about complete aircraft configurations and is used primarily for aeroelastic calculations in the critical transonic speed range. The longitudinal short-period equations of motion in state-space form have been coupled to the time-accurate lift and moment calculated by the program. Transient responses to an elevator pulse for free-flying aircraft demonstrate the new capability. A trim routine is also added to the code to obtain trim automatically during steady-state flow field convergence. Stability and control derivatives are estimated from the calculated transient response by a maximum likelihood estimation program. Results for a fighter configuration and a general aviation configuration are presented to assess the capability. Author

A88-50620*# Calspan Advanced Technology Center, Buffalo, N.Y.

INTERACTION OF FEEL SYSTEM AND FLIGHT CONTROL SYSTEM DYNAMICS ON LATERAL FLYING QUALITIES

RANDALL E. BAILEY (Calspan Advanced Technology Center, Buffalo, NY), BRUCE G. POWERS, and MARY F. SHAFER (NASA, Flight Research Center, Edwards, CA) AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988. 9 p. refs
(AIAA PAPER 88-4327)

An investigation of feel system and flight control system dynamics on lateral flying qualities was conducted using the variable stability USAF NT-33 aircraft. Experimental variations in feel system natural frequency, force-deflection gradient, control system command architecture type, flight control system filter frequency, and control system delay were made. The experiment data include pilot ratings using the Cooper-Harper (1969) rating scale, pilot comments, and tracking performance statistic. Three test pilots served as evaluators. The data indicate that as the feel system natural frequency is reduced lateral flying qualities degrade. At the slowest feel system frequency, the closed-loop response becomes nonlinear with a 'bobweight' effect apparent in the feel system. Feel system influences were essentially independent of the control system architecture. The flying qualities influence due to the feel system was different than when the identical dynamic systenm was used as a flight control system element. Author

A88-50621#
UNIFYING CONCEPTS FOR HANDLING QUALITIES CRITERIA
ROGER H. HOH (Systems Technology, Inc., Hawthorne, CA) AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988. 21 p. refs
(AIAA PAPER 88-4328)

With a view to the formulation of a unified approach to design and handling qualities evaluation, concepts and criteria are proposed for the overhaul of military handling qualities specifications of conventional aircraft, VSTOLs, and helicopters. The salient feature of this method is the selection of certain response characteristics in order to accomplish each of the flying qualities tasks required to complete the specified missions in the presence of specified visual environments and displays. Attention is given to the dynamic characteristics of quasi-open loop, divided attention, and full attention control. O.C.

A88-50622*# California Inst. of Tech., Pasadena.
APPLICATION OF DYNAMICAL SYSTEMS THEORY TO NONLINEAR AIRCRAFT DYNAMICS
FRED E. C. CULICK (California Institute of Technology, Pasadena) and CRAIG C. JAHNKE AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988. 13 p. Research supported by the California Institute of Technology and NASA. refs
(AIAA PAPER 88-4372)

Dynamical systems theory has been used to study nonlinear aircraft dynamics. A six degree of freedom model that neglects gravity has been analyzed. The aerodynamic model, supplied by NASA, is for a generic swept wing fighter and includes nonlinearities as functions of the angle of attack. A continuation method was used to calculate the steady states of the aircraft, and bifurcations of these steady states, as functions of the control deflections. Bifurcations were used to predict jump phenomena and the onset of periodic motion for roll coupling instabilities and high angle of attack maneuvers. The predictions were verified with numerical simulations. Author

A88-50766
ACTUATING DEVICES OF AIRCRAFT CONTROL SYSTEMS [ISPOLNITEL'NYE USTROISTVA SISTEM UPRAVLENIIA LETATEL'NYMI APPARATAMI]
BORIS GRIGOR'EVICH KRYMOV, LEV VLADIMIROVICH RABINOVICH, and VLADIMIR GRIGOR'EVIC STEBLETSOV Moscow, Izdatel'stvo Mashinostroenie, 1987, 264 p. In Russian. refs

The electrohydraulic, electropneumatic, and electrical actuating mechanisms of aircraft control systems are discussed. In particular, the principal requirements for the speed of response and load characteristics of drive mechanisms are examined; equations of motion describing the operation of control system drives are presented. The dynamic properties of the drives are investigated, and their transfer functions are determined. An analysis is made of the effect of load characteristics and saturation phenomena on drive dynamics. The dynamic characteristics of different types of steering drives are compared. V.L.

A88-50772
STABILITY AND CONTROLLABILITY OF AIRCRAFT IN THE OPERATIONAL REGION OF FLIGHT CONDITIONS [USTOICHIVOST' I UPRAVLIAEMOST' SAMOLETA V EKSPLUATATSIONNOI OBLASTI REZHIMOV POLETA]
IURII IVANOVICH SNESHKO Moscow, Izdatel'stvo Mashinostroenie, 1987, 136 p. In Russian. refs

The stability and controllability characteristics of modern aircraft with various automatic pilot systems are briefly reviewed. In particular, attention is given to the forces and moments acting on aircraft during flight and their dependence on the flight parameters. Balancing curves are examined for longitudinal and lateral motion. Dynamic aircraft characteristics, such as frequency characteristics and transfer functions, are discussed. V.L.

A88-50780#
HIGH-ANGLE-OF-ATTACK DYNAMIC BEHAVIOR OF A MODEL HIGH-PERFORMANCE FIGHTER AIRCRAFT
JAMES B. PLANEAUX (USAF, Institute of Technology, Wright-Patterson AFB, OH) and THOMAS J. BARTH (USAF, Armament Laboratory, Eglin AFB, FL) AIAA, Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988. 12 p. refs
(AIAA PAPER 88-4368)

This paper examines the high-angle-of-attack solution structure of equations of motion for a representative high-performance fighter. The aircraft model predicts that abrupt nonlinear changes in state will occur as controls vary, including transitions from equilibrium to periodic motions and jumps between rival equilibrium and periodic states. Numerical continuation methods are used to efficiently trace out entire branches of both equilibrium and periodic solutions. The structure of these solutions in control-parameter space is found to be quite complex. Most notably, several types of stable periodic solutions (limit cycles) appear which can be identified as either wing rock or oscillatory spin motions. Author

A88-50915*# Purdue Univ., West Lafayette, Ind.
FLIGHT DYNAMICS OF AEROELASTIC VEHICLES
MARTIN R. WASZAK and DAVID K. SCHMIDT (Purdue University, West Lafayette, IN) Journal of Aircraft (ISSN 0021-8669), vol. 25, June 1988, p. 563-571. Previously cited in issue 23, p. 3413, Accession no. A86-47666. refs
(Contract NAG1-254)

A88-50966
FLIGHT CONTROL SYSTEM DESIGN USING CAEBEL, A CACSD SYSTEM
A. L. BLACKWELL, R. P. BHATIA, C. J. WANG, C. C. BLACKWELL (Texas, University, Arlington), and T. L. WOOD (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 421-427. Research supported by Bell Helicopter Textron, Inc. refs

CAEBEL, an information management system for control system design, has been used in the design and development of automatic control systems for tiltrotor aircraft. CAEBEL was used in conjunction with a real-time simulation of a generic tiltrotor aircraft. The manner in which the functions needed to simulate the tiltrotor aircraft control system functions were accommodated within the structure of CAEBEL is detailed. I.E.

A88-50969#
AUTOMATIC LIMITERS IN AIR FORCE AIRCRAFT FLIGHT CONTROL SYSTEMS
RICHARD H. KOGLER (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 461-469.

The author examines the use of automatic limiters in the flight control systems of three Air Force aircraft, the F-III, F-16, and B-1B, to increase their resistance to loss of control during maneuvering flight. The limiters provide maximum usable maneuver envelopes while avoiding undesirable or unsafe regions. They function reliably, repeatably, and rapidly without the pilot 'getting in the loop,' allowing him to concentrate on his mission. The aerodynamics and flight control systems of three aircraft are discussed as well as the functions particular to each. The common characteristics of the three systems are summarized. Several issues related to the application of limiters to future aircraft are addressed, including aerodynamic modifications of aircraft, performance impacts, increased complexity, cost/schedule impacts, testing of aircraft, effect on design quality, and modeling. I.E.

A88-50970#
EIGENSTRUCTURE SELECTION FOR LONGITUDINAL FLYING QUALITIES CONSIDERATIONS
DANIEL G. GODDARD and DANIEL GLEASON (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 470-478. refs

A drawback to the use of eigenstructure assignment techniques for designing flight control systems for aircraft with multiple control surfaces is a lack of handling-quality guidelines to apply when selecting the eigenvalues and eigenvectors of the closed-loop system. This lack of specific eigenstructure requirements means that some uncertainty will remain as to whether the augmented control system will meet the MIL-F-8785C specifications. A method for choosing the desired eigenstructure is examined that consists of forming an optimal plant matrix which possesses desirable dynamic characteristics and performing a spectral decomposition of this matrix. The resulting eigenstructure provides the desired eigenvalues and eigenvectors during the full-state feedback process. An example using the X-29A aircraft is given. I.E.

A88-50971
ON DECIDING DISPLAY DYNAMICS REQUIREMENTS FOR FLYING QUALITIES
KEVIN BOETTCHER, KATHRYN LENZ, and DOUGLAS WEED (Honeywell Systems and Research Center, Minneapolis, MN) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 480-487. refs
(Contract F33615-86-C-3615)

An approach for deciding display dynamics is presented that is based on multivariable control analysis and synthesis techniques, specifically the structured singular value, and uses the optimal control model to represent nominal pilot behavior. Given an uncertainty structure for the nominal model that reflects likely pilot variabilities, structured singular value techniques are used to examine and determine display dynamics that strike a balance between the goal of optimal system performance and the goal of tolerance to pilot variability. The approach is illustrated by an example, the results of which support its potential utility. I.E.

A88-50973#
SELF-REPAIRING FLIGHT CONTROL SYSTEM PROGRAM OVERVIEW
ROBERT A. ESLINGER and PHILLIP R. CHANDLER (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 504-511. refs

A description is given of the Self-Repairing Flight Control System Program, which began in 1984. The program objective was to improve the reliability, maintainability, survivability, and life cycle cost of aircraft flight control systems through aerodynamic reconfiguration and maintenance diagnostics. A description is given of the four program tasks designed to satisfy the objective. Reconfiguration technology development for future fighters addresses the reliability, survivability, and life-cycle cost objectives. Maintenance diagnostics tasks address the maintainability objective. The proof of concept flight demonstration and advanced flight demonstration tasks support the transition to new weapon systems. The technology is being applied to current and advanced fighter aircraft through feasibility studies, development studies, design criteria development, ground simulations, field demonstrations, and fighter flight tests. I.E.

A88-50974
CONTROL RECONFIGURABLE COMBAT AIRCRAFT PILOTED SIMULATION DEVELOPMENT
RICHARD MERCADANTE (Grumman Corp., Aircraft Systems Div., Bethpage, NY), PHILIP N. WHEELER, MARILYN MIX, JOHN FARLEY (Century Computing, Inc., Beavercreek, OH), and PHILLIP R. CHANDLER (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 512-519. refs

The AFWAL/FIG Control Reconfigurable Combat Aircraft (CRCA) effort, part of the Self-Repairing Flight Control System (SRFCS) Program, exploits reconfiguration to maintain mission capability. Specifically, reconfigurable control laws, fault detection and isolation (FDI) logic, and a positive pilot alert (PPA) system have been developed for an advanced-tactical-fighter-class aircraft simulation. The authors describe the six degree-of-freedom CRCA piloted simulation recently conducted at the USAF Large Amplitude Multimode Aerospace Research Simulator (LAMARS) facility. The aircraft simulation, damage/failure aerodynamic math modeling, flight control computer (FCC) software, pilot/vehicle interface, and simulation environment are discussed. I.E.

A88-50975
EVALUATION OF A SECOND GENERATION RECONFIGURATION STRATEGY FOR AIRCRAFT FLIGHT CONTROL SYSTEMS SUBJECTED TO ACTUATOR FAILURE/SURFACE DAMAGE
A. K. CAGLAYAN, S. M. ALLEN (Charles River Analytics, Inc., Cambridge, MA), and K. WEHMULLER (Lear Siegler, Inc., Astronics Div., Santa Monica, CA) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 520-529. refs
(Contract F33615-84-C-3608; F33615-84-C-3609)

The authors report evaluation results obtained on the six-degree-of-freedom nonlinear simulation of the Grumman Combat Reconfigurable Control Aircraft (CRCA). The reconfiguration strategy consists of a robust flight control system tolerant of low-level surface damage, a hierarchical failure detection, isolation, and estimation (FDIE) system identifying actuator failures and moderate-to-serve surface damage, and a reconfiguration logic in which the pseudo surface resolver (PSR) is reconfigured after impairment to recover performance and minimize transients. Preliminary performance results are presented. I.E.

A88-50977
TIME CONTROLLED NAVIGATION AND GUIDANCE FOR 737 AIRCRAFT
MICHAEL K. DEJONGE (SLI Avionics System Corp., Grand Rapids, MI) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 546-549.

Specified time-of-arrival navigation and guidance control laws have been developed for the 737 flight management computer system. A required time of arrival can be specified at any geographical point in addition to altitude and airspeed. The earliest and latest arrival times within aircraft limits are computed along with the most cost-economic arrival time. Upon designation of a specified time, as may be requested by ATC for traffic spacing, the most fuel efficient speed is computed and automatically controlled as flight progresses to ensure that the aircraft meets the specified time. A variable time control window is provided to reduce unnecessary control activity when some time tolerance is permissible. The time control law uses the accurate time prediction capability of the flight management software. The control law can be retrofitted in existing 737 aircraft through software updating. The pilot interface requirements for time-controlled navigation and guidance are discussed, and the control laws used in this implementation are described. I.E.

A88-50978
DESIGN OF TUNABLE DIGITAL CONTROLLERS INCORPORATING DYNAMIC POLE-ASSIGNMENT COMPENSATORS FOR HIGH-PERFORMANCE AIRCRAFT
B. PORTER and C. L. BODDY (Salford, University, England) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 552-558. SERC-supported research. refs

It is shown that tunable digital controllers can be readily enhanced so as to cope with open-loop unstable multivariable plants, which can be either non-minimum-phase or minimum-phase, by incorporating dynamic pole-assignment compensators. Such inner-loop compensators facilitate the use of outer-loop PID controllers. The effectiveness of such a tunable digital controller is illustrated by designing a set-point tracking controller for the STOL/F-15 aircraft in a flight condition for which this aircraft is open-loop unstable. I.E.

A88-51026
TERRAIN FOLLOWING/TERRAIN AVOIDANCE PATH OPTIMIZATION USING THE METHOD OF STEEPEST DESCENT
SABI J. ASSEO (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1128-1136. refs

A path-optimization algorithm for terrain following/terrain avoidance and threat avoidance is presented. The algorithm uses the gradient method for generating the optimal ground track that minimizes a quadratic cost function of the aircraft's altitude above sea level to maximize terrain masking while penalizing large deviations from a prescribed initial ground track. The vertical flight path for each ground track is obtained by using parabolic flight segments that satisfy vertical path constraints. Confining the optimization process to the horizontal plane improves the convergence properties of the algorithm, reduces the storage requirements, and allows the algorithm to be used on fine-grain terrain data. Simulation results are presented which validate the algorithm. I.E.

A88-51044
KALMAN FILTER DESIGN FOR CONTROL SURFACE FAILURE DETECTION AND ISOLATION
HOWARD P. LEE and ROBERT J. DUDGINSKI (Lockheed Aeronautical Systems Co., Burbank, CA) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1495-1503. refs

The use of Kalman filters for residual generation for control surface failure detection and isolation (FDI) is studied. The FDI algorithm investigated consists of two main components: a Kalman filter for residual generation, and a set of pairwise log-likelihood-ratio (LLR) tests for decision processing. The performance of several Kalman filter designs under a severe gust level of 20-fps RMS is evaluated. The performance of the FDI algorithm is measured in terms of the probabilities of detection and false alarm which are closely related to the signal-to-noise ratios (SNRs) of the decision LLRs. The filter design process is aided by evaluating the SNRs of the different Kalman filter configurations. It was found that including the gust-shaping filters in the Kalman filter equations improved the FDI performance under severe wind turbulence. However, all the filter configurations evaluated were sensitive to parameter variations. I.E.

A88-51052
IMPROVED FAULT DETECTION USING A SELECTED GROUPING OF PARITY EQUATIONS FOR ADVANCED FLIGHT CONTROL SYSTEMS
JOHN J. SUDANO, JOSEPH R. PREISIG, and JOHN POKOTYLO (Singer Co., Kearfott Div., Little Falls, NJ) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1565-1569.

Redundant strapdown sensor assemblies (SSAs) are designed to provide greater reliability and survivability for inertial inputs to the aircraft flight control system. Flight control systems frequently use three or more SSAs with voting schemes to choose the best reference. However, the minimum number of SSAs required is two, provided that they are skewed with a transformation between the two systems having only nonzero terms. An improved redundancy management procedure (RMP) is reported that is being used to optimize inputs to the flight control loops, providing cost savings, improved accuracy, and faster fault detection. This procedure diagnoses fault situations faster than conventional parity analysis using a truth table or a look-up table method. This RMP is being implemented and tested on a prototype system that consists of two skewed, low-cost ring laser gyro standard attitude and heading reference systems (RLG SAHRSs), and a mission computer with a MUX for the transfer of information. The redundancy management software resides in the mission computer. The parity equations or preprocessing can fault isolate any one-axis or two-axis failure or a total unit failure. This system incorporates an optimal combination of outputs of the two SSAs and a graceful reconfiguration smoothing procedure to eliminate step-discontinuity inputs to flight control loops. The approaches and the simulation results are reviewed. I.E.

A88-51181#
RELATIONSHIPS BETWEEN FLYING QUALITIES, TRANSIENT AGILITY, AND OPERATIONAL EFFECTIVENESS OF FIGHTER AIRCRAFT
J. HODGKINSON, A. SKOW, R. ETTINGER, U. LYNCH, O. LABOY (Eidetics International, Inc., Torrance, CA) et al. AIAA, Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988. 9 p. refs
(AIAA PAPER 88-4329)

An air combat simulation program is presently used to evaluate the usefulness of fighter aircraft transient agility, which typically involves high pitch rates surpassing maximum lift, followed by an all-aspect air-to-air missile's launch, and then by rapid unload and reacceleration. Comparisons are conducted for the flying qualities and metrics of transient pitch, torsional, and axial agilities. It is recommended that transient agility need not be specified in flying qualities requirements, but rather that it should be preserved as a basis for comparison among competing aircraft. O.C.

A88-51429
BOEING 7J7 FLY-BY-WIRE CONTROL DEVELOPMENT
DALE M. RANZ (Boeing Co., Seattle, WA) and CHARLES J. BERTHE (Calspan Corp., Buffalo, NY) IN: 1987 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 31st, Beverly Hills, CA, Sept. 23-26, 1987, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1987, p. 33-50.

The B7J7 next-generation airliner will be the first aircraft of this type to incorporate FBW flight control technology; an account is presently given of efforts initiated in 1986, using both ground and in-flight simulators, to develop the B7J7 flight control system. A significant portion of the flight test program was devoted to the selection of the pilot's controller: a 'ministick' and a more conventional 'wheel-column' were tested. Other tasks encompassed FBW control law verification, the study of dual hand-controller interfacing and contention, and 'flare law' development. Attention is given to flight-test results. O.C.

A88-51430
AGILITY - ITS NATURE AND NEEDS IN THE 1990S
THOMAS P. MCATEE (General Dynamics Corp., Fort Worth, TX) IN: 1987 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 31st, Beverly Hills, CA, Sept. 23-26, 1987, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1987, p. 54-75.

It is noted that advanced variants of the F-15 and F-16 fighters are less agile than their initial versions. The consequences of this trend for prospective combat performance in the 1990s is presently evaluated in light of a discussion of fighter aircraft maneuverability and controllability, as well as of the lessons of history since the First World War. Figures of merit that can be used by designers and flight testers to develop and verify fighter agility are formulated. High-alpha conditions present the greatest design challenge; good controllability at very high alpha will yield substantial tactical advantage. O.C.

A88-51439
LAVI FLIGHT TEST PROGRAM
MENAHEM SHMUL (Israel Aircraft Industries, Ltd., Tel Aviv) IN: 1987 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 31st, Beverly Hills, CA, Sept. 23-26, 1987, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1987, p. 236-253.

The Lavi is a multimission light fighter capable of both day and night operations of the close air-support/battlefield interdiction type without forfeiture of a high air-to-air defense capability. The full-scale development of the Lavi called for five flying prototypes; attention is presently given to the flight test results obtained with the first two, identical, two-seat aircraft. Attention is given to the basic pitch-axis control laws employed by the Lavi, as well as its roll rate-command and antispin modes. Flying qualities graphic characterizations are presented for stick forces, lateral directional characteristics, and inflight refueling. O.C.

A88-51452*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, 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: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 2-1 to 2-13. refs

This paper describes some novel flight tests 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. The resulting open-loop and closed-loop frequency responses and the time history comparison using flight and linear simulation data are discussed. C.D.

A88-51458
P-180 THREE LIFTING SURFACE AIRCRAFT - LONGITUDINAL CONTROL DURING CONFIGURATION CHANGES
P. CINQUETTI and V. PEROTTI (Rinaldo Piaggio Industrie Aeronautiche e Meccaniche S.p.A., Genoa, Italy) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 10-1 to 10-10.

Preliminary flight tests on the longitudinal stability and control of the Piaggio P-180 Avanti aircraft during configuration changes are discussed. The advantages of the aircraft's three lifting surfaces, which provide a predicted stable break in the pitching moment curve at high angle of attack which is unusual for a forward-wing configuration, are described. The flap system, which allows slight changes in trim from a clean to a flapped configuration, is examined. Several operating times, speeds, and excursions have been tested to optimize the flap actuation, and preliminary results are shown and analyzed. C.D.

A88-51771
ACTUATOR POWER REQUIREMENTS FOR HIGHER HARMONIC CONTROL (HHC) SYSTEMS
KHANH NGUYEN and INDERJIT CHOPRA (Maryland, University, College Park) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 21 p. refs
(Contract DAAG29-83-K-0002)

An analytical formulation has been developed to predict the vibratory hub loads of a helicopter rotor system, and then used to calculate the optimum higher harmonic controls and associated actuator power required to minimize these loads. The formulation is based on a finite element method in space and time, and a linear time domain unsteady aerodynamic model is used to obtain the airloads. Predicted vibratory hub loads with and without higher harmonic controls are correlated with experimental data obtained from a scaled model rotor. Results of parametric studies show that blade flap, lag and torsion vibration characteristics, offset of blade aerodynamic center from elastic axis and blade pretwist all have moderate effect on the actuator power requirement, whereas the offset of center-of-mass from elastic axis has the largest effect. The actuator power requirement for a stiff-inplane rotor is substantially larger than that for a soft-inplane or an articulated rotor. Author

A88-51772* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
PERFORMANCE COMPARISON OF FIVE FREQUENCY DOMAIN SYSTEM IDENTIFICATION TECHNIQUES FOR HELICOPTER HIGHER HARMONIC CONTROL
STEPHEN A. JACKLIN (NASA, Ames Research Center, Moffett Field, CA) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 26 p. refs

This paper presents the results of a computer simulation comparing the performance of five system identification techniques currently proposed for use with helicopter, frequency domain, higher harmonic vibration control algorithms. The system identification techniques studied were: (1) the weighted least squares method in moving block format, (2) the classical Kalman filter, (3) a generalized Kalman filter, (4) the classical least mean square (LMS) filter, and (5) a generalized LMS filter. The generalized Kalman and LMS filters were derived by allowing for multistep operation, rather than the single-step update approach used by their classical versions. Both open-loop and closed-loop (vibration control mode) identification results are presented in the paper. The algorithms are evaluated in terms of their accuracy, stability, convergence properties, computation speeds, and the relative ease with which these techniques may be directly applied to the helicopter vibration control problem. Author

A88-51773
ANALYSIS AND DESIGN OF NONLINEAR FLIGHT CONTROL SYSTEMS FOR ROTORCRAFT
CHARLES DABUNDO and H. C. CURTISS, JR. (Princeton University, NJ) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 14 p. Research supported by Boeing Helicopter Co. refs

The Quasilinear Systems Analysis and Design method (QSAD), a numerical technique for the analysis and design of flight control systems containing simple nonlinearities, is described. The QSAD technique is based on describing function theory and is applicable to systems of fairly general structure as long as the usual describing function assumptions are adhered to. Various nonlinear effects are examined, and guidelines are provided for designing compensation to reduce such effects when they degrade system performance. The application of the QSAD method to the design of nonlinear flight control systems is demonstrated by specific examples. V.L.

A88-51784
ACTIVE AERODYNAMIC STABILIZATION OF A HELICOPTER/SLING-LOAD SYSTEM
AVIV ROSEN, TUVIA RONEN (Technion - Israel Institute of Technology, Haifa, Israel), and REUBEN RAZ IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 12 p. refs

A general theoretical model is used in order to investigate the possibility of an active aerodynamic stabilization of a helicopter/sling-load system, in the case of a single suspension point. The stabilization system includes two vertical aerodynamic surfaces which are located on the external sling load. The incidence angles of these surfaces are varied according to a set of control laws. A study leads to a system which is relatively easy to realize. The input measurements of the load stabilization system (LSS) include the helicopter and sling load lateral/directional angular rates. It is shown that adding a feedback loop which is based on the load lateral acceleration increases further the stability of the wohle system. Studies also show that a single rear surface is very effficient and can be used alone. The proposed LSS is capable of stabilizing the system in a wide range of airspeeds, load weights, suspension methods (geometries) and aerodynamic properties of the external sling load. Author

A88-51972#
SYNTHESIS OF A REDUCED ORDER MODEL AND DESIGN OF A MULTIVARIABLE FLIGHT CONTROL SYSTEM FOR A HIGH PERFORMANCE HELICOPTER
MARK EKBLAD AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 11 p. refs
(Contract DAAL03-86-K-0056)
(AIAA PAPER 88-4501)

This paper will discuss the use of balanced coordinates for obtaining a reduced order model and eigenspace assignment techniques for designing a controller for use in precise hover for handling qualities enhancement of a modern attack helicopter. The reduced order model required approximately one third of the number of states of the original model with an additive error norm upper bound of 0.35. Desired transient response characteristics were achieved through eigenvalue assignment and modal decoupling through eigenvector shaping. Loop transfer recovery techniques were used for the design of a state observer. Stability robustness of the controller is demonstrated using singular value techniques. Frequency and time responses are used to demonstrate the behavior of the feedback control system. Good closed loop characteristics were obtained. Author

A88-51973#
ADAPTIVE AIRCRAFT MODEL-FOLLOWER DESIGN
CLYDE E. GOODNER (Oklahoma State University, Stillwater) and NIRANJAN S. RAO (Boeing Military Airplane Co., Wichita, KS) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 6 p. refs
(AIAA PAPER 88-4502)

The model-follower design procedure has been combined with multiple model adaptive control to simplify and enhance the performance of gain scheduling techniques. This design procedure has been applied to the F-8 oblique wing research aircraft with variable-skewed wings. The wing skew angle produces assymmetry which results in significant aerodynamic and inertial cross-coupling bewteen the aircraft longitudinal and lateral directional axes. This paper presents a design of an adaptive control system which gives the desired decoupling while providing the necessary stability augmentation. The method involves the design of implicit model-following controllers for several flight conditions developed from the quadratic performance index. Kalman filters accompany each model-follower and the residuals of these filters are used by a Bayesian decision algorithm to determine the probabilities that each controller matches the current flight condition. The Multiple Model Adaptive Control system (MMAC) was used in a simulation to provide switching from one controller to another while the aircraft traversed in the flight envelope. Author

A88-51974#
INTEGRATED FLIGHT CONTROL SYSTEM DESIGN FOR FIGHTER AIRCRAFT AGILITY
HENRY BEAUFRERE (Grumman Corp., Aircraft Systems Div., Bethpage, NY) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 8 p. refs
(AIAA PAPER 88-4503)

Designing a flight control system for agility requires integrating the design with the airframe early in the design cycle. An overview of a design guides and criteria handbook for achieving integrated designs is presented. Control power is shown to be the key flight control element required to design a fighter aircraft for both maneuver and control agility, classically defined as maneuverability and controllability. 'Superagility', shortened to Super-A in this paper, emphasizes complex, high-angle-of-attack, coupled maneuvers, highly dependent on control power for their execution. It is shown that design guides and criteria similar to those found in the handbook can be extended to define Super-A control power requirements. Author

A88-52050
ESTIMATING THE PROBABILITY OF AIRCRAFT LANDING ON AN ASSIGNED AREA WHILE OBSERVING CONSTRAINTS ON PHASE COORDINATES [OTSENKA VEROIATNOSTI PRIZEMLENIIA LETATEL'NOGO APPARATA NA ZADANNYI UCHASTOK POVERKHNOSTI S SOBLIUDENIEM OGRANICHENII NA FAZOVYE KOORDINATY]
S. L. SEMAKOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 2, 1987, p. 54-61. In Russian.

Equations were developed in the form of quadratures for estimating the probability of aircraft landing on an assigned area while observing given constraints on the phase coordinates. The equations were applied to calculate the probability factor for an aircraft landing on an assigned segment of a runway with constrained vertical speed and pitching angle. I.S.

A88-52070
CONDITIONAL MAXIMA OF THE TRIMMED LIFT-DRAG RATIO FOR A NONMANEUVERABLE AIRCRAFT [USLOVNYE MAKSIMUMY BALANSIROVOCHNOGO AERODINAMICHESKOGO KACHESTVA NEMANEVRENNOGO SAMOLETA]
V. V. ROKHIN, V. K. SVIATODUKH, and V. B. SLUTSKII TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 3, 1987, p. 79-91. In Russian.

Conditions under which it is possible to obtain the maximum trimmed lift-drag ratio for a nonmaneuverable aircraft are studied as a function of configuration parameters and other structural limitations. The area of the horizontal tail surfaces is considered to be one of the independent variables while the downwash is dependent on the lift coefficient of the aircraft without the horizontal tail surfaces. K.K.

A88-52086
DETERMINATION OF THE COEFFICIENTS IN AN ALGORITHM FOR THE CONTROL OF THE LONGITUDINAL MOTION OF AN AIRCRAFT DURING AUTOMATIC LANDING, TAKING INTO ACCOUNT THE LIMITED EFFICIENCY OF THE CONTROL ELEMENTS [OPREDELENIE KOEFFITSIENTOV V ALGORITME UPRAVLENIIA PRODOL'NYM DVIZHENIEM SAMOLETA PRI AVTOMATICHESKOI POSADKE S UCHETOM OGRANICHENNOI EFFEKTIVNOSTI ORGANOV UPRAVLENIIA]
V. P. KUZ'MIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 4, 1987, p. 65-73. In Russian. refs

A method and results of calculations are presented for choosing the parameters of algorithms of automatic aircraft landing with allowance for constraints on the maximum angle and maximum rate of elevator deviation. The determination of parameters in the control algorithm is based on an analysis of transient processes for linearized equations and on numerical calculations of the limiting deviations of the vertical velocity of aircraft landing. R.B.

A88-52103
ESTIMATES OF THE PRECISION OF THE AUTOMATIC CONTROL OF AIRCRAFT LATERAL MOTION DURING LANDING [OTSENKI TOCHNOSTI AVTOMATICHESKOGO UPRAVLENIIA BOKOVYM DVIZHENIEM SAMOLETA PRI

POSADKE]
V. P. KUZ'MIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 5, 1987, p. 65-74. In Russian. refs

The problem of estimating the precision of automatic lateral motion control at the moment of touchdown is examined with allowance for the random nature of the landing distance. The aircraft motion is described by a linear system of differential equations. The probability distributions of various phase coordinates of the lateral motion are determined. V.L.

N88-27150*# Army Aviation Systems Command, Moffett Field, Calif.
A COMPARISON OF THEORY AND EXPERIMENT FOR AEROELASTIC STABILITY OF A HINGELESS ROTOR MODEL IN HOVER
DAVID L. SHARPE *In* NASA, Ames Research Center, Integrated Technology Rotor Methodology Assessment Workshop p 7-23 Jun. 1988
Avail: NTIS HC A17/MF A01 CSCL 01B

Theoretical predictions of aeroelastic stability are compared with experimental, isolated, hingeless-rotor data. The six cases selected represent a torsionally soft rotor having either a stiff or soft pitch-control system in combination with zero precone and droop, 5 degree precone, or -5 degree droop. Analyses from Bell Helicopter Textron, Boeing Vertol, Hughes Helicopters, Sikorsky Aircraft, the National Aeronautics and Space Administration, and the U.S. Army Aeromechanics Laboratory were compared with the experimental data. The correlation ranged from poor to fair. Author

N88-27151*# Army Aviation Systems Command, Moffett Field, Calif.
A COMPARISON OF THEORY AND EXPERIMENT FOR COUPLED ROTOR-BODY STABILITY OF A HINGELESS ROTOR MODEL IN HOVER UNDER SIMULATED VACUUM CONDITIONS
WILLIAM G. BOUSMAN *In* NASA, Ames Research Center, Integrated Technology Rotor Methodology Assessment Workshop p 27-40 Jun. 1988
Avail: NTIS HC A17/MF A01 CSCL 01B

Two cases were selected for correlation from an experiment that examined the aeromechanical stability of a small-scale model rotor that used tantalum rods instead of blades to simulate vacuum conditions. The first case involved body roll freedom only while the second case included body pitch and roll degrees of freedom together. Analyses from Hughes Helicopters and the U.S. Army Aeromechanics Laboratory were compared with the data and the correlations ranged from poor to good. Author

N88-27152*# Army Aviation Systems Command, Moffett Field, Calif.
A COMPARISON OF THEORY AND EXPERIMENT FOR COUPLED ROTOR-BODY STABILITY OF A HINGELESS ROTOR MODEL IN HOVER
WILLIAM G. BOUSMAN *In* NASA, Ames Research Center, Integrated Technology Rotor Methodology Assessment Workshop p 43-65 Jun. 1988
Avail: NTIS HC A17/MF A01 CSCL 01B

Three cases were selected for correlation from an experiment that examined the aeromechanical stability of a small-scale model of a hingeless rotor and fuselage in hover. The first case examined the stability of a configuration with 0 degree blade pitch so that coupling between dynamic modes was minimized. The second case was identical to the first except the blade pitch was set to 9 degrees which provides flap-lag coupling of the rotor modes. The third case had 9 degrees of blade pitch and also included negative pitch-lag coupling, and therefore was the most highly coupled configuration. Analytical calculations were made by Bell Helicopter Textron, Boeing Vertol, Hughes Helicopters, Sikorsky Aircraft, the U.S. Army Aeromechanics Laboratory, and NASA Ames Research Center and compared to some or all of the experimental cases. Overall, the correlation ranged from very poor-to-poor to good. Author

N88-27153*# Army Aviation Systems Command, Moffett Field, Calif.
A COMPARISON OF THEORY AND EXPERIMENT FOR THE AEROELASTIC STABILITY OF A BEARINGLESS MODEL ROTOR IN HOVER
SETH DAWSON *In* NASA, Ames Research Center, Integrated Technology Rotor Methodology Assessment Workshop p 67-80 Jun. 1988
Avail: NTIS HC A17/MF A01 CSCL 01B

Three cases were selected for correlation from an experiment that examined the aeroelastic stability of a small-scale bearingless motor rotor in hover. The 1.8 m diameter model rotor included flap, lead-lag, and torsional degrees of freedom, but no body degrees of freedom. The first case looked at a configuration with a single pitch link on the leading edge, the second case examined a configuration with a single pitch link on the trailing edge, and the third case examined a configuration with pitch links on the leading and trailing edges to simulate a pitch link with shear restraint. Analyses from Bell Helicopter Textron, Boeing Vertol, Hughes Helicopters, Sikorsky Aircraft, and the U.S. Army Aeromechanics Laboratory were compared with the data, and the correlation ranged from poor to fair. Author

N88-27154*# Army Aerostructures Directorate, Hampton, Va.
A COMPARISON OF THEORY AND EXPERIMENT FOR COUPLED ROTOR BODY STABILITY OF A BEARINGLESS ROTOR MODEL IN HOVER AND FORWARD FLIGHT
PAUL H. MIRICK *In* NASA, Ames Research Center, Integrated Technology Rotor Methodology Assessment Workshop p 87-101 Jun. 1988
Avail: NTIS HC A17/MF A01 CSCL 01B

Seven cases were selected for correlation from a 1/5.86 Froude-scale experiment that examined several rotor designs which were being considered for full-scale flight testing as part of the Bearingless Main Rotor (BMR) program. The model rotor hub used in these tests consisted of back-to-back C-beams as flexbeam elements with a torque tube for pitch control. The first four cases selected from the experiment were hover tests which examined the effects on rotor stability of variations in hub-to-flexbeam coning, hub-to-flexbeam pitch, flexbeam-to-blade coning, and flexbeam-to-blade pitch. The final three cases were selected from the forward flight tests of optimum rotor configuration as defined during the hover test. The selected cases examined the effects of variations in forward speed, rotor speed, and shaft angle. Analytical results from Bell Helicopter Textron, Boeing Vertol, Sikorsky Aircraft, and the U.S. Army Aeromechanics Laboratory were compared with the data and the correlations ranged from poor-to-fair to fair-to-good. Author

N88-27156*# Washington Univ., St. Louis, Mo. Dept. of Mechanical Engineering.
THE IMPORTANCE OF STEADY AND DYNAMIC INFLOW ON THE STABILITY OF ROTOR-BODY SYSTEMS
DAVID A. PETERS *In* NASA, Ames Research Center, Integrated Technology Rotor Methodology Assessment Workshop p 181-201 Jun. 1988
Avail: NTIS HC A17/MF A01 CSCL 01C

The induced flow field of a rotor responds in a dynamic fashion to oscillations in rotor lift. This was long known to affect the stability and control derivatives of the rotor. More recently, however, it was also shown that this dynamic inflow also affects rotor and rotor-body aeroelastic stability. Thus, both the steady and unsteady inflow have pronounced effects on air resonance. Recent theoretical developments were made in the modeling of dynamic inflow, and these were verified experimentally. Thus, there is now a simple, verified dynamic inflow model for use in dynamic analyses. Author

N88-27157*# Army Aeromechanics Lab., Moffett Field, Calif.
EFFECTS OF STATIC EQUILIBRIUM AND HIGHER-ORDER NONLINEARITIES ON ROTOR BLADE STABILITY IN HOVER
MARCELO R. M. CRESPODASILVA and DEWEY H. HODGES

In NASA, Ames Research Center, Integrated Technology Rotor Methodology Assessment Workshop p 205-215 Jun. 1988
Avail: NTIS HC A17/MF A01 CSCL 01C

The equilibrium and stability of the coupled elastic lead/lag, flap, and torsion motion of a cantilever rotor blade in hover are addressed, and the influence of several higher-order terms in the equations of motion of the blade is determined for a range of values of collective pitch. The blade is assumed to be untwisted and to have uniform properties along its span. In addition, chordwise offsets between its elastic, tension, mass, and aerodynamic centers are assumed to be negligible for simplicity. The aerodynamic forces acting on the blade are modeled using a quasi-steady, strip-theory approximation. Author

N88-27160*# California Univ., Los Angeles. Dept. of Mechanics and Structures.
COMPARISON OF EXPERIMENTAL COUPLED HELICOPTER ROTOR/BODY STABILITY RESULTS WITH A SIMPLE ANALYTICAL MODEL
P. P. FRIEDMANN and C. VENKATESAN *In* NASA, Ames Research Center, Integrated Technology Rotor Methodology Assessment Workshop p 253-266 Jun. 1988
Avail: NTIS HC A17/MF A01 CSCL 01C

The results of an analytical study aimed at predicting the aeromechanical stability of a helicopter in ground resonance, with the inclusion of aerodynamic forces are presented. The theoretical results are found to be in good agreement with the experimental results, available in literature, indicating that the coupled rotor/fuselage system can be represented by a reasonably simple mathematical model. Author

N88-27161*# Textron Bell Helicopter, Fort Worth, Tex.
AEROMECHANICAL STABILITY ANALYSIS OF COPTER
SHENG K. YIN and JING G. YEN *In* NASA, Ames Research Center, Integrated Technology Rotor Methodology Assessment Workshop p 271-276 Jun. 1988
Avail: NTIS HC A17/MF A01 CSCL 01C

A plan was formed for developing a comprehensive, second-generation system with analytical capabilities for predicting performance, loads and vibration, handling qualities, aeromechanical stability, and acoustics. This second-generation system named COPTER (COmprehensive Program for Theoretical Evaluation of Rotorcraft) is designed for operational efficiency, user friendliness, coding readability, maintainability, transportability, modularity, and expandability for future growth. The system is divided into an executive, a data deck validator, and a technology complex. At present a simple executive, the data deck validator, and the aeromechanical stability module of the technology complex were implemented. The system is described briefly, the implementation of the technology module is discussed, and correlation data presented. The correlation includes hingeless-rotor isolated stability, hingeless-rotor ground-resonance stability, and air-resonance stability of an advanced bearingless-rotor in forward flight. Author

N88-27202# Institut Franco-Allemand de Recherches, St. Louis (France).
INVESTIGATIONS OF AIRCRAFT CONTROL WITH JET SPOILERS [VERSUCHE ZUR STEUERUNG MIT STRAHLSPOILERN: UNTERHALB DES TITELS IST HINZUZUFUEGEN]
G. PATZ 15 Apr. 1987 27 p In GERMAN
(Contract BMVG-T/R-760/G-0002/G-1702)
(ISL-R-112/87; ETN-88-92733) Avail: NTIS HC A03/MF A01

Aerodynamic effectiveness of jet spoilers for high speed aircraft control in comparison with flaperons is studied. An increased effect is obtained by energy addition in the recirculation zone of the jet spoiler. Tests are carried out in a square section shock tube for Mach number 2 to study vaporization and possible reactions of the mixture air/helium jet and of the combustion of air/ethanol mixture. ESA

N88-27203# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Abteilung Drehfluegelflugzeuge.
ROBUST DIGITAL MODEL FOLLOWING CONTROLLER FOR HELICOPTERS Ph.D. Thesis - Technische Univ.
GERHARD BOUWER Jan. 1988 157 p In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-1041)
(DFVLR-FB-88-07; ISSN-0171-1342; ETN-88-92925) Avail: NTIS HC A08/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Federal Republic of Germany, 60.50 deutsche marks

The digital model following controller for multivariable systems consists of a linear P-I-controller, nonlinear control laws, and a controller output optimization. To meet the physical limits of the helicopter, especially the rotor speed, a special actuator simulation is developed. A low order model and a helicopter simulation model are used for the investigations. The effectiveness of the control system in model following as well as in disturbance rejection is tested in numerical simulations. Limits of the model following control system are shown by model parameter variation. The influence of a decoupled model on the handling qualities of a helicopter are investigated in piloted simulations. Selected flight test results show the performance of the control system in model following and flying a helicopter in gusty environment. The simulation of two different helicopters in flight demonstrates the possibilities of in-flight simulation. ESA

N88-27204# Bodenseewerk Geraetetechnik G.m.b.H., Ueberlingen (West Germany). Geschaeftsbereich Regelung und Navigation.
COMPUTER SYSTEM FOR THE PRIMARY FLY-BY-WIRE CONTROL OF CIVIL TRANSPORT AIRCRAFT (EXPERIMENTAL SYSTEM) Final Report, 31 Dec. 1987
FRANZ BOOS, HANS-JUERGEN MAIER, and RUDOLF SCHARPF 30 Apr. 1988 200 p In GERMAN; ENGLISH summary
(Contract BMFT-FE-LFL-8560-1)
(FBW-TB-2086/88; ETN-88-92963) Avail: NTIS HC A09/MF A01

For fly-by-wire control of civil transport aircraft, a fault tolerant computer system was specified, designed, and an experimental prototype produced. The system consists of four identical FBW-computers assembled from avionic computer building blocks. It is characterized by: multi-processor operation within an FBW-computer to guarantee the required real time data throughput, and fault tolerant behavior defined by the software implemented redundancy management of the concurrent operation of the four computers. For proving functions (signal-processing, redundancy management) an extensive test system was designed and built. Its major features are: computer supported stimulation and analysis for real-time open-loop tests with dynamic data sets, and computer supported hardware fault stimulation to test the redundancy management. ESA

N88-27205*# Advanced Rotorcraft Technology, Inc., Mountain View, Calif.
DYNAMIC MODELLING AND ESTIMATION OF THE ERROR DUE TO ASYNCHRONISM IN A REDUNDANT ASYNCHRONOUS MULTIPROCESSOR SYSTEM
LOC C. HUYNH and R. W. DUVAL May 1986 36 p
(Contract NASA ORDER A-30146-C)
(NASA-CR-177427; NAS 1.26:177427) Avail: NTIS HC A03/MF A01 CSCL 01C

The use of Redundant Asynchronous Multiprocessor System to achieve ultrareliable Fault Tolerant Control Systems shows great promise. The development has been hampered by the inability to determine whether differences in the outputs of redundant CPU's are due to failures or to accrued error built up by slight differences in CPU clock intervals. This study derives an analytical dynamic model of the difference between redundant CPU's due to differences in their clock intervals and uses this model with on-line parameter identification to idenitify the differences in the clock intervals. The ability of this methodology to accurately track errors due to asynchronisity generate an error signal with the effect of asynchronisity removed and this signal may be used to detect and isolate actual system failures. Author

N88-27373# Iowa Univ., Iowa City. Dept. of Mechanical Engineering.
OPTIMAL CONTROL OF THE WING ROCK PHENOMENON Final Report
CHRISTOPHER D. SIERRA *In* Universal Energy Systems, Inc., United States Air Force Graduate Student Summer Support Program, Volume 2 16 p Dec. 1987
Avail: NTIS HC A99/MF E03 CSCL 01C

The nonlinear phenomenon of the wing rock of a slender delta wing about the midspan axis was chosen for study. Time histories of the roll angle and the roll angle velocity were obtained and used to verify the results of the phase plane analysis of Nayfeh, Firbela and Mook. A simulation of the pilot changing the angle of shock of the wing was implemented in order to observe the effect the maneuver has on the behavior of the uncontrolled system. The time history of the build up of wing rock was developed. The need for a method of controlling this phenomena was observed. A control was then obtained using optimum systems control. The optimal control was also found for the system experiencing an unexpected pulse. The time histories of the roll angle for both cases were obtained. A Sub-Optimal Control Algorithm was also used to obtain a control for this wing rock phenomena. These results were presented so that a comparison between the two optimal control techniques could then be made. Author

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RESEARCH AND SUPPORT FACILITIES (AIR)

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

A88-49378*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TESTING AND CHECKOUT EXPERIENCES IN THE NATIONAL TRANSONIC FACILITY SINCE BECOMING OPERATIONAL
W. E. BRUCE, JR., B. B. GLOSS, and L. W. MCKINNEY (NASA, Langley Research Center, Hampton, VA) DFVLR, Cryogenic Technology Review Meeting, 2nd, Cologne, Federal Republic of Germany, June 28-30, 1988, Paper. 24 p. refs

The U.S. National Transonic Facility, constructed by NASA to meet the national needs for High Reynolds Number Testing, has been operational in a checkout and test mode since the operational readiness review (ORR) in late 1984. During this time, there have been problems centered around the effect of large temperature excursions on the mechanical movement of large components, the reliable performance of instrumentation systems, and an unexpected moisture problem with dry insulation. The more significant efforts since the ORR are reviewed and NTF status concerning hardware, instrumentation and process controls systems, operating constraints imposed by the cryogenic environment, and data quality and process controls is summarized. K.K.

A88-50066
A SYSTEM FOR THE ELECTROMAGNETIC LEVITATION OF MODELS IN A SUBSONIC WIND TUNNEL [SISTEMA ELEKTROMAGNITNOGO PODVESA MODELEI V DOZVUKOVOI AERODINAMICHESKOI TRUBE]
IU. D. VYSHKOV, S. A. KOVAL'NOGOV, V. N. USACHEV, and G. K. SHAPOVALOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 4, 1986, p. 94-97. In Russian.

An electromagnetic system is described which is capable of levitating models up to 2 kg in a subsonic wind tunnel. Aerodynamic drag measurements are presented for models tested in the 400x600-sq mm test section of a subsonic wind tunnel in the flow velocity range 0-60 m/s. Results of measurements of the effect of a false supporting device on the aerodynamic drag are also presented. V.L.

A88-50795
DISTORTION MODES OF DYNAMICALLY EXCITED WIND-TUNNEL MODELS EXAMINED USING A REAL-TIME MOIRE FRINGE TECHNIQUE
C. R. PYNE and W. DREW (Royal Aircraft Establishment, Bedford, England) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 140-145. refs

This paper discusses an improved moire fringe technique which provides an indication of aeroelastic distortion levels on dynamically excited wind-tunnel models. This noncontacting, nonintrusive technique utilizes closed circuit TV to gain a global overview of the model surface. Real-time contours facilitate the online measurement of dynamic displacement fields. Node lines are clearly defined, and mode shapes can be readily inferred. The system has been used to augment traditional methods of modal analysis, providing additional information concerning interactions between a model's driven axis, and its natural modes. Feasibility tests have been conducted in a low speed wind-tunnel with encouraging results, and in principle the system could be implemented in both high speed and cryogenic facilities. Author

A88-50831*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, Calif.
AIRCRAFT GROUND VIBRATION TESTING AT NASA AMES-DRYDEN FLIGHT RESEARCH FACILITY
MICHAEL W. KEHOE (NASA, Flight Research Center, Edwards, CA) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 728-736. Previously announced in STAR as N87-27655. refs

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 comparison of sine-dwell, single-input random, and multiple-input random excitation methods on a JetStar airplane. Author

A88-50904#
ELECTRO-IMPULSE DEICING OF THE NASA LEWIS ALTITUDE WIND TUNNEL TURNING VANES
RICHARD ROSS (Ross Aviation Associates, Wichita, KS) Journal of Aircraft (ISSN 0021-8669), vol. 25, June 1988, p. 499-502. Previously cited in issue 07, p. 852, Accession no. A86-19976. refs

A88-50907*# Federal Aviation Administration, Hampton, Va.
FLIGHT SIMULATION OF A WIDE-BODY TRANSPORT AIRCRAFT TO EVALUATE MLS-RNAV PROCEDURES
JAMES R. BRANSTETTER (FAA, Hampton, VA), JACOB A. HOUCK (NASA, Langley Research Center, Hampton, VA), and ARLENE D. GUENTHER (Unisys Corp., Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 25, June 1988, p. 515-521. refs

In a collaborative effort between the Federal Aviation Administration (FAA) NASA and the U.S. Air Force, a piloted simulation was conducted to look at the issues involved with flying a large, wide-body aircraft in the airport terminal area using Microwave Landing System Area Navigation (MLS)-RNAV procedures. A variety of approach paths, departure paths, and holding patterns were evaluated during the course of the study for operational use, flight technical errors, and safety. In addition, several methods for driving the horizontal situation indicator and flight director instruments were investigated along with needle sensitivity. The ultimate goal of the simulation was to develop and verify candidate paths and procedures prior to flight tests conducted in 1986/87. Subject pilots for the simulation study were provided by the FAA, NASA, the U.S. Air Force, and the airline industry. Author

A88-50914*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

EXPLORATORY EVALUATION OF MOVING-MODEL TECHNIQUE FOR MEASUREMENT OF DYNAMIC GROUND EFFECTS

GUY T. KEMMERLY, JOHN W. PAULSON, JR. (NASA, Langley Research Center, Hampton, VA), and MICHAEL COMPTON (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) Journal of Aircraft (ISSN 0021-8669), vol. 25, June 1988, p. 557-562. Previously cited in issue 20, p. 3164, Accession no. A87-45303.

A88-51017

VISIONICS SIMULATION IN THE AH-64 COMBAT MISSION SIMULATOR

EDWARD W. DREW, GARY R. GEORGE, and SAMUEL N. KNIGHT (Singer Co., Link Flight Simulation Div., Binghampton, NY) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1988, p. 947-953.
(Contract N61339-82-C-0088)

The AH-64 combat mission simulator's (CMS's) visual-avionics-sensor (visionics) system is discussed. The AH-64 visionics consists of the target acquisition and designation system (TADS), pilot night-vision sensor (PNVS), and the integrated helmet and display-sighting system (IHADSS). These systems provide the crew with sensor imagery for target detection, recognition, acquisition, and engagement, as well as night-vision imagery to aid in flying the aircraft. The simulation of the visionics systems is described, as well as the mission test and integration process. Controls, hardware interfaces, servo and visual simulations are also described. I.E.

A88-51039#

ACCEPTANCE TEST REQUIREMENTS FOR THE PROCUREMENT OF ELECTROSTATIC DISCHARGE (ESD) PROTECTIVE WORKSTATIONS

STEVEN C. GERKEN (USAF, Aerospace Guidance and Metrology Center, Newark AFB, OH) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1402-1408. refs

Test methods developed by the Aerospace Guidance and Metrology Center (AGMC) at Newark AFB for determining the acceptability of electrostatic discharge (ESD) protective workstations are reported. It is claimed that prior to this effort, no government specifications or standards for the procurement of ESD protective workstations or any other ESD control items existed. The lack of specifications for ESD control products has resulted in vulnerability and reliance on the product manufacturer as to whether effective products are received. MIL-W-87893, 'Workstation, Electrostatic Discharge (ESD) Control' is the first specification developed by AGMC that has been published as a military standard. It specifies resistance requirements, static decay values, and general construction requirements for static control workstations and their components for use in applications where the protection of ESD-sensitive items is required. I.E.

A88-51041#

INTEGRATED ELECTROMAGNETIC SYSTEM SIMULATOR (IESS)/LOGISTICS SUPPORT UTILITY ANALYSIS (LSUA): A STUDY INTO NEW TEST FACILITIES AND SUPPORT TECHNOLOGIES FOR INTEGRATED COMMUNICATION, NAVIGATION, IDENTIFICATION

RALPH A. BEARD and DANA L. HOWELL (USAF, Avionics Laboratory, Wright-Patterson AFB, OH) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1460-1465. refs

The Integrated Electromagnetic System Simulator (IESS) is being developed for test, evaluation, and future development of the Integrated Communication, Navigation, Identification Avionics (ICNIA) advanced development models (ADMs). A preliminary study was conducted, concurrent with the development of IESS, to assess the feasibility of IESS as a baseline for ICNIA automatic test equipment and eventually an integrated support complex (ISC). Some of the findings that are applicable to new generation ISCs for integrated systems are reported. I.E.

A88-51045

THE FLIGHT CONTROL MAINTENANCE DIAGNOSTIC SYSTEM

PAUL M. BURSCH, JOHN W. MEISNER, ROBERT MCAFOOS (Honeywell Systems and Research Center, Minneapolis, MN), and J. B. SCHROEDER (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1504-1509. refs
(Contract F33615-85-C-3613)

The flight control maintenance diagnostic system (FCMDS) program is concerned with investigating maintenance diagnostic approaches that will enhance the performance of US Air Force organizational-level maintenance technicians. Two aspects of the FCMDS program are discussed, namely, a ground-based maintenance diagnostic system and an embedded diagnostic system. I.E.

A88-51455

TECHNOLOGY CONSIDERATIONS FOR AVIONICS FLIGHT TEST SUPPORT FACILITIES

JAMES M. UNDERWOOD, JR. (USAF, Edwards AFB, CA) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 5-1 to 5-7. refs

The success of new avionics programs is highly dependent upon the application of integration testing technologies in bringing flight test support facilities on line. This paper draws upon experience at the Air Force Flight Test Center (AFFTC), Edwards Air Force Base, California, from 1978 through 1987 in developing and using the Integration Facility for Avionic Systems Testing (IFAST). This facility is being used to support flight testing for the F-16, F-15, B-1B, and HH-60 aircraft and in planning for future integrated attack aircraft like the Advanced Tactical Fighter (ATF). The most relevant technologies involved in this support are highlighted to improve awareness in planning and execution of new programs, thereby reducing risks. Most of the information presented is generally applicable to other types of avionics facilities. Author

A88-51500

DESIGN STRATEGIES FOR THE DEVELOPMENT OF A MODEL HELICOPTER ROTOR IMPEDANCE TEST FACILITY

RICHARD L. BIELAWA (Rensselaer Polytechnic Institute, Troy, NY) and KENG D. HSUEH (New York, State University, Plattsburgh) Vertica (ISSN 0360-5450), vol. 12, no. 1-2, 1988, p. 109-128. refs
(Contract DAAG29-82-K-0093; DAAL03-86-G-0118)

A model helicopter rotor impedance test facility is currently under construction which embodies novel design approaches in order to facilitate positive control of rotor hub fixity as well as the measurement of aeromechanical impedance. Attention is presently given to the results of analyses and their implementations, as well as the identification of the requisite data-processing algorithms and the selection of component hardware. The configuration of the apparatus encompasses a support pylon and vertical and lateral isolation systems, rotor hub instrumentation, data preprocessor and postprocessor systems, and a host computer. O.C.

A88-51770* Princeton Univ., N. J.
ACTIVE CONTROL ROTOR MODEL TESTING AT PRINCETON'S ROTORCRAFT DYNAMICS LABORATORY
ROBERT M. MCKILLIP, JR. (Princeton University, NJ) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 9 p. Research supported by the Engineering Foundation. refs
(Contract NAG2-415)

A description of the model helicopter rotor tests currently in progress at Princeton's Rotorcraft Dynamics Laboratory is presented. The tests are designed to provide data for rotor dynamic modeling for use with active control system design. The model rotor to be used incoporates the capability for Individual Blade Control (IBC) or Higher Harmonic Control through the use of a standard swashplate on a three bladed hub. Sample results from the first series of tests are presented, along with the methodology used for state and parameter identification. Finally, pending experiments and possible research directions using this model and test facility are outlined.

A88-51788
FIXED BASE DATA SYSTEM
D. L. MARSHALL and T. N. HUFFAKER (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. I-10 to I-15.

A new data system for the testing of current and future generation helicopters has been developed utilizing off-the-shelf main frame computers and a hybrid of peripherals not previously utilized in telemetry system applications. High-speed I/O processors are included as well as Cray computer disks, fast laser printer/plotters, and a unique utilization of distributed microcomputer preprocessors permitting future expandability. The design goal was to permit modular expansion and/or change with little or no effect on other modules of the system. K.K.

A88-51918#
SUBSONIC WIND TUNNEL DESIGN FOR LOW TURBULENCE AND FLOW VISUALIZATION CAPABILITIES
THOMAS TIGHE (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, NASA, and AFWAL, Conference on Sensors and Measurements Techniques for Aeronautical Applications, Atlanta, GA, Sept. 7-9, 1988. 9 p. refs
(AIAA PAPER 88-4672)

The Philip P. Antonatos Subsonic Aerodynamic Research Laboratory (SARL), located within the Flight Dynamics Laboratory at Wright-Patterson Air Force Base, Dayton, Ohio, is a new subsonic wind tunnel built for flow visualization and computation code validation studies at speeds between 0.2 and 0.6 Mach number. A brief history of the SARL's conception and utilization of existing equipment from older facilities will be presented along with a short discussion of the design choices for achieving a low turbulent flow stream. This paper is intended to give an overview of the SARL facility, which is currently going through shakedown activities. Calibration work will be started in the fall of 1988. Author

A88-52084
INVESTIGATION OF THE WORKING PROCESS OF A LOW-PRESSURE BLOWDOWN SUPERSONIC WIND TUNNEL [ISSLEDOVANIE PROTSESSA RABOTY SVERKHZVUKOVOI BALLONNO-VAKUUMNOI AERODINAMICHESKOI TRUBY KRATKOVREMENNOGO DEISTVIIA]
V. IA. BEZMENOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 4, 1987, p. 50-58. In Russian. refs

The working process of a low-pressure blowdown supersonic wind tunnel is analyzed. It is shown that such characteristics as pressure reduction, the duration of the flow core in the working section, and overloads are determined by universal dimensionless parameters. R.B.

N88-27206# Dundee Univ. (Scotland). Dept. of Civil Engineering.
ALTERNATE/MODIFIED BINDERS FOR AIRFIELD PAVEMENTS Periodic Report Nos. 1-3, Aug. 1986 - Jan. 1988
A. F. STOCK Jan. 1988 52 p
(Contract DAJA45-86-C-0043)
(AD-A192781; R/D-5499-EN-01) Avail: NTIS HC A04/MF A01 CSCL 11A

The report contains fact sheet data on the following modifiers:- Sealgum, Polybilt, Escorene, Eva, Trinidad natural asphalt, Cariflex, Neolastic, Neoflex and Novophalt. A procedure for successfully screening modifiers is proposed. The report identifies and classifies all the additives for asphalt which have been identified to date. It also includes a note of the suppliers,and where data is available, and costs. GRA

N88-27207# Oak Ridge National Lab., Tenn. Energy Div.
VIBRATIONAL IMPACTS OF HUSH HOUSE OPERATION
A. J. WITTEN 1988 13 p Presented at the Joint CSCE-ASCE Conference on Environmental Engineering, Vancouver, British Columbia, 13 Jul. 1988
(Contract DE-AC05-84OR-21400)
(DE88-006983; CONF-880741-2) Avail: NTIS HC A03/MF A01

United States Air Force (USAF) facilities are required to test turboprop and turbojet engines before or after maintenance or repair and prior to installation on aircraft to ensure that no problems were introduced or remain uncorrected. This requirement prevents the installation of engines in aircraft which require further maintenance. There are a number of facilities in use by USAF for conducting engine diagnostic tests. The most modern of these facilities is the hush house which is a hangar-like structure designed to isolate the noise associated with extended engine operations from the surrounding environment. One type of hush house, the T-10, is of particular concern because of vibrational impacts to surrounding structures induced by subaudible sound (infrasound) emitted during operation. While these facilities fulfill the design requirement of reducing audible noise, serious sitting problems were reported at several installations because of infrasound-induced vibrations. The worst of these include the abandonment of an avionics laboratory because induced vibrations interfered with this facilities function and structural damage to a concrete block maintenance facility. This paper describes a predictive method for assessing vibration-driven structural impacts. DOE

N88-27208# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Directions des Grands Moyens d'Essais.
EUROPEAN TRANSONIC WIND TUNNEL PROJECT: ASSISTANCE TO THE DESIGN GROUP Final Report [ETUDE DE LA SOUFFLERIE TRANSSONIQUE EUROPEENE. ASSISTANCE AU GROUPE DE PROJET]
GILBERT FRANCOIS Feb. 1988 6 p In FRENCH
(Contract DRET-87-820)
(ONERA-RSF-11/0694-GY-010-G; ETN-88-92746) Avail: NTIS HC A02/MF A01

The assistance provided to the European transonic wind tunnel design group by personnel from the Test Facilities Direction of ONERA in 1987 is reported. Names, type of meeting, and purpose of meeting are detailed. ESA

N88-27209# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Grands Moyens d'Essais.
STUDIES CONCERNING THE EUROPEAN TRANSONIC WIND TUNNEL Final Report [ETUDES DE LA SOUFFLERIE TRANSSONIQUE EUROPENNE]
X. BOUIS Feb. 1988 15 p In FRENCH
(Contract DRET-87-820)

(ONERA-RSF-10/0694-GY-010-G; ETN-88-92748) Avail: NTIS HC A03/MF A01

Activities of a design group participating in the PG-ETW transonic wind tunnel project are described. The phase 2.2 of the project includes the conceptual design, the distribution of tasks between national partners, the estimation of the investment and cost, and the definition of a legal status are presented. ESA

N88-27211# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). *Abteilung* Hochgeschwindigkeitsstroemungen.

HYBRID PROCEDURE FOR DYNAMIC MEASUREMENTS IN TRANSONIC WIND TUNNELS: DEMONSTRATED BY PITCH OSCILLATION Ph.D. Thesis - Technische Univ.

DETLEF KUCZKA Apr. 1988 95 p In GERMAN; ENGLISH summary

(DFVLR-FB-88-19; ISSN-0171-1342; ETN-88-92936) Avail: NTIS HC A05/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Federal Republic of Germany, 29 deutsche marks

For dynamic measurements in transonic wind tunnels a hybrid procedure is presented to obtain quasi interference-free results. Therefore, residual dynamic interferences are calculated, when first the stationary wall interferences are eliminated by wall adaptation for the stationary case. Using the Standard Dynamics Model, dynamic measurements were performed in the adaptive wall test section of the high-speed tunnel to validate the proposed procedure. The model was subjected to forced pitch oscillations. Measurements of stationary force coefficients, the dynamic derivatives, the stationary wall pressure distribution and significant dynamic wall pressures were taken as well in the straight walled test section, as in the test section adapted for the stationary case. Results are compared to those acquired in the 1 x 1 m transonic facility 4 x 4 ft tunnel and 0.9 x 0.9 m tunnel. Methods for the correction of dynamic derivatives are discussed to determine their range of validity. ESA

N88-27212# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Hauptabteilung Windkanaele.

EQUIPMENT FOR MASS FLOW MEASUREMENTS IN THE LOW-SPEED WIND TUNNEL AT DFVLR IN BRUNSWICK, WEST GERMANY

REINHARD FRIEDRICHS Dec. 1987 54 p In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-1125)

(DFVLR-MITT-88-02; ISSN-0176-7739; ETN-88-92937; AD-B122626L) Avail: NTIS HC A04/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Federal Republic of Germany, 22.50 deutsche marks

A mass flow measurement device inserted in the low speed wind tunnel determines air intake mass flow as a function of intake parameters. The device consists of a tank with ISA-1932 standard nozzles coupled to the existing vacuum pump and situated in the cellar beneath the wind tunnel. Nozzles are calibrated with choked nozzles for the test range 0.5 to 2.5 kg/sec and accuracy obtained is 0.3 percent. Tests results are compared with an air intake mass flow model and correction factors are derived. ESA

N88-27370# Puerto Rico Univ., Mayaguez. Dept. of Mechanical Engineering.

DESIGN OF A MECHANISM TO CONTROL WIND TUNNEL TURBULENCE Final Report

FILIBERTO SANTIAGO *In* Universal Energy Systems, Inc., United States Air Force Graduate Student Summer Support Program, Volume 2 33 p Dec. 1987

Avail: NTIS HC A99/MF E03 CSCL 14B

An intense literature survey was done covering the fundamental aspects of the turbulence phenomena. Turbulence of the air stream is generally recognized as a variable of considerable importance in many aerodynamics phenomena, especially those observed in wind tunnels. In the Acoustic Research Wind Tunnel, turbulence was generated in the stilling chamber using two devices. First, a grid, 20.5 by 20.5 in. with 1/2 in. diameter rods. This grid was used in two ways, one, the grid by itself, and the other, the grid with small tags attached to the horizontal center line and to the vertical center line. Second, a manifold with fourteen jets producing a flow of air perpendicular to its main stream flow in the wind tunnel. The turbulence level of the tunnel empty is approx. 3 percent. The turbulence level of the wind tunnel with the two devices is also given and a discussion of the results is presented. Author

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ASTRONAUTICS

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

A88-50078

PNEUMOMETRIC METHOD FOR DETERMINING THE FLIGHT PARAMETERS OF FLIGHT VEHICLES WITH CONICAL AND OGIVAL NOSE PARTS [PNEVMOMETRICHESKII METOD OPREDELENIIA PARAMETROV POLETA LETATEL'NYKH APPARATOV S KONICHESKOI I OZHIVAL'NOI NOSOVYMI CHASTIAMI]

V. N. MILIUTICHEVA and A. N. PETUNIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 5, 1986, p. 79-85. In Russian.

The pneumometric method is based on the dependence of local pressures on the surface of the nose part of a flight vehicle on the magnitude and direction of the velocity, as well as the flight altitude. The proposed measurement system was validated in a wind tunnel. Calibration characteristics obtained from the tests were used to determine the flight parameters of freely flying models. B.J.

A88-52104

DETERMINATION OF THE LINEAR AND ANGULAR ACCELERATIONS OF A CONSTRAINED SYSTEM OF TWO FLIGHT VEHICLES [OPREDELENIE LINEINYKH I UGLOVYKH USKORENII NESVOBODNOI SISTEMY DVUKH LETATEL'NYKH APPARATOV]

V. V. OVCHINNIKOV and V. I. SADCHIKOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 5, 1987, p. 75-82. In Russian. refs

Vector-matrix differential equations are derived which describe the three-dimensional motion of two flight vehicles (a carrier and a load) with an arbitrary number of ideal constraints allowing, in the general case, translational and rotational motion of the flight vehicles relative to each other. To determine the linear and angular accelerations of each of the flight vehicles, use is made of kinematic constraint conditions and constraints on the magnitudes of the principal vector and response force moment determined by the design properties of the constraint system under consideration. Analytical expressions for these vectors as functions of the external forces and moments and kinematic motion parameters are presented. V.L.

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CHEMISTRY AND MATERIALS

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

A88-49519
SIMULATION OF THE SOOT-FORMATION PROCESS DURING THE COMBUSTION OF A HOMOGENEOUS MIXTURE [MODELIROVANIE PROTSESSA SAZHEOBRAZOVANIIA PRI GORENII ODNORODNOI GOMOGENNOI SMESI]
O. V. STROGONOV, O. V. DUNAI, F. A. KHAMIDULLIN, V. A. SHCHUKIN, and A. V. TALANTOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1988, p. 71-75. In Russian. refs

An analysis is made of the sort-formation process during the combustion of homogeneous hydrocarbon-air fuel mixtures in three successive monomolecular reactions and one parallel monomolecular reaction. The results are pertinent to the study of processes in gas-turbine engines. B.J.

A88-49532
THE EFFECT OF ALCOHOL IN THE JET FUEL ON THE EMISSION OF POLLUTANTS FROM AIRCRAFT GAS TURBINE ENGINES [VLIIANIE SPIRTA I EGO DOBAVOK V REAKTIVNOE TOPLIVO NA VYBROS ZAGRIAZNIAIUSHCHIKH VESHCHESTV AVIATSIONNYKH GTD]
V. P. SVINUKHOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1988, p. 105-108. In Russian.

The paper presents an examination of the influence of the addition of ethanol to jet fuel on the emissions of the following pollutants from gas turbine engines: CO, unburnt hydrocarbons, nitrogen oxides, and smoke. It is shown that the use of alcohol as the main fuel for gas turbine engines as well as mixtures of alcohol with hydrocarbon fuels can significantly reduce the emission of nitrogen oxides and the smoking of the engine. Meanwhile, the emission level of CO and unburnt hydrocarbons remains roughly the same. B.J.

A88-49534
CHARACTERISTICS OF A TWO-STAGE COMBUSTION PROCESS OCCURRING IN COMBUSTION CHAMBERS IN QUASI-STOICHIOMETRIC REGIMES [OSOBENNOSTI PROTSESSA GORENIIA, PROTEKAIUSHCHEGO V DVE STADII V KAMERAKH SGORANIIA NA REZHIMAKH, BLIZKIKH K STEKHIOMETRICHESKIM]
V. M. IANKOVSKII, M. P. KOLESOV, V. A. SYCHENKOV, R. I. FAKHRUTDINOV, and A. N. DONDUKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1988, p. 110, 111. In Russian.

A88-49811
HYDROGEN EMBRITTLEMENT: PREVENTION AND CONTROL
LOUIS RAYMOND, ED. (L. Raymond and Associates, Newport Beach, CA) Philadelphia, PA, American Society for Testing and Materials, 1988, 438 p. For individual items see A88-49812 to A88-49815.

The control and prevention of hydrogen embrittlement in metals are discussed, with a focus on test methods, in reviews and reports presented at the ASTM national symposium held in Los Angeles in May 1985. Sections are devoted to current standards and projections, hydrogen in steel and Ti, relative susceptibility, hydrogen in welding, case histories of prevention and control, and ongoing research. Topics addressed include electrochemical aspects, accelerated acceptance testing methods, the barnacle electrode method, the disk pressure test, a bent-beam test for H2S stress corrosion cracking, diffusible hydrogen testing by gas chromatography, surface films for embrittlement prevention, the effects of strain on hydrogen entry and transport in ferrous alloys, and the temperature dependence of fatigue crack propagation in Nb-H alloys. T.K.

A88-49812
ACCELERATED ACCEPTANCE TESTING FOR HYDROGEN EMBRITTLEMENT CONTROL
ROBERT V. DREHER (Kaiser Electroprecision, Irvine, CA) IN: Hydrogen embrittlement: Prevention and control. Philadelphia, PA, American Society for Testing and Materials, 1988, p. 60-67.

An 8-h stepped-load hydrogen-embrittlement test for Ni- and Cr-plated type 4330 V steel components (for an aircraft hydraulic system) is described. The applicable U.S. military standards are reviewed; the conventional 200-h test procedures are outlined; and the practical and cost disadvantages of such testing are indicated. In the proposed method, 0.250-inch-diameter tension bar specimens are loaded for 1 h each at 50, 65, 75, 85, 90, and 95 percent of the (predetermined) fracture load and then pulled to fracture. The results are presented in tables and shown to be in good agreement with those of the 200-h constant-sustained-load tests: no hydrogen embrittlement is found. It is pointed out that the 8-h test permits prompt release of components for further processing. T.K.

A88-49814
EXAMINATION OF CADMIUM-PLATED AIRCRAFT FASTENERS FOR HYDROGEN EMBRITTLEMENT
MILTON LEVY and GORDON A. BRUGGEMAN (U.S. Army, Materials Technology Laboratory, Watertown, MA) IN: Hydrogen embrittlement: Prevention and control. Philadelphia, PA, American Society for Testing and Materials, 1988, p. 335-341; Discussion, p. 341, 342.

The Army Technology Materials Laboratory (AMTL) participated in a possible hydrogen embrittlement (HE) problem involving a variety of Cd-plating AISI 4340 steel fasteners (used in OH-58 and CH-47 helicopters) being reworked at an Army depot where Cd plating was carried out according to Federal Specification QQ-P-416C. A 3-month period was considered suspect, and AMTL was supplied with a number of fasteners (bolts), both new and reworked during the suspect period, for evaluation. These fasteners were sustained-load tested for evidence of HE. All of the bolts survived at least 200 h of testing without cracking or fracture. Several of the bolts were deliberately fractured for examination of failure mode. The fracture topography showed no evidence of HE effects. Hardness and Cd plating thickness measurements were consistent with specification requirements. Author

A88-50010
EVALUATION OF THE FATIGUE AND DURABILITY OF ALUMINUM ALLOYS UNDER NONSYMMETRIC CYCLIC LOADING USING FRACTURE MECHANICS RELATIONSHIPS [OTSENKI USTALOSTI I ZHIVUCHESTI ALIUMINIEVYKH SPLAVOV PRI NESIMMETRICHNOM TSIKLICHESKOM NAGRUZHENII NA OSNOVE SOOTNOSHENII MEKHANIKI RAZRUSHENIIA]
V. D. IL'ICHEV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 1, 1986, p. 91-96. In Russian. refs

Fracture mechanics relationships describing crack growth rates at the first and second stages of crack propagation are used to obtain estimates of the fatigue characteristics of aluminum alloys under conditions of nonsymmetric cyclic loading. The fatigue and durability estimates obtained here can be used for the parametric analysis of aircraft structures during their design. V.L.

A88-51780
MODELING COMPOSITE COMPONENTS FOR ROTORCRAFT WIND TUNNEL MODELS
JEFFREY C. BREAKS (Dynamic Engineering, Inc., Newport News, VA) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 6 p.

The appearance of composite materials in rotor systems has presented new challenges to the builder of dynamically scaled models. As more components are made of composites the volume and complexity of the tooling required to produce these scaled components also increases. This paper is intended to give an overview of the scope of a modeling effort by noting the progression of composite usage from the single composite blade to the completely composite X-wing blade system and by citing three examples of successfully modeled composite components. Data from calibration and verification testing of fiberglass and Kevlar flexbeams are presented to demonstrate the ability of these parts to meet target stiffness and be durable enough for extended test programs. Tooling requirements and fabrication techniques utilized for the X-wing systems model are also presented and discussed. Author

A88-51814* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
HIGH PERFORMANCE COMPOSITES RESEARCH AT NASA-LANGLEY
TERRY L. SAINT CLAIR, NORMAN J. JOHNSTON, and ROBERT M. BAUCOM (NASA, Langley Research Center, Hampton, VA) IN: Polymer composites for automotive applications; Proceedings of the International Congress and Exposition, Detroit, MI, Feb. 29-Mar. 4, 1988. Warrendale, PA, Society of Automotive Engineers, Inc., 1988, p. 1-19. refs
(SAE PAPER 880110)
Barriers to the more extensive use of advanced composites in heavily loaded structures on commercial transports are discussed from a materials viewpoint. NASA Langley matrix development activities designed to overcome these barriers are presented. These include the synthesis of processable, tough, durable matrices, the development of resin-property/composite-property relationships which help guide the synthesis program, and the exploitation of new processing technology to effectively combine reinforcement filaments with polymer matrices. Examples of five classes of polymers being investigated as matrix resins at NASA Langley are presented, including amorphous and semicrystalline thermoplastics, lightly crosslinked thermoplastics, semi-interpenetrating networks, and toughened thermosets. Relationships between neat resin modulus, resin fracture energy interlaminar fracture energy, composite compression strength, and postimpact compression strength are shown. Powder and slurry processing techniques are discussed. Author

A88-51941#
DAMAGE TOLERANCE OF BISMALEIMIDE COMPOSITES
S. T. TYAHLA (McDonnell Aircraft Co., Saint Louis, MO) and H. J. STORR (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 8 p.
(Contract F33615-85-C-3212)
(AIAA PAPER 88-4421)
Advanced aircraft require structures that can sustain temperatures in the 350 to 450 F range. First generation bismaleimide (BMI) resins were developed for this purpose, but at the expense of toughness and damage tolerance. Newer, second generation BMIs have toughnesses comparable to lower temperature epoxy resins while maintaining the required higher temperature capability. To evaluate the damage tolerance of second generation BMIs, low-velocity impact tests were performed on flat coupon specimens and hat-stiffened panels. Residual compression strength testing showed that coupon specimens lost more than 50 percent of the undamaged strength while hat-stiffened panels lost only 26 percent of the undamaged strength. A straightforward crippling analysis was used to predict the impact damage strength reduction in the hat-stiffened panels. The analysis accounted for delaminations created by low-velocity impact. Author

A88-51954#
RAPIDLY SOLIDIFIED ALUMINUM-TRANSITION METAL ALLOYS FOR AEROSPACE APPLICATIONS
P. S. GILMAN, M. S. ZEDALIS, J. M. PELTIER, and S. K. DAS (Allied-Signal, Inc., Morristown, NJ) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 8 p. refs
(AIAA PAPER 88-4444)
Rapid solidification and consolidation P/M technologies have facilitated the development of a family of Al-Fe-V-Si alloys exhibiting a combination of good room temperature ductility and fracture toughness with excellent elevated-temperature strength. Also obtained are high moduli and excellent thermal stability and corrosion resistance, with sufficiently high fabricability to allow economic production of sheet, extrusion, and forging feedstocks applicable to a wide range of aerospace applications; these applications encompass aircraft primary structures, gas turbine compressors, and missile airframes. O.C.

N88-27247# Construcciones Aeronauticas S.A., Madrid (Spain). Div. de Proyectos.
DESIGN AND IMPLEMENTATION OF CONTACT ULTRASONIC SENSORS TO ASSESS INTERNAL DAMAGE [DESARROLLO Y PUESTA A PUNTO DE PALPADORES ULTRASONICOS FIJOS PARA EL SEGUIMIENTO DE DANOS INACCESIBLES]
9 Apr. 1987 13 p In SPANISH Sponsored by the Investigacion y Desarrollo de Tecnologia y Materiales
(I-177/87; ETN-88-92713) Avail: NTIS HC A03/MF A01
A sensor was developed to assess inner damage in fatigue tests of the carbon fiber-epoxy composite horizontal stabilizer of the A-320 aircraft. The sensor is implemented with a modified lead titanate crystal, a copper mesh acting as impedance adapter, plastic bodies, and aluminum case. The sensor is adhesive bonded to the surface of the element to be checked. The procedure works correctly when the damage region is well identified. It does not measure the real size of the defect. ESA

N88-27253# Technische Univ., Brunswick (West Germany). Inst. fuer Flugzeugbau und Leichtbau.
SIMULATION OF MOISTURE DIFFUSION OF FIBER REINFORCED COMPONENTS OF AIRCRAFT FOR GENERAL AIR TRANSPORTATION [SIMULATION DER FEUCHTEVERTEILUNG IN BAUTEILEN AUS FASERVERBUNDWERKSTOFFEN FUER FLUGZEUGE DER ALLGEMEINEN LUFTFAHRT]
PETER WETJEN Sep. 1987 85 p In GERMAN
(Contract BMFT-LFF-8432/9)
(IFL-IB-87-05; ETN-88-92964) Avail: NTIS HC A05/MF A01
Investigation and comparison of diffusion properties of cold and hot cured fiber reinforced epoxy resins are performed. Diffusion models are developed by finite difference method and a simulation program is established for the prediction of water absorption by reinforced epoxy resins aircraft parts. Results indicate no difference in diffusion behavior between both types of epoxy resins. ESA

N88-27283# Naval Postgraduate School, Monterey, Calif.
ANALYSIS OF GRAIN REFINEMENT AND SUPERPLASTICITY IN ALUMINUM-MAGNESIUM ALLOYS Ph.D. Thesis
AHMED A. ABOU-SALAMA Dec. 1987 167 p
(AD-A193029) Avail: NTIS HC A08/MF A01 CSCL 11F
Previous research had demonstrated superplastic behavior in aluminum-magnesium alloys of high magnesium content to result from deformation processing to an initially non-recrystallized condition. Analysis here of those data has demonstrated that such a result may be understood in terms of constitutive equations developed for fine-grained materials and that the constitutive equations are applicable to materials achieving grain boundary misorientations in the range of only 2 to 7 by a process of continuous recrystallization. The constitutive equations provide a basis for analysis of anomalous temperature dependence of the strength and of the activation energy for plastic deformation seen as well in this work. A study of the separate effects of processing variables has lead to a model for continuous recrystallization during deformation processing. This model considers recovery of dislocations to sub-boundaries to be the critical step in this process. Application of this model to development of advanced aluminum alloys for air frame structural applications will result in increased weight savings by such processing methods. GRA

N88-27307# Construcciones Aeronauticas S.A., Madrid (Spain). Div. de Proyectos.
STRESS CORROSION OF C RING SPECIMEN IN SALT SPRAY TESTS [ENSAYO DE TENSOCORROSION DE PROBETAS EN C (C-RING) REALIZADOS EN NIEBLA SALINA]
7 Jul. 1987 16 p In SPANISH Sponsored by the Investigacion y Desarrollo de Tecnologia y Meteriales
(I-186/87; ETN-88-92714) Avail: NTIS HC A03/MF A01

A metal component of the C-101 aircraft was tested including different thermal treatments and surface protections. The specimens were stressed to the maximum working load and sprayed with 5 percent ClNa solution at 37C till the first specimen fracture. A large corrosion strength difference due to the heat treatment is observed. The results confirm that failure in service is caused by stress corrosion and that a change in heat treatment is necessary. ESA

N88-27308# Societe Nationale Industrielle Aerospatiale, Suresnes (France).
STUDY OF SURFACE TREATMENTS BEFORE ADHESIVE BONDING OF LIGHT ALLOYS Final Report [ETUDE DES TRAITEMENTS DE SURFACE AVANT COLLAGE DES ALLIAGES LEGERS]
J. ODORICO 1987 5 p In FRENCH
(Contract DRET-85-34-444)
(ETN-88-92743) Avail: NTIS HC A02/MF A01

Adhesion tests were carried out on 1.6 mm aluminum alloy plate specimens after surface treatment with sulfochromic scaling and chromic or phosphoric anodizing. Dry and wet exposures at variable lengths of time before bonding were also imposed. The results show that a hot wet (50 percent to 100 percent) exposure alters significantly the surface properties, especially in the case of phosphoric anodizing. ESA

N88-28097# McDonnell Aircraft Co., St. Louis, Mo.
DURABILITY OF CONTINUOUS FIBER REINFORCED METAL MATRIX COMPOSITES Final Report, Sep. 1983 - Dec. 1986
D. M. HARMON, C. R. SAFF, and C. T. SUN Oct. 1987 219 p Prepared in cooperation with Purdue Univ., Lafayette, Ind.
(Contract F33615-83-C-3219)
(AD-A193868; AFWAL-TR-87-3060) Avail: NTIS HC A10/MF A01 CSCL 11F

The objective of this program was to develop the test data and analysis techniques required to insure the structural integrity of fiber reinforced metal matrix composites (FRMMC) when applied to airframe structures. Approximately 300 tests of unidirectional boron/6061 aluminum, (B4C)/15-3-3-3 titanium, and crossplied boron/6061 aluminum were performed. Testing was concentrated on notched (central hole) specimens to evaluate the notch sensitivity of these materials and to discriminate between the failure modes of aluminum and titanium matrix composites. It was found that the relative fiber and matrix stiffnesses and strengths determine primary failure modes in fatigue. Analysis methods were developed based on fiber and matrix properties to predict notched and unnotched static strength, crack initiation, fatigue failure mode, life to failure, and residual strength. One half of the tests (150 specimens) were performed to verify the predicted properties of the aluminum and titanium matrix composites. GRA

N88-28119# Commanders Naval Air Forces US Atlantic and Pacific Fleets, Norfolk, Va.
AVIONIC AND ELECTRICAL SYSTEM CORROSION PREVENTION AND CONTROL MAINTENANCE
G. T. BROWNE *In* AFWAL, Proceedings of the 1987 Tri-Service Conference on Corrosion, Volume 1 p 369-406 May 1987 Previously announced as N88-13334
Avail: NTIS HC A23/MF A01 CSCL 11F

A study of premature failures of installed avionics, electrical equipment, and systems experienced in U.S. Fleet operational aircraft in the 1960's and 70's has been reported. These failures were caused by corrosion, water intrusion, and other contaminating agents. To reverse this trend the Commanders Naval Air Forces U.S. Atlantic and Pacific Fleets requested that Commander Naval Air System Command develop a corrosion prevention and control program for avionics, electrical and installed systems used in Naval aircraft. The Naval Air Development Center was directed to develop the program together with a technical manual. A conference of interested parties was held in 1976 and action initiated to develop the program and technical manual for use by the fleet technicians. Author

N88-28122# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Materials Lab.
ELECTRONIC FAILURE ANALYSIS-CORROSION OF AVIONICS
M. MARCHESE, E. WHITE, G. SLENSKI, and B. DOBBS *In its* Proceedings of the 1987 Tri-Service Conference on Corrosion, Volume 1 p 475-480 May 1987
Avail: NTIS HC A23/MF A01 CSCL 11F

Six examples of corrosion failure in aircraft electrical and electronic devices are described. The experience indicates that about 20 percent of the failed devices submitted for examination are caused by corrosion. The corrosion can result in leakage currents and opens which can eventually lead to electrical failure. The use of dissimilar metals, small dimensions and voltage gradients greatly accelerate the corrosion process in electronic hardware. This extreme sensitivity of electronics to corrosion requires special consideration for cleanliness and moisture content. Author

N88-28142*# Garrett Turbine Engine Co., Phoenix, Ariz.
THERMAL BARRIER COATING LIFE-PREDICTION MODEL DEVELOPMENT Annual Report No. 2
T. E. STRANGMAN, J. NEUMANN, and A. LIU 20 Oct. 1986 91 p
(Contract NAS3-23945)
(NASA-CR-179507; GTEC-21-5988; NAS 1.26:179507) Avail: NTIS HC A05/MF A01 CSCL 11C

The program focuses on predicting the lives of two types of strain-tolerant and oxidation-resistant thermal barrier coating (TBC) systems that are produced by commercial coating suppliers to the gas turbine industry. The plasma-sprayed TBC system, composed of a low-pressure plasma-spray (LPPS) or an argon shrouded plasma-spray (ASPS) applied oxidation resistant NiCrAlY or (CoNiCrAlY) bond coating and an air-plasma-sprayed yttria partially stabilized zirconia insulative layer, is applied by both Chromalloy, Klock, and Union Carbide. The second type of TBS is applied by the electron beam-physical vapor deposition (EB-PVD) process by Temescal. The second year of the program was focused on specimen procurement, TMC system characterization, nondestructive evaluation methods, life prediction model development, and TFE731 engine testing of thermal barrier coated blades. Materials testing is approaching completion. Thermomechanical characterization of the TBC systems, with toughness, and spalling strain tests, was completed. Thermochemical testing is approximately two-thirds complete. Preliminary materials life models for the bond coating oxidation and zirconia sintering failure modes were developed. Integration of these life models with airfoil component analysis methods is in progress. Testing of high pressure turbine blades coated with the program TBS systems is in progress in a TFE731 turbofan engine. Eddy current technology feasibility was established with respect to nondestructively measuring zirconia layer thickness of a TBC system. Author

N88-28150# Rolls-Royce Ltd., Derby (England).
THE EFFECT OF COATINGS ON FATIGUE IN AEROSPACE MATERIALS
T. P. CUNNINGHAM and T. N. RHYS-JONES 15 Oct. 1987 15 p Presented at the Surface Engineering Society, Oct. 1987
(PNR90460; ETN-88-92690) Avail: NTIS HC A03/MF A01

The effect coatings can have on high strength materials in fatigue is examined. Failure mechanisms are reviewed. Fatigue penalties involved in using coatings are recalled. ESA

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ENGINEERING

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

A88-49470
THE METHODS AND THE RESULTS OF TESTS FOR QUASI-RANDOM LOADING WHICH IS CHARACTERISTIC FOR WING ELEMENTS [METODIKA I REZUL'TATY ISPYTANII PRI KVAZISLUCHAINOM NAGRUZHENII, KHARAKTERNOM DLIA ELEMENTOV KRYLA]
IU. A. SVIRSKII, S. F. DERGUNOV, V. N. BASOV, and I. E. USHAKOV Problemy Prochnosti (ISSN 0556-171X), June 1988, p. 53-58. In Russian. refs

Damage results, obtained in load tests performed according to standard loading programs for the wings of heavy transports and programs for the wings of highly-stressed high-maneuverability aircraft, were used to obtain governing laws for damages in these wings due to local and nominal stresses. Data presented include the results of quasi-random loading tests on test samples of the D16T and D19chAT alloys. Recommendations are proposed for increasing the accuracy of data from tests performed under quasi-random loading. I.S.

A88-49504
APPLIED THEORY AND A COMPUTATIONAL ALGORITHM FOR AIRCRAFT STRUCTURES BASED ON A GEOMETRICALLY NONLINEAR FORMULATION [PRIKLADNAIA TEORIIA I ALGORITM RASCHETA AVIATSIONNYKH KONSTRUKTSII V GEOMETRICHESKI NELINEINOI POSTANOVKE]
V. G. GAINUTDINOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1988, p. 15-18. In Russian. refs

An algorithm is proposed for the numerical solution of geometrically nonlinear problems concerned with the statistical calculation of aircraft structures using the variational-matrix method. Linearized equations are obtained for constructing structure stiffness matrices with allowance for the finite nature of elastic displacements. The algorithm proposed here is convenient for software implementation. V.L.

A88-49510
THE USE OF SOLUTIONS TO INVERSE STRUCTURAL MECHANICS PROBLEMS IN COMPREHENSIVE STUDIES OF THE STRENGTH OF FLIGHT VEHICLES [O PRIMENENII RESHENII OBRATNYKH ZADACH STROITEL'NOI MEKHANIKI DLIA KOMPLEKSNYKH ISSLEDOVANII PROCHNOSTI LETATEL'NYKH APPARATOV]
I. G. KOLKER and A. IU. ODINOKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1988, p. 36-39. In Russian. refs

The use of solutions to inverse structural mechanics problems in the strength analysis of flight vehicles is examined with particular reference to the analysis of loads acting on a flight vehicle and the reconstruction of the general stress-strain state from a limited amount of experimental data. In order to obtain reliable solutions to these problems, an approach is suggested whereby the computational scheme used does not impose constraints on the warping of cross sections. V.L.

A88-49909#
NATURAL VIBRATION ANALYSIS AND FLUTTER ANALYSIS OF WING-TYPE COMPOSITE STRUCTURES AND RELEVANT OPTIMAL DESIGN
SHENG LIU (Chinese Aeronautical Establishment, Chengdu, People's Republic of China) and XIN QIAO (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, May 1988, p. A237-A243. In Chinese, with abstract in English. refs

The static finite element model for wing-type composite structures is formulated. A variable-linking technique is used to reduce the order of design-variable space. The transformation from the static model to the dynamic one is done by use of the static compliance method. Several algorithms for eigenproblems are employed to analyze natural vibration of structures. The optimal design with the frequency constraint is studied by means of analytical derivatives. Three-dimensional unsteady aerodynamic analysis of harmonically oscillating surfaces and flutter analysis are done using a subsonic doublet-lattice method. The paper presents derivatives of the unsteady aerodynamic load with respect to design variables and investigates the optimum design subjected to flutter constraint by means of a feasible-direction method. Author

A88-49911#
ANALYTICAL AND EXPERIMENTAL INVESTIGATIONS ON STABILITY OF COMPOSITE HAT-STIFFENED PANELS UNDER COMPRESSION
XIANXIN TONG, ZHIHENG GAO, and DEXIN GUAN (Aircraft Strength Research Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, May 1988, p. A253-A259. In Chinese, with abstract in English.

The behavior of buckling and postbuckling of composite hat-stiffened panels of aircraft wings under compression was investigated experimentally and analytically. The critical instability load was measured and examined carefully. According to the test results, two methods for experimentally determining the critical instability load are presented, and the postbuckling stresses distribution and buckling mode of the skin are described. The effect of the lateral support conditions on the stability of the panels is analyzed and the analytical method is discussed and improved. Author

A88-50008
FRICTION FORCE AND THE MOMENT OF FRICTION FORCES IN ATTACHMENT JOINTS DURING THE TURNING OF TWO FLIGHT VEHICLES RELATIVE TO THE JOINTS. II - SPHERICAL JOINT [SILA TRENIIA I MOMENT SIL TRENIIA V SHARNIRNYKH UZLAKH KREPLENIIA PRI RAZVOROTE DVUKH LETATEL'NYKH APPARATOV OTNOSITEL'NO ETIKH UZLOV. II - SFERICHESKII SHARNIR]
V. A. IL'IN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 1, 1986, p. 64-81. In Russian. refs

Expressions are obtained for calculating friction forces and moments in a spherical joint with allowance for the force interaction between flight vehicles over the contact area in the form of double integrals. Based on the analytical expressions and numerical calculations, the friction forces and moments are related qualitatively and quantitatively to the following principal parameters: the angle determining the dimension of the contact area, the angle determining the mutual orientation of the relative angular velocity vectors of the flight vehicles, and the resultant of normal forces in the joint. V.L.

A88-50017
NUMERICAL AND ANALYTICAL INVESTIGATION OF FRICTION FORCES AND MOMENTS IN A SPHERICAL JOINT [CHISLENNOE I ANALITICHESKOE ISSLEDOVANIE SILY TRENIIA I MOMENTA SIL TRENIIA V SFERICHESKOM SHARNIRE]
V. A. IL'IN, N. A. ISTOMIN, and A. P. LEUTIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 1, 1986, p. 130-137. In Russian. refs

Basic relationships are proposed for calculating friction forces and moments in a spherical joint with allowance for the distributed (over the contact area) force interaction of two bodies (flight vehicles) connected through the joint. Results of calculations of dimensionless correction functions allowing for the effect of the distributed force interaction are presented. Exact analytical results are also presented for the case of the orthogonality of the relative angular velocity and the compressive force vectors. V.L.

A88-50024
CALCULATION OF DISTRIBUTED LOADS ON THE BASIS OF AN ANALYSIS OF THE RANDOM STATIC-DYNAMIC STRESSED STATE OF STRUCTURES. I - CALCULATION OF EXTREME STRESSED STATES [RASCHET PASPREDELENNYKH NAGRUZOK NA OSNOVE ANALIZA SLUCHAINOGO STATIKO-DINAMICHESKOGO NAPRIAZHENNOGO SOSTOIANIIA KONSTRUKTSII. I - RASCHET EKSTREMAL'NYKH NAPRIAZHENNYKH SOSTOIANII]
V. D. IL'ICHEV and V. A. KLIMENKO TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 2, 1986, p. 49-56. In Russian. refs

A probabilistic method is proposed for determining the extreme (with respect to intensity) complex stressed state of flight vehicles under conditions of random static-dynamic loading. The method proposed here makes it possible to determine the extreme stressed states and the strength-rated zones of three-dimensional structures. The results obtained by this method can then be used for determining general and local distributed loads for repeated static strength testing and for design analysis. V.L.

A88-50026
A STUDY OF STRESS INTENSITY FACTORS IN AIRCRAFT STRUCTURAL ELEMENTS WITH PART-THROUGH CRACKS [ISSLEDOVANIE KOEFFITSIENTOV INTENSIVNOSTI NAPRIAZHENII V ELEMENTAKH AVIATSIONNYKH KONSTRUKTSII S NESKVOZNYMI TRESHCHINAMI]
T. K. BEGEEV and V. I. GRISHIN TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 2, 1986, p. 65-73. In Russian. refs

A method is presented for determining stress intensity factors in three-dimensional structural elements with part-through cracks. The method, which is based on the modeling of crack tips by singular elements, has been implemented in a set of computer programs. Solutions are obtained for a series of elasticity problems, and the results are compared with the known analytical and numerical solutions. V.L.

A88-50051
THE POSSIBILITY OF AN ANALYSIS OF VARIOUS FORMS OF FLUTTER ON ONE DYNAMIC MODEL [O VOZMOZHNOSTI ANALIZA RAZLICHNYKH FORM FLATTERA NA ODNOI DINAMICHESKOI MODELI]
G. A. BULYCHEV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 3, 1986, p. 126-132. In Russian. refs

The objective of the study was to determine the possibility of analyzing various forms of two-degrees-of-freedom flutter using a single dynamic model selected as the base model. An algorithm for identifying the parameters of the selected model is presented, and results of an analysis are reported for the bending-torsion flutter of the lifting and controlled surfaces of an aircraft. V.L.

A88-50058
CALCULATION OF DISTRIBUTED LOADS ON THE BASIS OF AN ANALYSIS OF THE RANDOM STATIC-DYNAMIC STRESSED STATE OF STRUCTURES. II - LOAD CALCULATION [RASCHET RASPREDELENNYKH NAGRUZOK NA OSNOVE ANALIZA SLUCHAINOGO STATIKO-DINAMICHESKOGO NAPRIAZHENNOGO SOSTOIANIIA KONSTRUKTSII. II - RASCHET NAGRUZOK]
V. D. IL'ICHEV and V. A. KLIMENKO TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 4, 1986, p. 45-52. In Russian.

A method is proposed for calculating distributed loads acting on a structure which produce, under static loading conditions, a specified complex stressed state in the zones of interest. The method described here has been implemented in software as a specialized set of programs in a system for the multilevel complex strength analysis of aircraft. As an example, calculations are presented for an aircraft with a small-aspect-ratio wing (TU-144). V.L.

A88-50061
A METHOD FOR STUDYING FLOW ON A MODEL SURFACE BY MEANS OF SPREADING FLUORESCENT DOTS IN SUBSONIC AND SUPERSONIC FLOWS [METOD ISSLEDOVANIIA TECHENIIA NA POVERKHNOSTI MODELEI S POMOSHCH'IU RAZMYVAEMYKH FLUORESTSIRUIUSHCHIKH TOCHEK V DOZVUKOVOM I SVERKHZVUKOVOM POTOKE]
A. V. KOGUT TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 4, 1986, p. 69-72. In Russian.

A procedure and equipment are described which use the method of spreading fluorescent dots to visualize flows on the surface of a model. The liquid used in this flow visualization method should be capable of radiating visible light under the effect of invisible ultraviolet radiation. Particularly high-contrast flow patterns are recorded when the surface-reflected emission is absorbed and the intensity of the fluorescent emission is minimized, which can be achieved by using a certain combination of filters. The possibilities of the method are illustrated by examples. V.L.

A88-50098
MAXIMIZATION OF THE STIFFNESS OF ANISOTROPIC PLATES UNDER BENDING [MAKSIMIZATSIIA ZHESTKOSTI ANIZOTROPNYKH PLASTIN PRI IZGIBE]
N. V. BANICHUK, V. I. BIRIUK, and D. M. EPURASH TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 6, 1986, p. 89-94. In Russian. refs

Consideration is given to the problem of maximizing the integral stiffness (the inverse potential strain energy) of a plate undergoing bending which models a wing. Numerical calculations are presented for model wings of large and small aspect ratios. B.J.

A88-50328*# Old Dominion Univ., Norfolk, Va.
COMPUTATION OF STEADY AND UNSTEADY VORTEX-DOMINATED FLOWS WITH SHOCK WAVES
OSAMA A. KANDIL and H. ANDREW CHUANG (Old Dominion University, Norfolk, VA) AIAA Journal (ISSN 0001-1452), vol. 26, May 1988, p. 524-531. refs
(Contract NAG1-648)

The unsteady Euler equations have been derived in the conservation form for the flow relative motion with respect to a rotating frame of reference. The resulting equations are solved by using a central-difference finite-volume scheme with four-state Runge-Kutta time stepping. For steady flow applications local time stepping is used, and for unsteady applications the minimum global time stepping is used. A three-dimensional fully vectorized computer program has been developed and applied to steady and unsteady maneuvering delta wings. The capability of the three-dimensional program has been demonstrated for a rigid sharp-edged delta wing undergoing uniform rolling in a conical flow and rolling oscillations in a locally conical flow. Author

A88-50725
PNEUMATIC DRIVE FOR AIRCRAFT CONTROL SYSTEMS [PNEVMOPRIVOD SISTEM UPRAVLENIIA LETATEL'NYKH APPARATOV]
VLADISLAV ALEKSEEVIC CHASHCHIN, OLEG GOBRONOVICH KAMLADZE, ALEKSANDR BORISOVICH KONDRAT'EV, IRINA ALEKSANDROVNA MAROCHKINA, SEMEN L'VOVICH SAMSONOVICH et al. Moscow, Izdatel'stvo Mashinostroenie, 1987, 248 p. In Russian. refs

The book deals with methods for the analysis and design of pneumatic servo drives (and their components) for aircraft control systems. Mathematical models are proposed for pneumatic drive systems with piston, turbine, wave, and jet engines and throttle distributing devices. Attention is also given to gasdynamic drives for stabilization systems. Algorithms are presented for the engineering analysis of the static and dynamic characteristics of pneumatic drives. V.L.

A88-50765
METHODS FOR PRODUCING DURABLE RIVETED AND BOLTED JOINTS IN AIRCRAFT STRUCTURES [TEKHNOLOGIIA VYPOLNENIIA VYSOKORESURSNYKH ZAKLEPOCHNYKH I BOLTOVYKH SOEDINENII V KONSTRUKTSIIAKH SAMOLETOV]
ANDREI IVANOVICH IARKOVETS, OLEG SERGEEVICH SIROTKIN, VLADIMIR ALEKSANDROV FIRSOV, and NIKOLAI MIKHAILOVICH KISELEV Moscow, Izdatel'stvo Mashinostroenie, 1987, 192 p. In Russian. refs

Design and process improvements aimed at extending the long service life of riveted and bolted joints in aircraft structures of aluminum alloys, steels, titanium alloys, and composite materials are reviewed. In particular, attention is given the main factors determining the life of riveted and bolted joints, stresses and strains in riveted and bolted joints, machining of holes for rivets and bolts, and the use of radial and axial interference fit to extend the joint life. The discussion also covers the production of durable joints for high-temperature operation, specific characteristics of joints in composites, and methods for the comparative evaluation of different types of joints. V.L.

A88-50790
ASSESSMENT AND COMPARISON OF THREE DIFFERENT EXPERIMENTAL MODAL ANALYSIS METHODS APPLIED TO A WING-PLATE MODEL
W. Q. FENG, P. Q. ZHANG, and T. C. HUANG (Wisconsin, University, Madison) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 1-8. refs

Three different experimental modal analysis methods, a frequency-domain method (FDM), a time-domain method(TDM), and a multiple single-input space-time regression method (MS-STRM), are performed on a wing-plate model. A total of 11 modes were identified for FDM and TDM, and a total of 17 modes for MS-STRM. To evaluate the accuracy of identification results, the relative percentage difference for damped natural frequencies and mode shape correlation coefficients for mode shapes are used. The identified results are compared, and the advantages and disadvantages of the three methods are discussed. Author

A88-50903#
SUBLIMATING CHEMICAL TECHNIQUE FOR BOUNDARY-LAYER FLOW VISUALIZATION IN FLIGHT TESTING
CLIFFORD J. OBARA (PRC Kentron, Inc., Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 25, June 1988, p. 493-498. refs

With the introduction of modern aircraft utilizing laminar flow, flow visualization has become an important diagnostic tool in determining aerodynamic characteristics such as surface flow direction and boundary-layer state. Oil flow and sublimating chemical techniques are discussed, and the use of sublimating chemicals is examined in detail. Oil is used to visualize boundary-layer transition location, shock-wave location, regions of separated flow, and surface flow direction. Sublimating chemicals are used to visualize both the location and mode of boundary-layer transition. The different modes of transition are characterized by different patterns in the developed sublimating chemical coating. The discussion includes interpretation of these chemical patterns and the temperature and velocity operating limitations of the chemical substances. Information for selection and application of appropriate chemicals for a desired set of flight conditions is provided. Author

A88-50929
A VHSIC DEMONSTRATION RADAR SIGNAL PROCESSOR
JOHN FITZPATRICK and WILLIAM VOJIR (Grumman Corp., Aircraft Systems Div., Bethpage, NY) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 28-34. refs

An approach is being implemented that utilizes sophisticated computer-aided engineering (CAE) technology to facilitate meeting US Department of Defense advanced-technology-evaluation requirements for the Very High Speed Integrated Circuits (VHSIC) program. As a first step in this direction, a VHSIC Demonstration Radar Signal Processor (VDRSP) was designed, simulated, built, and tested. The VDRSP executes a standard moving-target-indication (MTI) function at a 5-MHz complex data rate. In order to minimize cost, schedule, and glue logic requirements, the VHSIC I IBM CMAC (Complex Multiply and Accumulate Chip) was selected for this project. The final system executes at a throughput of 450 million operations per second. I.E.

A88-50942
PERFORMANCE OF FIBER OPTIC SENSORS FOR AIRCRAFT APPLICATIONS
NORRIS E. LEWIS and MICHAEL B. MILLER (Litton Systems, Inc., Poly-Scientific Div., Blacksburg, VA) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 162-167.

Measured performance is presented for passive fiber-optic sensors including a rotary position sensor, a pressure sensor, and a temperature sensor. A linear position sensor derived from the principles of the rotary sensor is also presented. The use of a common sensing principle utilizing wavelength-division multiplexing is detailed. The requirements for the light source and receiver/decoder and the current status of development are discussed. Environmental performance data for the rotary sensor system are given. I.E.

A88-50952
CFAR ANALYSIS FOR MEDIUM PRF AIRBORNE PULSE DOPPLER RADARS
ZHENRU YE, ZHAODA ZHU, and XINPING HUANG (Nanjing Aeronautical Institute, People's Republic of China) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 259-263. refs

MTI-FFT-frequency cell-averaging CFAR processors are discussed. The assumption that the clutter samples in the test cell and the reference cells are independent and identically distributed (IID) is shown to be no longer valid for the frequency cell-averaging CFAR processor in medium PRF airborne pulse Doppler radars. A hybrid method of analytical computation and Monte-Carlo simulation for quantifying the processor performance is described. The effect of various MTI cancelers and weighting forms on the detection performance under different conditions of clutter is analyzed. I.E.

A88-50959
UD FACTORIZATION APPLIED TO AIRBORNE KALMAN-FILTER-BASED FUSION
RONALD M. YANNONE (General Electric Co., Utica, NY) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 326-333.

To ensure numerical accuracy and stability for real-time Kalman filter implementation, Bierman's upper diagonal (UD) factorization is used. The use of multiple sensors to form a more accurate state vector has included combining infrared search and track (IRST), electronic support measures (ESM), and radar sensor data, with applications to track initialization/deletion, association, correlation, and track-update fusion functions. Each area of fusion is discussed and the interfaces between sensors and fusion are given. Different fusion architectures are shown and their impact on state vector estimation accuracy is shown to vary. All three methods use the extended Kalman filter (EKF) as the base. Correlation, association, and track initialization are examined relative to the different fusion architectures. The correlated process noise which exists for the multisensor application is examined. Root-mean-square position and velocity plots versus time for aircraft are given which incorporate a six-state aircraft EKF. I.E.

A88-50997#

GENERIC VOICE INTERFACE FOR COCKPIT APPLICATION

DAVID T. WILLIAMSON and GREGORY L. FEITSHANS (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1988, p. 780-782.

A voice technology interface is proposed that would allow both novice and expert users of voice input and output devices to quickly interface them to their applications while maintaining optimum performance. The objective of this generic voice interface (GVI) is to provide a device-independent interface to existing voice systems. The system will be designed so that any application, not just cockpit applications, can be used with the GVI. Once it has been successfully integrated into a few key applications, the same techniques can be transitioned to other areas. The system will initially be targeted for the rapidly reconfigurable crew-station (RRC) program, which will provide a rapid prototyping environment for advanced crew-station design. I.E.

A88-51024*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

DIGITAL AVIONICS SUSCEPTIBILITY TO HIGH ENERGY RADIO FREQUENCY FIELDS

WILLIAM E. LARSEN (NASA, Ames Research Center; FAA, Moffett Field, CA) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1098-1107. refs

Generally, noncritical avionic systems for transport category aircraft have been designed to meet radio frequency (RF) susceptibility requirements set forth in RTCA DO 160B, environmental conditions and test procedures for airborne equipment. Section 20 of this document controls the electromagnetic interference (EMI) hardening for avionics equipment to levels of 1 and 2 V/m. Currently, US equipment manufacturers are designing flight-critical fly-by-wire avionics to a much higher level. The US Federal Aviation Administration (FAA) has requested that the RTCA SC-135 high-energy radio frequency (HERF) working group develop appropriate testing procedures for section 20 of RTCA DO 160B for radiated and conducted susceptibility at the box and systems level. The FAA has also requested the SAE AE4R committee to address installed systems testing, airframe shielding effects and RF environment monitoring. Emitters of interest include radar (ground, ship, and aircraft) commercial broadcast and TV station, mobile communication, and other transmitters that could possibly affect commercial aircraft. I.E.

A88-51037

A DIAGNOSTIC EXPERT SYSTEM FOR AIRCRAFT GENERATOR CONTROL UNIT (GCU)

TING-LONG HO, ROBERT A. BAYLES (Westinghouse Electric Corp., Lima, OH), and BRUCE L. HAVLICSEK (Westinghouse Electric Corp., Hunt Valley, MD) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1355-1362.

The modular VSCF (variable-speed constant-frequency) generator families are described as using standard modules to reduce the maintenance cost and to improve the product's testability. A general diagnostic expert system shell that guides troubleshooting of modules or line replaceable units (LRUs) is introduced. An application of the diagnostic system to a particular LRU, the generator control unit (GCU) is reported. The approach to building the diagnostic expert system is first to capture general diagnostic strategy in an expert system shell. This shell can be easily applied to different devices or LRUs by writing rules to capture only additional device-specific diagnostic information from expert repair personnel. The diagnostic system has the necessary knowledge embedded in its programs and exhibits expertise to troubleshoot the GCU. I.E.

A88-51051#

AN AVIONICS INTEGRITY MECHANICAL ANALYSIS

THOMAS E. RITTINGER (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1557-1564.

In silicon power transistor applications, thermal cycling of the transistor may activate a failure mechanism called thermal fatigue. This phenomenon is caused by the mechanical stresses set up by the differential in the thermal expansions of the various materials used in the assembly of the transistor and heat sink. Thermal fatigue often results in cracking of the silicon pellet or fatigue of the silicon mounting interface. The author considers the avionics integrity process along with an example of a mechanical analysis using the avionics integrity approach. The example involves the determination of the stress-strain relationships found in power transistors and an experimental approach for determining cycles to failure. I.E.

A88-51296

ON THE OPTIMIZATION OF VIBRATION FREQUENCIES OF ROTORS

V. STEFFEN, JR. (Uberlandia, Universidade Federal, Brazil) and J. L. MARCELIN (Lyon, Institut National des Sciences Appliquees, Villeurbanne, France) International Journal of Analytical and Experimental Modal Analysis (ISSN 0886-9367), vol. 3, July 1988, p. 77-80. refs

At the design stage of construction of rotating machinery, the natural frequencies and critical speeds must be optimized in such a way that the operating speed of rotation is safely far from the criticals. This can be performed by manipulating design variables taking into account technological constraints. This paper presents an optimizing program coupled to a rotor-dynamics finite-elements code to perform the optimization of rotors. Three different applications for which natural frequencies optimization were performed are presented. Author

A88-51328*# Purdue Univ., West Lafayette, Ind.

AEROELASTIC EFFECTS OF ALTERNATE BLADE SWEEP ON ADVANCED PROPFAN ROTOR

MARC H. WILLIAMS (Purdue University, West Lafayette, IN) ASME, Winter Annual Meeting, Boston, MA, Dec. 13-18, 1987. 6 p. refs

(Contract NAG3-499)

(ASME PAPER 87-WA/AERO-8)

Recent progress in the development of a general purpose unsteady aerodynamic and aeroelastic analysis capability for Advanced Turboprops will be reviewed. An application to a rotor with alternating forward and backward swept blades is described, which illustrates the general 'mistuning' capability of the method. Author

A88-51329*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

MODERN WING FLUTTER ANALYSIS BY COMPUTATIONAL FLUID DYNAMICS METHODS

HERBERT J. CUNNINGHAM, JOHN T. BATINA, and ROBERT M. BENNETT (NASA, Langley Research Center, Hampton, VA) ASME, Winter Annual Meeting, Boston, MA, Dec. 13-18, 1987. 9 p. Previously announced in STAR as N88-14965. refs

(ASME PAPER 87-WA/AERO-9)

The application and assessment of the recently developed CAP-TSD transonic small-disturbance code for flutter prediction is described. The CAP-TSD code has been developed for aeroelastic

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

A88-51779
A FINITE ELEMENT MODEL FOR COMPOSITE BEAMS UNDERGOING LARGE DEFLECTION WITH ARBITRARY CROSS-SECTIONAL WARPING
ALAN D. STEMPLE and SUNG W. LEE (Maryland, University, College Park) IN: International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings. Alexandria, VA, American Helicopter Society, 1988, 11 p. refs
(Contract DAAG29-83-K-0002)

A finite element formulation has been developed to take into account the warping effect of composite beams undergoing large deflection or finite rotation. This formulation is to be used to model combined bending, torsional and extensional behavior of composite helicopter rotor blades. The new approach can model thin walled composite beams with complicated cross-sections, tapers, and arbitrary planforms. The strain is assumed to vary linearly through the wall thickness. The warping effects are incorporated by assuming small warping displacements superimposed over cross-sections normal to the beam axis in the deformed configuration of a shear-flexible beam. The Fixed or Total Lagrangian description is adopted in the present formulation and the Newton-Raphson method is used to solve the nonlinear equilibrium equation resulting from the finite element approximation. Numerical tests of example problems demonstrate the validity and effectiveness of the present approach. Author

A88-51790
SPATE AS A NONCONTACT NDI TOOL
WILLIAM C. BOYCE (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. II-1 to II-6.

The use of SPATE as a noncontact nondestructive inspection (NDI) tool during cyclic testing has been studied on several representative helicopter components. The thermoelastic principles upon which SPATE is based are described as well as the results of test comparisons on an aluminum airframe fitting, a composite rotor spar, a landing gear strut, and an oil filter bowl. The ability of SPATE to improve data quality and to reduce the testing efforts is discussed. K.K.

A88-51797
U.S. NAVY VIBRATION ANALYSIS EVALUATION PROGRAM FOR HELICOPTER GEARBOXES
LAWRENCE J. MERTAUGH (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: Rotary wing test technology; Proceedings of the National Specialists' Meeting, Bridgeport, CT, Mar. 15, 16, 1988. Alexandria, VA, American Helicopter Society, 1988, p. IV-1 to IV-8.

An ongoing Navy program to determine the feasibility of using vibration analysis to detect the presence of gear and bearing defects in a complex helicopter gearbox is discussed. This program was started in 1983 and is directed specifically toward the detection of defects within the main gearbox of the CH-53E helicopter. This paper reviews the results of evaluations of a number of vibration analysis techniques and some of the equipment used to implement these techniques. Problems associated with this kind of a program are discussed. Author

A88-51878
THE USE OF THE PENALTY FUNCTION TO COMPUTE POTENTIAL FLOW IN A CASCADE [ANWENDUNG DER STRAFFUNKTION ZUR BERECHNUNG DER POTENTIALSTROEMUNG IM GITTER]
M. CIALKOWSKI (Poznan, Politechnika, Poland) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Stuttgart, Federal Republic of Germany, Apr. 13-17, 1987) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 68, no. 5, 1988, p. T 286-T 289. In German. refs

The technique developed by Cialkowski (1986) to linearize the gasdynamic equations for flow in turbomachines is applied to the case of cascade flow. The derivation of the governing equations is reviewed; the use of penalty functions to minimize the resulting functional with the upstream and downstream periodicity conditions is explained; and an iterative solution method is outlined. Numerical results for cascades with three different blade profiles are presented in graphs and shown to be in better agreement with experimental data and FEM computations than results obtained with conformal mapping or by direct introduction of the periodicity conditions.
T.K.

A88-51917*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INSTRUMENTATION AND DATA ACQUISITION ELECTRONICS FOR FREE-FLIGHT DROP MODEL TESTING
PRESTON I. CARRAWAY, III (NASA, Langley Research Center, Hampton, VA) AIAA, NASA, and AFWAL, Conference on Sensors and Measurements Techniques for Aeronautical Applications, Atlanta, GA, Sept. 7-9, 1988. 6 p.
(AIAA PAPER 88-4669)

This paper presents instrumentation and data acquisition electronics techniques used in free-flight drop model testing at the NASA Langley Research Center. Free-flight drop model testing is a technique for conducting complex aircraft controls research using reduced scale models of experimental aircraft. An introduction to the Free-Flight Drop Model Program is presented first. This is followed by a description of the recently upgraded airborne and ground based instrumentation and data acquisition electronics. Lastly current and future development efforts and opportunities are discussed. Author

A88-51920*# Old Dominion Univ., Norfolk, Va.
PHENOMENOLOGICAL ASPECTS OF INFRARED IMAGING IN AERONAUTICAL RESEARCH
EHUD GARTENBERG and A. SIDNEY ROBERTS, JR. (Old Dominion University, Norfolk, VA) AIAA, NASA, and AFWAL, Conference on Sensors and Measurements Techniques for Aeronautical Applications, Atlanta, GA, Sept. 7-9, 1988. 5 p.
(Contract NAG1-735)
(AIAA PAPER 88-4674)

The various factors leading to obtaining a thermography of an aerodynamic body of interest using an infrared imaging camera are scrutinized. Included is a description of how the various heat transfer mechanisms determine the final surface temperature that may be time dependent even for steady state flows. Some constraining factors of the camera are also discussed. Finally, a method is outlined showing how the infrared imaging of aerodynamic configurations may ultimately evolve as a computational fluid dynamics code validation tool. Author

A88-52044
A METHOD FOR DETERMINING THE GEOMETRICAL PARAMETERS OF A SEMIRIGID DYNAMICALLY SIMILAR MODEL EQUIVALENT TO THE ORIGINAL WING FROM FLUTTER EQUATION COEFFICIENTS [SPOSOB OPREDELENIIA GEOMETRICHESKIKH PARAMETROV POLUZHESTKOI DINAMICHESKI PODOBNOI MODELI, EKVIVALENTNOI ISKHODNOMU KRYLU PO KOEFFITSIENTAM URAVNENII FLATTERA]
V. M. FROLOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 1, 1987, p. 140-144. In Russian.

A method for determining the principal geometrical characteristics of a dynamically similar semirigid model is proposed which is based on the condition that the aerodynamic characteristics of the flutter equations of this model, obtained by using the steady-state hypothesis and the Galerkin method, correspond to similar coefficients for a full-scale elastic wing with arbitrary flutter-generating shapes of bending and torsional natural vibrations. The method proposed here is illustrated by numerical examples. V.L.

A88-52051
A LIMITING CASE OF THE TORSIONAL-BENDING WING VIBRATION PROBLEM [ODIN PREDEL'NYI SLUCHAI ZADACHI OB IZGIBNO-KRUTIL'NYKH KOLEBANIIAKH KRYLA]
IA. M. PARKHOMOVSKII TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 2, 1987, p. 62-73. In Russian. refs
An analytical solution of the torsional-bending wing vibration problem is developed for the case when the natural moment of mass inertia for the wing section equals zero. The properties of natural characteristics are determined, and it is shown that the situations corresponding to this limiting case may occur in a wing bearing a large number of external rigidly attached loads. I.S.

A88-52061
SOME ASPECTS OF THE DETERMINATION OF FATIGUE-STRENGTH EQUIVALENCE UNDER MULTICOMPONENT LOADING [NEKOTORYE VOPROSY OPREDELENIIA EKVIVALENTNOSTI SOPROTIVLENIIA USTALOSTI PRI MNOGOKOMPONENTNOM NAGRUZHENII]
O. A. BESSOLOVA and V. L. RAIKHER TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 2, 1987, p. 143-147. In Russian.
A method is presented for calculating the combined effect of several loading components on the fatigue strength of an aircraft structure. The application of the method is demonstrated on an analysis of the effects of parameters of two-component loading by harmonic forces with identical frequency values. I.S.

A88-52071
ERRORS IN CALCULATING THERMAL STRESSES IN THIN-WALLED REINFORCED BEAM STRUCTURES USING THE FINITE ELEMENT METHOD [O POGRESHNOSTIAKH RASCHETA TEMPERATURNYKH NAPRIAZHENII V TONKOSTENNYKH PODKREPLENNYKH BALOCHNYKH KONSTRUKTSIIAKH PO METODU KONECHNYKH ELEMENTOV]
V. A. DUBINIA and G. N. ZAMULA TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 3, 1987, p. 92-104. In Russian. refs
An exact solution is obtained to the problem of errors in the finite-element modeling of thin-walled beams using rectangular plane-stress elements. It is shown that the errors in the calculation of the thermal bending stresses in typical aircraft structures are significantly greater than those arising in the calculation of the effects of mechanical loading. Methods are presented for reducing the number of errors. K.K.

A88-52177
SEALING SOLUTIONS LIGHT WEIGHT MILITARY AIRCRAFT HIGH PRESSURE HYDRAULIC SYSTEMS
JOHN W. KOSTY (W. S. Shamban and Co., Santa Monica, CA) IN: International Conference on Fluid Sealing, 11th, Cannes, France, Apr. 8-10, 1987, Proceedings. London and New York, Elsevier Applied Science Publishers, 1987, p. 493-508. refs
The design of lighter, and faster military aircraft has required that the hydraulic systems deliver more power at higher temperatures within a smaller envelope at a reduced weight. The 550 bar hydraulic systems which are being proposed together with the testing program will be reviewed in this paper. Several rod and piston seal design concepts which utilize high modulus plastic materials to bridge the extrusion gaps and protect the sealing elements shall be presented which have provided seal solutions for the high pressure hydraulic systems. Author

A88-52178
HIGH PERFORMANCE GAS COMPRESSOR SEALS
JAMES P. NETZEL (John Crane-Houdaille, Inc., Morton Grove, IL) IN: International Conference on Fluid Sealing, 11th, Cannes, France, Apr. 8-10, 1987, Proceedings. London and New York, Elsevier Applied Science Publishers, 1987, p. 532-547.
This paper traces the design and development of high performance gas compressor seals. The objective of this type of sealing system is to provide industry with a maintenance-free system which does not require any oil for cooling and lubrication of the seal faces. Technology for this design is based on spiral groove face geometry and its ability to generate a gas film. Commonly referred to as a dry seal, field results in terms of wear are discussed and compared to a liquid lubricated seal. A range of successful applications is outlined. Author

N88-27162*# Hughes Helicopters, Culver City, Calif.
AEROELASTIC CHARACTERISTICS OF THE AH-64 BEARINGLESS TAIL ROTOR
D. BANERJEE *In* NASA, Ames Research Center, Integrated Technology Rotor Methodology Assessment Workshop p 279-297 Jun. 1988 Previously announced in IAA as A85-20142
Avail: NTIS HC A17/MF A01 CSCL 20K
The results of a wind tunnel test program to determine the performance loads and dynamic characteristics of the Composite Flexbeam Tail Rotor (CFTR) for the AH-64 Advanced Attack Helicopter are reported. The CFTR uses an elastomeric shear attachment of the flexbeam to the hub to provide soft-inplane S-mode and stiff-inplane C-mode configuration. The properties of the elastomer were selected for proper frequency placement and scale damping of the inplane S-mode. Kinematic pitch-lag coupling was introduced to provide the first cyclic inplane C-mode damping at high collective pitch. The CFTR was tested in a wind tunnel over the full slideslip envelop of the AH-64. It is found that the rotor was aeroelastically stable throughout the complete collective pitch range and up to rotor speeds of 1403 rpm. The dynamic characteristics of the rotor were found to be satisfactory at all pitch angles and rotor speeds of the tunnel tests. The design characteristics of the rotor which permit the high performance characteristics are discussed. Several schematic drawings and photographs of the rotor are provided. IAA

N88-27407# Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
TDWR (TERMINAL DOPPLER WEATHER RADAR) PRF (PULSE REPETITION FREQUENCY) SELECTION CRITERIA
S. C. CROCKER 15 Mar. 1988 44 p
(Contract DTFA01-80-Y-10546)
(AD-A193089; DOT/FAA/PM-87/25) Avail: NTIS HC A03/MF A01 CSCL 17I
The Terminal Doppler Weather Radar (TDWR) system shall provide high quality Doppler radar data on weather phenomena near high traffic airports. These data shall be used in real time by automated TDWR algorithms to detect weather situations which may be hazardous to the safe operation of aircraft within the vicinity of the airport. One of the major factors which could cause the degradation of the quality of these TDWR data is obscuration by distant storm cells. This obscuration is caused by storms located beyond the range interval being sampled by the radar, yet whose radar echo ambiguously folds within the range interval of interest. These range aliased echoes could trigger false detections by the algorithms, and/or cause actual hazardous situations near the airport to remain undetected. By carefully selecting the pulse repetition frequency (PRF) of the radar, range obscuration from distant storms can be minimized over specified airport regions. This document describes techniques for predicting the obscuration as a function of PRF, and details the criteria which shall be used by the TDWR system to automatically and adaptively select an optimal PRF in order to minimize these obscuration effects. GRA

N88-27480# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AERODYNAMICS OF HYPERSONIC LIFTING VEHICLES: FLUID DYNAMICS PANEL AGARD SYMPOSIUM
S. M. BOGDONOFF, H. HORNUNG, ed., and R. E. WHITEHEAD, ed. (Office of Naval Research, Arlington, Va.) Apr. 1988 20 p
Symposium held in Bristol, United Kingdom, 6-9 Apr. 1987
(AGARD-AR-246; ISBN-92-835-0453-4; AD-A195892) Avail: NTIS HC A03/MF A01

This report reviews and evaluates the Fluid Dynamics Panel AGARD Symposium entitled, Aerodynamics of Hypersonic Lifting Vehicles, held 6 to 9 June 1987 in Bristol, UK. The purpose of the Symposium was to assess the technology status in the field of hypersonics after a comparative lull in the past decade. The author addresses each of the papers separately and makes general comments on the 5 major topic sessions. The limitations of test facilities for experimental studies at high Mach numbers were clearly evident. New developments in computational fluid dynamics provide possibilities that did not exist in the past. The reviewer stressed the areas that need special emphasis in the future. The papers presented at the Symposium are published in AGARD Conference Proceedings CP-429 and are listed in an Appendix to this report.
Author

N88-27483# Scientific Research Associates, Inc., Glastonbury, Conn.
A NAVIER-STOKES STUDY OF CASCADE FLOW FIELDS INCLUDING INLET DISTORTION AND ROTATING STALL Final Report, Sep. 1984 - Aug. 1987
F. DAVOUDZADEH, N. S. LIU, S. J. SHAMROTH, and S. J. THOREN Dec. 1987 158 p
(Contract F33615-84-C-2479)
(AD-A193109; AFWAL-TR-87-2077) Avail: NTIS HC A08/MF A01 CSCL 20D

A two-dimensional, unsteady, Navier-Stokes computer code has been developed and applied to general cascade problems including inlet distortion and rotating stall. The code allows an arbitrary number of passages with periodicity conditions applied below the first and above the last passage, thus allowing flows in the computational domain to differ on a passage-by-passage basis. Calculations were performed for both C-grid and H-grid coordinate systems for single passage steady flows, multiple passage flows with steady and time-dependent inlet distortions and for multiple passage flows with a disturbance first imposed and then removed. This latter set of calculations demonstrated the ability of the procedure to simulate rotating stall flow fields. Calculations for conditions of incipient rotating stall showed good agreement with data for a J-79 stator set.
GRA

N88-27490*# Old Dominion Univ., Norfolk, Va. Institute for Computational and Applied Mechanics.
INVESTIGATION OF VISCOUS/INVISCID INTERACTION IN TRANSONIC FLOW OVER AIRFOILS WITH SUCTION
C. S. VEMURU and S. N. TIWARI Apr. 1988 124 p
(Contract NAG1-363)
(NASA-CR-183112; NAS 1.26:183112; ODU/ICAM-88-101)
Avail: NTIS HC A06/MF A01 CSCL 20D

The viscous/inviscid interaction over transonic airfoils with and without suction is studied. The streamline angle at the edge of the boundary layer is used to couple the viscous and inviscid flows. The potential flow equations are solved for the inviscid flow field. In the shock region, the Euler equations are solved using the method of integral relations. For this, the potential flow solution is used as the initial and boundary conditions. An integral method is used to solve the laminar boundary-layer equations. Since both methods are integral methods, a continuous interaction is allowed between the outer inviscid flow region and the inner viscous flow region. To avoid the Goldstein singularity near the separation point the laminar boundary-layer equations are derived in an inverse form to obtain solution for the flows with small separations. The displacement thickness distribution is specified instead of the usual pressure distribution to solve the boundry-layer equations. The Euler equations are solved for the inviscid flow using the finite volume technique and the coupling is achieved by a surface transpiration model. A method is developed to apply a minimum amount of suction that is required to have an attached flow on the airfoil. The turbulent boundary layer equations are derived using the bi-logarithmic wall law for mass transfer. The results are found to be in good agreement with available experimental data and with the results of other computational methods.
Author

N88-27500# Kentucky Univ., Lexington.
DETERMINATION OF THE LOCAL HEAT-TRANSFER CHARACTERISTICS ON GLAZE ICE ACCRETIONS ON A CYLINDER AND A NACA 0012 AIRFOIL Ph.D. Thesis
MARTIN RABINDRA PAIS 1987 172 p
Avail: Univ. Microfilms Order No. DA8802030

Laboratory scale experiments conducted in the subsonic wind tunnel facility at the University of Kentucky are discussed. Experimental convective local heat transfer coefficients were obtained for a simulated, full scale, selected set of 2, 5, 15 minute glaze ice models on a cylinder, and 0, 5 minute glaze ice models on a NACA 0012 airfoil. A steady state heat flux method was employed. The results show very good quantitative and qualitative agreement. The local heat transfer rate increases with increasing Reynolds number and as the ice grows shows a decreasing trend within the cup-like region formed in the forward zone. An attempt was made to define surface roughness by applying two-dimensional Fourier analysis to surface profiles of a 15 minute glaze ice accretion on a cylinder. When results of smooth glaze ice models are compared to those of rough models increases of up to 115 percent in the local heat-transfer rate are observed to occur primarily at the tips of the horns. This increase is partially attributed to the increase in area subtended by the roughness elements to the flow. A numerical formulation of a two-dimensional, unsteady, compressible Navier-Stokes code is introduced. Numerical tests are performed on the NACA 0012 profile and compared with experimental results.
Dissert. Abstr.

N88-27571 Wisconsin Univ., Madison.
DYNAMIC STABILITY OF ELASTIC ROTOR-BEARING SYSTEMS VIA LIAPUNOV'S DIRECT METHOD Ph.D. Thesis
ABD ALLA M. ELMARHOMY 1987 218 p
Avail: Univ. Microfilms Order No. DA8727231

The effects of the various end support parameters coupled with the shaft stiffness parameters on the whirling stability of rotor-bearing systems are examined. The analysis is based on an appropriate model of a continuous elastic rotating shaft mounted on two dissimilar bearings having anisotropic and cross coupling stiffness and damping coefficients. The method of analysis utilizes Liapunov's direct method applied to the nonlinear equations of motion with modal expansions used for the spatial description of rotor elastic deflections. A general set of closed form sufficient conditions for whirling stability in terms of the various system parameters is formulated which functionally shows the effect of including additional modal terms on the accuracy of the stability boundaries of this elastic system. Thus, questions relating to the effect of truncation error on the stability of the system can be readily studied by this method. The results show that the use of a single modal term gives a very satisfactory approximation to the exact stability boundaries. Stability boundaries are presented in graphical form as functions of system parameters.
Dissert. Abstr.

N88-27589# Texas Technological Univ., Lubbock. Dept. of Mechanical Engineering.
NONLINEAR STOCHASTIC INTERACTION IN AEROELASTIC STRUCTURES Final Report, 1 Nov. 1984 - 31 Dec. 1987
RAOUF A. IBRAHIM 29 Jan. 1988 117 p
(Contract AF AFOSR-0008-85)
(AD-A193427; AFOSR-88-0368TR) Avail: NTIS HC A06/MF A01 CSCL 20D

The linear and nonlinear modal interactions in aeroelastic structures under wide band random excitation are examined analytically and experimentally. The analytical investigation deals with the random response characteristics of two- and three-degree-of-freedom nonlinear models in the neighborhood of internal resonance conditions. These conditions take the form of linear relationships between the normal mode frequencies and are established from the linear model analysis of each model. The Fokker-Planck equation approach is used to derive a general differential equation is found to constitute a set of infinite coupled first order differential equations. These equations are closed by using two different truncation schemes which are based on the properties of response joint cumulants. These two schemes are known as Gaussian and non-Gaussian closures. The analytical manipulations are performed by using the computer algebraic software MACSYMA, while the response statistical moments are determined by numerical integration by using the IMSL software DVERK. The Gaussian closure solution gives a quasi-stationary response in the form of fluctuations between two limits. However, the non-Gaussian closure results in a strict stationary response. The general trend of the nonlinear interaction takes the form of energy exchange between the interacted modes when the system is internally tuned. GRA

N88-27598 Washington Univ., Seattle.
NONLINEAR VIBRATIONS OF PERIODICALLY STIFFENED PLATES Ph.D. Thesis
RONALD N. MILES 1987 200 p
Avail: Univ. Microfilms Order No. DA8802301

A study is presented of the vibration and sound radiation of airplane fuselage structures when they are excited by intense driving fields. The fuselage structure is idealized as a section of a shell which is supported on a grid of periodically spaced stiffeners. An analytical method is presented for including nonlinear effects in the analysis of the vibrations of periodically stiffened plate structures. The approach consists of first determining the mode shapes and natural frequencies of a finite periodic structure when nonlinearities are neglected. These mode shapes are then used as approximate shape functions in a nonlinear model of the structure. The result is a coupled system of nonlinear ordinary differential equations which are solved numerically.
Dissert. Abstr.

N88-28280# Rolls-Royce Ltd., Derby (England). Advanced Research Lab.
A NEW METHOD OF CALCULATING THE BOUNDARY LAYER CHARACTERISTICS DOWNSTREAM OF MANIPULATORS. PART 2: SKIN FRICTION AND NET DRAG REDUCTION
P. E. ROACH 15 Sep. 1987 19 p Presented at the Royal Society Conference on Turbulent Drag Reduction by Passive Means, London, England, Sep. 1987
(PNR90456; ETN-88-92686) Avail: NTIS HC A03/MF A01

A simple wake model which described the qualitative and quantitative skin friction reducing potential of manipulators was developed. The device drag may be ascertained with a reasonable degree of certainty for flat plate manipulators. Consideration of the average friction drag shows that the optimum device height is 0.6 delta. From net drag considerations, this optimum height is found to be 0.55 delta. Device trailing edge chamfer is shown to be very important, having a first-order influence upon the drag reduction potential. Further work is necessary, particularly to more accurately determine the influence of such devices under flight conditions. The parasitic drag of airfoil devices at flight-type Reynolds numbers and the influence of device geometry both warrant further investigation. The analysis suggests that net drag reductions of 20 percent are feasible, possibly even under flight conditions. ESA

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GEOSCIENCES

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

A88-50909#
CLASSIFYING AND FORECASTING MICROBURST ACTIVITY IN THE DENVER, COLORADO, AREA
FERNANDO CARACENA (NOAA, Boulder, CO) and JOHN A. FLUECK (Colorado, University, Boulder) Journal of Aircraft (ISSN 0021-8669), vol. 25, June 1988, p. 525-530. Previously cited in issue 08, p. 1137, Accession no. A87-22636. refs

N88-27612# Army Engineer Topographic Labs., Fort Belvoir, Va.
METHODS OF DETERMINING PLAYA SURFACE CONDITIONS USING REMOTE SENSING
J. P. HENLEY 8 Oct. 1987 11 p
(AD-A192663; ETL-R-135) Avail: NTIS HC A03/MF A01 CSCL 08F

Playas (dried lakes) commonly found in arid regions are geomorphic surfaces of importance for military and civilian use as aircraft landing sites, areas of easy or difficult vehicular movement, sources of dust produced by vehicles or munitions, and as a source of chemical and mineral deposits. The ability to remotely detect and determine the surface character of playas is of concern to the modern Army in preparing terrain intelligence for desert operations. To this end, 20 Mojave Desert playas were sampled and classified as to surface type, ranging from hard and dry to wet and soft. Spectral reflectance measurements were collected using a Geophysical Environmental Research IRIS MkIV spectroradiometer over the 400 to 2500 nm spectral range. This range includes the non-thermal bands of LANDSAT TM and all the bands of the Airborne Imaging Spectrometer (AIS). Physical and chemical analyses of the surfaces were compared to the spectral curves and to the surface character of the playas. Air photo pattern analysis was also used to determine special patterns associated with the surface types. The results show limited success in assessing the mineralogy important to surface hardness. The relative moisture conditions could be detected using reflectance spectra in the short wave infrared region and gypsum surfaces could be determined. The use of the spectral data in conjunction with air photo pattern analysis gave the best results for determining surface conditions. GRA

N88-27669# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ATMOSPHERIC TURBULENCE RESEARCH AT DFVLR
ANNE M. JOCHUM (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Wesseling, West Germany) Jul. 1988 19 p
(AGARD-R-752; ISBN-92-835-0462-3; AD-A198045) Avail: NTIS HC A03/MF A01

A brief overview is given of work on atmospheric turbulence at DFVLR (German Aerospace Research Establishment), and describes the research tools, which include instrumented aircraft and numerical models. Some results of research on turbulence characteristics are given; these are mostly in the convective boundary layer. The report discusses their application to the study of aircraft response and airframe loadings. Author

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A88-49505
SYNTHESIS OF THE MATHEMATICAL STRUCTURE OF A FLIGHT VEHICLE ASSEMBLY PROCESS [POSTROENIE MATEMATICHESKOI STRUKTURY TEKHNOLOGICHESKOGO PROTSESSA SBORKI LETATEL'NYKH APPARATOV]
R. I. GUSEVA and A. V. MIKUNOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1988, p. 18-21. In Russian.

A mathematical structure is synthesized which is used as a framework for formalizing basic relationships between the elements of a flight vehicle assembly process. The algorithm used in the structure synthesis is examined, and the synthesis procedure is described. The properties of the synthesized mathematical structure are discussed with reference to two specific examples. V.L.

A88-50184*# Georgia Inst. of Tech., Atlanta.
AN APPROXIMATE LOOP TRANSFER RECOVERY METHOD FOR DESIGNING FIXED-ORDER COMPENSATORS
ANTHONY J. CALISE and J. V. R. PRASAD (Georgia Institute of Technology, Atlanta) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 203-209. Army-supported research. refs
(Contract NAG1-243)
(AIAA PAPER 88-4078)

A method for designing fixed-order dynamic compensators for multivariable time invariant linear systems is presented which is based on the minimization of a linear quadratic performance index. The present formulation is performed in an output feedback setting which uses an observer cononical form to represent the compensator dynamics. Techniques for penalizing the plant and compensator states and for selecting the distribution on initial conditions such that the loop transfer matrix approximates that of a full-state feedback design have been developed. The effectiveness of the method is demonstrated using the examples of the pointing of a flexible structure and a helicopter flight control problem. R.R.

A88-50188#
A NOTE ON THE PARAMETERIZATION OF STABILIZING CONTROLLERS FOR SISO SYSTEMS
L. R. PUJARA (Wright State University, Dayton, OH) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 232-236. refs
(Contract F33615-87-C-3615)
(AIAA PAPER 88-4082)

The technique proposed in this paper gives a simple and useful procedure for solving the Bezout identity in the domain of stable rational transfer functions for finding the parameterization of all stabilizing controllers for single-input single-output control systems. This procedure leads to a solution of linear simultaneous equations involving the parameters of the solution-functions of the Bezout identity. One important consequence of this procedure is that it leads to a relatively lower-order for the controller and the compensated closed loop transfer functions. The procedure is illustrated by designing the longitudinal mode control systems for the aircraft YF-16 satisfying its flying qualities. Author

A88-50218#
STATE-SPACE REALIZATION FROM TIME DOMAIN DATA OF FLIGHT CONTROL SYSTEMS
AMIR A. ANISSIPOUR (Boeing Co., Seattle, WA) and CHIN S. HSU (Washington State University, Pullman) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 529-535. refs
(AIAA PAPER 88-4115)

A technique is presented that permits the generation of reduced-order state-model data from time-domain data, such as impulse and unit-step response information. Attention is given to computational examples for the cases of the flight-control systems of the F-4E fighter and the L-1011 airliner at the cruise flight condition. The extension of these results to stochastic control system modeling techiques is judged to be an achievable task. O.C.

A88-50935
ITARS ROBUST DEMONSTRATION SYSTEM INTEGRATION
RAY PATRICK and G. MEL BARNEY (Merit Technology, Inc., Plano, TX) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 83-87.

An avionics simulation has been developed that interfaces directly to Digital Terrain Elevation Data (DTED) mass storage systems, and specifically the Integrated Terrain Access and Retrieval System (ITARS) digital map. The system, known as the Robust Demonstration System (RDS) effectively demonstrates how ITARS digital terrain data could be used by aircraft of the future involving terrain-following, terrain avoidance, and SITAN avionics algorithms. The authors describe the ITARS/RDS system architecture, integration results, and areas of possible improvement. I.E.

A88-50937
LAVI 1553B COMMUNICATION SYSTEM
ALEX KUSHNIR and YEHUDA KASIRER (Israel Aircraft Industries, Ltd., Lod) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 114-120.

The avionics in the LAVI aircraft is comprised of about 20 embedded computer subsystems interconnected by means of a MIL-STD-1553B communication network. This network, consisting of two dual redundant communication channels, handles approximately 300 messages, part of which are periodic and part of which are randomly generated. In addition, many messages cannot tolerate long delay times. The authors present the protocol of the communication system, its hardware/software structures that free the HOST processor from communication overhead, and describe the set of software tools used to develop and maintain the communication system and to monitor its performance. I.E.

A88-50939
RESOURCE SHARING IN A COMPLEX FAULT-TOLERANT SYSTEM
ROBERT M. DOLEZAL and GEORGE J. VALENTINO (BDM Corp., Dayton, OH) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 129-136.

Sharing of pooled hardware resources is examined as an efficient solution to the problem of ensuring fault tolerance in a complex real-time system. Efficiency is discussed in terms of both the number of hardware units required to implement a system and the amount of fault tolerance provided by the hardware. In the context of a general avionics application, the PRIMA architecture described here applies resource sharing to processors, buses, and stores. Processors are pooled in groups preserving the topologies of multiprocessor architectures, while buses are pooled according to the processor groups which they serve. Stores are pooled by updating local memory to reflect all system updates. Local reconfiguration of the system within each processor class enables the system to detect and handle faults rapidly. Global reconfiguration of the system enables the system to maintain critical functionality despite multiple hardware failures. I.E.

A88-50940
REAL-TIME OPERATING SYSTEM FOR ADVANCED AVIONICS ARCHITECTURE
STEPHEN L. BENNING (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) and R. SCOTT EVANS (TRW Dayton Engineering Laboratory, OH) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 138-145.

A real-time operating system, the Ada Avionics Real-Time Software (AARTS) Operating System (AOS), is discussed, which under development for the US Air Force. The AOS is intended to mitigate problems with Ada executing in real time on 16-bit data processors in a distributed architecture configuration. The AOS consists of a three part executive: system executive, kernel executive, and distributive executive. Each is described along with AOS operation and system functions. I.E.

A88-50941#
PAVE PACE: SYSTEM AVIONICS FOR THE 21ST CENTURY
D. REED MORGAN (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 146-157. refs

The rationale is presented for the continuation of the advanced architecture development, established by the PAVE PILLAR initiative, under the PAVE PACE program. The goals are to achieve: (1) practical and affordable airborne versions of modular parallel-processing network architectures for a large array of new applications (currently beyond real-time implementation); (2) highly available avionics for use across all avionics; and (3) dramatically improved techniques to reduce the cost of software development and support. A novel approach to the overall design structure for future avionics is also presented. Continued use of the PAVE PILLAR high-speed data bus and operating system is recommended as the means to integrate and control the data input and output of physically and functionally separate parallel networks. I.E.

A88-50946#
GEOMETRIC MODELING OF FLIGHT INFORMATION FOR GRAPHICAL COCKPIT DISPLAY
MARK A. KANKO and PHIL AMBURN (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 201-208. USAF-sponsored research. refs

The authors discuss the design and implementation of a computer graphics-based environment capable of modeling tactical situation arenas as viewed from the cockpit. A user can position mountains, hostile threat envelopes, and a projected flightpath through the region. The resulting three-dimensional models are intended to be used to prototype graphical display formats for future aircraft. An overall goal of this investigation was to allow the cockpit display researcher to create an entirely new tactical solution display model in less than one hour via mouse input. I.E.

A88-50989#
MULTIPROCESSOR SOFTWARE DEVELOPMENT FOR AN UNMANNED RESEARCH VEHICLE
DANIEL B. THOMPSON (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 654-659. refs

The Control Systems Development Branch of the Air Force Flight Dynamics Laboratory has been utilizing unmanned research vehicles as low-cost flight testbeds for flight control concepts developed in-house. Recently, the limitations of the aircraft and control system used led to the decision to develop a new low-cost research vehicle and complementary multiprocessor avionics/control system architecture. Effective use of the testbed multiprocessor requires that the applications software of the system must be programmable by applications engineers, who may not be experienced in parallel programming and may not have detailed knowledge of the underlying architecture. The author presents the communications protocols and parallel software design methodology used to develop the applications function for the first phase prototype with this requirement in mind. I.E.

A88-50990
A CASE STUDY IN PROVISIONS NEEDED IN AN ADA RUNTIME TO SUPPORT ATF- AND LHX-LIKE REAL-TIME EMBEDDED SYSTEMS
CHUCK ROARK, RON STRAUSER, and RICHARD POWERS (Texas Instruments, Inc., Defense Systems and Electronics Group, Plano) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 714-720.

Special provisions needed in an Ada runtime to support loosely coupled, distributed, real-time, embedded systems with runtime reconfiguration requirements for systems such as the Army's Light Helicopter Experimental and the Air Force's Advanced Tactical Fighter have been studied. The investigation focused on three major areas: (1) real-time programming support, (2) distributed messaging support, and (3) runtime reconfiguration support. Special provisions and well-defined Ada runtime interfaces needed to support these three areas have been determined. Tartan Laboratories collaborated with Texas Instruments on this investigation by providing the necessary special interfaces and provisions in its 1750A target Ada runtime. The requirements for and a package-level description of the special interfaces and provisions are presented, along with their use by TI. I.E.

A88-50991
CONTROLLING LARGE CYCLIC AVIONICS SOFTWARE SYSTEMS WRITTEN IN ADA
JOHN R. ELLIS (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) and STEVEN A. VON EDWINS (Integrated Software, Inc., Palm Bay, FL) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 727-731. refs

Although Ada was created to standardize programming for real-time embedded computer applications, especially in defense systems, it has inherent limitations when applied to large numbers of concurrent periodic processes. Modern integrated avionics systems, such as are in use on the AGUSTA A-129 Mangusta Helicopter, involve as many as 140 concurrent periodic tasks running at a variety of frequencies from 180 Hz to once every 30 seconds. Published Ada solutions to managing concurrent periodic tasks revert to a 1960s 'cyclic executive' technology, thrust control logic into the applications code, or introduce significant system overhead. When software systems get very large and involve tasks of varying duration and execution frequencies, these solutions become unmanageable. The problem domain and several of these approaches are outlined, and alternate solutions are presented. Central to the issue is the preservation of determinism in the execution control of integrated avionics software systems. I.E.

A88-50993#
APPLICABILITY OF ADA TASKING FOR AVIONICS EXECUTIVES
ROGER E. KONTAK (USAF, Electronic Systems Div., Hanscom AFB, MA) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 739-746. refs

The author evaluated Ada tasking performance and its suitability for avionics schedulers known as executives by comparing variations of Ada executives written in JOVIAL using the existing Digital Avionics Information System. The system overhead of each model was evaluated during the running of a series of representative application tasks. The study found that Ada tasking had considerably more overhead than its JOVIAL counterpart in order to maintain precise cyclical timing. Another outcome was that several Ada compilers were unable to produce code which could be run on the MIL-STD-1750A computer. This points to the present immaturity of Ada compilers targeted toward embedded aircraft computers and confirms the need to revise standards and develop compilers to provide an efficient run-time system for Ada executives. I.E.

A88-50995

THE AUTOMATIC GENERATION OF COMPUTER GRAPHICS SOURCE CODE: NO PROGRAMMING EXPERIENCE NECESSARY

TIMOTHY P. BARRY (Tau Corp., Dayton, OH), JAMES A. UPHAUS, JR., and MICHAEL ROWLAND (USAF, Wright Aeronautical Laboratories, Wright-Patterson, AFB, OH) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 757-764.

The methodology and results of a project to determine the feasibility of designing and developing a system for automatic development of computer graphics software are considered. A major goal was to allow personnel without programming experience to develop new aircraft display concepts and produce the source code necessary to simulate these concepts on any one of three laboratory graphics engines. The resulting proof-of-concept system, the Simplified Automated Layout Center (SALC), is discussed. The discussion covers the SALC system architecture, software, menu structure, and operation. I.E.

A88-51015

ASAP: AI-BASED SITUATION ASSESSMENT AND PLANNING

GREG D. GIBBONS, JONATHAN S. ABEL, and JILL V. JOSSELYN (Systems Control Technology, Inc., Palo Alto, CA) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1988, p. 932-939.

The ASAP framework for planning has been developed, based on the concept of limiting search by narrowing and partitioning the solution search space. Replanning is triggered by the occurrence of certain events in the developing situation. Upon occurrence of a triggering event, appropriate skeletal plans are instantiated with values based on the current situation, leading to a new, modified plan. The concept is demonstrated through a simulation of the ASAP automated-wingman decision aid which performs situation assessment and replanning. I.E.

A88-51034

A COOPERATIVE EXPERT SYSTEM ARCHITECTURE FOR EMBEDDED AVIONICS

ANDREW NG (Honeywell, Inc., Technology Dept., Albuquerque, NM) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1282-1286. refs

An underlying requirement for artificial intelligence software in avionics environments is real-time throughput and behavior. By using multiple processors and efficient communication mechanisms, the concept of cooperative expert systems can be used effectively in real-time applications. A hardware and software environment for supporting cooperative expert systems with multiple streamlined set (RISC-influenced) processors and a real-time shared memory multicomputer operating system executive is presented and analyzed. By using the parallelism of cooperative expert systems and RISC-influenced real-time shells in conjunction with conventional preemptive multitasking, the execution speed of artificial intelligence programs can be increased to meet real-time requirements while also maintaining the predictable response characteristics expected of avionics systems. I.E.

A88-51036

RAES: RELIABILITY ADVISOR EXPERT SYSTEM

WILSON D. YATES, III (McDonnell Aircraft Co., Saint Louis, MO) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 4. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1346-1348.

The Reliability Advisor Expert System (RAES) is a prototype artificial intelligence (AI) expert system developed as a nontraditional reliability-assessment tool for performing advanced design trade studies. Developed for use on the IBM PC, RAES provides the design engineer with an easy to use tool that recommends alternative design enhancements which will improve the reliability of the system under study. RAES provides an assessment of system reliability for the recommended design alternatives as a function of projected aircraft weight change, development cost, and projected change in customer life-cycle costs. I.E.

A88-51071#

SOFTWARE FOR BUS MONITOR

T. V. RAMA MURTHY (National Aeronautical Laboratory, Bangalore, India) and SANATH KUMAR VARAMBALLY (Karnataka Regional Engineering College, Srinivasnagar, India) Defence Science Journal (ISSN 0011-748X), vol. 37, July 1987, p. 297-304. refs

Software for Bus Monitor (SOBUM) is a package developed for MIL-STD-1553B based on Intel's Microprocessor Development System (MDS). SOBUM, consisting of modules in ASM 86 and PASCAL 86 when used with proper hardware interface can transfer the bus messages to the RAM in real time. SOBUM is then used in the off-line analysis of the message traffic on the bus. It displays or prints the data gathered in very useful and iterpretive formats. Author

A88-51465

THE DATA ACQUISITION SYSTEM FOR THE FOKKER 100 TEST AIRCRAFT

S. STORM VAN LEEUWEN (Nationaal Lucht -en Ruimtevaartlaboratorium, Amsterdam, Netherlands) and A. VOSKES (Fokker Aircraft, Amsterdam, Netherlands) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 17-1 to 17-11. refs

The data acquisition system system for the Fokker 100 test aircraft, including the capacity electrical layout, real-time presentation facilities, and performance parameters, is described. Special attention is given to the takeoff and landing performnace measuring system and the automatic noise measuring system. It is concluded that the overall system conforms to specifications and is very powerful. C.D.

A88-51466

AIRBORNE DATA MONITORING SYSTEM (ADMS)

DAVID M. BOWMAN and HARVEY SMITH (Douglas Aircraft Co., Long Beach, CA) IN: Society of Flight Test Engineers, Annual Symposium, 18th, Amsterdam, Netherlands, Sept. 28-Oct. 2, 1987, Proceedings. Lancaster, CA, Society of Flight Test Engineers, 1987, p. 18-1 to 18-22.

A system has been developed for use on board test vehicles to accurately duplicate many of the data processing techniques used in the Flight Control and Data Center of Douglas Aircraft Company. This system not only increases the latitude of flight safety monitoring, but actually reduces flight testing hours through a more detailed real-time pass/fail determination relating to design, instrumentation, environment, or pilot technique anomalies. In addition, this system gives the cognizant test engineers the added insight for much more accurate and expedient final test reporting. Currently, all Douglas instrumented test aircraft accommodating an airborne data acquisition system can utilize this system. The Airborne Data Monitoring System (ADMS) development, hardware configuration, software approach, integrity control, and engineering applications are presented in this paper. Author

A88-51930#
SYSTEMS ENGINEERING CONSIDERATIONS FOR AN AIRCRAFT DISTRIBUTED DISPLAY SYSTEM
ALAN L. BRIDGES (Lockheed Aeronautical Systems Co., Marietta, GA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 12 p.
(AIAA PAPER 88-4406)

This paper describes how the engineering design of a distributed digital display system is influenced by the 'ilities' or systems engineering as designs and alternatives are formulated and assessed. Many trade studies and technical issues have to be resolved in order to provide an optimum solution. These include architectural features, performance, network topology and implementation, hardware qualification, software creation in a networked environment, transition from a non-real-time development system (UNIX) to a real-time environment (VRTX32), and high-level language and graphics standards. Important system design and effectiveness issues include human factors (crew duties, information requirements, and system interaction), built-in test and serviceability, environmental performance, reliability, maintainability, safety, and future growth capabilities. Author

A88-51945*# Massachusetts Inst. of Tech., Cambridge.
A FLEXIBLE COMPUTER AID FOR CONCEPTUAL DESIGN BASED ON CONSTRAINT PROPAGATION AND COMPONENT-MODELING
MARK A. KOLB (MIT, Cambridge, MA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 12 p. refs
(Contract NAG2-478)
(AIAA PAPER 88-4427)

The Rubber Airplane program, which combines two symbolic processing techniques with a component-based database of design knowledge, is proposed as a computer aid for conceptual design. Using object-oriented programming, programs are organized around the objects and behavior to be simulated, and using constraint propagation, declarative statements designate mathematical relationships among all the equation variables. It is found that the additional level of organizational structure resulting from the arrangement of the design information in terms of design components provides greater flexibility and convenience. R.R.

A88-51971#
DESIGN CONSIDERATIONS OF OUTPUT FEEDBACK IN VARIABLE STRUCTURE SYSTEMS
BONNIE S. HECK and ALDO A. FERRI (Georgia Institute of Technology, Atlanta) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 6 p. refs
(AIAA PAPER 88-4500)

This paper addresses the use of static (or direct) output feedback in variable structure systems as a means of simplifying the control scheme implementation. Specific design procedures are given for selecting the switching surface and for selecting the contol to ensure that the sliding surface is stable (both locally and globally). An example applying the developed techniques to the longitudinal dynamics of an aircraft is presented. Author

A88-52228#
A RAPID PROTOTYPING TOOL FOR PILOT VEHICLE INTERFACE DESIGN
BRAD S. MILLER, JACK B. SHELNUTT, and RICHARD FARRELL (Boeing Military Airplane Co., Seattle, WA) IN: AAAIC '87 - Aerospace Applications of Artificial Intelligence; Proceedings of the Third Annual Conference, Dayton, OH, Oct. 5-9, 1987. Dayton, OH, AAAIC Conference Secretariat, 1988, p. 7-14. refs

The Pilot Vehicle Interface Development Tool (PVIDT) is an integrated group of computer work stations used for (1) rapid prototyping of pictorial format displays and cockpit automation concepts, (2) identifying avionics software requirements, and (3) developing a knowledge base for an expert system to assist the pilot with the operation of an aircraft. The expert system automates pilot-vehicle interface management (PVIM) tasks which the pilot would otherwise have to perform. It controls the amount of information displayed on each format, determines how each format is configured before it is brought up on a cockpit display and merges pilot inputs from different sources such as cursor, voice, touch screen and hard switch into integrated commands to the avionics and display systems. The rules for the expert system are developed by experienced pilots, human factors experts and computer scientists acting in concert to maximize the utility of the expert system as it is evaluated by testing on the PVIDT. Author

A88-52229#
ADVANCED BLACKBOARD APPROACHES FOR COCKPIT INFORMATION MANAGEMENT
L. BAUM, R. DODHIAWALA, V. JAGANNATHAN (Boeing Computer Services Co., Seattle, WA), D. BLEVINS, and R. STENERSON (Boeing Military Airplane Co., Seattle, WA) IN: AAAIC '87 - Aerospace Applications of Artificial Intelligence; Proceedings of the Third Annual Conference, Dayton, OH, Oct. 5-9, 1987. Dayton, OH, AAAIC Conference Secretariat, 1988, p. 15-30. refs

Effective management of the cockpit environment requires a sophisticated control technology which embodies the 'contract' between the pilot and his intelligent cockpit information management system, which responds asynchronously to the event driven flight environment, and which manages visual displays and synthesized voice channels to aid the pilot in maintaining his flight context. The Avionics Technology Group of the Boeing Military Airplane Company has employed the 'blackboard' programming paradigm to develop a sequence of prototype cockpit information management systems of increasing complexity and capability. The work reported here is an extension of earlier work which replaces the simple domain blackboard software with blackboard software having both a control and a domain component developed by Boeing Computer Services. The new cockpit information management systems implemented in this technology provide the capability to dynamically allocate priorities of pending tasks. Author

A88-52231#
ARTIFICIAL INTELLIGENCE IN THE AIR - A BLUEPRINT FOR REAL-TIME AI
JEFFREY G. GUSTIN (Westinghouse Defense and Electronics Center, Baltimore, MD) IN: AAAIC '87 - Aerospace Applications of Artificial Intelligence; Proceedings of the Third Annual Conference, Dayton, OH, Oct. 5-9, 1987. Dayton, OH, AAAIC Conference Secretariat, 1988, p. 44-51.

The demands placed on airborne AI are examined along with implementation issues. Consideration is given to issues of quality, parallelism, rule-based translation vs. embedded inference engines, generic vs. domain specific tools, and the verification of AI. Finally, a 'blueprint' for real-time AI is presented. B.J.

A88-52232#
NEURAL NETWORK APPROACH TO PROBLEMS DEALING WITH UNCERTAINTY
PAUL HESS (Barron Associates, Inc., Stanardsville, VA) IN: AAAIC '87 - Aerospace Applications of Artificial Intelligence; Proceedings of the Third Annual Conference, Dayton, OH, Oct. 5-9, 1987. Dayton, OH, AAAIC Conference Secretariat, 1988, p. 89-100. refs
(Contract F33615-84-C-3609; F33615-87-C-3610)

The paper describes two applications of ASPN (Algorithm for Synthesis of Polynomial Networks): (1) the automated design of robust error-adaptive flight control laws; and (2) rule-based expert systems. The first application results in improved aircraft performance over a wide range of impaired and unimpaired flight conditions without explicit fault detection or fault isolation. The second application provides an uncertainty mechanism which, for each case of uncertainty, automatically synthesizes a mathematical function that is well suited to the particular descision. A common representation scheme to allow both deductive and inductive algorithms to function on the same knowledge base is also discussed. B.J.

A88-52300*# Virginia Polytechnic Inst. and State Univ., Blacksburg.

IMPROVING AIRCRAFT CONCEPTUAL DESIGN - A PHIGS INTERACTIVE GRAPHICS INTERFACE FOR ACSYNT

S. G. WAMPLER (IBM Corp., Kingston, NY), A. MYKLEBUST, S. JAYARAM (Virginia Polytechnic Institute and State University, Blacksburg), and P. GELHAUSEN (NASA, Ames Research Center, Moffett Field, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 10 p. refs

(AIAA PAPER 88-4481)

A CAD interface has been created for the 'ACSYNT' aircraft conceptual design code that permits the execution and control of the design process via interactive graphics menus. This CAD interface was coded entirely with the new three-dimensional graphics standard, the Programmer's Hierarchical Interactive Graphics System. The CAD/ACSYNT system is designed for use by state-of-the-art high-speed imaging work stations. Attention is given to the approaches employed in modeling, data storage, and rendering. O.C.

16

PHYSICS

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

A88-49719

ACOUSTIC INTERFERENCE OF COUNTER-ROTATION PROPELLERS

C. K. W. TAM (Florida State University, Tallahassee), M. SALIKUDDIN (Lockheed-Georgia Co., Marietta), and D. B. HANSON (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) Journal of Sound and Vibration (ISSN 0022-460X), vol. 124, July 22, 1988, p. 357-366. Research supported by Lockheed-Georgia Co. and United Technologies Corp. refs

The noise fields from the rotors of counter-rotating propellers having the same number of blades and angular frequency tend to cancel or reinforce each other depending on the relative phase of the two fields at the point of observation. Because of this, the total noise field at the blade passage frequency or harmonics forms a characteristic standing wave pattern. A general investigation of this acoustic interference phenomenon is carried out. Unlike previous works, the present analysis allows the front and the rear rotor to have different blade geometry and loading. Further, the effect of forward flight is included. Numerical results indicate that at high subsonic cruise Mach number the acoustic interference pattern differs substantially from that at static condition. Author

A88-49720

THE USE OF ACOUSTICALLY TUNED RESONATORS TO IMPROVE THE SOUND TRANSMISSION LOSS OF DOUBLE-PANEL PARTITIONS

J. M. MASON and F. J. FAHY (Southampton, University, England) Journal of Sound and Vibration (ISSN 0022-460X), vol. 124, July 22, 1988, p. 367-379.

Double-leaf partitions are often utilized in situations requiring low weight structures with high transmission loss, an example of current interest being the fuselage walls of propeller-driven aircraft. In this case, acoustic excitation is periodic and, if one of the frequencies of excitation lies in the region of the fundamental mass-air-mass frequency of the partition, insulation performance is considerably less than desired. The potential effectiveness of tuned Helmholtz resonators connected to the partition cavity is investigated as a method of improving transmission loss. This is demonstrated by a simple theoretical model and then experimentally verified. Results show that substantial improvements may be obtained at and around the mass-air-mass frequency for a total resonator volume 15 percent of the cavity volume. Author

A88-52036

OSCILLATIONS OF THE AIRCRAFT FUSELAGE SKIN EXCITED BY A TURBULENT BOUNDARY LAYER [KOLEBANIIA OBSHIVKI FIUZELIAZHA SAMOLETA, VYZYVAEMYE TURBULENTNYM POGRANICHNYM SLOEM]

B. M. EFIMTSOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 18, no. 1, 1987, p. 90-97. In Russian. refs

The oscillations of the fuselage skin in a turbulent boundary layer are investigated experimentally in the Mach range 0.4-1.6, and the results are compared with calculations based on approximate asymptotic relations. It is shown that the proposed method for predicting the rms values of the normal accelerations of the fuselage skin excited by turbulent flow pulsations and the corresponding spectra provides reliable results over a wide range of frequencies. V.L.

N88-27875# Bolt, Beranek, and Newman, Inc., Cambridge, Mass.

THEORY OF SOUND PRODUCTION BY VORTEX-AIRFOIL INTERACTION

M. S. HOWE Jan. 1988 53 p

(Contract N00167-87-C-0021)

(AD-A193386; BBN-6710) Avail: NTIS HC A04/MF A01 CSCL 20A

An analysis is made of the sound produced when a field of vorticity is cut by an airfoil in low Mach number flow. A general formula is given for the acoustic pressure when the airfoil is rigid and the chord is acoustically compact. This expresses the radiation in terms of an integral over the region occupied by the vorticity; the integrand contains factors describing the influence of the thickness, twist and camber of the airfoil. Explicit analytical results are derived for the case of a rectilinear vortex, having small core diameter and finite axial velocity defect, which is chopped by an airfoil of large aspect ratio. The acoustic signature generally comprises two components associated respectively with the axial and azimuthal vorticity, the latter being determined by the velocity defect distribution within the core. Sound is generated predominantly when the core is in the neighborhoods of the leading and trailing edges. The contribution from the trailing edge is usually small, however, because of destructive interference between sound produced by edge-diffraction of near field energy of the vortex and that produced by vorticity shed into the wake of the airfoil in order to satisfy the unsteady Kutta condition that the pressure and velocity should be bounded at the edge. GRA

N88-27876# Bolt, Beranek, and Newman, Inc., Cambridge, Mass.

THE INFLUENCE OF SURFACE ROUNDING ON TRAILING EDGE NOISE

M. S. HOWE Jan. 1988 48 p

(Contract N00167-87-C-0021)

(AD-A193387; BBN-6715) Avail: NTIS HC A03/MF A01 CSCL 20A

An analysis is made of the sound produced by low Mach number turbulent flow over an asymmetrically rounded trailing edge of an airfoil. Such airfoils are used in experimental studies of trailing edge noise and vortex shedding phenomena, and have a flat pressure side and a rounded, or 'beveled', suction surface at the trailing edge, so that in the immediate vicinity of the edge the airfoil has a wedge shaped profile. There are two principal interaction noise sources: a lift dipole associated with the unsteady transverse forces exerted on the airfoil, and a thickness dipole which radiates preferentially in the plane of the airfoil. The latter is usually negligible except possibly at low frequencies, and at large included angles of the trailing edge wedge. Detailed results are given for included angles of 90 deg and less. It is concluded that, for given turbulence intensity, surface beveling has a significant effect on the radiation only at sufficiently high frequencies that the trailing edge may be regarded as a straight-sided wedge over distances of the order of the turbulence length scale. GRA

N88-27877*# Virginia Polytechnic Inst. and State Univ., Blacksburg.

APPLICATION OF PATTERN RECOGNITION TECHNIQUES TO THE IDENTIFICATION OF AEROSPACE ACOUSTIC SOURCES Annual Report No. 1

CHRIS R. FULLER, WALTER F. OBRIEN, and RANDOLPH H. CABELL Jun. 1988 11 p
(Contract NAG1-762)
(NASA-CR-183116; NAS 1.26:183116) Avail: NTIS HC A03/MF A01 CSCL 20A

A pattern recognition system was developed that successfully recognizes simulated spectra of five different types of transportation noise sources. The system generates hyperplanes during a training stage to separate the classes and correctly classify unknown patterns in classification mode. A feature selector in the system reduces a large number of features to a smaller optimal set, maximizing performance and minimizing computation. Author

N88-27879# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Abteilung Technische Akustik.

AEROACOUSTIC INVESTIGATION ON THE NOISE FROM ULTRALIGHT AIRCRAFT

HELMUT DAHLEN, WERNER DOBRZYNSKI, and HANNO HELLER Aug. 1987 275 p In GERMAN; ENGLISH summary
(DFVLR-FB-88-03; ISSN-0171-1342; ETN-88-92921) Avail: NTIS HC A12/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Federal Republic of Germany, 76.50 deutsche marks

Flyover and ground/static noise measurements as well as wind tunnel tests on individual propellers of ultralight aircraft led to the identification of the essential noise sources and to recommendations for noise reduction. For undisturbed inflow conditions (tractor propellers) and blade tip Mach numbers below 0.5 the resulting propeller noise is of broadband nature, while above that limit discrete-frequency rotational-noise sources dominate. Additional sources occur with pusher-propeller configurations as a consequence of the disturbed inflow. It is demonstrated that ground/static noise measurements are not suitable for certification testing. ESA

N88-27880# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Abteilung Instationaere Aerodynamik.

PROPAGATION OF ACOUSTIC DISTURBANCES IN TRANSONIC FLOW FIELDS OF LIFTING WINGS Ph.D. Thesis - Goettingen Univ.

RALPH VOSS Feb. 1988 151 p In GERMAN; ENGLISH summary
(DFVLR-FB-88-13; ISSN-0171-1342; ETN-88-92931) Avail: NTIS HC A08/MF A01; DFVLR, VB-PL-DO, 90 60 58, 5000 Cologne, Federal Republic of Germany, 53.50 deutsche marks

The propagation of small disturbances in the vicinity of transonic flutter surfaces with mixed sub-/supersonic regions is investigated based on the approximation of geometrical acoustics. Waves, rays, and the spatial density distribution of the dissipated disturbance energy are numericaly calculated using a system of 18 differential equations. The effects of various two and three-dimensional fields, of the source locus, and of reflections on the wing surface are investigated. The results of the acoustic theory are used to derive a general influence function for sources of disturbance in arbitrary transonic fields. This function represents a step toward a surface panel method to calculate unsteady transonic flows. The acoustic results are compared with measured unsteady pressure distributions on oscillating transonic wings and with results of a numerical field panel method. ESA

N88-27894# Sandia National Labs., Albuquerque, N. Mex.

HYPERSONIC FLIGHT TESTING

W. WILLIAMSON 1987 48 p Presented at the Joint US/Europe Short Course on Hypersonics, Paris, France, 7 Dec. 1987
(Contract DE-AC04-76DP-00789)
(DE88-001655; SAND-87-2570C; CONF-871227-1; CONF-8704229-1) Avail: NTIS HC A03/MF A01

This presentation is developed for people attending the University of Texas week-long short course in hypersonics. The presentation will be late in the program after the audience has been exposed to computational techniques and ground test methods. It will attempt to show why we flight test, flight test options, what we learn from flight tests and how we use this information to improve out knowledge of hypersonics. It presupposes that our primary interest is in developing vehicles which will fly in the hypersonic flight region and not in simply developing technology for technology's sake. The material is presented in annotated vugraph form so that the author's comments on each vugraph are on the back of the preceding page. It is hoped that the comments will help reinforce the message on the vugraph. Author

N88-28719# Rolls-Royce Ltd., Derby (England).

AIRCRAFT NOISE: A REVIEW

M. J. T. SMITH 3 Feb. 1988 9 p Presented at the City of Birmingham's Environmental Service Public Health Division One Day Meeting, Birmingham, United Kingdom, 3 Feb. 1988
(PNR90450; ETN-88-92681) Avail: NTIS HC A02/MF A01

Aircraft noise exposure forecasting is reviewed. Technological and operational developments in noise reduction are discussed. Global noise trends from 1960 to 1990, and from 1985 to 2005 are presented. ESA

N88-28722# Royal Aircraft Establishment, Farnborough (England).

A METHOD OF IMPROVING REMOTE REPRODUCTION OF A SOUND FIELD BY ONE-THIRD-OCTAVE ANALYSIS AND DIGITAL FILTERING

J. B. COLLISTER Oct. 1987 36 p
(RAE-TM-FS(F)-679; BR105554; ETN-88-92829) Avail: NTIS HC A03/MF A01

Work done to improve the agreement between a target one-third-octave spectrum and its reproduction via a remote sound source is described. Digital filters create limited bandwidth data which are modified and finally recombined to produce a new time history. Studies of fixed and rotary wing aircraft show mean errors significantly reduced by this technique. ESA

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A88-49980

COST-ORIENTED DESIGN [EL DISENO ORIENTADO AL COSTE]

JUAN JOSE HERNANDEZ LOPEZ Ingenieria Aeronautica y Astronautica (ISSN 0020-1006), June-July 1988, p. 26-30. In Spanish.

An account is given of current aircraft design practices fundamentally informed by direct operating cost and life cycle cost considerations, as illustrated by numerous cases of their use in the design of tactical aircraft. Design-to-cost methods proceed from cost objectives formulated during the conceptual design development phase of a program for a production run of a given magnitude. Parametric equation codes have been devised that can project total cost estimates; these then serve as the bases for successive tradeoffs between given levels of performance and projected aircraft costs. O.C.

A88-51978#

WRIGHT BROTHERS LECTURESHIP IN AERONAUTICS: THE SKUNK WORKS' MANAGEMENT STYLE - IT'S NO SECRET

BEN R. RICH (Lockheed Aeronautical Systems Co., Burbank, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems and Operations Meeting, Atlanta, GA, Sept. 7-9, 1988. 10 p.
(AIAA PAPER 88-4516)

An historical development and organizational-principles account is presented for the 'Skunk Works' management philosophy created at the Lockheed Aeronautical Systems Company by Clarence 'Kelly' Johnson, beginning in 1943, in order to tightly organize and expedite small, highly-classified advanced aircraft design and prototype construction projects. This management philosophy has produced such aircraft as the U-2 and SR-71 spy aircraft and the P-80 and F-104 fighters. The 14 management principles formulated by Johnson are presented and discussed. O.C.

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GENERAL

A88-51440* National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, Calif.

A HISTORY OF THE X-15 PROGRAM

WILLIAM H. DANA (NASA, Flight Research Center, Edwards, CA) IN: 1987 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 31st, Beverly Hills, CA, Sept. 23-26, 1987, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1987, p. 257-272.

The present historical account of the X-15 hypersonic research aircraft development program, which began in 1952 with the determination by NACA's Committee on Aeronautics to attempt speeds of Mach 10-12 and altitudes of 12-50 miles. While the technical proposal adopted by the program in 1954 reduced speed requirements to Mach 6.6, representing the state-of-the-art capability in high temperature structures, the X-15 would ultimately reach a speed of Mach 6.7. The structural material employed was Inconel X, an Ni-Cr alloy slightly heavier than steel. The X-15 program studied problems in exoatmospheric flight control, structural heating, control in weightlessness, and atmospheric reentry. The last flights were conducted in 1968. O.C.

A88-51442

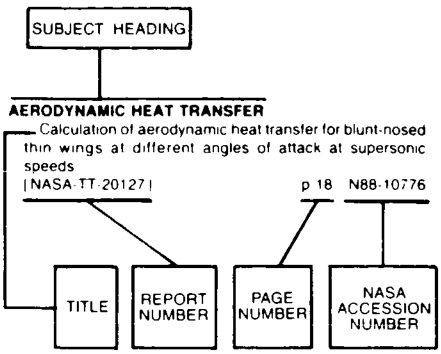
WORLD FLIGHT, THE VOYAGER

RICHARD G. RUTAN, JEANA YEAGER, BURT RUTAN, and JACK NORRIS IN: 1987 report to the aerospace profession; Society of Experimental Test Pilots, Symposium, 31st, Beverly Hills, CA, Sept. 23-26, 1987, Proceedings. Lancaster, CA, Society of Experimental Test Pilots, 1987, p. 289-304.

A comprehensive discussion is presented concerning the engineering criteria driving the design of the unrefueled circumnavigational-range Rutan Voyager aircraft, which had to exceed a 25,000-mile great circle distance by 1000 miles on little more than 7000 lbs of fuel. Attention is given to the climatological considerations that figured in the circumnavigation mission's planning, as well as the Breguet formula-derived requirements whose satisfaction by the Voyager configuration lay the groundwork for a safe and efficient flight. The configuration thus developed possessed a canard layout, with both pusher and tractor propulsion installations at the bow and stern of the fuselage. O.C.

SUBJECT INDEX

Typical Subject Index Listing



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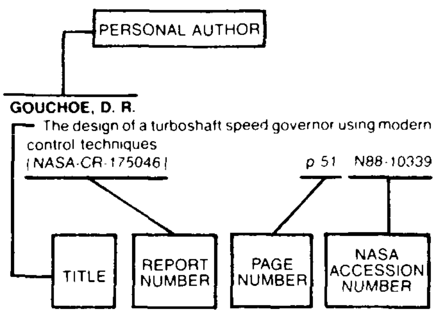

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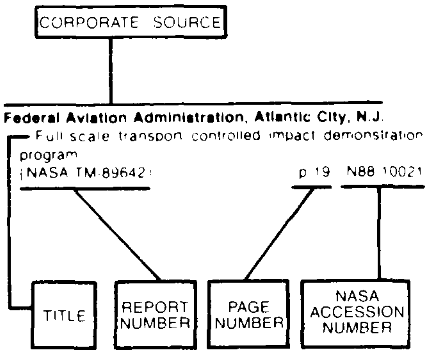

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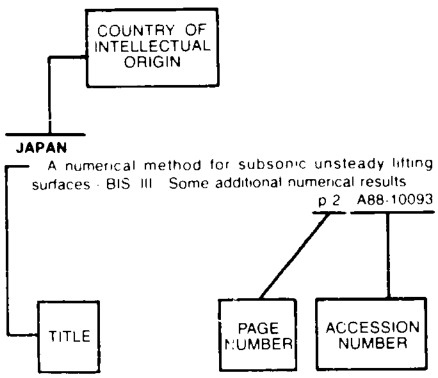

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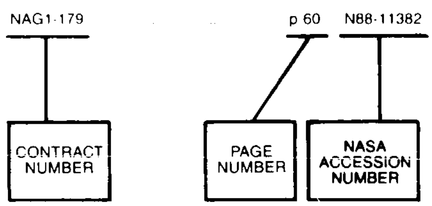
UNITED KINGDOM

Typical Contract Number Index Listing



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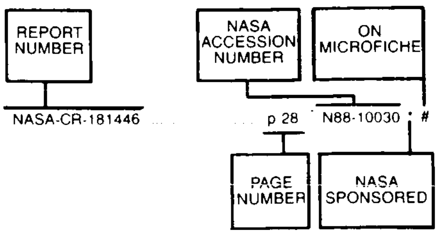

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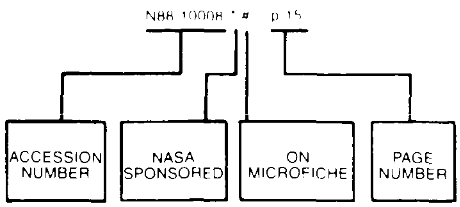

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