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A Continuing Bibliography with Indexes

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Aeronautical Engineering

ACCESSION NUMBER RANGES

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AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 204)

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 August 1986 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 419 reports, journal articles, and other documents originally announced in August 1986 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 cumulative index will be published.

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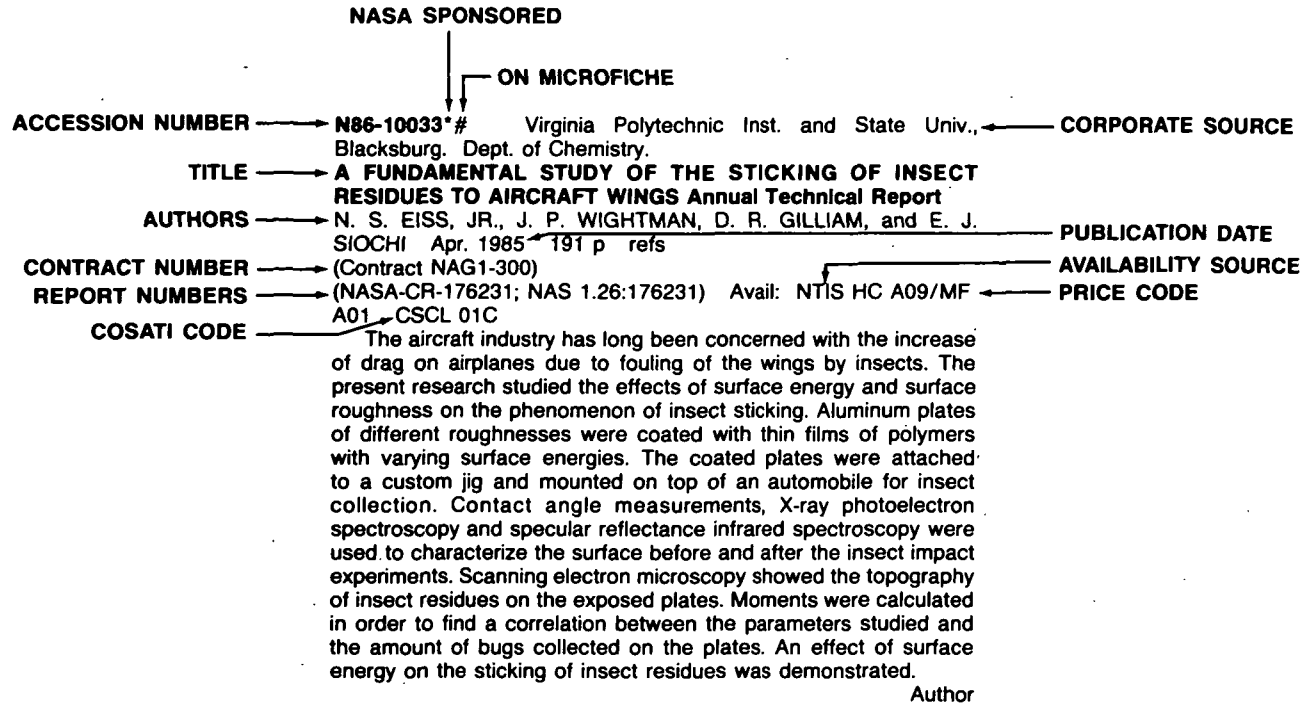

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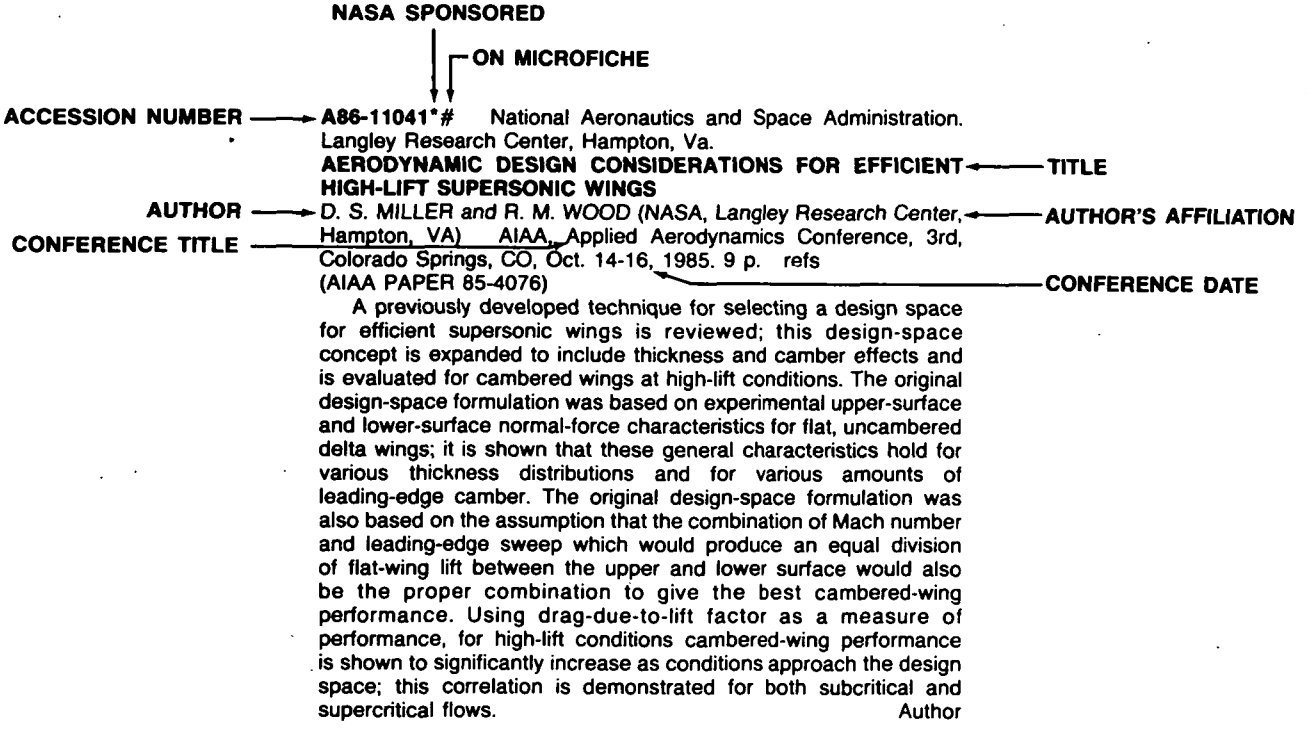

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 204)

SEPTEMBER 1986

01

AERONAUTICS (GENERAL)

A86-35163#
DEVELOPMENT TRENDS IN THE CASE OF HIGH-PERFORMANCE AIRCRAFT [ENTWICKLUNGSTENDENZEN BEI HOCHLEISTUNGSFLUGZEUGEN]
K. H. HEILMANN (Bundesministerium der Verteidigung, Bonn, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 33 p. In German.
(DGLR PAPER 85-106)

The present paper is mainly concerned with fighter aircraft. The design of the European Fighter Aircraft (EFA) and the U.S. Advanced Tactical Fighter (ATF) represents an initiation of fighter aircraft projects which are particularly suited for providing an illustration of the developments in the considered area. In a discussion of these development trends, relations to other types of aircraft in the civil and military sectors are also considered. The requirements which have to be satisfied to justify the initiation of a program for the development of a fighter are examined. Attention is given to new operational capabilities provided by new technologies, new tactics, the feasibility of combat against airborne targets at a distance of 70 km under all-weather conditions, requirements regarding an employment of additional technological advances, developments regarding flight mechanics and flight control, the continuation of a utilization of both fiber-reinforced and metallic materials, the characteristics of the engines of the future, advances related to avionics, and general technological development trends. G.R.

A86-35448
COCKPIT AND CABIN CREW COORDINATION AND COMMUNICATION
N. KOAN (Association of Flight Attendants, Washington, DC) *IN*: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 189-193.
(SAE PAPER 851918)

Methods for improving cockpit/crew coordination and communication are examined. FAA recommendations and bulletins for enhancing crew interaction are described. The need for crew members to understand each others' duties, standardized emergency procedures, clarified sterile cockpit procedures, joint training of crew members, and independently powered communication equipment to ensure safe flights is discussed. I.F.

A86-35601
AMERICAN HELICOPTER SOCIETY, ANNUAL FORUM, 41ST, FORT WORTH, TX, MAY 15-17, 1985, PROCEEDINGS
Alexandria, VA, American Helicopter Society, 1985, 881 p. For individual items see A86-35602 to A86-35615, A86-35617 to A86-35665.

The present conference considers topics in the fields of helicopter dynamics, avionics, propulsion systems, acoustics, handling qualities, helicopter design configurations and aerodynamics, helicopter airframe structures and materials, helicopter manufacturers' product support services, test and evaluation techniques, helicopter rotor icing phenomena and deicing methods, manufacturing and product assurance methods, and helicopter crashworthiness. Attention is given to tilt-rotor aircraft stability test results, hover performance and crashworthiness, hingeless rotor gust response and stability, X-wing helicopter performance potential in naval applications, the aerodynamics of circulation control rotors, robotics in helicopter manufacturing, and composite structural damage assessment methods. O.C.

A86-35983
CLASSIFICATION OF FLIGHT VEHICLES ACCORDING TO THE TYPE OF PROPULSION - DETERMINATION OF THE TYPE AND NUMBER OF LIFT SOLUTIONS [KLASSIFIKATSIIA LETATEL'NYKH APPARATOV PO VIDU DVIZHITELEI OPREDELENIE VIDA I CHISLA NESUSHCHIKH RESHENII]
M. A. GURIANOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 33-39. In Russian. refs

A86-36939
FLIGHT SIMULATION/SIMULATORS; PROCEEDINGS OF THE AEROSPACE TECHNOLOGY CONFERENCE AND EXPOSITION, LONG BEACH, CA, OCTOBER 14-17, 1985
Congress and Exposition sponsored by SAE. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-634), 1985, 81 p. For individual items see A86-36940 to A86-36947.
(SAE SP-634)

The conference presents papers on the role of flight simulation in helicopter crew station design, changes in engineering flight simulation, and the application of the optimal control model to the design of flight simulation experiments. Also considered are the capabilities of airborne and ground-based flight simulation, alternatives to the high cost and the long time associated with typical flight simulation efforts, and the impact of Ada on simulators. Additional papers cover the simulation of aircraft components for training purposes and the effects of visual-cue dominance hierarchies on simulator design. K.K.

N86-24652# National Aeronautics and Space Administration, Washington, D.C.
SELECTIONS FROM FLUG REVUE UND FLUGWELT INTERNATIONAL. A. ON THE BORDER OF TIME-HYPERSONIC FLIGHT. B. NASA PROGRAMS PAVE THE WAY FOR THE HYPERSONIC AIRCRAFT. C. SHUTTLE FLIGHT 61-B; CONSTRUCTION IN SPACE. D. FASTER THAN A BULLET; HYPERSONIC MILITARY AIRCRAFT
H. PENNER, K. MUELLER, H. MULLER, G. WANGE, and N. LYNN May 1986 40 p Transl. into ENGLISH of Flug Revue and Flugwelt International (West Germany), Feb. 1986 p 9-22 and 46-50 Transl. by SCITRAN, Santa Barbara, Calif.
(Contract NASW-4004)
(NASA-TM-88418; NAS 1.15:88418) Avail: NTIS HC A03/MF A01 CSCL 01B

Planned research and future developments in hypersonic aircraft, including possible military applications of hypersonic transport aircraft are discussed. NASA's development of hypersonic aircraft is discussed. Other topics include an overview of the 61-B Space Shuttle mission that pertains to the construction of space structures. Author

02

AERODYNAMICS

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

A86-34160
THE INDUCED DOWNWASH AND LIFT ON A WING OF HIGH ASPECT RATIO IN UNSTEADY MOTION
P. WILMOTT (Oxford University, England) Aeronautical Journal (ISSN 0001-9240), vol. 90, Feb. 1986, p. 63-72. Research supported by the Admirality Research Establishment. refs

An unsteady lifting line theory for a general motion of a wing of high aspect ratio is presented. The analysis parallels that of Van Dyke (1964) in his solution for the steady lifting line by the method of matched asymptotic expansions but is complicated by the shedding of transverse vortices associated with variation of circulation with time. Expressions are found for the downwash due to three-dimensional (finite span) effects and the lift on the wing. Calculation are presented for a wing of elliptic planform following a curved path. Author

A86-34411#
INTRABLADE VELOCITY MAPPING IN TRANSONIC FAN PASSAGES OF GAS TURBINE
M. C. WILLIAMS (United Technologies Corp., Pratt and Whitney Group, East Hartford, CT) IN: International Symposium on Laser Anemometry, 2nd, Miami Beach, FL, November 17-22, 1985, Proceedings . New York, American Society of Mechanical Engineers, 1985, p. 19-26. refs

Characterization of the aerodynamics of the flows within gas turbine intrablade passages requires the development of sensitive laser Doppler velocimeters, data acquisition systems capable of efficiently and accurately handling substantial quantities of data, and appropriate methods of post test data analysis and display to maximize the value of the recorded data. Pratt and Whitney developed a confocal LDV which was first employed in the mid 1970's for gas turbine intrablade studies. Experience gained through the instrument's use in several programs coupled with recent advances in optical coating technology formed the basis for a redesign which has recently been completed. The performance of this refined instrument has been demonstrated in a NASA sponsored fan study in which approximately 200 million valid velocity signals were detected and recorded. This study, the data acquisition system employed, and post test data reduction and presentation methods are reviewed. A novel recently developed data format which permits a three-dimensional depiction of intrablade air flows is also discussed. Author

A86-34485
RISING OF THE FERRIE POINT ON THE WINDWARD SIDE OF DELTA WINGS [O VSPLYVANII TOCHKI FERRI NA NAVETRENNOI STORONE V-OBRAZNYKH KRYL'EV]
N. A. OSTAPENKO (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR) Akademiia Nauk SSSR, Doklady (ISSN 0002-3264), vol. 287, no. 2, 1986, p. 295-298. In Russian. refs

The position of the Ferrie singularity point on the windward side of a delta wing in supersonic flow (Mach 3) is examined. It is established that, depending on the flow regime, this point can be situated at the point of discontinuity of the transverse contour of the wing, or it can rise from the wing surface to the bow shock in the flow symmetry plane. Conical-flow restructuring in the presence of a Mach shock configuration is found which is connected with the fact that streamlines that have passed through an oblique/straight shock system are associated with smaller spherical losses of total pressure than streamlines that have passed through a bridge-shaped shock. B.J.

A86-35082
FATIGUE LIFE IN A COUPLED PROBLEM CONCERNING THE MOTION OF A FLEXIBLE WING [USTALOSTNAIA DOLGOVECHNOST' V SVIAZANNOI ZADACHE O DVIZHENII GIBKOGO KRYLA]
B. A. ERSHOV Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), Jan. 1986, p. 122, 123. In Russian. refs

A method is presented for calculating the fatigue life of a flexible wing moving at a supersonic velocity in a turbulent atmosphere. In accordance with the method proposed here, the fatigue life is calculated using a formula in which the following parameters must be known: the Wohler curve parameters determined experimentally, parameters of an atmospheric turbulence model, parameters characterizing the random vibrations of the flexible wing, and flow parameters in a formula for the spectral density of wing vibrations. V.L.

A86-35154#
DETERMINATION OF WING DEFORMATION IN WIND TUNNEL MODELS USING STRESS MEASUREMENT SECTION TECHNOLOGY [BESTIMMUNG DER FLUEGELVERFORMUNG VON WINDKANAL-MODELLEN MIT HILFE DER DEHNGSMESSSTREIFEN-TECHNIK]
T. WOLF (Darmstadt, Technische Hochschule, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 19 p. In German. refs
(DGLR PAPER 85-091)

A procedure using stress measurement section technology to control elastic wing deformation in wind tunnels is described. This method permits the deformation to be determining during wind tunnel tests without exact knowledge of the load distribution. An example of the method's application is presented. C.D.

A86-35167#
ANALYTIC REPRESENTATION OF STEADY AND UNSTEADY AERODYNAMIC COEFFICIENTS OF MODERN HELICOPTER ROTORS [ANALYTISCHE DARSTELLUNG DER STATIONAEREN UND INSTATIONAEREN AERODYNAMISCHEN BEIWERTE MODERNER HUBSCHRAUBERROTOREN]
U. LEISS and S. WAGNER (Muenchen, Universitaet der Bundeswehr, Munich, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 20 p. In German. refs
(Contract BMFT-LFF-83408)
(DGLR PAPER 85-114)

The development of modern highly stressed helicopter rotors requires an accurate knowledge of the dynamic and aerodynamic properties. Unsteady processes can be the cause for very long times of computation. With the objective to overcome these difficulties, the present investigation provides a universal model for the calculation of the aerodynamic forces and moments of a

rotor blade. A modular, not too large structure, is needed for the employment of the flight-mechanics real-time simulation and for design and optimization objectives. Time-consuming computational procedures are replaced by simple theories and empirical parameters with aerodynamic significance. Attention is given to relations between forces and moments and the new dimensionless aerodynamic coefficients, steady flow, separated displacement flow, separated cyclic flow, supersonic flow, transonic flow, a comprehensive model of the steady flow, unsteady flow, a comparison of the obtained data with experimental values and other procedures, three-dimensional effects, and the analytic integration of differential forces and moments. G.R.

A86-35171#
A COMPARISON OF SOLUTIONS OF THE COMPLETE POTENTIAL EQUATION AND THE EULER EQUATIONS FOR THE TRANSONIC FLOW AROUND THE DFVLR-F4-WING [VERGLEICH VON LOESUNGEN DER VOLLSTAENDIGEN POTENTIALGLEICHUNG UND DER EULERGLEICHUNGEN FUER DIE TRANSSONISCHE UMSTROEMUNG DES DFVLR-F4-FLUEGELS]
G. WICHMANN, R. RADESPIEL (DFVLR, Brunswick, West Germany), and S. LEICHER (Dornier GmbH, Friedrichshafen, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 19 p. In German. refs
(DGLR PAPER 85-121)

In the context of the design of transonic wings for modern transport aircraft, reliable computational procedures are needed to verify design objectives and to predict performance limits. The present investigation is concerned with a study of the characteristics and suitability of currently available computational methods, taking into account an employment in the case of the DFVLER-F4-wing, which has been designed for an aircraft of the type Airbus A310. The results obtained with procedures for the study of the flow around wings are discussed and compared, giving attention to the solution of the potential equation on the basis of the finite-difference and finite-volume schemes. A time-marching approach has been used for the solution of the Euler equations. G.R.

A86-35172#
A VORTEX LATTICE METHOD FOR CALCULATING NONLINEAR AERODYNAMIC CHARACTERISTICS OF INTERFERING AIRFOILS [EIN WIRBELGITTERVERFAHREN ZUR BERECHNUNG NICHTLINEARER AERODYNAMISCHER CHARAKTERISTIKA VON INTERFERIERENDEN TRAGFLAECHEN]
CH. URBAN and S. WAGNER (Muenchen, Universitaet der Bundeswehr, Munich, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 12 p. In German. refs
(Contract DFG-WA-42413)
(DGLR PAPER 85-122)

A numerical method is presented for calculating nonlinear, steady, and unsteady interference effects in incompressible potential flow for individual and staggered airfoils with and without front and lateral edge flow separation. The velocity potential is represented by discretely distributed dipole panels of constant strength on the wings and free vortex surfaces. In addition to the kinematic boundary conditions at the flat, thin wings, the remaining boundary conditions are implicitly fulfilled using the singularity model. The problem is solved using a time-dependent, stepped procedure in which the free vortex sheets form suddenly and evolve to a stationary state. The results of the flow interferences are illustrated for individual airfoils and wing-wing configurations. C.D.

A86-35253
INVISCID VORTEX-STRETCHED TURBULENT SHEAR-LAYER FLOW COMPUTED AROUND A CRANKED DELTA WING
A. RIZZI (Flygtekniska Forsoksanstalten, Bromma, Sweden) and C. J. PURCELL (ETA Systems, Inc., St. Paul, MN) Communications in Applied Numerical Methods (ISSN 0748-8025), vol. 2, Mar.-Apr. 1986, p. 139-144.

A numerical simulation technique that evaluates the inviscid, turbulent flow-field, which develops around a wing at the high Reynolds number of free-flight conditions, is described. The development of a database using the transfinite interpolation method of Eriksson (1982) to construct a boundary-conforming O-O type mesh and Euler equations to form an artificial viscosity model is examined. Simulation data demonstrating the flow for a twisted, cranked-and-cropped delta wing are discussed. I.F.

A86-35633* Continuum Dynamics, Inc., Princeton, N. J.
A NEW APPROACH TO THE FREE WAKE PROBLEM FOR HOVERING ROTORS
D. B. BLISS, D. A. WACHSPRESS (Continuum Dynamics, Inc., Princeton, NJ), and T. R. QUACKENBUSH (Princeton University, NJ) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 463-477. refs
(Contract NAS2-11730)

In the present approach to the hovering rotor free wake problem, an influence coefficient solution method is used to find that rotor wake solution which is steady in a reference frame that rotates with the blades; this scheme solves directly for the conditions of free wake equilibrium by a procedure that does not involve time-stepping and the associated use of numerical damping or special convergence methods. The solution method has been implemented in a hover wake computer program having a three-part wake model for the tip vortex. All three wake regions are represented by the new Basic Curved Vortex Elements. Sample hover calculations are presented for single blade and multiblade rotors. O.C.

A86-35634
APPLIED AERODYNAMICS OF CIRCULATION CONTROL AIRFOILS AND ROTORS
E. O. ROGERS, A. W. SCHWARTZ, and J. S. ABRAMSON (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 479-490.

For a lifting/stoppable circulation control airfoil rotor, the critical flight condition of minimum available lift occurs in the 0.85-1.10 advance ratio range. Analysis of the aerodynamic flowfield for each blade element at the critical flight condition indicates that the airfoils operate in a low speed, highly yawed environment at a negative angle-of-attack. These data furnish guidelines for the proper design of airfoils and for the assessment of their performance. Recent tests of circulation control airfoils have further defined the stall boundaries and the influence of airfoil geometry on optimal operating conditions. O.C.

A86-35636* United Technologies Research Center, East Hartford, Conn.
HOVERING ROTOR AIRLOAD PREDICTION USING A FULL POTENTIAL FLOW ANALYSIS WITH REALISTIC WAKE GEOMETRY
T. A. EGOLF and S. P. SPARKS (United Technologies Research Center, East Hartford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 515-530. refs
(Contract NAS2-11150)

A three-dimensional, full potential flow analysis with realistic hover wake geometry is presented for the prediction of hovering rotor airloads. The method of analysis is based on the concept of matching inner and outer domain solutions in three dimensions. The inner domain nonlinear solution is obtained using a finite

difference analysis and the outer domain solution is based on prescribed wake methodology. This formulation which includes three-dimensional wake influence, was initially validated using a fixed-wing analysis, and has been extended to hovering rotor flight. Detailed chordwise and spanwise loading results are compared with subsonic and transonic test results from two rotor configurations to illustrate the predictive capabilities of the analysis. The extension of the method to steady-level forward flight is also discussed. Author

A86-35655* Ohio State Univ., Columbus.
THE AERODYNAMICS OF ROTOR BLADES WITH ICE SHAPES ACCRETED IN HOVER AND IN LEVEL FLIGHT
J. D. LEE (Ohio State University, Columbus) and R. J. SHAW (NASA, Lewis Research Center, Cleveland, OH) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 735-742. refs

Through a series of flights in artificial clouds, ice accretions on the main rotor of a UH-1H helicopter were documented in detail upon landing by silicone-rubber molds for both hover and level flights. Full scale reproductions of typical accretions in hover were fabricated by means of epoxy castings and used for a wind-tunnel test program. Surface static pressure distributions were recorded and used to evaluate lift and pitching moment increments while drag was determined by wake surveys. For comparison, accreted ice shapes are presented for two level flight cases as well as preliminary analytical predictions. Author

A86-35855* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FLOW FIELD AND NEAR AND FAR SOUND FIELD OF A SUBSONIC JET
K. B. M. Q. ZAMAN (NASA, Lewis Research Center, Cleveland, OH) Journal of Sound and Vibration (ISSN 0022-460X), vol. 106, April 8, 1986, p. 1-16. refs

Flow and sound field data are presented for a 2.54 cm diameter air jet at a Mach number of 0.50 and a Reynolds number of 300,000. Distributions of mean velocity, turbulence intensities, Reynolds stress, spectral components of turbulence as well as of the near field pressure, together with essential characteristics of the far field sound are reported. This detailed set of data for one particular flow, erstwhile unavailable in the literature, is expected to help promoote and calibrate subsonic jet noise theories. 'Source locations' in terms of the turbulence maxima, coupling between the entrainment dynamics and the near pressure field, the sound radiation paths, and the balance in mass, momentum and sound energy fluxes are discussed. The results suggest that the large scale coherent structures of the jet govern the 'source locations' by controlling the turbulence and also strongly influence the near field pressure fluctuations. Author

A86-35925
VELOCITY DISTRIBUTION AROUND A WING IN A WIND TUNNEL VERIFICATION OF A CALCULATION METHOD BY MEANS OF A LASER ANEMOMETER [ROZKLAD PREDKOSCI WOKOL PLATA UMIESZCZONEGO W TUNELU PRZEPLYWOWYM - WERYFIKACJA PEWNEJ METODY OBLICZENIOWEJ ZA POMOCA ANEMOMETRU LASEROWEGO]
J. KONIECZKA and J. STELLER Instytut Maszyn Przeplywowych, Prace (ISSN 0079-3205), no. 88, 1985, p. 3-16. In Polish. refs

Velocity distribution around a wing between parallel walls is calculated theoretically with allowance for the effect of separation using an adaptation of Jacob's method. The results obtained are then compared with laser anemometer measurements conducted in a wind tunnel. It is found that the calculation method used here provides realistic velocity distributions for normal flow with or without separation. Details of the measurement procedure are given. V.L.

A86-35979
CALCULATION OF THE DYNAMIC RESPONSE OF A FLIGHT VEHICLE USING A DISCRETE-CONTINUOUS MODEL [RASCHET DINAMICHESKOI REAKTSII LETATEL'NOGO APPARATA NA OSNOVE DISKRETNO-KONTINUAL'NOI MODELI]
M. B. VAKHITOV, A. S. SAFONOV, and I. A. KUZNETSOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 16-20. In Russian. refs

A numerical procedure is presented for calculating the dynamic response of a flight vehicle to external perturbations produced by changes in the kinematic parameters of the flight vehicle motion resulting from control actions or gusts. The elastic deformations of the lifting surfaces are determined in the context of a discrete-continuous model; the nonstationary aerodynamic load is determined using the method of discrete vortices. A solution is obtained in time steps, and results of calculations are presented. V.L.

A86-35985
CALCULATION OF THE AERODYNAMIC CHARACTERISTICS OF THREE-DIMENSIONAL WINGS OF FINITE SPAN IN A POTENTIAL INCOMPRESSIBLE FLOW [RASCHET AERODINAMICHESKIKH KHARAKTERISTIK OB'EMNYKH KRYL'EV KONECHNOGO RAZMAKHA, OBTEKAEMYKH POTENTSIAL'NYM NESZHIMAEMYM POTOKOM]
S. D. ERMOLENKO and E. A. KIAGUZOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 43-48. In Russian.

The problem of potential flow past a wing is solved using the discrete vortex method. The principles of the method are reviewed, and formulas are presented for calculating the distributed and integral aerodynamic characteristics. The efficiency of the method is illustrated by examples. The method described here is applicable to wings of both large (including infinite) and small aspect ratios corresponding to nonseparated flow. V.L.

A86-35991
ANALYSIS OF A THREE-DIMENSIONAL STATIONARY TURBULENT BOUNDARY LAYER ON THE ROOT SECTION OF A WING WITHOUT ALLOWANCE FOR COMPRESSIBILITY [RASCHET TREKHMERNOGO STATSIONARNOGO TURBULENTNOGO POGRANICHNOGO SLOIA NA KORNEVOM OTSEKE KRYLA BEZ UCHETA SZHIMAEMOSTI]
G. A. SHCHEKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 72-76. In Russian. refs

A procedure is presented for calculating a three-dimensional stationary boundary layer in the laminar, transition, and turbulent flow regions on wings. As an example, calculations are carried out for a three-dimensional stationary boundary layer on the upper surface of the root section of a swept wing. With the exception of the separation region, the results are found to be in good agreement with data in the literature. V.L.

A86-35994
GROUP STUDIES OF EQUATIONS OF THE LAMINAR BOUNDARY LAYER ON A ROTATING WING [GRUPPOVYE ISSLEDOVANIIA URAVNENII LAMINARNOGO POGRANICHNOGO SLOIA NA VRASHCHAIUSHCHEMSIA KRYLE]
M. A. DARAGAN and S. A. DERBENEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 81-84. In Russian.

A group analysis is made of the unsteady laminar boundary layer on a rotating wing, a problem relevant to many aircraft engineering applications. Invariant solutions are obtained which, in certain particular cases, simplify the analysis of the initial system of equations by reducing by one the number of independent variables. The results of the study provide a way to obtain similar invariant solutions in some other cases. V.L.

A86-36201
ANALYTICAL TOOLS FOR SYSTEMATIC TRANSONIC DESIGN
H. SOBIECZKY (DFVLR, Institut fuer Theoretische Stroemungsmechanik, Goettingen, West Germany) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 22, Feb. 1986, p. 309-326. refs

Special transonic flows are illustrated on the basis of near-sonic model equations, in order to generate both test cases for numerical methods and simple, educational models of observed phenomena in high speed aircraft and turbomachine components. The 'fictitious gas' technique employed was originally used to find special solutions to the transonic partial differential equations; the addressing of practical requirements then led to the refinement of the method for application in numerical analysis algorithms. Such algorithms will become increasingly valuable if systematic three-dimensional configurational design can rest on mature numerical codes as well as on a better understanding of three-dimensional flow phenomena. O.C.

A86-36202
INVERSE METHOD WITH GEOMETRIC CONSTRAINTS FOR TRANSONIC AEROFOIL DESIGN
J. M. FRAY, J. W. SLOOFF, J. W. BOERSTOEL, and A. KASSIES (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 22, Feb. 1986, p. 327-339. refs

An engineering method for the design of aerofoils having a prescribed pressure distribution in subsonic or transonic flow is described. The method is based on an iterative procedure of 'residual-correction' type. In each iteration step, the difference between a current and a target pressure distribution (residual) is determined by a fast (multi-grid) finite-volume full-potential code. Corrections to the geometry driving the pressure residual to zero are determined by a global, inverse, thin-aerofoil theory based method for the subsonic part of the flow field, and by means of a local, inverse, wavy-wall theory based formula for the supersonic part of the flow field. The determination of the geometry correction has been formulated as a minimization problem in the sense that pressure distribution and geometry requirements may be balanced in a weighted least squares sense. The method is described briefly, including the basic mathematical/physical formulation and the main computational aspects. The capabilities of the method are illustrated by means of examples of aerofoil designs. Author

A86-36206
APPLICATION OF ELLIPTIC CONTINUATION METHOD FOR TRANSONIC AEROFOIL DESIGN AND EXPERIMENTAL VERIFICATION
G. REDEKER, G. WICHMANN (DFVLR, Institut fuer Entwurfst Aerodynamik, Brunswick, West Germany), and H.-CHR. OELKER (Braunschweig, Technische Universitaet, Brunswick, West Germany) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 22, Feb. 1986, p. 395-416. refs

With the aid of the elliptic continuation method, transonic aerofoils for two different purposes have been optimized. The design process is described and it is shown that the optimization is more difficult for higher design Mach numbers. The results of experimental investigations confirmed to good aerodynamic performances of the designed aerofoils, although no real shock-free pressure distributions could be achieved in the experiments and the highest aerodynamic efficiencies occurred always at higher lift coefficients, with pressure distributions already having shock waves. Author

A86-36207
INVERSE DESIGN OF SUPERCRITICAL NOZZLES AND CASCADES
E. SCHMIDT and P. BERGER (Stuttgart, Universitaet, West Germany) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 22, Feb. 1986, p. 417-432. refs

A computation method for the inverse design of supercritical cascades is described. It yields the flow field and the cascade geometry for a prescribed velocity distribution, which may be optimized by boundary-layer calculation. Some developments of the method for convenient application and high accuracy - automatic tuning of the upstream boundary distributions, local mesh refinement with emboxed regions for high resolution of steep gradients - are shown. Comparison between calculation and experiment of the complete flow field is made for a supercritical nozzle flow, and comparisons with another method for a turbine cascade. A supercritical compressor cascade and blades for a three-stage axial compressor have been designed. They produced lower losses and higher efficiency in comparison with conventional NACA blades. Author

A86-36285
THE METHOD OF FUNDAMENTAL SOLUTIONS IN AERODYNAMICS. II APPLICATIONS TO THE THEORY OF LIFTING SURFACES IN SUPERSONIC FLOW
L. DRAGOS (Bucuresti, Universitatea, Bucharest, Rumania) Archiwum Mechaniki Stosowanej (ISSN 0373-2029), vol. 37, no. 3, 1985, p. 221-230. refs

A new theory of the lifting surface in supersonic flow is given. The perturbation produced by a momentum source in uniform flow is determined, and the representation of the perturbation produced by the surface in the basic flow is obtained by assimilating the lifting surface by a continuous distribution of momentum sources of unknown intensity. The boundary conditions lead to the formula and the integral equation which determine the unknown functions. The method of fundamental solutions is shown to lead directly to the Homentcovschi representation and equation. The plane solution is obtained as a particular case. C.D.

A86-36458
INVESTIGATION OF HEAT TRANSFER IN SEPARATION REGIONS IN SUPERSONIC FLOW IN A LAVAL NOZZLE [ISSLEDOVANIE TEPLOOBMENA V OTRYVNYKH OBLASTIAKH, OBTEKAEMYKH SVERKHZVUKOVYM POTOKOM V SOPLE LAVALIA]
E. G. ZAULICHNYI and V. M. TROFIMOV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Jan.-Feb. 1986, p. 99-106. In Russian. refs

The paper describes experiments and an approximate calculation method intended to analyze heat transfer between a supersonic flow and a wall in a separation region arising on a cavity in the contour of the divergent part of a Laval nozzle. Attention is given to the behavior of the heat transfer coefficients on the cavity walls, and to the dependence of these coefficients on the longitudinal velocity gradient and Mach number at the separation point, as well as on the length of the horizontal wall of the cavity. In addition, a method for calculating heat transfer under the aforementioned conditions is proposed; the method assumes that a new boundary layer develops at the point of commencement of elevated pressure on the cavity wall, and takes into account the elevated level of flow turbulence in the attachment region. B.J.

A86-36459
CHARACTERISTICS OF THE INTERACTION OF INTERFERENCE AND DIFFRACTION FLOWS AT SUPERSONIC VELOCITIES [OSOBENNOSTI VZAIMODEISTVIIA INTERFERENTSIONNYKH I DIFRAKTSIONNYKH TECHENII PRI SVERKHZVUKOVYKH SKOROSTIAKH]
M. D. BRODETSKII, A. I. MAKSIMOV, and A. M. KHARITONOV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Jan.-Feb. 1986, p. 106-116. In Russian. refs

Oil-soot and laser visualization techniques were used to investigate the supersonic flow past a plate with a longitudinal projection in the form of a combination of outer and inner bilateral corners. Experiments were conducted at freestream Mach numbers of 2.27, 3, and 4 for wide ranges of attack and slip angles. A substantially three-dimensional mixed interference-diffraction flow was observed. The interference of shocks and their interaction with boundary layers in the case of limited vertical-edge height are accompanied by the diffraction of inner shocks on the edge of the outer corner, with the formation of additional vortex systems. B.J.

A86-37050*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NONLINEAR LIFT CONTROL AT HIGH SPEED AND HIGH ANGLE OF ATTACK USING VORTEX FLOW TECHNOLOGY
J. E. LAMAR (NASA, Langley Research Center, Hampton, VA) NATO, AGARD, Special Course on Fundamentals of Fighter Aircraft Design, Rhode-Saint-Genese, Belgium, Feb. 17-21, 1986, Paper. 24 p. refs

Nonlinear lift control at subsonic, transonic and low supersonic speeds owes its origin to the separated but organized vortical flows interacting with the wing upper surface. Since most of this flow originates near the wing or control-surface leading-edge, a variety of devices have been studied experimentally which interact with and/or control this flow in order to gain a beneficial effect. The benefits (effects) originally studied were only associated with lift enhancement. Whereas, now the studied benefits encompass performance increase, attention to changes in trimmed conditions and longitudinal stability, improvements in lateral stability, and the attendant variation with changing Mach number. For those devices that can be theoretically modeled, state-of-the-art computer codes have been used for device design and/or analysis. Comparisons at design and off-design conditions are presented for validation purposes. Author

N86-24657*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
UNSTEADY TRANSONIC FLOW CALCULATIONS FOR WING-FUSELAGE CONFIGURATIONS
J. T. BATINA Mar. 1986 16 p refs Presented at the 27th AIAA/ASME/ASCE/AHS Structures, Structural Dynamics and Materials Conference, San Antonio, Tex., 19-21 May 1986
(NASA-TM-87707; NAS 1.15:87707; AIAA-86-0862) Avail: NTIS HC A02/MF A01 CSCL 01A

Unsteady transonic flow calculations are presented for wing-fuselage configurations. Calculations are performed by extending the XTRAN3S unsteady transonic small-disturbance code to allow the treatment of a fuselage. Details of the XTRAN3S fuselage modeling are discussed in the context of the small-disturbance equation. Transonic calculations are presented for three wing-fuselage configurations with leading edge sweep angles ranging from 0 deg to 46.76 deg. Simple bending and torsion modal oscillations of the wing are calculated. Sectional lift and moment coefficients for the wing-alone and wing-fuselage cases are compared and the effects of fuselage aerodynamic interference on the unsteady wing loading are revealed. Tabulated generalized aerodynamic forces used in flutter analyses, indicate small changes in the real in-phase component and as much as a 30% change in the imaginary component when the fuselage is included in the calculation. These changes result in a 2 to 5% increase in total magnitude and a several degree increase in phase. E.A.K.

N86-24658*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A NUMERICAL ANALYSIS APPLIED TO HIGH ANGLE OF ATTACK THREE-DIMENSIONAL INLETS
D. P. HWANG 1986 16 p refs Presented at the 22nd Joint Propulsion Conference, Huntsville, Ala., 16-18 Jun. 1986; sponsored by AIAA, ASME, SAE, and ASEE
(NASA-TM-87298; E-3004; NAS 1.15:87298; AIAA-86-1627)
Avail: NTIS HC A02/MF A01 CSCL 01A

The three-dimensional analytical methods used to analyze subsonic high angle of attack inlets are described. The methods are shown to be in good agreement with experimental results for various three-dimensional high angle of attack inlets. The methods are used to predict aerodynamic characteristics of scarf and slotted-lip inlets. E.A.K.

N86-24659*# Boeing Commercial Airplane Co., Seattle, Wash.
NATURAL LAMINAR FLOW FLIGHT EXPERIMENTS ON A SWEPT WING BUSINESS JET-BOUNDARY LAYER STABILITY ANALYSES Contractor Report, Sep. 1983 - Mar. 1985
R. A. ROZENDAAL May 1986 98 p refs
(Contract NAG1-401)
(NASA-CR-3975; NAS 1.26:3975; D6-53071) Avail: NTIS HC A05/MF A01 CSCL 01A

The linear boundary layer stability analyses and their correlation with data of 18 cases from a natural laminar flow (NLF) flight test program using a Cessna Citation 3 business jet are described. The transition point varied from 5% to 35% chord for these conditions, and both upper and lower wing surfaces were included. Altitude varied from 10,000 to 43,000 ft and Mach number from 0.3 to 0.8. Four cases were at nonzero sideslip. Although there was much scatter in the results, the analyses of boundary layer stability at the 18 conditions led to the conclusion that crossflow instability was the primary cause of transition. However, the sideslip cases did show some interaction of crossflow and Tollmien-Schlichting disturbances. The lower surface showed much lower Tollmien-Schlichting amplification at transition than the upper surface, but similar crossflow amplifications. No relationship between Mach number and disturbance amplification at transition could be found. The quality of these results is open to question from questionable wing surface quality, inadequate density of transition sensors on the wing upper surface, and an unresolved pressure shift in the wing pressure data. The results of this study show the need for careful preparation for transition experiments. Preparation should include flow analyses of the test surface, boundary layer disturbance amplification analyses, and assurance of adequate surface quality in the test area. The placement of necessary instruments and usefulness of the resulting data could largely be determined during the pretest phase. Author

N86-24661*# Old Dominion Univ., Norfolk, Va.
VAPOR-SCREEN FLOW-VISUALIZATION EXPERIMENTS IN THE NASA LANGLEY 0.3-M TRANSONIC CRYOGENIC TUNNEL Final Report
G. V. SELBY Washington NASA May 1986 38 p refs
(Contract NGT-47-003-029)
(NASA-CR-3984; NAS 1.26:3984) Avail: NTIS HC A03/MF A01 CSCL 01A

The vortical flow on the leeward side of a delta-wing model has been visualized at several different tunnel conditions in the NASA Langley 0.3-Meter Transonic Cryogenic Tunnel using a vapor-screen flow-visualization technique. Vapor-screen photographs of the subject flow field are presented and interpreted relative to phenomenological implications. Results indicate that the use of nitrogen fog in conjunction with the vapor-screen technique is feasibile. Author

N86-24663*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NONISENTROPIC UNSTEADY THREE DIMENSIONAL SMALL DISTURBANCE POTENTIAL THEORY
M. D. GIBBONS, W. WHITLOW, JR., (Purdue Univ., West Lafayette, Ind.), and M. H. WILLIAMS, (Purdue Univ., West Lafayette, Ind.) Apr. 1986 12 p refs Presented at the 27th AIAA/ASME/ASCE/AHS Structures, Structural Dynamics and Materials Conference, San Antonio, Tex., 19-21 May 1986
(Contract NAG1-372)
(NASA-TM-87726; NAS 1.15:87726; AIAA-PAPER-86-0863)
Avail: NTIS HC A02/MF A01 CSCL 01A

Modifications that allow for more accurate modeling of flow fields when strong shocks are present were made into three dimensional transonic small disturbance (TSD) potential theory. The Engquist-Osher type-dependent differencing was incorporated into the solution algorithm. The modified theory was implemented in the XTRAN3S computer code. Steady flows over a rectangular wing with a constant NACA 0012 airfoil section and an aspect ratio of 12 were calculated for freestream Mach numbers (M) of 0.82, 0.84, and 0.86. The obtained results are compared using the modified and unmodified TSD theories and the results from a three dimensional Euler code are presented. Nonunique solutions in three dimensions are shown to appear for the rectangular wing as aspect ratio increases. Steady and unsteady results are shown for the RAE tailplane model at M = 0.90. Calculations using unmodified theory, modified theory and experimental data are compared. Author

N86-24664*# United Technologies Corp., East Hartford, Conn.
ALESEP. PART 2: A COMPUTER PROGRAM FOR THE ANALYSIS OF LEADING EDGE SEPARATION BUBBLES ON INFINITE SWEPT WINGS
R. L. DAVIS 3 Feb. 1986 75 p refs
(Contract NAS1-16585)
(NASA-CR-178015; NAS 1.26:178015) Avail: NTIS HC A04/MF A01 CSCL 01A

A program called ALESEP is presented for the analysis of the inviscid-viscous interaction which occurs due to the presence of a closed laminar-transitional separation bubble on an airfoil or infinite swept wing. The ALESEP code provides an iterative solution of the boundary layer equations expressed in an inverse formulation coupled to a Cauchy integral representation of the inviscid flow. This interaction analysis is treated as a local perturbation to a known solution obtained from a global airfoil analysis; hence, part of the required input to the ALESEP code are the reference displacement thickness and tangential velocity distributions. Special windward differencing may be used in the reversed flow regions of the separation bubble to accurately account for the flow direction in the discretization of the streamwise convection of momentum. The ALESEP code contains a forced transition model based on a streamwise intermittency function, a natural transition model based on a solution of the integral form of the turbulent kinetic energy equation, and an empirical natural transition model. Author

N86-24665*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ROTOR PERFORMANCE CHARACTERISTICS FROM AN AEROACOUSTIC HELICOPTER WIND-TUNNEL TEST PROGRAM
D. R. HOAD, J. W. ELLIOTT, and N. M. ORIE May 1986 99 p refs
(Contract DA PROJ. 1L1-62209-AH-76)
(NASA-TM-87661; L-16078; NAS 1.15:87661; AVSCOM-TM-86-B-1) Avail: NTIS HC A05/MF A01 CSCL 01A

An investigation of helicopter rotor noise at model scale was conducted in the Langley 4 by 7 meter tunnel. The program described was the first of a planned three-phase project whose purpose was to examine the characteristic noise mechanism involved in main rotor/tail rotor interaction noise. This first phase was conducted with a main rotor only, in order to identify the characteristic noise generated by only the main rotor. The aerodynamic operating conditions of the rotor system were defined during the test. The acoustic data were properly referenced. Author

N86-24666# Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.
THE BEHAVIOUR AND PERFORMANCE OF LEADING EDGE VORTEX FLAPS
D. G. ELLIS Feb. 1986 79 p refs
(CAR-8601; ISBN-0-947767-34-7) Avail: NTIS HC A05/MF A01

A series of leading edge vortex flaps was studied in subsonic wind tunnel tests to determine the possibility of improving the lift/drag ratio. Various flap sizes and deflection angles, and trailing edge flap effects on leading edge vortex flap behavior were investigated. Lift/drag ratio improvements of more than 2% are found at moderate angles of attack. It is indicated that the vortex flap can improve the efficiency of slender wings when operating in aerodynamic environments which are governed by leading edge separation and flow. E.A.K.

N86-24667*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
IN-FLIGHT MEASUREMENTS OF WING ICE SHAPES AND WING SECTION DRAG INCREASES CAUSED BY NATURAL ICING CONDITIONS
K. MIKKELSEN, N. JUHASZ, R. RANAUDO, R. MCKNIGHT, R. FREEDMAN, and J. GREISSING May 1986 27 p refs
(NASA-TM-87301; E-3013; NAS 1.15:87301) Avail: NTIS HC A03/MF A01 CSCL 01A

Aircraft icing flight research was performed in natural icing conditions with a twin engine computer type STOL aircraft. In-flight measurements were made of the icing cloud environment, the shape of the ice accretion on the wing, and the corresponding increase in the wing section drag. Results are presented for three icing encounters. On one flight, the wing section drag coefficient increased 35 percent over the uniced baseline for cruise conditions while a 43 percent increase was observed at an aircraft angle of attack of 6.2 degrees. Author

N86-24668# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
INVESTIGATION OF ROLLING-UP AND INTERACTION OF LEADING-EDGE AND TRAILING-EDGE VORTEX SHEETS ON A SLENDER DELTA WING
X. YIN, N. XIA, and G. DENG 15 Jan. 1986 24 p refs Transl. into ENGLISH from Lixue Xueboa (China), v. 16, no. 5, Sep. 1984 p 454-462
(AD-A163692; FTD-ID(RS)T-1041-85) Avail: NTIS HC A02/MF A01 CSCL 20D

The objective of this paper is to establish a simple two-dimensional theoretical model in an attempt to use a computer to numerically simulate the experimental results of Hummel regarding the rolling-up and interaction of the leading-edge and trailing edge vortex sheets on a delta wing. It was found experimentally that when the leading vortex is present the trailing-edge vortex sheet will roll up another vortex downstream from the trailing-edge. Furthermore, the circulation of the leading-edge vortex is opposite in direction to that of the trailing-edge vortex. The numerical results are in good agreement with the experimental pictures. GRA

N86-24669# Texas Univ., Austin. Dept. of Aerospace Eng. and Eng. Mech.
EXPERIMENTAL STUDY OF THE SUPERSONIC TURBULENT BOUNDARY LAYER ON A BLUNTED AXISYMMETRIC BODY Final Report, 1 Aug. 1982 - 31 Jul. 1985
D. S. DOLLING 30 Sep. 1985 25 p refs
(Contract DAAG29-84-M-0432)
(AD-A163736; ARO-22362.1-EG) Avail: NTIS HC A02/MF A01 CSCL 20D

Surface pressure distributions and turbulent boundary layer velocity profiles have been measured on a tangent-ogive cylinder model at small angles of attack (0-4.5 deg) in a high Reynolds

number, Mach 3 airflow. The model wall temperature was approximately adiabatic. The measurements were made using pointed, tangent-hemisphere and flat-faced nose tips. The effects of tip blunting on the wind- and leeside velocity profiles, integral thicknesses, shape factor, power law exponent, skin friction coefficient and wake strength parameter are presented. It is shown that the results obtained using different geometry tips can be correlated using a bluntness length-scale obtained by integration of the local tip surface angle from the stagnation point to the point corresponding to shock detachment. GRA

N86-24670# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
USE OF STATE ESTIMATION TO CALCULATE ANGLE-OF-ATTACK POSITION ERROR FROM FLIGHT TEST DATA M.S. Thesis
T. H. THACKER Oct. 1985 99 p refs
(AD-A163962; AFIT/GAE/AA/85J-3) Avail: NTIS HC A05/MF A01 CSCL 20D

This thesis determined the position errors of an aircraft's angle-of-attack (AOA) sensor using state estimation with flight test data. The position errors were caused by local flow and upwash and were found to be a function of AOA and Mach number. The test aircraft used in this project was a T-38A Talon supersonic trainer from the USAF Test Pilot School configured with a Vought yaw and pitch system noseboom and an internal Aydin-Vector data acquisition system (DAS). The position errors were found by calculating the true AOA using equations of motion and DAS parameters. The data from the DAS were noise corrupted and had to be filtered. This was accomplished using state estimation in a Kalman filter. The estimated AOA was compared to the measured AOA from the noseboom sensor to obtain the position error. Accurate position errors were obtained, even in dynamic maneuvers. This method should be considered in future AOA error testing. The method was accurate enough to identify a hysteresis error in the T-38's AOA sensor of + or - 0.5 degrees, which was confirmed by ground calibration. GRA

N86-25325 ESDU International Ltd., London (England).
INCREMENTS IN AEROFOIL MAXIMUM LIFT COEFFICIENT DUE TO DEPLOYMENT OF VARIOUS HIGH-LIFT DEVICES
Dec. 1985 36 p refs
(ESDU-85033; ISBN-0-85679-539-9; ISSN-0141-397X) Avail: ESDU

This data item ESDU 85033, an addition to the Aerodynamics Sub-Series, uses a semi-empirical method to predict the increase in the maximum lift coefficient from that of the basic aerofoil either estimated by the method of ESDU 84026 or obtained by test. Devices considered are plain leading-edge flaps, slats, Krueger flaps with or without vents, and plain and split trailing-edge flaps. The method applies to low speed flow for a practical range of Reynolds number and geometries, and also yields the zero lift incidence with the devices deployed. Comparison of prediction with test is made, and standard deviations are tabulated for each type of device. The overall accuracy for all devices over 141 experimental points is a standard deviation of 0.018 in maximum lift coefficient. Author

N86-25328*# Kansas Univ. Center for Research, Inc., Lawrence. Flight Research Lab.
TRANSONIC AIRFOIL ANALYSIS AND DESIGN IN NONUNIFORM FLOW
J. F. CHANG and C. E. LAN Washington NASA Jun. 1986 84 p refs
(Contract NAG1-308)
(NASA-CR-3991; NAS 1.26:3991; CRINC-FRL-602-2) Avail: NTIS HC A05/MF A01 CSCL 01A

A nonuniform transonic airfoil code is developed for applications in analysis, inverse design and direct optimization involving an airfoil immersed in propfan slipstream. Problems concerning the numerical stability, convergence, divergence and solution oscillations are discussed. The code is validated by comparing with some known results in incompressible flow. A parametric investigation indicates that the airfoil lift-drag ratio can be increased by decreasing the thickness ratio. A better performance can be achieved if the airfoil is located below the slipstream center. Airfoil characteristics designed by the inverse method and a direct optimization are compared. The airfoil designed with the method of direct optimization exhibits better characteristics and achieves a gain of 22 percent in lift-drag ratio with a reduction of 4 percent in thickness. Author

N86-25329# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
PITCH-LOCATION EFFECTS ON DYNAMIC STALL M.S. Thesis
R. L. DIMMICK Dec. 1985 188 p refs
(AD-A164322; AFIT/GAE/AA/85D-4) Avail: NTIS HC A09/MF A01 CSCL 20D

Experimental investigations were conducted in the AFIT Smoke Tunnel to study the effects of pitch-location on dynamic stall. A NACA 0015 airfoil was rotated about four different locations at a constant angular rate and digital position and pressure information were recorded. This information was then converted into airfoil pressure distributions and integrated numerically to obtain airfoil force coefficients. Results of this investigation showed a direct relationship between the dynamic-stall angle of attack and the non-dimensionalized angular rotation rate, ND, defined as one-half the airfoil chord length times the angular rate divided by the freestream velocity. Based on the rotation points forward of the mid-chord, it was also shown that dynamic stall is delayed as the pitch location is moved aft from the leading edge. Experimental data was obtained for pitch locations of .08c, .25c, .50c and .61c and non-dimensional angular rates between .011 and .065. GRA

N86-25534# Joint Publications Research Service, Arlington, Va.
HYPERSONIC FLOW AROUND A WING AT LARGE ANGLES OF ATTACK WITH DETACHED COMPRESSION JUMP Abstract Only
V. N. GOLUBKIN and V. V. NEGODA *In its* USSR Report: Engineering and Equipment (JPRS-UEQ-86-006) p 87 14 Mar. 1986 refs Transl. into ENGLISH from Izv. Akad. Nauk SSSR: Mekhanika Zhidosti i Gaza (USSR), no. 3, May-Jun. 1985 p 149-157 Original language document was announced in IAA as A85-44788
Avail: NTIS HC A06/MF A01

A study is made of the flow around a thin delta wing with finite delta angle at large angles of attack. A theory presented in earlier works describes a conical flow with a compression jump attached only at the apex of the delta wing. Possible conditions of flow around the wing at large angles of attack are classified. The results indicate that the asymptotic theory of the shock layer for a wing of finite span is the most general, since it describes all three qualitatively different flow conditions; with a compression jump attached to the leading edge, attached only to the apex or completely detached. A general solution is obtained which allows for nonequilibrium physicochemical processes and heat radiation of the gas at high temperatures. Author

N86-25558# Joint Publications Research Service, Arlington, Va.
SUPERSONIC FLOW AROUND BLUNT PERFORATED SHIELDS Abstract Only
S. V. GUVERNYUK, K. G. SAVINOV, and G. S. ULYANOV *In its* USSR Report: Engineering and Equipment (JPRS-UEQ-86-001) p 2 24 Jan. 1986 Transl. into ENGLISH from Izvestiya Akademii Nauk SSSR: Mekhanika Zhidkosti i Gaza (Moscow, USSR), no. 1, Jan. - Feb. 1985 p 143-149 Original language document was announced in IAA as A85-28442
Avail: NTIS HC A06/MF A01

Experimental results are presented on flow past thin porous metallic disks and square plates at high angles of attack (75 to 90 deg), Mach numbers of 2.0 to 3.0 and Reynolds number of 2 to 4 million in a supersonic wind tunnel. The features characterizing flow past such screens are found to be determined by intense self sustaining gas injection into the base region. The dependence of the aerodynamic characteristics on the porosity coefficient of the screen is studied for a freestream Mach number of 3. B.J.

N86-25560# Joint Publications Research Service, Arlington, Va.
FLOW AROUND DELTA WINGS WITH BROKEN-LINE LEADING EDGES Abstract Only
A. I. SHVETS *In its* USSR Report: Engineering and Equipment (JPRS-UEQ-86-001) p 3 24 Jan. 1986 Transl. into ENGLISH from Izvestiya Akademii Nauk SSSR: Mekhanika Zhidkosti i Gaza (Moscow, USSR), no. 1, Jan. - Feb. 1985 p 171-175
Avail: NTIS HC A06/MF A01

Two design concepts of delta wings for optimal performance at hypersonic velocities are compared on the basis of experimental data and analytic evaluation. Plain delta wings triangular in the plan view, with the dihedral angle ranging from 180 deg in a flat triangular wing to 0 deg in a completely folded one were considered. Tests were performed on such wings with 150 to 180 deg at angles of attack from -2 to +15 deg in a wind tunnel with the wind velocity varied over the Mach number 4 to 8. Tests were performed on five models of delta wing with broken line leading edges with a 70 deg sweepback angle of the nose and a 50 deg sweepback angle of the tail, all having the same 100 mm half span in the plan view but each having a different dihedral angle of 60, 100, 140, 180, and 220 deg respectively. Both the lift coefficient and the drag coefficient were measured in the wind tunnel at a wind velocity corresponding to the Mach number 3, for determining their dependence and the lift to drag ratio on the angle of attack. The aerodynamic characteristics of the wing models with the optimal dihedral angle were found to be better than those of flat wings with broken line leading edges. Author

N86-25562# Joint Publications Research Service, Arlington, Va.
MOVEMENT OF FLEXIBLE WING AT SUPERSONIC VELOCITY UNDER INFLUENCE OF RANDOM GUST Abstract Only
B. A. YERSHOV *In its* USSR Report: Engineering and Equipment (JPRS-UEQ-86-001) p 4-5 24 Jan. 1986 Transl. into ENGLISH from Vestnik Leningradskogo Universiteta: Matematika, Mekhanika, Astronomiya (Leningrad, USSR), no. 1, Jan. - Mar. 1985 p 59-63
Avail: NTIS HC A06/MF A01

The motion of an elastic wing of infinite span in an ideal compressible fluid under the action of a turbulent stream is modeled by a random vertical gust. The unperturbed motion is the movement of a rigid wing at constant horizontal velocity greater than the speed of sound in the undisturbed stream. The perturbed motion is the deformation of the wing. The problem is reduced to an integro-differential equation in partial derivatives. The problem is one of connected aeroelasticity, such that the deformation of the elastic wing excited by the air stream changes the air stream itself. The present problem is determined by the wave equation for the excited velocity potential and the equation of oscillation of the infinite wing plate, related by the boundary condition on the wing. Author

03

AIR TRANSPORTATION AND SAFETY

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

A86-33780
SETTING ACCEPTABLE LEVELS OF SAFETY FOR THE NATIONAL AIRSPACE SYSTEM
A. C. BUSCH and B. F. COLAMOSCA (FAA, Technical Center, Atlantic City, NJ) IN: Human Factors Society, Annual Meeting, 29th, Baltimore, MD, September 29-October 3, 1985, Proceedings. Volume 1 . Santa Monica, CA, Human Factors Society, 1985, p. 52-56.

The FAA is engaged in a major effort to safely reduce the vertical separation standard to 1,000 feet between aircraft flying above 29,000 feet, and to develop system performance requirements which, if met, will ensure safe operation of the National Airspace System. To accomplish this an overall program structure of defining risk/safety criteria, a risk assessment program, and a risk management program are proposed. Included in this effort is an extensive in situ data collection effort. Hopefully, the conclusion of this effort will result in providing to management the quantitative decision tools and information necessary to make the decision for the safe reduction of the vertical separation standard and to implement changes to the National Airspace System to support new separation procedures. Author

A86-33799
PILOT ERROR ACCIDENTS - A TOTAL SYSTEM APPROACH TO ANALYSIS
P. G. STRINGER and D. D. RILEY (Essex Corp., Alexandria, VA) IN: Human Factors Society, Annual Meeting, 29th, Baltimore, MD, September 29-October 3, 1985, Proceedings. Volume 1 . Santa Monica, CA, Human Factors Society, 1985, p. 526-530.

A total system approach (TSA) for evaluating aircraft/pilot performance and safety, and for recommending aircraft design improvements is described. The TSA involves an analysis of pilot error accident data in order to develop a model of task performance. The system elements of the TSA model, which include mission, aircraft characteristics, environment, pilot capacity, and cockpit interface, are examined. The model assesses the balance between flight requirements and pilot capabilities. The development of an aircraft and accident data management and analysis program is proposed. I.F.

A86-35365* Analytical Mechanics Associates, Inc., Mountain View, Calif.
DESIGN OF AN ADVANCED FLIGHT PLANNING SYSTEM
J. A. SORENSEN and T. GOKA (Analytical Mechanics Associates, Inc., Mountain View, CA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 663-668. refs
(Contract NAS1-17345)

The demand for both fuel conservation and four-dimensional traffic management require that the preflight planning process be designed to account for advances in airborne flight management and weather forecasting. The steps and issues in designing such an advanced flight planning system are presented. Focus is placed on the different optimization options for generating the three-dimensional reference path. For the cruise phase, one can use predefined jet routes, direct routes based on a network of evenly spaced grid points, or a network where the grid points are existing navaid locations. Each choice has its own problem in determining an optimum solution. Finding the reference path is further complicated by choice of cruise altitude levels, use of a time-varying weather field, and requiring a fixed time-of-arrival (four-dimensional problem). Author

A86-35367
PRACTICAL CONSIDERATIONS IN OPTIMAL FLIGHT MANAGEMENT COMPUTATIONS
S. LIDEN (Sperry Corp., Aerospace and Marine Group, Phoenix, AZ) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 675-681. refs

The relationships between cost index, speed, flight time, fuel burn, and wind are investigated via simulations of flight of a DC-10 aircraft, as controlled by a flight management computer system (FMCS), over a representative 1000 NM flight plan. In this context, a two-part procedure is described for achieving minimum total flight cost; that is, direct operating cost plus arrival error cost. First the optimum cost index and the associated optimum arrival time (which sometimes turns out to be the scheduled arrival time) are sought. A simple method for fine tuning the speed to achieve the desired arrival time is then described. The methods are practical to incorporate in the FMCS. Author

A86-35368
TIME NAVIGATION BENEFITS IN EN ROUTE METERED ATC
R. W. SCHWAB and R. L. ERWIN, JR. (Boeing Commercial Airplane Co., Seattle, WA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 682-686. refs

This paper evaluates benefits to be expected from an early use of Time Navigation (TNAV) capabilities now under engineering development for Flight Management Computer Systems (FMS) operating in the U.S. into airports where En Route Metering (ERM) is currently operational or is scheduled to become operational. The benefits estimates are based on the ability to define and fly fuel-efficient, ATC compatible profiles to meet metering objectives into busy terminal areas. Near-term benefits are quantified from simulation studies of two currently metered airports, Denver and Dallas-Ft. Worth, projected to all planned ERM airports. Consideration of frequency of obtaining nonconflicting 'TNAV Clearances' is examined. The savings quantified are based on the use of improved delay absorption techniques using an enhanced FMS. Future operations of TNAV may provide additional fuel savings through reduction of system delay levels and the incorporation of optimization methods to maximize fuel savings.
Author

A86-35449
DEVELOPMENT OF AN AUTHORITATIVE AID TO WIND SHEAR TRAINING
C. R. HIGGINS (Boeing Commercial Airplane Co., Seattle, WA) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 195-197.
(SAE PAPER 851919)

The development of an authoritative aid to provide pilots with wind shear training guidance is proposed. Analyses of accident data reveal that it is necessary to establish flight crew training requirements for handling wind shear. The need to coordinate meteorological, engineering, flight operation, and flight crew training data in order to produce the authoritative aid is discussed. I.F.

A86-35450
UNITED AIRLINES WINDSHEAR TRAINING UPDATE
D. A. SIMMON, JR. (United Airlines, Inc., Chicago, IL) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 199-208.
(SAE PAPER 851920)

The formation of the United Airlines wind shear training program is described. The human engineering aspects of wind shear training and crew coordination are examined. Flight crew actions regarding wind shear involve: (1) avoidance of wind shear; (2) evaluation of the weather conditions; (3) following standard takeoff and landing techniques; (4) following precautions during takeoff and landing; and (5) recovery from wind shear. I.F.

A86-35451
COCKPIT COMMUNICATION AND AIRCRAFT SAFETY - AN EMPIRICAL STUDY
J. WOELFEL and B. STOVER (New York, State University, Albany) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985. Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 213-224. refs
(SAE PAPER 851858)

Recent investigations into the cause of aircraft accidents have revealed that the way flight-crew members interact has a dramatic effect on the ultimate outcome of a flight. The Galileo System is presented as a research tool designed to measure attitudes within any cognitive system for a given population. The results of one Galileo study (conducted on general aviation crews) demonstrate that the average structure of flight crew attitudes is without defects or areas for concern. The study concluded by calling for caution in changing an attitude system that has served the aviation system well. K.K.

A86-35452
FAULTY COCKPIT COMMUNICATION AS A FACTOR IN THE FAILURE OF FLIGHT 90
D. A. COUCHMAN (New Mexico State University, Las Cruces) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 225-230. refs
(SAE PAPER 851859)

The importance of cockpit communication is described by analyzing flight data. The relationship between poor cockpit communication and role differentiation, problem solving strategies, lack of decisive command, and crew attitude is investigated. The need for a good interface between cockpit automation and the crew is examined. The improvement of aviation safety through group interaction training is discussed. I.F.

A86-35456
TWIN-ENGINE TRANSPORT EXTENDED RANGE OPERATIONS
J. HOWELL (Air Line Pilots Assocation International, Washington, DC) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 389-395.
(SAE PAPER 851960)

Design improvements recommended by pilots for extended range operations with twin-engine transport aircraft (ETOPS) are described. The need for hardware design changes in the fuel tank and the flight management computer system is examined. New standards for propulsion system reliability APUs, enroute alternate weather minima, validation flight, and status software are proposed. The advantages these recommendations will provide to ETOPS are discussed. I.F.

A86-35609
FAA CERTIFICATION CRITERIA FOR LIGHTNING PROTECTION OF HELICOPTER DIGITAL ENGINE CONTROL
R. L. VAUGHN (FAA, Fort Worth, TX) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 131-136. refs

'Change 2' to the FAA advisory circular 29-2, 'Certification of Transport Category Rotorcraft', concerns the lightning strike-related requirements for helicopters equipped with full authority digital engine control systems. Attention is presently given to the advisory circular's characterization of the worst case lightning environment, and the types of tests and analyses that are acceptable in lieu of a full scale, full level vehicle test. The pilot must be able to maintain helicopter operation through the worst case scenario. O.C.

A86-35656* Sikorsky Aircraft, Stratford, Conn.
THE PERFORMANCE CHARACTERISTICS OF SIMULATED ICE ON ROTORCRAFT AIRFOILS
R. J. FLEMMING (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT), R. J. SHAW (NASA, Lewis Research Center, Cleveland, OH), and J. D. LEE (Ohio State University, Columbus) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 743-757. refs

Attention is given to the results of NASA-sponsored rotorcraft icing research which was aimed at the formulation of a predictive method for the computation of performance penalties due to rotor and airfoil icing. Parametric simulated ice test results obtained in wind tunnels are compared with those of other investigations. These comparisons indicate that proper design of simulated ice shapes can adequately represent ice on airfoil sections, with incremental lift, drag, and pitching moments matching those generated in icing wind tunnels. O.C.

N86-24672*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LOADS AND MOTIONS OF AN F-106B FLYING THROUGH THUNDERSTORMS
R. M. WINEBARGER May 1986 53 p refs
(NASA-TM-87671; L-16014; NAS 1.15:87671) Avail: NTIS HC A04/MF A01 CSCL 01C

Data are presented on loads and motions of a NASA F-106B airplane flying inside thunderstorms. No significant differences in piloting techniques were observed among the three pilots involved. It is indicated that airliners in normal operations occasionally encounter turbulence almost as severe as those encountered in these thunderstorm flights. E.A.K.

N86-24673*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ICE DETECTOR Patent Application
L. M. WEINSTEIN, inventor (to NASA) 31 Mar. 1986 14 p
(NASA-CASE-LAR-13403-1; NAS 1.71:LAR-13403-1; US-PATENT-APPL-SN-846429) Avail: NTIS HC A02/MF A01 CSCL 01C

An ice detector for aircraft that can accurately determine the presence and thickness of ice and control devices to remove it is proposed. A small depression on the surface of an aircraft structure is filled with a plastic or epoxy material. Two capacitance gauges and a temperature gauge are embedded in this material near the surface. When moisture forms on the surface the capacitance of each of the gauges changes. This signal combined with the signal from a temperature gauge determines whether the moisture is water or ice. If ice is present its thickness may be measured based on the output of the second capacitance gauge. Once the presence of ice is determined, the thickness is easily determined. The output of the device may be used to provide an indication to the pilot or to automatically control heating elements to remove the ice. Author

N86-24674# Naval Postgraduate School, Monterey, Calif.
APPLICATION OF ARTIFICIAL INTELLIGENCE TO IMPROVE AIRCRAFT SURVIVABILITY M.S. Thesis
W. L. DECKER Dec. 1985 76 p refs
(AD-A164172; AD-E750890) Avail: NTIS HC A05/MF A01 CSCL 06D

The hazards associated with the critical flight phases of civil as well as military flight operations can seriously degrade pilot efficiency, and therefore aircraft survivability, if the number or complexity of tasks that the pilot must manage exceeds his/her capabilities. This thesis explores the feasibility of applying artificial intelligence (AI) research to the construction of a Survivability Manager (SM) knowledge based system (KBS) that will assist the pilot by assuming a portion of the survivability task management load. The application of KBS principles to survivability management is illustrated using the normal and emergency management procedures for a hypothetical engine fuel supply system as a working example. Though the SM is not a reality today, there is considerable research in both AI and survivability enhancement studies to draw upon. It is recommended that a prototype be developed using currently available assets to further investigate the feasibility of the Survivability Manager. GRA

N86-24675# National Transportation Safety Board, Washington, D. C.
AIRCRAFT ACCIDENT/INCIDENT SUMMARY REPORTS: DENVER, COLORADO, AUGUST 19, 1983; BLOUNTVILLE, TENNESSEE, JULY 16, 1983; TUCSON, ARIZONA, FEBRUARY 6, 1983, COCKEYSVILLE, MARYLAND, APRIL 28, 1984; AKRON, OHIO, SEPTEMBER 30, 1984; SEATTLE, WASHINGTON, OCTOBER 18, 1984; MIAMI, FLORIDA, NOVEMBER 11, 1983
30 Sep. 1985 63 p
(PB85-910409; NTSB/AAR-85/01/SUM) Avail: NTIS HC A04/MF A01; HC also available on subscription, North American Continent price $60.00, all others write for quote CSCL 13L

Reports of eight separate aircraft accidents investigated by the National Transportation Safety Board are presented. The accident locations and their dates are as follows: Denver, Colorado, August 19, 1983; Blountville, Tennessee, July 16, 1983; Tucson, Arizona, February 6, 1983; Sioux Falls, South Dakota, December 20, 1983; Cockeysville, Maryland, April 28, 1984; Akron, Ohio, September 30, 1984; Seattle, Washington, October 18, 1984; and Miami, Florida, November 11, 1983. A brief containing the probable cause of accident is included for each case. GRA

N86-25331# Lockheed-California Co., Burbank.
KRASH DYNAMICS ANALYSIS MODELING: TRANSPORT AIRPLANE CONTROLLED IMPACT DEMONSTRATION TEST Final Report, Jan. 1984 - Sep. 1984
G. WITTLIN and B. LABARGE Mar. 1986 178 p refs Revised
(Contract DTFA03-84-C-00004)
(DOT/FAA/CT-85/9-REV; LR-30776-REV) Avail: NTIS HC A09/MF A01

A transport airplane Controlled Impact Demonstration (CID) test is analyzed with program KRASH. Prior to modeling the test conditions, supporting analysis of both narrow-body and wide-body transport airplane frame segments were modeled with KRASH and compared to existing test results. The results of the analysis are utilized as input data for the KRASH CID model. Prior to the CID test a narrow-body transport airplane was impacted with the ground, via a free fall drop, to obtain structure crush and damage data. The KRASH modeling of this test was used to refine the CID KRASH model. The CID KRASH model is exercised to obtain anticipated floor acceleration, underside crush, fuselage forces, and deflections. All KRASH modeling is performed utilizing current enhancement features. Recent KRASH85 coding changes; KRASH models and results for both narrow-body and wide-body transport airplane frame section drop tests; KRASH model and results for a narrow-body airplane drop test; KRASH model and results for a CID test; and conclusions based on the CID pre-test analysis results are presented. Author

N86-25332# National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
AIRCRAFT ACCIDENT REPORT: AIR CANADA FLIGHT 797, MCDONNELL DOUGLAS DC-9-32, C-FTLU, GREATER CINCINNATI INTERNATIONAL AIRPORT, COVINGTON, KENTUCKY, JUNE 2, 1983
31 Jan. 1986 118 p
(PB86-910402; NTSB-AAR-86-02) Avail: NTIS MF A01; also available on subscription, North American Continent price HC $60.00/year; all others write for quote CSCL 01B

On June 2, 1983, Air Canada Flight 797, a McDonnell Douglas DC-9-32, of Canadian Registry C-FTLU, was a regularly scheduled international passenger flight from Dallas, Texas, to Montreal, Quebec, Canada, with an en route stop at Toronto, Canada. The flight left Dallas with 5 crewmembers and 41 passengers on board. About 1903, eastern daylight time, while en route at flight level 330, the cabin crew discovered a fire in the aft lavatory. After contacting air traffic control (ATC) and declaring an emergency, the crew made an emergency descent, and ATC vectored Flight 797 to the Greater Cincinnati International Airport, Covington, Kentucky. At 1920.09, eastern daylight time, Flight 797 landed on runway 27L at the Greater Cincinnati International Airport. As the pilot stopped the airplane, the airport fire department was in place and began firefighting operations. 23 passengers were not able to get out of the plane and died in the fire. The airplane was destroyed. GRA

N86-25333# National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
AIRCRAFT ACCIDENT/INCIDENT SUMMARY REPORTS: CONCORD, CALIFORNIA, JULY 14, 1984; ATLANTA, GEORGIA, SEPTEMBER 24, 1984; JASPER, ALABAMA, DECEMBER 16, 1984; AVALON, CALIFORNIA, JANUARY 30, 1984; CHARLOTTESVILLE, VIRGINIA, FEBRUARY 17, 1984; KANSAS CITY, KANSAS, JANUARY 9, 1985
31 Dec. 1985 46 p
(PB86-910410; NTSB-AAR-85-02-SUM) Avail: NTIS MF A01; also available on subscription, North American Continent price HC $60.00/year; all others write for quote CSCL 01B

The publication is a compilation of the reports of six separate aircraft accidents investigated by the National Transportation Safety Board. The accident locations and their dates are as follows: Concord, California, July 14, 1984; Atlanta, Georgia, September 24, 1984; Jasper, Alabama, December 16, 1984; Avalon, California, January 30, 1984; Charlottesville, Virginia, February 17, 1984; and Kansas City, Kansas, January 9, 1985. A Brief of Accident *containing the probable cause is included for each case.* GRA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A86-33741#
NEW DEVELOPMENTS IN ANTENNAS OF CLASSICAL RADIO NAVIGATIONAL AND LANDING SYTEMS [NEUE ENTWICKLUNGEN VON ANTENNEN KLASSISCHER FUNKNAVIGATIONSUND LANDESYSTEME]
G. GREVING (Standard Elektrik Lorenz AG, Stuttgart, West Germany) (URSI and Nachrichtentechnische Gesellschaft, Gemeinsame Tagung, Kleinheubach, West Germany, Oct. 7-11, 1985) Kleinheubacher Berichte (ISSN 0343-5725), vol. 29, 1986, p. 453-458. In German. refs

The development of three new high-performance antennas for the VOR (Very high frequency Omnidirectitonal Range) TACAN (Tactical Air Navigation), and ILS (Instrumentenlandesystem) navigational systems is reviewed. The objectives of the new antennas are discussed. The structure and function of the antennas are briefly described. Author

A86-33988#
FIRST TESTS OF AN ONBOARD MLS RECEIVER [PREMIERS ESSAIS D'UN RECEPTEUR DE BORD MLS]
A. CHAPELET and J.-P. MARGALA (LMT Radio Professionnelle, Boulogne-Billancourt, France) Revue Technique Thomson - CSF (ISSN 0035-4279), vol. 17, Sept. 1985, p. 591-615. In French.

The first European airborne testing of an MLS receiver, to replace the ILS in providing angular azimuth and elevation information, is reported at Bretigny-sur-Orge. Testing in November 1984 aboard the Nord 260 aircraft was conducted primarily on approach maneuvers at constant azimuth and elevation, but also on cross beam maneuvers and on runway centerline flights at constant height. Control Motion Noise (CMN) calculations, based on comparison between onboard MLS data and ground radar tracking data, were well within the maximum ICAO values. At runway threshold, the receiver azimuth function CMN is less than 0.02 degrees and the elevation function is less than 0.03 degrees. R.R.

A86-35293
COMPUTER-CONTROLLED NAVIGATION FOR AEROMAGNETIC SURVEY FLIGHTS DURING THE GANOVEX IV ANTARCTIC EXPEDITION DURING THE SOUTHERN SUMMER OF 1984/85 [COMPUTER-KONTROLLIERTE NAVIGATION FUER AEROMAGNETISCHE VERMESSUNGSFLUEGE BEI DER ANTARKTISEXPEDITION GANOVEX IV IM SUEDSOMMER 1984/85]
F.-J. HEIMES (Bochum, Fachhochschule, West Germany) Bildmessung und Luftbildwesen (ISSN 0006-2421), vol. 54, March 1986, p. 92-99. In German.

The role of the Computer Controlled Navigation System (CCNS) in the GANOVEX Antarctic expedition is described. The CCNS supplies computer-supported mission planning, exact steering information for the pilot on a CRT-type display, can command a camera, and records actual flight parameters. The functional principle of the CCNS is summarized, and experiences with CCNS during the Antarctic expedition are reviewed, including the contruction and operation of the transponder station and the flight *operation.* C.D.

A86-35369*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SIMULATION OF TIME-CONTROL PROCEDURES FOR TERMINAL AREA FLOW MANAGEMENT
M. ALCABIN, H. ERZBERGER, L. TOBIAS (NASA, Ames Research Center, Moffett Field, CA), and P. J. OBRIEN (FAA Technical Center, Atlantic City, NJ) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 687-695. refs

Simulations of a terminal area traffic-management system incorporating automated scheduling and time-control (four-dimensional) techniques conducted at NASA Ames Research Center jointly with the Federal Aviation Administration, have shown that efficient procedures can be developed for handling a mix of 4D-equipped and conventionally equipped aircraft. A crucial role in this system is played by an ATC host computer algorithm, referred to as a speed advisory, that allows controllers to maintain accurate time schedules of the conventionally equipped aircraft in the traffic mix. Results are of the most recent simulations in which two important special cases were investigated. First, the effects of a speed advisory on touchdown time scheduling are examined, when unequipped aircraft are constrained to follow fuel-optimized profiles in the near-terminal area, and rescheduling procedures are developed to handle missed approaches of 4D-equipped aircraft. Various performance measures, including controller opinion, are used to evaluate the effectiveness of the procedures. Author

A86-35437
THE CONSIDERATION OF PILOT FACTORS IN DEVELOPMENT OF FUTURE COLLISION AVOIDANCE SYSTEMS
G. P. BOUCEK, JR., W. D. SMITH, and T. A. PFAFF (Boeing Commercial Airplane Co., Seattle, WA) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 93-102. refs
(SAE PAPER 851807)

Pilot factors affecting the development of collision avoidance systems are studied. The requirements and functions of a collision avoidance system are described. The need to design the avionics system to transmit relevant operational information to the crew is examined. The integration of the controls and displays of the system into the flight deck and the development of a pilot/machine interface are analyzed. The evaluation of the system considering *pilot factors and the certification process are discussed.* I.F.

A86-35444
IN FLIGHT ACCESS TO MINIMUM VECTORING ALTITUDES - A PILOT'S PERSPECTIVE
J. M. MCCORMICK, JR. (Air Line Pilots Association International, Washington, DC) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 159-171. refs
(SAE PAPER 851837)

The need for minimum vectoring altitude (MVA) data during in-flight is discussed. Various aircraft accidents caused by aircraft at incorrect altitudes, improper ATC clearances, or communication failures are described; these examples reveal the need for improved MVA information. The establishment of minimum safe altitude for instrument flight rules is examined. The advantages and disadvantages of a minimum safe altitude warning program and ground proximity warning system for improving ATC are analyzed. The inertial reference system combined with a navigation system data base, which produces a computer-generated moving-map display is studied. The use of a Mode-S Beacon system to provide timely and cost-effective MVA information to pilots is proposed. I.F.

A86-35464
RADAR CHARACTERISTICS OF FLIGHT VEHICLES [RADIOLOKATSIONNYE KHARAKTERISTIKI LETATEL'NYKH APPARATOV]
M. E. VARGANOV, IU. S. ZINOVEV, L. IU. ASTANIN, A. A. KOSTYLEV, A. IA. PASMUROV et al. Moscow, Izdatel'stvo Radio i Sviaz', 1985, 236 p. In Russian. refs

Methods for describing the scattering properties of flight vehicles and measuring their radar characteristics are reviewed, with particular attention given to the determination of the local and geometric characteristics of the scattering centers. The use of spatial processing of narrow-band signals (radioholography) for measuring local scattering characteristics is discussed, and the scattering properties of targets are analyzed for the case of complex and ultrawide-band signals. Methods for modeling dynamic and statistical radar characteristics are discussed in detail. V.L.

A86-35608* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
DEVELOPMENT AND FLIGHT TEST OF A HELICOPTER, X-BAND, PORTABLE PRECISION LANDING SYSTEM CONCEPT
T. J. DAVIS, G. R. CLARY (NASA, Ames Research Center, Moffett Field, CA), J. P. CHISHOLM, and S. L. MACDONALD (Sierra Nevada Corp., Reno) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 121-130. Previously announced in STAR as N85-26721.

A beacon landing system (BLS) is being developed and flight tested as a part of NASA's Rotorcraft All-Weather Operations Research Program. The system is based on state-of-the-art X-band radar technology and digital processing techniques. The BLS airborne hardware consists of an X-band receiver and a small microprocessor, installed in conjunction with the aircraft instrument landing system (ILS) receiver. The microprocessor analyzes the X-band, BLS pulses and outputs ILS-compatible localizer and glide slope signals. Range information is obtained using an on-board weather/mapping radar in conjunction with the BLS. The ground station is an inexpensive, portable unit; it weighs less than 70 lb and can be quickly deployed at a landing site. Results from the flight-test program show that the BLS has a significant potential for providing rotorcraft with low-cost, precision instrument approach capability in remote areas. Author

A86-35610
PRECISION IMC APPROACHES TO HELIPORTS USING COLLOCATED MLS
S. SHOLLENBERGER, J. H. ENIAS (FAA, Technical Center, Atlantic City, NJ), and P. S. DEMKO (U.S. Army, Ft. Monmouth, NJ) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 137-143. refs

This paper addresses several factors which influence the application of MLS operations to heliports. Determination of MLS siting criteria and course widths are addressed. These factors, along with approach angle, deceleration distance, and control of approach speed ultimately determine precision approach speed ultimately determine precision approach decision height (DH). Test results presented in the paper show that the MLS elevation antenna should be located in front of the heliport to allow for adequate deceleration distance while permitting lowest possible DH. Test results also show that if the MLS must be collocated at the heliport, DH must increase. In this case, an azimuth course width of + or - 3.5 degrees and an elevation course width of + or - one-third of the selected elevation angle yield the best overall performance. Author

N86-24677*# Ohio State Univ., Columbus. ElectroScience Lab.
A STUDY OF A COLLISION AVOIDANCE SYSTEM MOUNTED ON A CURVED GROUND PLANE Semiannual Report
P. H. LAW, W. D. BURNSIDE, and R. G. ROJAS Mar. 1986 114 p refs
(Contract NSG-1498)
(NASA-CR-176771; NAS 1.26:176771; REPT-716199-8) Avail: NTIS HC A06/MF A01 CSCL 17G

Research conducted on a traffic advisory and collision avoidance system (TCAS 2) mounted on a curved ground plane is described. It is found that a curved finite ground plane can be used as a good simulation model for the fuselage of an aircraft but may not be good enough to model a whole aircraft due to the shadowing of the vertical stabilizer, wings, etc. The surface curvature of this curved disc significantly affects the monopulse characteristics in the azimuth plane but not as much in the elevation plane. These variations of the monopulse characteristics verify the need of a lookup table for the 64 azimuth beam positions. The best location of a TCAS 2 array on a Boeing 737 is to move it as far from the vertical stabilizer as possible. Author

N86-24678*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
THE EVALUATION OF THE OSGLR ALGORITHM FOR RESTRUCTURABLE CONTROLS Final Report, Dec. 1985 - Apr. 1986
W. F. BONNICE, E. WAGNER, S. R. HALL, and P. MOTYKA Mar. 1986 177 p refs
(Contract NAS1-17556)
(NASA-CR-178083; NAS 1.26:178083; CSDL-R-1849) Avail: NTIS HC A08/MF A01 CSCL 09B

The detection and isolation of commercial aircraft control surface and actuator failures using the orthogonal series generalized likelihood ratio (OSGLR) test was evaluated. The OSGLR algorithm was chosen as the most promising algorithm based on a preliminary evaluation of three failure detection and isolation (FDI) algorithms (the detection filter, the generalized likelihood ratio test, and the OSGLR test) and a survey of the literature. One difficulty of analytic FDI techniques and the OSGLR algorithm in particular is their sensitivity to modeling errors. Therefore, methods of improving the robustness of the algorithm were examined with the incorporation of age-weighting into the algorithm being the most effective approach, significantly reducing the sensitivity of the algorithm to modeling errors. The steady-state implementation of the algorithm based on a single cruise linear model was evaluated using a nonlinear simulation of a C-130 aircraft. A number of off-nominal no-failure flight conditions including maneuvers, nonzero flap deflections, different turbulence levels and steady winds were tested. Based on the no-failure decision functions produced by off-nominal flight conditions, the failure

detection performance at the nominal flight condition was determined. The extension of the algorithm to a wider flight envelope by scheduling the linear models used by the algorithm on dynamic pressure and flap deflection was also considered. Since simply scheduling the linear models over the entire flight envelope is unlikely to be adequate, scheduling of the steady-state implentation of the algorithm was briefly investigated. Author

N86-24679# Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.
PRESSURE BASED SEPARATION IN THE UPPER AIRSPACE
M. E. ESHELBY Feb. 1986 13 p
(CAR-8614; ISBN-0-947767-39-8) Avail: NTIS HC A02/MF A01

The vertical separation between aircraft above FL290 is 2000 ft which imposes a severe restriction on operations in the upper airspace. The possibility of reducing separations to 1000 ft has been discussed for many years but does not appear to be possible if current altimetry methods are used. The use of atmospheric pressure is proposed as the means of providing upper airspace separation. Current technology in altimetry would be adequate to enable separations based on pressure differentials to be used which allow a 50% increase in airspace utilization FL290 and FL350. The implementation cost of such a system is minimal. Author

N86-24681# Federal Aviation Agency, Atlantic City, N.J.
COMPUTED CENTERLINE MLS (MICROWAVE LANDING SYSTEM) APPROACH DEMONSTRATION AT WASHINGTON NATIONAL AIRPORT
J. H. REMER Oct. 1985 42 p refs
(AD-A163722; DOT/FAA/CT-TN85/63) Avail: NTIS HC A03/MF A01 CSCL 17G

This report describes the Computed Centerline Microwave Landing System (MLS) Approach Demonstration Project at the Washington National Airport. The purpose of this project was to demonstrate the capability of generating and flying a computed centerline approach for a nonstandard MLS siting. Specifically, the system which was developed enables final approaches to be made to runways which have azimuth units offset from the runway centerline. This system was successfully flight tested at the Federal Aviation Administration (FAA) Technical Center, Atlantic City Airport, NJ, and at the Washington National Airport. Runway 33 was used at Washington, with its MLS azimuth unit situated 275 feet to the right of the centerline. Conclusions derived from this project indicate that computed centerline approaches are indeed feasible. Precautions must be taken however, to properly tailor the course width. Site geometry and minima also impact system performance. In addition to the flight test data plots, the report contains system hardware and software design data. GRA

N86-25334# Massachusetts Inst. of Tech., Lexington.
PILOT EVALUATION OF TCAS IN THE LONG RANGER HELICOPTER
J. W. ANDREWS 3 Jun. 1986 30 p refs Sponsored by Massachusetts Inst. of Tech., Lexington. Prepared in cooperation with Federal Aviation Administration,Washington, D.C.
(Contract F19628-85-C-0002; DOT-FA77WAI-817)
(FAA/PM-85/30; ATC-136) Avail: NTIS HC A03/MF A01 CSCL 17G

A specially modified version of the Traffic Alert and Collision Avoidance System (TCAS) was installed in a Bell Long Ranger helicopter in order to investigate the feasibility of TCAS operation in rotorcraft. This installation employed TCAS air-to-air surveillance to provide automated traffic advisories that were displayed in the cockpit on a color cathode ray tube display. As part of this study, 12 subject pilots evaluated the utility of the installation through brief test flights in the vicinity of a major airport. Among the topics investigated were the rate of alarms, the computer logic for issuing advisories, the bearing accuracy, and the display symbology. Several recommendations for adapting TCAS to the rotorcraft environment resulted from the testing. Author

N86-25335*# Douglas Aircraft Co., Inc., Long Beach, Calif.
GUIDANCE STUDIES FOR CURVED, DESCENDING APPROACHES USING THE MICROWAVE LANDING SYSTEM (MLS)
J. B. FEATHER May 1986 90 p refs
(Contract NAS1-16202)
(NASA-CR-178030; NAS 1.26:178030) Avail: NTIS HC A05/MF A01 CSCL 17G

Results for the Microwave Landing System (MLS) guidance algorithm development conducted under the Advance Transport Operating System (ATOPS) Technology Studies (NAS1-16202) are documented. The study consisted of evaluating guidance law for vertical and lateral path control, as well as speed control, for approaches not possible with the present Instrument Landing System (ILS) equipment. Several specific approaches were simulated using the MD-80 aircraft simulation program, including curved, descending (segmented glide slope), and decelerating paths. Emphasis was placed on development of guidance algorithms specifically for approaches at Burbank, where proposed flight demonstrations are planned. Results of this simulation phase are suitable for use in future fixed base simulator evaluations employing actual hardware (autopilot and a performance management system). Author

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AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A86-33989
THE SOVIET FIGHTER - FOUR DECADES OF DEVELOPMENT
R. BRAYBROOK Air International (ISSN 0306-5634), vol. 30, April 1986, p. 163-167, 199-203.

The development of the Soviet fighter from a single-role aircraft to a multirole aircraft is reviewed. Advances in designs, avionics, capabilities, and weapon systems are described. The initial designs of MiG fighter bombers and Sukhoi jet fighters are analyzed. The Sukhoi aircraft, Yak-25, was the first Soviet all-weather jet fighter and the MiG-25 Foxbat was the first in a series of multirole fighter interceptors. The development of an aircraft with short field performance, which was initiated by the Soviets, is discussed. The capabilities of MiG-20 Fulcrum which is a two-seat configuration and the Su-27 Flanker which is an aircraft with low-wing loading and a high thrust/weight ratio are studied. The capabilities and designs of Soviet aircraft are compared with their American counterparts. I.F.

A86-33998
A METHOD FOR NUMERICAL ANALYSIS OF THE DYNAMICS OF A CONTROLLED ROTOR BLADE OF A HELICOPTER
J. MANEROWSKI Journal of Technical Physics (ISSN 0324-8313), vol. 26, no. 1, 1985, p. 75-86. refs

A model for the numerical analysis of a controlled helicopter rotor blade in hover is presented. The finite element method in its displacement version is used, and numerical integration is performed using the Wilson-Newmark method. The rotor blade is treated as a deformable beam, its rigidity, inertia, and damping parameters varying along the blade. The influence of the cross-sectional rotational inertia on the form of the blade's elastic line is taken into account. An algorithm for the numerical analysis of the dynamics of a controlled blade is proposed, and examples of computational results are presented. C.D.

A86-34158
A NOTE ON THE PREDICTION OF FLYING BOAT TAKE-OFF
D. HOWE (Cranfield Institute of Technology, England) Aeronautical Journal (ISSN 0001-9240), vol. 90, Feb. 1986, p. 49-52.

It is useful to have available simple prediction formulas for preliminary design work. In the case of landplane take-off such formulas exist, being expressed only in terms of a few major parameters. The flying boat situation is more complex due to the much greater and more variable total drag. By making appropriate assumptions an equivalent formula for flying boat take-off has been derived. Comoparison of typical cases of the landplane and flying boat shows that whereas the take-off distance of the former is approximately inversely proportional to thrust/weight ratio to the power of 1.35, in the case of a flying boat it is inversely proportional to the square of thrust/weight ratio. Author

A86-34196
EVOLVING 8000 PSI HYDRAULIC SYSTEMS
J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, April 1986, p. 64-70.

The development of nonflammable hydraulic and lightweight high-pressure hydraulic systems nd components for military factical aircraft is discussed. Based on preliminary Navy computer simulation studies, an 8000-psi hydraulic system T-2C trainer limited flight test program, full-scale A-7E evaluation, and full-scale Iron Bird simulation were conducted. Test results revealed normal and stable operation, low pressure fluctuations, and a 30-percent weight and 36-percent volume reduction. An Air-Force-developed nonflammable low-molecular-weight chlorotrifluoroethylene (CTFE) polymer possesses the desired viscosity characteristics, but has a density 2.2 times that of the current hydraulic fluids. Ongoing studies are being conducted to minimize horsepower/heat rejection, to stiffen the actuators, and to improve the CTFE fluid properties. R.R.

A86-34475
FOKKER 50 - REPLACING A LEGEND
D. LEARMOUNT and I. EPTON Flight International (ISSN 0015-3710), vol. 129, March 22, 1986, p. 28-33.

The design of the Fokker 50 is examined. Features designed to improve the comfort of the passengers are discussed. Alterations in the wing configuration including changes in the wing tips and ailerons are described. The fuselage structure is composed of metal adhesive bonded laminate sheets with stringers and has an increased number of doors and windows. The use of hydraulics in the undercarriage, braking, nosewheel steering systems, and flip sections is analyzed. The flying controls of the aircraft are mechanically and manually operated by a cable system. The improvements to the flight deck of the vehicle are studied. I.F.

A86-34920#
DEVELOPMENT OF THE BO 105 LS
A. HORLEBEIN and G. POLZ (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) (CASI, Annual General Meeting, 32nd, Montreal, Canada, May 27, 1985) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 31, Dec. 1985, p. 300-314.

The BO 105 LS is the newest version of the BO 105-family. It is specifically designed for operation at high altitudes and extreme temperature conditions as well as for improved single engine performance. This paper summarizes the technical main features and milestones of the BO 105 LS program. Performance and flight characteristics in the extreme regions of the extended flight envelope are discussed. The developmental flight test phase and the results of the numerous certification test campaigns are presented. The growth potential and versatile improvements of BO 105 LS due to the application of modern technology are discussed. Author

A86-34924#
DESIGN OF THE CL-227 AIR VEHICLE
D. J. PAISLEY (Canadair, Ltd., Montreal, Canada) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 31, Dec. 1985, p. 346-359.

The CL-227 rotary wing VTOL RPV, designated 'Sentinel', is capable of carrying imaging payloads in the 30-kg mass range. Attention is presently given to the mechanical, structural, dynamic, aerodynamic, and control aspects of the Sentinel as they have developed in the course of full scale engineering development efforts. The configuration of Sentinel is that of a vertically-oriented axisymmetric body with a counterrotating rotor system mounted at its center. The rotors are powered by a gas turbine engine. Sentinel's hovering capability simplifies sensor requirements. The design is highly modular to facilitate maintenance in the course of a 500-hour design service life. A full authority autopilot and inertial reference unit are used. O.C.

A86-35151#
FROM WIND TUNNEL TO LARGE AIRCRAFT [VOM WINDKANAL ZUM GROSSFLUGZEUG]
R. HILBIG (Messerschitt-Boelkow-Blohm GmbH, Bremen, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 22 p. In German.
(DGLR PAPER 85-088)

The development of a large aircraft from wind tunnel testing to large-scale construction is briefly discussed. The characteristic-tasks of the preparatory phase, the definitional phase, and the development phase are examined, and data for some important wind tunnels are presented. The determination of relevant aircraft parameters in wind tunnels is summarized. C.D.

A86-35152#
DETAILS ON THE OPTIMIZATION OF CRUISING DRAG OF THE AIRBUS A320 [DETAILS ZUR OPTIMIERUNG DES REISEFLUGWIDERSTANDES DES AIRBUS A320]
B. HAFTMANN (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) and B. KIEKEBUSCH (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 38 p. In German.
(DGLR PAPER 85-089)

One of the objectives of the Airbus A320 is a six percent improvement in the drag standard as compared with the standard of the A310-200. Design studies conducted toward this end on the engine-pylon configuration and on the design of the tail assembly is reviewed. The influence of rearward position, pylon position, and nozzle length on drag is discussed, and an aerodynamic design concept for the tail assembly is presented and described. The influence of the design of the horizontal stabilizers and elevators on the total drag is also addressed. C.D.

A86-35170#
COMPARATIVE INVESTIGATION OF OPTIMIZATION PROCEDURES IN AIRCRAFT PRELIMINARY DESIGN [VERGLEICHENDE UNTERSUCHUNG VON OPTIMIERUNGSVERFAHREN IM FLUGZEUGVORENTWURF]
O. KRANZ (Berlin, Technische Universitaet, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 18 p. In German. DFG-supported research. refs
(DGLR PAPER 85-119)

This paper reports an analysis of the behavior of numerical optimization procedures in aircraft preliminary design. Basic aspects regarding the employment of optimization procedures are discussed, taking into account the error characteristics in different flight tasks, the wing aspect ratio as a function of maximum wing loading, and the derivatives of the target function in design space. The optimization procedures in aircaft preliminary design considered include tangent search methods and Lagrange methods. It is found that the tangent search methods are distinctly superior to the Lagrange methods, giving attention to computation time requirements, reliability, and user friendlines. G.R.

A86-35176#
CONFIGURATION ASPECTS OF MODERN HIGH-PERFORMANCE AIRCRAFT [KONFIGURATIONSASPEKTE MODERNER HOCHLEISTUNGSFLUGZEUGE]
G. KANNAMUELLER (Dornier GmbH, Friedrichschafen, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 34 p. In German.
(DGLR PAPER 85-130)

The parameters which influence the design of the fighter aircraft JF 90 are discussed. Fighting ability, availability, and costs are related to each other in the context of a conflict model. The important design parameters are derived analytically along with the weapon systems design. These results are used to show what a fighter aircraft of the next generation may look like. Examples are used to demonstrate how the same fighter aircraft goals can be met in different ways by using different technologies. C.D.

A86-35189#
OPTIMIZATION OF SEAPLANES [OPTIMIERUNG VON SEEFLUGZEUGEN]
E. WILCZEK (Aachen, Rheinisch-Westfaelische technische Hochschule, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 34 p. In German.
(DGLR PAPER 85-170)

The optimization of seaplanes for marketing in coastal countries is discussed. The way in which the distribution of population in such countries affects the market for seaplanes is considered, and the market niches that could be taken by seaplanes in these countries are examined. The optimal design of seaplanes, including hydrodynamic and aerodynamic characteristics and the best selection of materials, is discussed. C.D.

A86-35201
THE IMPACT OF ACCOMMODATING DEFECTS ON THE EFFICIENCY OF AIRCRAFT DESIGN
E. M. PETRUSHKA and G. E. LAW (General Dynamics Corp., Fort Worth, TX) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 10 p. refs
(SAWE PAPER 1635)

The history of the evolution of damage tolerance criteria for metals as related to the B-58, F-111, and F-16 programs is reviewed, and the yet-to-be resolved damage tolerance issues for composite structures are discussed. In particular, the effect of defects on composite compression members is discussed in relation to defect location and size information provided by new automated nondestructive inspection techniques. It is pointed out that innovative ways of cost-effective three-dimensional reinforcement must be found so that the criticality of defects can be minimized directly by design. The importance of developing more durable and damage tolerant matrix materials is also emphasized. V.L.

A86-35202
IMPACT OF ADVANCED MATERIALS ON AIRCRAFT DESIGN WEIGHTS - THE WEIGHT IMPROVEMENT FACTOR
W. D. WISSEL (Airbus Industrie, Toulouse, France) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 24 p. refs
(SAWE PAPER 1636)

The improved metallic and nonmetallic materials currently used in the advanced aircraft are reviewed. A new generation of advanced materials is then examined with particular reference to their weight improvement potential and to the effect of the weight improvement factor on the overall design. The new materials examined include improved epoxy matrix systems providing both high strain and good hot/wet properties, advanced thermoplastics with high mechanical and temperature/solvent properties, and aluminum-lithium alloys. The effect of the new materials on the aircraft weight is analyzed with allowance for both fixed and variable weight components, and formulas for the weight improvement factor are derived. V.L.

A86-35203* Boeing Commercial Airplane Co., Seattle, Wash.
APPLICATION OF DIGITAL/ELECTRIC SYSTEMS TO ADVANCED TECHNOLOGY AIRCRAFT
A. R. BAILEY (Boeing Commercial Airplane Co., Seattle, WA) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 13 p.
(Contract NAS1-17528)
(SAWE PAPER 1639)

Potential improvements in weight and performance of the digital/electric airplane of the 1990s are investigated, using data based on the Integrated Digital/Electric Airplane (IDEA) study, a nine-month investigation of integrated digital/electric concepts. A baseline configuration was compared to these IDEA configurations in terms of economic performance, fuel efficiency, and significant system and aircraft configuration characteristics. The 1990 baseline configuration represents a six to eight percent performance improvement over current technology; however, the IDEA airplane shows an additional three percent improvement in fuel burn performance. This improvement is due to a reduction of over 3000 pounds in systems weight alone. K.K.

A86-35206
WING ASPECT RATIO OPTIMIZATION PROBLEMS FOR TRANSPORT TURBOJET AIRPLANES
P. A. GILI and F. B. QUAGLIOTTI (Torino, Politecnico, Turin, Italy) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 26 p. refs
(SAWE PAPER 1660)

A calculation method, based on Breguet's formula for the distance range, for deriving the wing aspect ratio that will optimize the fuel consumption and the payload of the transport turbojet aircraft is described. The calculation of the load ratio and fuel wing consumption is discussed; the dependence of load ratio and *fuel wing consumption on the wing aspect ratio, the cruising altitude*, and the range and cruising lift coefficient is examined. The fuel consumption during climb is calculated using energetic evaluation. Diagrams and graphs of the data are provided. Examples displaying the applicability of this procedure to transport aircraft are presented. I.F.

A86-35208
AN AIRFRAMER'S VIEW OF AN ELECTRIC FIGHTER
J. R. MCKENZIE (General Dynamics Corp., St. Louis, MO) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 13 p. refs
(SAWE PAPER 1662)

The idea of an 'All-Electric' airplane which does not require on-board or ground-support generation of hydraulic or pneumatic power is quite attractive at first glance. Facets of this concept have received much study over the last few years (primarily in the commercial arena), and many benefits and pitfalls have been determined. The most likely scenario is development of a 'More-Electric' airplane that incorporates those features that provide benefits for a specific design. This paper surveys some of the key design issues and projects hypothetical airplane implementations. Author

A86-35210
THE GRUMMAN X-29 TECHNOLOGY DEMONSTRATOR - TECHNOLOGY INTERPLAY AND WEIGHT EVOLUTION
J. E. RAHA (Grumman Aerospace Corp., Bethpage, NY) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 22 p. refs
(SAWE PAPER 1665)

The history of Forward Swept Wing (FSW) design prior to the X-29A technology demonstrator is briefly recalled. The integration of the FSW with other elements of the demonstrator technology suite and the necessary interplay is described. A brief description or substantiation of the technology elements is included. The goals of the demonstrator program are reviewed and related to the design characteristics of the aircraft. Challenges facing the X-29A weight engineer are recounted, stressing weight-related development, which includes: (1) flight weight design of the FSW, (2) commonality

with other aircraft, (3) weight evolution and meeting weight goals, and (4) balance-critical aspects. The X-29A design is described from a weight and balance standpoint. Finally, future technologies are described and related to the existing technology suite.
Author

A86-35219
THE MODEL 530MG - THE FORERUNNER TO THE ULTIMATE LIGHT-COMBAT HELICOPTER
R. V. MARCH (Hughes Helicopters, Inc., Mesa, AZ) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 44 p. refs
(SAWE PAPER 1677)

The Hughes Model 530MG Defender is a state-of-the-art rotorcraft, incorporating advances in performance as well as in cockpit and weaponization designs with minimal weight growth. In addition, an agile and effective flying platform with growth capability has been established, whose purpose is to provide broad mission flexibility for military services with variations in operational and environmental requirements around the world. It is shown that advances in performance as well as in the designs of an integrated cockpit and a modular, quick-change weapon system are present today and are expected to be standard for the U.S. Army's LHX advanced helicopter series. K.K.

A86-35220
HIGHER HARMONIC CONTROL - VIBRATION REDUCTION FOR REDUCED WEIGHT
E. R. WOOD and B. P. GUPTA (Hughes Helicopters, Inc., Culver City, CA) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 30 p. refs
(SAWE PAPER 1679)

Higher Harmonic Control (HHC) technology has been successfully applied to helicopter vibration reduction by exercising rotor blade pitch control at frequencies which are high harmonics of rotor rotation. The control motions are generated by three electrohydraulic actuators which are commanded by an airborne microprocessor. This processor receives vibration sensor measurements, estimates the helicopter's state using a Kalman filter type algorithm, and computes the optimal controls to reduce vibrations. A conventional helicopter equipped with this device would suffer a weight penalty of 0.75 percent gross weight, but new fly-by-wire controlled helicopters would, with HHC, experience a weight penalty that is essentially zero. For these aircraft, the only contributors to weight would be the miniaturized electronic circuit boards for the HHC system and the small additional weight of the HHC panel on the pilot's instrument console. K.K.

A86-35223
STARSHIP I - A WEIGHT CONTROL CHALLENGE
H. L. FRISCH (Beech Aircraft Corp., Wichita, KS) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 17 p.
(SAWE PAPER 1682)

The Starship I utilizes many new state-of-the-art concepts in design, materials selection, and fabrication techniques for development of a next generation business aircraft. Composite materials comprise approximately 72 percent of the aircraft structural weight and are a major contribution to the success of the program. This presentation includes a description of the aircraft configuration, weight control philosophy, and computerized mass properties accounting system. Author

A86-35224
WEIGHT CONTROL OF AIRCRAFT MODIFICATION PROJECTS
P. J. BUDDINE (Grumman Aerospace Corp., Bethpage, NY) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 11 p.
(SAWE PAPER 1683)

It is pointed out that the Mass Properties Control and Management Plans (MPCMP's), which are normally required by the government, are extremely useful. Modification programs are considered, taking into account the EF-111A program. This program was concerned with the modification of an F-111A to an EF-111A. In the event of an emergency, the F-111A Crew Module provides the primary means of escape from the aircraft. The location of the center of gravity of the crew module represents an extremely critical factor for a safe ejection and landing process, and the permissible weight is limited to 3200 pounds. Attention is given to some elementary principles which are essential for the design of a reasonable and effective mass properties control program. It is important that a weight control program is implemented early.
G.R.

A86-35385* Boeing Commercial Airplane Co., Seattle, Wash.
ESTIMATION OF TRANSPORT AIRPLANE AERODYNAMICS USING MULTIPLE STEPWISE REGRESSION
D. A. KESKAR (Boeing Commercial Airplane Co., Seattle, WA), V. KLEIN (NASA, Langley Research Center; Joint Institute for Advancement of Flight Sciences, Hampton, VA), and J. G. BATTERSON (NASA, Langley Research Center, Hampton, VA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 927-932.

This paper presents an application of multiple stepwise regression to the flight test data of a typical transport airplane. The flight test data was carefully preprocessed to eliminate aliasing, time skews and high frequency noise. The data consisted both of basic certification maneuvers, such as wind-up-turns and maneuvers suitable for parameter estimation, such as responses to elevator pulses and doublets. It is shown that the results of multiple stepwise regression techniques compare favorably with the results obtained from maximum likelihood estimation. Finally, it is concluded that multiple stepwise regression could be a fast economical way to estimate transport airplane aerodynamics.
Author

A86-35405
TRANSIENT MODEL OF A PNEUMATIC EJECTOR - APPLICATION TO THE SIMULATION OF AIRCRAFT BLEED AIR TEMPERATURE CONTROL SYSTEMS
R. ELANGOVAN and D. L. J. BRUSHWOOD (Boeing Military Airplane Co., Wichita, KS) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1187-1193. refs
(Contract F34601-82-C-2981)

A transient pneumatic ejector model suitable for use in simulation of aircraft environmental control systems is presented. The ejector model is formulated to accommodate modulation of both primary and secondary ejector flows using butterfly modulating valves. The two-state variable ejector model is employed in the simulation of an actual aircraft bleed air temperature control sytem, which utilizes ejector secondary air as the heat sink for a heat exchanger. The thermo-fluid system simulation equations and a qualitative description of control system operation are presented. Additionally, comparisons of the closed loop transient math model performance characteristics relative to actual ground and flight test results are presented. Author

A86-35436
PILOT EXECUTIVE PROJECT - PILEX
R. W. WHITE and W. D. SMITH (Boeing Commercial Airplane Co., Seattle, WA) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 87-91.
(SAE PAPER 851806)

The design and implementation of the Flight Status Monitor (FSM) concept are described. The pilot interfaces used for the altering, guidance, and feedback components of the FSM, and the supervisory logic provided by a knowledge-based expert system (KBES) are examined. The Pilot Executive project developed to study the FSM KBES requirements and to formulate a procedure for acquiring pilot knowledge of alert checklist integration techniques is analyzed. The three phases of the project which

include concept demonstration, the integration of the system with an aircraft simulator for test and evaluation, and complete implementation of FSM KBES simulation and evaluation are discussed. I.F.

A86-35438* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ADVANCED CONCEPTS TRANSPORT AIRCRAFT OF 1995
S. L. CHAPPELL (NASA, Ames Research Center; Informatics General Corp., Moffett Field, CA) and G. A. SEXTON (Lockheed-Georgia Co., Marietta) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 103-108.
(SAE PAPER 851808)

The components of the Advanced Concepts Flight Simulation Facilities used to evaluate proposed human-machine interfaces are described. The facilities consist of: (1) an advanced concept flight station, which is a wide-body, composite airframe propelled by two turbo-fan engines; (2) an integrated air traffic control simulation; and (3) experimenter/observer stations. The flight controls and displays, and their operation are studied. The air traffic control provided in the simulation is examined. The control of the flight conditions and data collection by the experimenter are discussed. I.F.

A86-35442
SIKORSKY AIRCRAFT CREW STATION TECHNOLOGY RESEARCH HELICOPTER
L. STILES, JR. (United Technologies Corp., Sikorsky Aircraft Div., Strattford, CT) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 143-150.
(SAE PAPER 851780)

Sikorsky Aircraft has developed a new research helicopter dedicated to the study of crew station technology. A high visibility single seat cockpit has been added to an S-76 airframe just forward of the existing cockpit. The new cockpit is linked to the aircraft systems via a variable stability fly-by-wire flight control system and is equipped with various display media, including touch sensitive CRTs, a voice interactive system, head-up display, and a visually-coupled wide field of view helmet-mounted display system. The aircraft can be operated autonomously from the new crew station, with an independent safety pilot position retained at the original right pilot station. This aircraft will permit the evaluation of advanced control and display concepts in the agile S-76 air vehicle under a full range of flight conditions. Author

A86-35455
EXTENDED RANGE OPERATION OF TWIN-ENGINE COMMERCIAL AIRPLANES
R. W. TAYLOR (Boeing Commercial Airplane Co., Seattle, WA) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 377-388.
(SAE PAPER 851959)

This paper discusses safety and reliability considerations that were examined in the development of new guidelines for commercial use of twin-engine airliners for extended range operations. The 767-200ER airplane is referred to extensively becausee it was the first twin to be approved for extended range operations under the new guidelines. The key technical issues involved are engine reliability and the ability of the propulsion and airplane systems to provide safe, sustained operation during the anticipated time period of the diversion after an inflight engine and/or system failure. Airline operational considerations for extended range operations with twins are reviewed, as well as the future impact on the traveling public and the airline industry brought about by the service introduction of new technology twins. Author

A86-35520
THE FLYING SIMULATOR AND TECHNOLOGY CARRIER ATTAS FROM DFVLR [DER FLIEGENDE SIMULATOR UND TECHNOLOGIETRAEGER ATTAS DER DFVLR]
D. HANKE (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) Luft- und Raumfahrt (ISSN 0173-6264), vol. 7, 1st Quarter, 1986, p. 4-8. In German.

A new test aircraft called ATTAS (Advanced Technologies Testing Aircraft System), constructed as a modified VFW 614 and intended to replace the flying HFB 320 simulator, is described. The features and capabilities of this system include a cockpit with electric control and indicator systems, redundant computer system with optical data transmission system, extensive measurement and avionics systems, self-monitoring electrohydraulic control elements, and safety features. The aircraft's range of applications will include flight simulations, load minimization systems, avionics testing, traffic simulation, and pilot training. C.D.

A86-35565*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
TILTROTOR - 'COPTER AND PLANE IN ONE
M. BONDI (NASA, Ames Research Center, Moffett Field, CA) Mechanical Engineering (ISSN 0025-6501), vol. 108, April 1986, p. 52-59.

This paper is concerned with a most unusual aircraft, called the Tiltrotor XV-15, which combines the versatility of the helicopter with the characteristics of a conventional aircraft. Two large, three-bladed propellers are mounted at the tips of the wings. For takeoff, the propellers and their engines are rotated 90 degrees, and the XV-15 can climb vertically into the air as a helicopter. When the vehicle is off the ground, propellers and engines rotate forward, and the lift is transferred from the propellers to the wings. As a conventional aircraft, the Tiltrotor can cruise for more than two hours. Operating as a vertical-takeoff aircraft, the XV-15 can fly twice as fast as a helicopter and deliver payloads on half the fuel when traveling distances greater than 185 kilometers. The results of the first three years of flight-testing are discussed, taking into account the relationship of rotor vibrations and/or air turbulence to resonance of a section of the Tiltrotor's wing. G.R.

A86-35603
CORRELATION OF STABILITY TEST RESULTS AND ANALYSIS FOR THE 1/5 SCALE V-22 AEROELASTIC MODEL
D. POPELKA, J. BILGER (Bell Helicopter Textron, Fort Worth, TX), and M. SHEFFLER (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 17-31. refs

A semispan, 1/5-scale aeroelastic model of the V-22 tilt-rotor VTOL aircraft has been tested in the NASA-Langley Transonic Dynamics tunnel while undergoing modifications in such design parameters as hub design, blade bending stiffness, wing spar stiffness, rotor pitch-flap coupling, and pylon downstop configuration. Compressibility effects were investigated by tests in both air and freon; aerostatic stability data were obtained for a wide range of airspeeds, rotor speeds, and conversion angles. These data were correlated with aeroelastic stability analysis programs in order to validate the analytical tools being used in the V-22's full scale design process. O.C.

A86-35605
EFFECTS OF ANALYTICAL MODELING ASSUMPTIONS ON THE PREDICTED STABILITY OF A MODEL HINGELESS ROTOR
R. SOPHER and S. J. CASSARINO (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 85-99. refs

The ability to predict flap lag torsion stability is presently evaluated for an aeroelastic stability analysis that is applied to test results for a stiff, inplane hingeless rotor model in hover, with a view to identifying the variables to which the analysis is sensitive. Results are obtained for six different model configurations; a

good-to-fair ability is noted in the prediction of edgewise mode stability variations with pitch angle, pitch flexure stiffness, preconing, and droop. High sensitivities to equilibrium deflections, torsional representations, and aerodynamic assumptions are found. O.C.

A86-35607
AIRCRAFT LIGHTING SYSTEMS
J. F. VERNEY (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 111-120.

Current aircraft lighting systems design involves both consideration of unaided eye viewing as well as compatibility with night vision goggles (NVG). The prospective lighting systems engineer must have knowledge of photometrics and radiometrics as well as an understanding of the NVG's electro-optical characteristics. In checking a preliminary design concept, laboratory mock-ups must be performed using NVGs in conjunction with empirical test methods. Quantitative parameters are then established which allow preliminary specifications to be generated. A flight-worthy mock-up should be built to provide dynamic verification of design concept. Applying this basic process to the UH-60A night vision lighting development program has resulted in some important findings. In particular the use of red light for warning indicators is permissible if modified to incorporate an infrared blocking filter. Also some general guidelines for infrared exterior lighting and interior blue-green integral lighting have emerged.
Author

A86-35613
THE HEALTH AND USAGE MONITORING OF HELICOPTER SYSTEMS - THE NEXT GENERATION
J. D. ROE and D. G. ASTRIDGE (Westland Helicopters, Ltd., Yeovil, England) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 175-187. refs

The Helicopter Airworthiness Requirements Board's review of helicopter airworthiness made recommendations to which Health and Usage Monitoring (HUM) systems may be relevant; these onboard maintenance processor systems encompass sensors, interfaces, data links, processors, and output devices. HUMs undertake vibration analyses, debris monitoring for transmissions, power assurance checking, low cycle fatigue and thermal creep monitoring for engines, and torque and strain monitoring for complete transmission/rotor systems. Attention is given to HUM sensors and algorithms recently developed and flight tested, as well as to the effect of these systems on maintenance policies.
O.C.

A86-35620
HELICOPTER CABIN NOISE - ACTUAL VS. STATISTICAL ENERGY PREDICTIONS
C. A. YOERKIE and P. J. GINTOLI (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 277-287.

The Statistical Energy Analysis (SEA) technique's predictions are subjected to comprehensive comparisons with measured aircraft cabin noise data obtained for an S-76 helicopter. SEA modeling is found to provide a complete description of the energy flow within the structure with a relatively small number of degrees-of-freedom, while retaining the high frequency prediction capability required for acoustics. The vibration trends for such structural elements as panels and frames are found to be in good agreement with predictions; cabin sound pressure level predictions also agree with measurements. SEA is also noted to provide insight into the flow of energy through the structure. O.C.

A86-35624
FLIGHT INVESTIGATION OF BELL MODEL 206 RING FIN
H. K. HARR, P. J. HOLLIFIELD (Bell Helicopter Textron, Fort Worth, TX), and R. P. SMITH (U.S. Army, Applied Technology Laboratory, Fort Eustis, VA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 327-337. refs

Flight testing has been conducted for a Model 206 helicopter whose conventional vertical fin was removed and replaced by several 'ring fin' configurations; these furnish a protective annulus around the tail rotor in the plane of rotation. Attention was given to the effects of such design variables as ring and dorsal fin incidence and areas. The handling quality results obtained indicate the feasibility of the ring fin as a tail rotor protection device.
O.C.

A86-35627
APPLICATION OF HELICOPTER AIR-TO-AIR COMBAT TEST (AACT) DATA TO CURRENT LHX CONCERNS
F. J. EBERT and N. D. LAPPOS (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 367-385. refs

Extensive air-to-air combat tests have been conducted by U.S. Army, Navy and industry teams with instrumented AH-1S, OH-58, AUH-76, UH-60A, and BK-117 helicopters; the agressive maneuvers undertaken comprise elements of the projected LHX light combat helicopter's nap-of-the-earth mission. On the basis of the data thus obtained, pertinent combat issues are presently explored, and previously employed modeling tecniques are validated. Attention is given to maneuvering concepts, rotor thrust, static structures, excess power, rotating structural loads, transient load factors, and available turn rates. O.C.

A86-35628* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
FREE-TIP-ROTOR WIND-TUNNEL TEST RESULTS
R. H. STROUB, L. A. YOUNG (NASA, Ames Research Center, Moffett Field, CA), C. KEYS, and M. CAWTHORNE (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 387-411. refs

Seven controller mechanisms and several tip geometries were proposed and evaluated in the course of a free tip rotor development program which integrated those components into a model rotor system for wind tunnel testing. After a rigid whirl test was run to determine controller mechanism performance and structural integrity, a second whirl test was performed with a model rotor incorporating a selected controller design and a selected tip platform to determine the transient behavior of the tips in response to aerodynamic excitation. The results obtained demonstrate that a swept, tapered tip with a tension-torsion strap controller furnished satisfactory mechanical operation, achieved the specified output torque, possessed a low spring rate, and had fast and stable response to excitation. O.C.

A86-35629
THE DESIGN OF THE EH101 FOR SAFETY AND PERFORMANCE
R. I. CASE and K. J. ANDREWS (Westland Helicopters, Ltd., Yeovil, England) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 413-422.

A development history and a performance evaluation are presented for the Anglo-Italian EH101 military helicopter. Attention is given to those aspects of structural design in the EH101 that have been optimized for flight safety, damage tolerance and crashworthiness. The extensive use of primary structure composites introduces a substantial degree of integrity for a high frequency fatigue environment, in virtue of their slow crack propagation and fail-safe characteristics. Health and usage monitoring techniques

are applied, as well as a three-engine installation with highly redundant systems. O.C.

A86-35630* Boeing Vertol Co., Philadelphia, Pa.
DESIGN ASPECTS OF THE XV-15 ADVANCED TECHNOLOGY BLADE PROGRAM
K. E. SMITH, H. R. ALEXANDER (Boeing Vertol Co., Philadelphia, PA), and M. D. MAISEL (NASA, Ames Research Center; U.S. Army, Aeromechanics Laboratory, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 423-433.

The paper discusses the design of a tiltrotor blade for application to the XV-15 research demonstration aircraft. The design features 43 deg nonlinear twist and nonuniform tapered planform. The structure is composite with extensive use of graphite in the primary structure. Instrumentation and wiring is encapsulated in the composite structure during the cure cycle. The tip shell is removable, providing access to the tracking and balance weights. This feature provides research facility of alternate tip configurations. The cuff is similarly removable. The graphite epoxy system used is high strain American Cyanamid's Celion 6000ST/Cycom 950. This is the first application of this material in rotor blades. Author

A86-35631
X-WING POTENTIAL FOR NAVY APPLICATIONS
A. W. LINDEN (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) and J. C. BIGGERS (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 435-450.

An evaluation is made of the performance potential offered by X-wing configuration VTOL aircraft in typical U.S. Navy missions. X-wing aircraft function as helicopters at takeoff and hover, but turn the X-planform rotor into a fixed wing platform for high speed forward flight. A development history is also given for successive refinements of the X-wing configuration in wind tunnel models and experimental aircraft. Attention is given to such performance attributes as the power required in hover and in cruise, hover control power, and empty and payload weight fractions; such Navy missions as fleet defense and combat search and rescue are defined, and the configuration of a technology demonstration aircraft is projected. O.C.

A86-35632
INFLUENCES OF TWO LANDING GEAR DESIGNS ON HELICOPTER CRASHWORTHINESS AND WEIGHTS
J. K. SEN, M. W. VOTAW (Hughes Helicopters, Inc., Culver City, CA), and G. R. DOWNER (U.S. Army, Applied Technology Laboratory, Fort Eustis, VA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 451-461.
(Contract DAAK51-83-C-0039)

The systems approach to crashworthiness is applied to a study of two landing gear designs to evaluate their influences on helicopter weights for survivable crash-impact conditions. Both landing gear designs share a trailing arm configuration; however, one is coupled and the other uncoupled. The coupled design requires that both main landing gear struts stroke and absorb energy together during high roll impacts. The designs and their influences on the crushing behavior of the landing gear, fuselage and crew seat, and the responses of the occupants are evaluated with program KRASH. The results of the analysis are used to develop weight trend curves for the two designs as a function of the impact parameters (impact velocity, roll angle and pitch angle) and the probability of occurrence of survivable helicopter accidents. Author

A86-35635* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AERODYNAMIC PERFORMANCE OF A 27-PERCENT-SCALE AH-64 WIND-TUNNEL MODEL WITH BASELINE/ADVANCED ROTOR BLADES
H. L. KELLEY and J. C. WILSON (NASA, Langley Research Center; U.S. Army, Structures Laboratory, Hampton, VA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 491-499. refs

Performance of a 27-percent scale model of an advanced rotor designed for the AH-64 helicopter was measured in hover and at forward speeds of 50 to 130 knots. A baseline rotor, modeled after the current AH-64 rotor, was also tested to provide data for comparison. The investigation was conducted to validate procedures used at Langley to design rotors with increased performance potential and to provide a database for evaluation of current and future rotor systems. Both rotors were operated at full-scale tip speeds. Rotor thrust, forward speed, and ground height were varied for each rotor. Author

A86-35637
A SKIN-STRINGER DESIGN FOR A CRASHWORTHY COMPOSITE FUSELAGE FOR THE HUGHES 500E HELICOPTER
J. K. SEN and M. W. VOTAW (Hughes Helicopters, Inc., Culver City, CA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 547-558. refs

The design of the lower fuselage of the Hughes 500E helicopter is part of the Composite Fuselage program of Hughes Helicopters, Inc. The objectives of the program are to design, fabricate, test and fly a composite fuselage which will meet the vertical impact requirements of MIL-STD-1290 with a minimum of 22 percent savings in weight over the metal design. The design approach used on the crashworthy composite lower fuselage assembly is a simple skin-stringer design without honeycomb structural elements, but which is similar to the existing metal design. The decision to use this approach is a result of trade-off studies, design development tests, and the requirement of mating existing support components, such as the landing gear, to the composite fuselage. The design has been evaluated through impact tests and KRASH analyses. The results of the tests show that the crashworthy objectives can be met with 26 percent savings in weight and 39 percent fewer parts. Author

A86-35638
EFFECTS OF VARIATIONS IN CRASHWORTHINESS CRITERIA ON SIKORSKY S-75 ACAP LANDING GEAR WEIGHTS
B. L. LEE and S. P. GARBO (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 559-571. refs
(Contract DAAK51-83-C-0016)

Attention is given to the results of a study evaluating the effects of variations in airworthiness design criteria on the weight of landing gear and backup structures, using the S-75 helicopter's Advanced Composite Airframe Program design as a baseline. Such critical design parameters as sink speed, roll angles and pitch angles were separately varied in order to assess their individual effect on landing gear system loads and weights. Parametric studies of the various combinations of maximum sink speed, roll, and pitch crash conditions indicate 24-32 percent required increases in landing gear system weights. Crashworthiness criteria for future U.S. Army helicopter designs are thereby quantified. O.C.

A86-35639
PRELIMINARY ESTIMATE OF FATIGUE LIFE FOR DYNAMIC COMPONENTS OF A NEW HELICOPTER
K. B. AMER, D. H. MANCIL, and J. R. NEFF (Hughes Helicopters, Inc., Culver City, CA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 573-582.

Attention is given to a procedure for the sizing of major helicopter dynamic components for satisfactory fatigue life during preliminary design. The procedure establishes a limited number of representative flight maneuvers and a criterion for the ratio of load in each representative maneuver to the fatigue strength; it then predicts the load at each of the maneuvers and sizes the dynamic component to meet the payload-ratio criteria. The criteria that must be met in order to achieve a 4500-hr service life are presented. O.C.

A86-35642
SURVEY OF CRASHWORTHINESS ACHIEVEMENTS ON AEROSPATIALE HELICOPTERS
J. MENS (Aerospatiale, Division Helicopteres, Paris, France) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 595-608. refs

Attention is given to proprietary helicopter crash protection techniques that have been under development since 1976 for cabin seating, fuel systems, and landing gear units; these crashworthiness-enhancing measures have entered mass production in such aircraft as the Super Puma and Dauphin helicopters. The theoretical studies on which development of these techniques was predicated consisted of parametric analyses of structural element resistance to crash damage. Attention is given to the resulting airframe structures, crashworthy seats, high energy absorption landing gear, and crashworthy fuel tanks and their interconnections. O.C.

A86-35648
COMBINING ANALYSIS AND TEST FOR ROTOR BLADE DEVELOPMENT
R. JONES and N. GIANSANTE (Kaman Aerospace Corp., Bloomfield, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 639-645. refs

Attention is given to a method combining test results with analyses in order to enhance predictive capability in rotor blade development. This method has been applied to the SH-2F Composite Main Rotor Blade. Nonlinear regression equations for blade bending moments are developed as a function of blade ballast configuration, using data obtained from an aeroelastic loads program. These equations are subsequently modified on the basis of simulated test data obtained from the Rotorcraft Flight Simulation Computer Program. O.C.

A86-35649
DEVELOPMENT OF A COMPOSITE TAIL ROTOR BLADE FOR THE MH-53E
A. J. LAPATI and A. E. THOMPSON (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 647-660.

MH-53E airborne mine countermeasures helicopter requirements for improved performance, unlimited replacement time, and damage tolerance in tail rotor blades have been addressed by a cocured composite blade design. Attention is given to the methods and results of the new blade's qualification tests. Full scale fatigue testing in specially designed facilities has demonstrated the required strength and damage tolerance characteristics; the critical fatigue modes revealed at the root, midspan and tip locations by crack initiation tests have been propagated to determine damage tolerance. Preflight whirl tests also yielded stability, performance, acoustic, and endurance data. O.C.

A86-35652
DESCRIPTION AND INITIAL FLIGHT EXPERIMENTS - BOEING ARTI TEST BED
C. HUTCHINSON, E. BANEY-BARTON, and R. GRADLE (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 679-690.

A test program has been conducted to examine the automated cockpit systems required by the LHX light combat helicopter, including avionics, visionics, etc, to accomplish its missions under single pilot control. A modified Agusta 109A helicopter is the Advanced Rotorcraft Technology Integration testbed employed in these development tests. Electronic scene generation has been used to validate simulator/aircraft correlation. It is established that, in order to fly nap-of-the-earth missions in adverse nocturnal weather conditions, some type of electronic scene generation will be required. O.C.

A86-35653* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
RSRA FLIGHT DEVELOPMENT TEST IN THE AIRPLANE CONFIGURATION
R. E. ERICKSON, R. M. KUFELD, J. L. CROSS, and C. W. ACREE (NASA, Ames Research Center, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 691-704.

The Rotor Systems Research Aircraft (RSRA) was flown in the airplane configuration. Eleven successful flights were made from May 8 to October 3, 1984. The takeoff and landing method was demonstrated and the resultant parameters were obtained. Control power data were obtained. In addition, main rotor hub drag, airplane configuration acoustics data, and aircraft stability data were obtained. Hub drag, acoustics, and stability will be separately reported in more detail. The tail rotor was installed for all tests. Author

A86-35654
VSTOL AIRCRAFT ICE PROTECTION DESIGN CONSIDERATIONS
A. A. PETERSON (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 714-723. refs

Ice Protection Systems for VSTOL aircraft such as the Bell-Boeing V-22 OSPREY Tilt-Rotor must operate in both the helicopter and the fixed-wing aircraft flight modes. This paper presents the design approaches selected and illustrates the control concepts for activating each of the ice protection subsystems. Author

A86-35661
TILT ROTOR CRASHWORTHINESS
J. D. CRONKHITE (Bell Helicopter Textron, Fort Worth, TX) and A. E. TANNER (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 801-816. refs

Large mass relief, rollover stability, reduced pitch and roll attitude on impact, and flotation stability, are among the advantages in crashworthiness design that tilt-rotor aircraft possess over conventional helicopters. The results of a crashworthiness design feature tradeoff study conducted for the V-22 'Osprey' tilt-rotor aircraft are presented, with attention to the weight and cost effectiveness of various crashworthiness levels. The V-22 design also employs a systems approach to the provisions of occupant crash protection; the highly crashworthy composite structure incorporates a dual purpose energy absorbing underfloor, and allows controlled failure of the wings to prevent fuselage collapse. O.C.

A86-35662
THE DESIGN AND DEVELOPMENT OF NEW CRASHWORTHY SEATS FOR NAVY HELICOPTERS
B. L. CARNELL (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 817-826. refs

U.S. Navy funded programs to design and develop new crashworthy crew seats for the SH-3D, G, and H anti-submarine and the CH-53A/D troop/cargo helicopters are described. The specifications for the seats include the peculiar requirements of installing stroking, load-attenuating seats in the confines of the cockpit and the need to match the loads on the seat support structures to the strengths of those structures. The seats, designed by Simula, Inc., Tempe, AZ, use variable load energy attenuators to accommodate a wide range of occupant weights. The seats for the CH-53A/D helicopters also provide armor protection for the crewmembers. Comprehensive qualification tests including operational, environmental, static, and dynamic tests are described. The improvements in crash safety are related to those of the U.S. Army BLACK HAWK helicopter. Author

A86-35663
THE HUGHES INTEGRATED APPROACH TO HELICOPTER CRASHWORTHINESS PAST, PRESENT, AND FUTURE
A. H. LOGAN and M. W. VOTAW (Hughes Helicopters, Inc., Culver City, CA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 827-835. refs

Military requirements for improved performance and crashworthiness have necessitated changes in the design of helicopters. Future helicopters will be designed around a system of energy absorbing components that are sized to maximize performance and survivability while minimizing weight. Designs made from advanced composite materials promise higher performance levels by taking advantage of the materials' specific strength and stiffness characteristics. The effects on crashworthiness of these emerging composite designs have not been fully investigated; however, the data generated to-date, from static and dynamic crush tests, suggest that the crashworthiness levels of present metal structures can be matched or exceeded through innovative composite designs. The future generation of crashworthy helicopters will draw on these and other technological advances as well as the experience from previous successful designs. Author

A86-35664
ARMY HELICOPTER CRASHWORTHINESS - LOADING THE BATTLEFIELD DICE IN OUR FAVOR
K. F. SMITH (U.S. Army, Applied Technology Laboratory, Fort Eustis, VA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 837-849. refs

This paper presents aspects of Army helicopter crashworthiness design with emphasis on the systems approach to energy absorption. Past successes, such as the crashworthy fuel system, are reviewed and some of the more recent findings in energy absorbing seats, composite subfloors and landing gear designs are presented. Finally, a review of proposed changes to the Army crashworthy crewseat specification (MIL-S-58095) and the aircraft crashworthiness military standard (MIL-STD-1290) are discussed. Author

A86-35665
CRASHWORTHY DESIGN OF ROTORCRAFT - A BASIC RESEARCH APPROACH
S. HANAGUD, J. I. CRAIG, D. SCHRAGE, and P. SRIRAM (Georgia Institute of Technology, Atlanta) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 851-866. refs
(Contract DAAG29-82-K-0094)

Crashworthy design of a rotorcraft constitutes a very important branch of the general field of rotorcraft design. A successful crashworthy design leads to many potential benefits. However, many different disciplines are involved and a number of constraints must be met when the subject of rotorcraft crashworthy design is analyzed. Some of the significant constraints involve the considerations of weight, cost, and performance. Potential weight savings that can be realized using composite materials when offset by additional material required for energy absorption or to maintain structural integrity offers the promise of extending the survivable crash envelope for future rotorcraft. A very brief discussion of the field, some potential problems in different disciplines concerning the crashworthy design of composite rotorcraft, and some suggestions, including basic research approaches, are presented in this paper. Author

A86-35668*# Texas A&M Univ., College Station.
PERFORMANCE DEGRADATION OF HELICOPTERS DUE TO ICING - A REVIEW
K. D. KORKAN (Texas A & M University, College Station), L. DADONE (Boeing Vertol Co., Philadelphia, PA), and R. J. SHAW (NASA, Lewis Research Center, Cleveland, OH) AHS, Annual Forum and Technology Display, 41st, Fort Worth, TX, May 15-17, 1985, Paper. 22 p. refs
(Contract NAG3-242)

Methodology developed to predict the performance degradation of rotating systems in natural icing conditions is described and discussed. Theoretical studies of the increments performance degradation due to icing involving the propeller, helicopter in hover and forward flight, and XV-15 propulsion modes are summarized. Related experimental studies on the NACA 0012 airfoil and model helicopter with/without generic ice shapes are reviewed. The results of these experimental and theoretical studies are used to suggest refinements to current methodology. C.D.

A86-35977
A RELIABILITY CONCEPT IN STRUCTURAL OPTIMIZATION OF FLIGHT VEHICLES [OB ODNOI KONTSEPTSII NADEZHNOSTI PRI OPTIMIZATSII KONSTRUKTSII LETATEL'NYKH APPARATOV]
S. V. ARINCHEV and V. V. BYSTROV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 7-12. In Russian. refs

A multidimensional quantile of the parameters of a system of a given order is adopted as a reliability function of the system. A lower bound on the multidimensional quantile is obtained in terms of one-dimensional quantiles, and a relationship is established between the lower bound and the known upper bound of multidimensional probability. The possibility of using this estimate as an optimization function in flight vehicle design is illustrated through numerical modeling. V.L.

A86-35978
THE OPTIMAL TAKE-OFF RUN OF AN AIRCRAFT ON AN UNPAVED SURFACE [OPTIMAL'NYI RAZBEG SAMOLETA PO GRUNTU]
A. A. BADIAGIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 12-16. In Russian. refs

The problem of optimizing the take-off run of an aircraft is investigated analytically. It is shown that the most favorable lift coefficient of a wing during the take-off run depends on the rolling resistance coefficient of the wheels. It is further shown that for a soft unpaved surface there exists an optimal-in-the-limit take-off run with fixed and relatively large angles of attack. V.L.

A86-35981
THE EFFECT OF THE ADMISSIBLE CENTERING MISALIGNMENT OF A TRANSPORT AIRCRAFT ON ITS MASS [VLIIANIE DOPUSTIMOGO RAZBEGA TSENTROVOK TRANSPORTNOGO SAMOLETA NA EGO MASSU]
V. P. GOGOLIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 24-28. In Russian.

A solution is presented for the problem of determining changes in the mass of an aircraft resulting from a centering misalignment occurring during service. The solution is based on the concept of aircraft mass increase coefficients. Computational formulas are presented, and their use is illustrated by an example. V.L.

A86-36333
SUKHOI FROGFOOT
R. BRAYBROOK Air International (ISSN 0306-5634), vol. 30, May 1986, p. 222-226.

The SU-25 Soviet fighter is configured for counterinsurgency missions, such as is evident in its Afghanistan applications. Modeled after the USAF A-X design of the late 1960s, the SU-25 has STOL capabilities similar to the A-10 aircraft, and is a large, very maneuverable jet. Differences include a slightly higher speed, smaller overall dimensions, more static thrust and a flat thrust curve. Its relatively short intake ducts are elliptical, which is thought to minimize flow distortions. The pilot relies on three rear-view mirrors and possibly a HUD display for extending the visual field. The aircraft has pylons for exterior weapons stores and fuel tanks, and is thought to be ultimately envisioned as a close support, local air superiority fighter for Central Europe. M.S.K.

A86-36334
STEALTH COMES STEALTHILY
J. JONES Air International (ISSN 0306-5634), vol. 30, May 1986, p. 227-229, 258, 259.

Stealth aircraft, actually a series of military aircraft that is part of the Covert Survivable In-Weather Reconnaissance Strike program, are asserted to have reached an initial operational stage with the F-19A fighter/reconnaissance aircraft. The design goals, defined after tests in the early 1970s, included a very low radar cross section, radar absorbent airframe and internal structure, minimized engine noise levels, cooled engine exhaust to reduce IR signature and inclusion of advanced ECM equipment. The fuselage is blended into the planform, as with the Orbiter, and the anhedral of the wing increases from root to tip. Air intakes are side-by-side above the wing and partially shielded by small winglets. The F-19A is thought to have a cruise speed of Mach 2.0 and to be made mainly of Fiberloy, i.e., boron fiber reinforced plastic. The pure metal fraction of the aircraft is under 5 percent and is mostly in the engine. The leading edges of the wings, fins and canards and the outer engine skins are made of nonreflecting CFRP material to reduce thermal and radar signatures. Much of the technology is being incorporated into the B-2B bomber prototype, which may be a flying wing for low altitude, subsonic penetration bombing missions. M.S.K.

A86-36818
PACIFIC AEROSYSTEMS CONTINUES DEVELOPMENT OF HERON 26 VEHICLE
Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, April 28, 1986, p. 63, 64, 66.

The current stage of development of the Heron 26 RPV includes an on-board FLIR system and a television platform. Although eliminated from competition for a Navy procurement of the vehicles, consideration is being given to supplying the Heron avionics and ground stations for use in the Mirach-20 system, which has sales overseas. An innovative feature of the Heron is the navigation system, the Mizar, which uses Omega VLF as a primary positioning link at present and will access the GPS when it is operational. Updates can also be issued to the aircraft from the ground station through high speed burst links. The autonomy of the system permits the Heron to fly a predetermined course and return for pick-up, all automatically. The course accuracy is a 400 m circular error probability (CEP) with Omega and 50 m CEP with GPS. The Heron has a composite airframe, twin-boom tails, a pusher propeller, an overall length of 12.9 ft and a height of 3.8 ft. Flight performance is an 11,500 ft altitude normal, 20,000 ft with modifications, and cruise speed of 85 kt for 5 hr. M.S.K.

A86-36819
DEVELOPMENTAL SCIENCES PREPARES SKYEYE FOR ARMY COMPETITION
Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, April 28, 1986, p. 68, 69, 72 (3 ff.).

The Skyeye R4E-40 mini-RPV is a 520 lb. maximum weight entry into the Army intelligence and EW unmanned aerial vehicle competition. The new generation of RPVs is targeted for uses as decoys and for reconnaissance and damage assessment roles. The RPV has already carried a 90 lb. FLIR system for 9.3 hr at 3000 ft altitude and a 70 kt loiter speed. The vehicle is capable of a 500 fpm climb speed to 10,000 ft and a 130 kt top speed. Besides the FLIR cameras, the Skyeye can carry IR line scanners, a 35 mm panoramic scanner and a meteorological package. The airframe is an all-composite structure with a 13.8 ft length and a 17.5 ft wingspan. A crew of six is required for operations, linked to the Skyeye by 1-2 GHz telemetry. Flight is controlled manually, by an autopilot or is preprogrammed for reference to up to 25 waypoints to satisfy desired heading, altitude, airspeed and sensor commands. The autonomous mode includes the capacity for loiter if the base link is broken, followed by a return to the last known base position after a preset time interval. Previous projects the manufacturer was involved in are summarized to partially describe the climate for producing RPVs during the period of low demand since the end of the Vietnam War. M.S.K.

A86-36820
ARMY COMPLETING DEVELOPMENT TESTS FOR LOCKHEED AQUILA RPV SYSTEM
Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, April 28, 1986, p. 85-87, 89.

The Aquila RPV is the lead contender in an Army effort to procure an unmanned, miniaturized airborne reconnaissance and laser designating system which is mobile and survivable on a modern battlefield. The Kevlar/epoxy vehicle is 7 ft long, has a wingspan under 13 ft, weighs less than 265 lb. with payload, and can be fitted with an INS for autonomous navigation past preprogrammed waypoints. The maximum of 60 lb. payloads can include a television camera, the laser designator and stabilized optics, and a FLIR for nighttime operations. An antijam capability has been developed for Aquila, which is carried on an Army truck and is caught by a net following flight. The ground crew numbers three personnel. Preliminary tests to prove the production-worthiness of the vehicle have resulted in performances that meet or exceed the requirements, including over 20 min. unattended flight, simultaneous control of two vehicles in flight by the ground station, and 100 percent success at designating moving or stationary targets with the laser apparatus. A 1990 operational status is projected for squadrons of the million dollar Aquilas. M.S.K.

A86-36821
U. S. ARMY PLANS TO EVALUATE CANADAIR CL-227 SENTINEL
Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, April 28, 1986, p. 103, 105.

The CL-227 RPV is under development for service in short- to medium-range operations at the brigade level. The 10-ft wingspan CL-227 consists of two spherical modules, powerplant at the bottom and payload at the top, and two 3-bladed counterrotating propellers. The blades have Kevlar skins surrounding foam cores. The vehicle is designed to fly for 3-4 hr, carry a 60-100 lb. payload, travel at up to 70 kt or hover, and climb up to 10,000 ft. The powerplant, furnishing 50 shp and functioning at 100 krpm stepped down to 1 krpm, exhausts upward to mix the exhaust with the downwash and thus to lower the IR signature. Directional changes and flight stability are controlled through low order differential alterations in the propeller speeds. The vehicle is either flown by a joystick

handled by the ground crew or can be programmed to take-off and automatically follow waypoints. Landing is automatic once the vehicle is positioned over a designated landing spot. The CL-227 may be used for reconnaissance, decoy, communications relay or ECM applications. M.S.K.

A86-36822
NORTHROP DELIVERS RPVS TO NAVY TO AID IN DEVELOPMENT PROPOSAL
Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, April 28, 1986, p. 123, 125, 127.

Deliveries have begun of the BQM-74C target drone reconfigured to serve in reconnaissance applications. The modifications include a nose with a fixed, unstabilized video camera for real-time image transmissions and a 10:1 zoom capability. The camera is equipped with a video cassette for storage when out of telemetry link. A 240-400 n.mi. range is provided, along with flight altitudes of 30-30,000 ft and speeds of 250-500 kt. Video telemetry can be broadcast from 50-70 n.mi., depending on the flight altitude, and the command and control range is 35-50 n.mi. The entire flight of the RPV can be conrolled by an on-board autopilot which can handle speeds, altitudes and maneuvers according to a preprogrammed sequence. The video telemetry is linked to video processors with full storage and playback, real-time and stop-frame capabilities. A larger version of the vehicle is under development to extend the range of use for decoy, reconnaissance, electronic signal intercept, weather data gathering and jamming. M.S.K.

A86-36946
SIMULATION OF AIRCRAFT COMPONENTS FOR TRAINING PURPOSES
D. HOWE (Burtek, Inc., Tulsa, OK) IN: Flight simulation/simulators; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 51-59.
(SAE PAPER 851965)

A simulation system applied to a primary and secondary flight controls trainer, using nonaircraft commercial parts to teach maintenance and rigging, is presented. Simulation techniques include the use of reduced pressure hydraulics, substitution of electrical drivers and generation of synthetic signals to test equipment. Realism, system functionality and electrical and mechanical interfaces were not compromised, while benefits such as cost savings, schedule improvement and greater safety were derived. It is concluded that all the objectives of using simulated, rather than actual aircraft, components were achieved. K.K.

A86-37064*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
SUMMARY OF RESULTS OF NASA F-15 FLIGHT RESEARCH PROGRAM
F. W. BURCHAM, JR., G. A. TRIPPENSEE, D. F. FISHER, and T. W. PUTNAM (NASA, Flight Research Center, Edwards, CA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 32 p. NASA-supported research. refs
(AIAA PAPER 86-9761)

NASA conducted a multidisciplinary flight research program on the F-15 airplane. The program began in 1976 when two preproduction airplanes were obtained from the U.S. Air Force. Major projects involved stability and control, handling qualities, propulsion, aerodynamics, propulsion controls, and integrated propulsion-flight controls. Several government agencies and aerospace contractors were involved. In excess of 330 flights were flown, and over 85 papers and reports were published. This document describes the overall program, the projects, and the key results. The F-15 was demonstrated to be an excellent flight research vehicle, producing high-quality results. Author

A86-37081#
FLIGHT TESTING FOR BETTER FLIGHT TRAINING SIMULATORS
W. G. SCHWEIKHARD and R. R. L. RENZ (Kohlman Systems Research, Inc., Lawrence, KS) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 5 p.
(AIAA PAPER 86-9728)

The development of a data acquisition system for flight simulation testing is described. The flight test instrumentation and analysis techniques required for testing the aircraft are examined. The flight testing of thirteen business jets and one turboprop aircraft is discussed. Problems encountered in the formation of the data acquisition system are analyzed. I.F.

A86-37082#
AV-8B HIGH ANGLE OF ATTACK/DEPARTURE RESISTANCE SYSTEM FLIGHT TEST PROGRAM
R. A. BIGLER (McDonnell Aircraft Co., St. Louis, MO) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 9 p.
(AIAA PAPER 86-9729)

The AV-8B High Angle of Attack (HAOA) Test Program used a four phase approach to accomplish the goals within the established time constraints. The major goals were evaluating the HAOA flight characteristics as required by military specification and developing stability augmentation software to enhance the aircraft's maneuvering capability. These goals were accomplished during a thirteen month/251 flight program which incorporated Naval Air Test Center participation flights throughout to eliminate extraneous testing and provide the customer with an early appraisal of the HAOA characteristics. The flight test program concluded with a dedicated spin mode and recovery investigation. The test results defined the maneuvering boundary and indicated the aircraft possessed a high resistance to spin dynamics throughout the normal flight regime. Author

A86-37108
STRUCTURAL CERTIFICATION AND IN-SERVICE FLIGHT EXPERIENCE OF THE RB 211-524 FAN COWL DOORS UTILISING CARBON FIBRE COMPOSITE MATERIALS
B. P. BROADLEY (Rolls-Royce, Ltd., Derby, England) IN: Composite structures 3; Proceedings of the Third International Conference, Paisley, Scotland, September 9-11, 1985 . London, Elsevier Applied Science Publishers, 1985, p. 118-134. refs

N86-24685*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
GROUND VIBRATION TEST OF AN F-16 AIRPLANE WITH MODIFIED DECOUPLER PYLONS
F. W. CAZIER, JR.. and M. W. KEHOE (NASA. Dryden Flight Research Center) Apr. 1986 64 p refs
(NASA-TM-87634; L-16065; NAS 1.15:87634) Avail: NTIS HC A04/MF A01 CSCL 01C

The decoupler pylon is a passive wing/store flutter suppression device. It was modified to reduce friction following initial flight tests. A ground vibration test was conducted on an F-16 aircraft loaded on each wing with a one-half-full (center bay empty) 370-gallon fuel tank mounted on a standard pylon, a GBU-8 store mounted on the decoupler pylon, and an AIM-9J missile mounted on a wingtip launcher. The test was conducted prior to flight tests with the modified pylon to determine modal frequencies, mode shapes, and structural damping coefficients. Data presented include frequency response plots, mode shape plots, and limited force-effect plots. Author

N86-24687*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
AN ENGINEERING APPROACH TO THE USE OF EXPERT SYSTEMS TECHNOLOGY IN AVIONICS APPLICATIONS
E. L. DUKE, V. A. REGENIE, M. BRAZEE, and R. W. BRUMBAUGH (PRC Kentron, Edwards, Calif.) May 1986 12 p refs Presented at the IEEE National Aerospace and Electronics Conference (NAECON), Dayton, Ohio, 19-23 May 1986
(NASA-TM-88263; H-1364; NAS 1.15:88263) Avail: NTIS HC A02/MF A01 CSCL 01D

The concept of using a knowledge compiler to transform the knowledge base and inference mechanism of an expert system into a conventional program is presented. The need to accommodate real-time systems requirements in applications such as embedded avionics is outlined. Expert systems and a brief comparison of expert systems and conventional programs are reviewed. Avionics applications of expert systems are discussed before the discussions of applying the proposed concept to example systems using forward and backward chaining. Author

N86-24688# Boeing Military Airplane Development, Seattle, Wash.
FIREPROOF HYDRAULIC BRAKE SYSTEM Final Report, 1 Jul. 1983 - 31 Jul. 1985
D. W. HULING and F. H. HILLMAN Oct. 1985 318 p refs (Contract F33615-83-C-2322)
(AD-A163542; AFWAL-TR-85-2072) Avail: NTIS HC A14/MF A01 CSCL 01C

The design, development, and manufacture of a flightworthy two-fluid fireproof hydraulic brake system (FHBS) kit for flight testing on a C/KC-135 has been accomplished. The results of system concepts trade studies, the concept selection procedure and rational, component and system design analyses, and component and system testing are summarized herein. The FHBS design selected is a two-fluid concept that uses nonflammable chlorotrifluoroethylene (CTFE) in the high fire-potential area of the brake and landing gear area. The barrier between the CTFE fluid and the MIL-H-5606 hydraulic fluid is a new component; a reservoir/separator. Based on the analysis and laboratory testing, it was concluded that the FHBS design is both flightworthy and has braking performance equivalent to the C/KC-135 brake system for runway/tire friction coefficients of 0.2 to 0.5. It is recommended that the FHBS kit be installed on a C/KC-135 and flight testing be accomplished. Recommendations regarding test conditions and instrumentation for flight testing are included. GRA

N86-24689# Department of the Air Force, Washington, D.C.
FRAMELESS TRANSPARENCIES FOR AIRCRAFT COCKPIT ENCLOSURES Patent Application
W. R. PINNELL, inventor (to Air Force) 4 Dec. 1985 18 p refs
(AD-D012155; US-PATENT-APPL-SN-805008) Avail: NTIS HC A02/MF A01 CSCL 01C

This patent application is for a frameless aircraft cockpit enclosure comprising transparent panels of polycarbonate or other plastics of varying thickness and material properties. The edges of the transparent panels are made thicker than the rest of the panels to engage aircraft canopy and windshield arch sections and aircraft sill structures to thus eliminate prior art frames and edge reinforcements. Fibers may be embedded in the thicker edges to add strength. The material properties of the transparent panel may be varied to provide higher static load strength near aircraft sill structures and higher dynamic load strength and plastic behavior near the center of a canopy where bird impact may occur. The material properties of the panel may also be varied to minimize over a pilot's head or near aircraft critical equipment the amplitude of a flexure wave in an aircraft transparency resulting from a bird impact. Direct forming methods, such as injection molding, are discussed as a means for making the frameless aircraft transparencies. GRA

N86-24690# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
EXPERIMENTAL ASSESSMENT OF VORTEX RETAINING CAVITY FLAPS FOR MANEUVERABILITY IMPROVEMENT ON DELTA WING FIGHTER AIRCRAFT M.S. Thesis
H. C. SMITH Dec. 1985 244 p refs
(AD-A164104; AFIT/GAE/AA/85D-13) Avail: NTIS HC A11/MF A01 CSCL 01C

An experimental study was conducted to determine the effectiveness of cavity flaps on delta wing aircraft maneuverability. Cavity flaps are conformal control surfaces deployed in the apex region on the wing's lower surface. A 60 degree swept delta wing model was built and tested in the Air Force Institute of Technology five-foot diameter, subsonic wind tunnel. Ten different cavity flap configurations were tested at deflection angles ranging from 30 degrees to 90 degrees for both asymmetric and symmetric deployments. Coefficients of aerodynamic forces and moments versus angle of attack along with the lift to drag ratio versus lift coefficient and the drag polar were plotted for each flap configuration. The changes to the aerodynamic coefficients produced by adding the cavity flaps were also plotted. Results indicate that for longitudinal, lateral and directional maneuverability, the best cavity flap deflection angle will vary depending on the desired response. Data results also indicated it is best not to have the cavity flap hinge line located along or parallel to the fuselage for rolling and pitching moment considerations. Hinge Line Sweep. GRA

N86-25338 ESDU International Ltd., London (England). Engineering Sciences Data Unit.
CONVERSION OF AIR-DATA SYSTEM PRESSURE ERRORS INTO HEIGHT AND SPEED CORRECTIONS
Nov. 1985 37 p refs
(ESDU-85036; ISBN-0-85679-542-9; ISSN-0141-4054) Avail: ESDU

Approximate formulae for converting errors in pitot and static pressure into corrections to height, Mach number and indicated airspeed are presented as both equations and graphs. The methods give acceptable accuracy for constructing charts or tables of height and speed corrections for flight and operating manuals when pressure errors are not large. Exact methods for correcting speed and height are also included for use when the pressure errors are large, and guidance is included on the correction procedure under nonsteady conditions when any of the errors may depend on the height, Mach number or airspeed. A practical work example illustrates the use of the method. Author

N86-25339# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
EVALUATION OF A FREQUENCY RESPONSE TECHNIQUE FOR AIRCRAFT SYSTEM IDENTIFICATION M.S. Thesis Final Report, Feb. 1984 - Oct. 1985
A. T. REED 31 Oct. 1985 108 p refs
(AD-A164367; AFIT/GAE/AA/85J-2) Avail: NTIS HC A06/MF A01 CSCL 01A

This paper presents the results of a project which used frequency analysis methods applied to flight test data in order to identify aircraft parameters. Computer programs were developed to generate simulated flight test data so the frequency response programs could be tested using a noise free data source. Once the simulated data programs were complete, the frequency response methods were developed. The frequency response method uses the cross-spectral density technique to generate magnitude and phase information. The program also generates the power spectral density functions. Noise contamination studies were made. The programs were used with the test project, HAVE DELAY, which was conducted at the USAF Test Pilot School. The frequency response program worked well up to a frequency of about 15 radians per second. Above 15 radians per second the programs suffer from additional noise and aliasing effects. Recommendations were made to study means of reducing noise effects to include anti-aliasing filters and noise processing schemes for digital data. GRA

N86-25340# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
MULTIVARIABLE OUTPUT CONTROL LAW DESIGN FOR THE STOL (SHORT TAKEOFF AND LANDING) F-15 IN LANDING CONFIGURATION M.S. Thesis
B. H. ACKER Dec. 1985 294 p refs
(AD-A164516; AFIT/GE/ENG/85D-1) Avail: NTIS HC A13/MF A01 CSCL 01B

Using the MULTI computer aided design and simulation program, multivariable, output feedback digital control laws are designed for the F-15 STOL aircraft in the landing configuration. The STOL F-15 landing configuration includes canards and reversible thrust in addition to conventional F-15 control surfaces. The additional controls allow decoupling of the output variables in the longitudinal plane. Longitudinal aircraft dynamics, derived from data provided by the prime contractor, McDonnell-Douglas, are presented in linearized state space form for the design procedure. Control laws are developed to stabilize the aircraft to perform longitudinal landing maneuvers (flight path control and flare) at six flight conditions. The design encompasses actuator dynamics, computational delay, sensor dynamics, sensor noise, and plant nonlinearities. Designs of two of the flight conditions are sufficiently insensitive to plant variations to be used at all but one of the remaining flight conditions. The technique of multivariable output feedback, with the MULTI program provides good robust designs for the STOL F-15. GRA

N86-25341# Aeronautical Research Labs., Melbourne (Australia).
REPORT ON INTEREST EXPRESSED IN SOME AUSTRALIAN DEFENCE ESTABLISHMENT PRODUCTS DISPLAYED AT THE 1985 PARIS AIR SHOW
U. R. KRIESER Aug. 1985 29 p
(AD-A160807; ARL-AERO-PROP-TM-429; AR-004-040) Avail: NTIS HC A03/MF A01 CSCL 01C

During June 1985 a number of aerospace products developed in Australia were displayed at the Paris Air Show. The Department of Defense was one of 16 exhibitors, and presented 14 products which it considered to have commercial potential on the world market. Considerable interest was shown in the Department of Defense products presented in Paris, and subsequent visits to aerospace companies in Israel, further demonstrated strong overseas interest in both manufacture and purchase of these products. Author

N86-25601# Joint Publications Research Service, Arlington, Va.
INFORMATION ON NEW AN-124 GIANT CARGO PLANE Abstract Only
N. DOMBKOVSKIY *In its* USSR Report: Engineering and Equipment (JPRS-UEQ-86-002) p 4 7 Feb. 1986 Transl. into ENGLISH from Trud (Leningrad, USSR), 23 May 1985 p 1
Avail: NTIS HC A06/MF A01

The dimensions and capabilities of the AN-124 cargo aircraft are described. The problems that were involved in the aircraft design are also characterized. B.G.

N86-25602# Joint Publications Research Service, Arlington, Va.
DATA ON MI-26 HELICOPTER Abstract Only
L. CHERNOV *In its* USSR Report: Engineering and Equipment (JPRS-UEQ-86-002) p 7-8 7 Feb. 1986 Transl. into ENGLISH from Kommunist (Moscow, USSR), 19 May 1985 p 4
Avail: NTIS HC A06/MF A01

The MI-26 helicopter, which has the highest payload capacity of any existing helicopter, can transport items that weigh more than 20 tons over long distances in severe climatic conditions. The helicopter is used in the construction of bridges and other structures, and in the delivery and installation of heavy equipment for industrial enterprises and drilling rigs in remote areas. The increased power of the MI-26 was achieved through the use of new materials, structural design, and two economic D-136 gas turbine engines. The design and arrangement of the MI-26 systems make ground maintenance possible without special airfield equipment. An auxiliary power unit ensures the prolonged operation of the helicopter. For mechanization of loading operations, the cargo bay is equipped with two electric winches and a hoisting mechanism which can handle cargo items up to 5 tons each. With a length of 15 meters, the cargo bay can easily hold two trucks or motor buses. B.G.

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A86-33583* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AN AIRBORNE MULTIPLE-BEAM 1.4 GHZ PUSHBROOM MICROWAVE RADIOMETER
R. F. HARRINGTON and R. W. LAWRENCE (NASA, Langley Research Center, Hampton, VA) IN: 1985 International Geoscience and Remote Sensing Symposium (IGARSS '85), Amherst, MA, October 7-9, 1985, Digest. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 601-606.

A method is described for providing soil moisture measurements from satellites by performing simultaneous measurements across track (the pushbroom approach). The method has the advantage of obtaining the required swath width without sacrificing sensitivity. A prototype Pushbroom Microwave Radiometer developed at NASA's Langley Research Center is described. It is a multibeam L-Band (1413 MHz) radiometer system providing simultaneous cross track measurements. Results of flight tests onboard a P-3 aircraft are discussed. D.H.

A86-33590* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HIGH RESOLUTION MILLIMETER-WAVE IMAGING SENSOR
W. J. WILSON, R. J. HOWARD, and G. S. PARKS (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: 1985 International Geoscience and Remote Sensing Symposium (IGARSS '85), Amherst, MA, October 7-9, 1985, Digest. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 647-649. Army-supported research.

A scanning 3-mm radiometer is described that has been built for use on a small aircraft to produce real time high resolution images of the ground when atmospheric conditions such as smoke, dust, and clouds make IR and visual sensors unusable. The sensor can be used for a variety of remote sensing applications such as measurements of snow cover and snow water equivalent, precipitation mapping, vegetation type and extent, surface moisture and temperature, and surface thermal inertia. The advantages of millimeter waves for cloud penetration and the ability to observe different physical phenomena make this system an attractive supplement to visible and IR remote sensing systems. D.H.

A86-33802* Michigan Univ., Ann Arbor.
HEAD-UP DISPLAY (HUD) UTILITY. II - RUNWAY TO HUD TRANSITIONS MONITORING EYE FOCUS AND DECISION TIMES
D. J. WEINTRAUB (Michigan, University, Ann Arbor), R. F. HAINES, and R. J. RANDLE (NASA, Ames Research Center, Moffett Field, CA) IN: Human Factors Society, Annual Meeting, 29th, Baltimore, MD, September 29-October 3, 1985, Proceedings. Volume 1 . Santa Monica, CA, Human Factors Society, 1985, p. 615-619.
(Contract NCA2-OR-440-301)

An experiment conducted using a head-up display (HUD) suggests that the demonstrated superiority of the HUD over a conventional instrument panel stems from its superior layout of information. A HUD display presents instrument-panel information to pilots in such a way that the symbols appear as a virtual image at optical infinity superimposed on the landscape. In the experiment conducted, the luminance of the display symbology and its angle

subtended at the eye remained fixed, while optical distance and gaze angle were varied. Concomitant measures of eye movements, eye accommodative state, and decision-making time concerning airspeed, altitude and runway condition were obtained. It is found that, while looking straight ahead, at zero diopters, the HUD shortens decision time by 80 to 90 msec, not statistically significant at the 0.05 (slope of diopter/gaze interaction) level. The question of a cognitive overload induced by the luminous symbols of the HUD is subsequently addressed. K.K.

A86-33814
COCKPIT AUTOMATION TECHNOLOGY - A FURTHER LOOK
M. D. MCNEESE, R. WARREN, and B. K. WOODSON (USAF, Aerospace Medical Research Laboratories, Wright-Patterson AFB, OH) IN: Human Factors Society, Annual Meeting, 29th, Baltimore, MD, September 29-October 3, 1985, Proceedings. Volume 2 . Santa Monica, CA, Human Factors Society, 1985, p. 884-888. refs

Issues related to the development of a structured human factors crew station design methodology are discussed. The benefits to pilots, design teams, and the US Air Force from cockpit automation technology (CAT) design methodology are described. The relationship between CAT components and procedures, and the user's needs is studied. The iterative cycle of the methodology and the parameterization of CAT components are analyzed. I.F.

A86-34276#
STUDIES ON TURNING ERRORS OF THE MAGNETIC COMPASS IN FLIGHT EXPERIMENTS
T. HIDESHIMA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 34, no. 385, 1986, p. 74-80. In Japanese, with abstract in English. refs

To clarify the behavior of turning errors of the magnetic compass, many turns are conducted from various courses by the trainers of Civil Aviation College. In turning to the right, the maximal lag error of the compasss occurs between the heading of 10 and 40 deg, and the maximal lead error occurs between the heading of 130 and 160 deg. The extent of the maximal error depends upon the angle of aircraft bank. An angle of bank has the greatest effect on compass errors among the flight characteristics of an aircraft. The effect of flying speed, the time rate of bank and flying altitude are investigated. The results of flight experiments agree quite well with those of computing errors through Lindemann's procedure. As a result of the studies, turning error curve is proposed. The computed turning error curves to one angle of bank are almost the same for the compasses used today. This curve can be applied to any turning by using the magnetic compass. Author

A86-35207
WEIGHT ASSESSMENT OF ELECTRONIC BOXES
L. A. HARTLEY and O. HANREITER (Boeing Military Airplane Co., Wichita, KS) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 37 p.
(SAWE PAPER 1661)

The present paper is concerned with the prediction and assessment of the weights of electronic boxes on a new aircraft. A statistical basis is provided for the evaluation of weights of electronic boxes, taking into account the use of simple parameters which are universally available. The Offensive and Defensive System avionics developed for the B-1 bomber program provide a sufficiently large data base to permit development of a statistical basis for evaluating electronic box weights. It is found that a distinct electronic box, which is called a Line Replaceable Unit (LRU), can undergo tremendous weight growth. Attention is given to a data base description, LRU construction, aspects of program phasing and milestones, sources of uncertainty for new hardware, sources of uncertainty for off-the-shelf hardware, statistical data, probability curves defined, parameters defined, probability of LRU weight growth, LRU weight density probability, a weight quality history, and aspects of data application. G.R.

A86-35366* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A PRELIMINARY STUDY OF THE BASIC DISPLAY/GUIDANCE REQUIREMENTS FOR FLYING NEAR OPTIMAL TRAJECTORIES
D. D. VICROY (NASA, Langley Research Center, Hampton, VA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 669-674. refs

NASA has responded to the increased emphases on cost-efficient operation of today's airline fleet with an ongoing research program to investigate the requirements and benefits of using new airborne guidance and pilot procedures designed to yield cost-optimal flight profiles that are compatible with advanced air traffic control system concepts. A trajectory optimization algorithm has been incorporated into one of NASA Langley's fixed-based simulators to investigate the pilot/cockpit interface requirements. The trajectories that are generated by this algorithm differ from conventional profiles in that they are constantly varying in both flight path angle and airspeed. Considering the dynamic nature of these profiles, conventional guidance may be insufficient for practical use. This paper summarizes the results of an initial set of piloted simulation tests to investigate the basic guidance requirements for flying the near-optimal trajectories. Author

A86-35439
COMPUTER-AIDED COCKPIT WORKLOAD ANALYSIS FOR ALL WEATHER, MULTIROLE TACTICAL AIRCRAFT
B. B. ROBERTS (Computer Sciences Corp., Edwards AFB, CA) and C. D. CRITES (USAF, Flight Test Center, Edwards AFB, CA) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 111-123.
(SAE PAPER 851876)

The development of computer-aided cockpit workload analysis that predicts man/machine interface problems is discussed. The logic flow for the Timebased Analysis of Significant Coordinated Operations (TASCO) model is described. The components and procedures of the crew station task analysis and busy rate index analysis performed by the TASCO model are examined. Computer-aided testing is applied to the TASCO model to establish pass/fail criteria associated with operator task performance profficiency. I.F.

A86-35606
STORED TERRAIN DATA BASE AIDED PILOTAGE FOR HELICOPTERS
N. C. SEILER and J. A. GRACIA (Harris Corp., Harris Government Aerospace Systems Div., Melbourne, FL) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 101-109. refs

A panoramic pilotage display, enhanced by a topographical data base, can significantly improve military helicopter pilot efficiency while reducing workloads. The basic task of geographic orientation is automated through the provision of a planview map with tactical symbology on a head-down display. The stored data base required allows for a look-ahead capability from topographical cover positions; this is especially useful when presented in a perspective format on the head-down display. A system of this type is applicable to the U.S. Army's next-generation 'LHX' single-crewmember combat helicopter. O.C.

A86-35650
AN AVIONICS SOFTWARE TEST AND EVALUATION TECHNIQUE
T. B. PRIEST, JR. and B. P. DOUGLASS (Bell Helicopter Textron, Fort Worth, TX) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 661-664.

Quality control must be ensured for advanced helicopter avionics systems requiring complex software for the performance of a variety of tasks; attention is presently given to a four-phase

software testing method of this type. The phases are: (1) individual software module testing; (2) testing of the complete program constructed from the linked modules; (3) real time, manned tests with simulated inputs; and (4) flight testing. O.C.

A86-35666#
INTEGRATED AVIONICS SUITE AS IMPLEMENTED ON THE AGUSTA A-129
K. E. FARSON (Harris Corp.; Government Aerospace Systems Div., Melbourne, FL) AHS, Annual Forum and Technology Display, 41st, Fort Worth, TX, May 15-17, 1985, Paper. 12 p.

The integrated avionics suite implemented on the Agusts A-129 attack helicopter is described. The integrated Multiplex System (IMS), performing all of the on-board subsystem management, processing, data transfer, display, and control is the main asset of the craft, with features including pilot and copilot multimode displays, dual redundant mission processors, dual MIL-STD-1553B data bus network, electrical power management through solid-state power controllers, and modular software. Implementation of IMS into the helicopter meant a reduction in the number of required LRUs, lower total system weight, incrased reliability, and improved performance. The extremely flexible system architecture allows for changes and growth. I. S.

A86-36725
DIGITAL CORRECTION OF THE READINGS OF AN AIRCRAFT FUEL-MEASUREMENT SYSTEM [TSIFROVAIA KORREKTSIIA POKAZANII TOPLIVOIZMERITEL'NOI SISTEMY LETATEL'NOGO APPARATA]
A. L. ALIMOV Avtometriia (ISSN 0320-7102), Jan.-Feb. 1986, p. 100-102. In Russian.

The paper examines the compression and compact storage of data required for the digital correction of the readings of an aircraft fuel-measurement system. It is shown that memory-size minimization involves the division of a special graph into a minimum number of complete subgraphs. A heuristic algorithm for solving this model is proposed. B.J.

A86-37045*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CRASH RESPONSE DATA SYSTEM FOR THE CONTROLLED IMPACT DEMONSTRATION (CID) OF A FULL-SCALE TRANSPORT AIRCRAFT
R. S. CALLOWAY and V. H. KNIGHT, JR. (NASA, Langley Research Center, Hampton, VA) ISA, International Instrumentation Symposium, 32nd, Seattle, WA, May 5-8, 1986, Paper. 20 p.

A study involving the Controlled Impact Demonstration (CID) of a transport category aircraft was conducted with the objective to improve occupant safety during survivable crash scenarios. in connection with this study, the first remotely-piloted Full-Scale Transport aircraft was purposely crashed into the California desert. The program was initated to demonstrate the effectiveness of an imisting kerosene (AMK), a fuel additive emplyed to reduce postcrash fires. The unmanned CID flight carried 73 life-like flight research dummies, multiple experiments, high-speed interior cabin cameras, and the high-environment Crash Response Data System. Attention is given to the design approach, a block diagram of the Crash Response Data System, measurements, the digital data subsystem, signal conditioning, telemetry, on-board recording, the power subsystem, preflight checkout and calibration, and aspects of system qualification. G.R.

A86-37083*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ADVANCED BOUNDARY LAYER TRANSITION MEASUREMENT METHODS FOR FLIGHT APPLICATIONS
B. J. HOLMES, C. C. CROOM, P. D. GAIL, G. S. MANUEL, and D. L. CARRAWAY (NASA, Langley Research Center, Hampton, VA) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 14 p. refs
(AIAA PAPER 86-9786)

In modern laminar flow flight research, it is important to understand the specific cause(s) of laminar to turbulent boundary-layer transition. Such information is crucial to the exploration of the limits of practical application of laminar flow for drag reduction on aircraft. The transition modes of interest in current flight investigations include the viscous Tollmien-Schlichting instability, the inflectional instability at laminar separation, and the crossflow inflectional instability, as well as others. This paper presents the results to date of research on advanced devices and methods used for the study of laminar boundary-layer transition phenomena in the flight environment. Recent advancements in the development of arrayed hot-film devices and of a new flow visualization method are discussed. Arrayed hot-film devices have been designed to detect the presence of laminar separation, and of crossflow vorticity. The advanced flow visualization method utilizes color changes in liquid-crystal coatings to detect boundary-layer transition at high altitude flight conditions. Flight and wind tunnel data are presented to illustrate the design and operation of these advanced methods. These new research tools provide information on disturbance growth and transition mode which is essential to furthering our understanding of practical design limits for applications of laminar flow technology. 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.

A86-33970
FATIGUE FAILURE OF JET ENGINE DRIVE SHAFTS
H. J. KOLKMAN and J. P. K. VLEGHERT (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) International Journal of Fatigue (ISSN 0142-1123), vol. 8, Jan. 1986, p. 3-8.

The cause and prevention of service failures of jet engine drive shafts was investigated by various methods. A materials investigation revealed a low fatigue resistance associated with material deficiencies for certain shafts, including the failed ones. Nevertheless the final and most economic solution to the problem was found by vibration analysis. Author

A86-34279#
THE SUPERPOSITION DISTORTION INDEX
T. ABE Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 34, no. 385, 1986, p. 97-106. In Japanese, with abstract in English. refs

In this paper, a superposition distortion index KA2 is introduced to indicate the relationship between the distortion intensity and the fan speed. The data to calulate the KA2 was obtained by the distortion experiments using the two stages axial flow fan and distortion screens. A number of conventional distortion indices such as Kra2, DI, Dmin, K-theta, KD2, and DC60 are presented to evaluate the each radial and circumferential distortion intensity. In a previous paper, both radial and circumferential distortion indices were expressed in one figure to evaluate the distortion intensity more accurately. This method, however, cannot tell the influence of the fan speed. The index KA2 includes the radial distortion index Kra2 and the circumferential distortion index K-theta, the

influence of fan speed. The influence of fan speed was obtained from the stall margin decrease of the fan chracteristics curves. Author

A86-35168#
PROCEDURES FOR THE DIGITAL SIMULATION OF HELICOPTER PROPULSION SYSTEMS [VERFAHREN ZUR DIGITALEN SIMULATION VON HUBSCHRAUBER-ANTRIEBSSYSTEMEN]
M. MENRATH and H. RICK (Muenchen, Technische Universitaet, Munich, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 31 p. In German. refs
(DGLR PAPER 85-115)

The advances made in aircraft engine technology are partly related to the available simulation methods for the design and the optimization of propulsion systems, and, in addition, also to the study of the steady and dynamic performance and operational characteristics of the entire system aircraft-engine. Numerical synthesis programs for the digital simulation of steady and dynamic operational characteristics of propulsion systems are discussed, taking into account engine monitoring with a gas dynamic diagnosis procedure. Attention is also given to the digital simulation of the dynamic operational characteristics with function generators, digital simulation according to 'state space models', and test stand technology for the development of simulation models. G.R.

A86-35188#
THE PROP-FAN - INITIATION FOR A NEW GENERATION OF PROPULSION SYSTEMS [DER PROPFAN - INITIALZUENDUNG FUER EINE NEUE TRIEBWERKSGENERATION]
P. SCHIMMING (DFVLR, Institut fuer Antriebstechnik, Cologne, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 11 p. In German.
(DGLR PAPER 85-166)

New applications of prop-fans are briefly discussed. The advantages of prop-fans are reviewed, and studies being conducted to evaluate the spectrum of possible propulsion systems using prop-fans are summarized. Concepts now being explored for ameliorating the drawbacks of prop-fans are described. C.D.

A86-35334
GAIN-SCHEDULED MULTIVARIABLE COTNROL FOR THE GE-21 TURBOFAN ENGINE USING THE LQG/LTR METHODOLOGY
P. KAPASOURIS, M. ATHANS, and H. A. SPANG, III (MIT, Cambridge, MA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 109-118. Research supported by the General Electric Co. refs

This paper presents a feasibility study related to the design of a global nonlinear multivariable compensator for a model of the GE-21 double-bypass variable cycle jet engine. The nonlinear engine dynamics are linearized at nine distinct operating conditions. Scaling of variable units and Singular Value Decomposition at DC identified the subset of controls and outputs for dynamic control. At each operating condition an LQG/LTR compensator is designed; the parameters of the LQG/LTR compensator are then scheduled to produce a global dynamic compensator. Transient simulations are included to illustrate the characteristics of the nonlinear multivariable control system. Author

A86-35400* Alphatech, Inc., Burlington, Mass.
APPLICATION OF FDI METRICS TO DETECTION AND ISOLATION OF SENSOR FAILURES IN TURBINE ENGINES
J. L. WEISS, A. S. WILLSKY, K. R. PATTIPATI, and J. S. ETERNO (Alphatech, Inc., Burlington, MA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1114-1120. refs
(Contract NAS3-24078)

This paper develops a framework for the design of failure detection and isolation (FDI) algorithms. Rather than trying to apply 'optimal' techniques in a top-down manner, the system redundancies are evaluated with respect to their ability to provide reliable FDI information. Previous work of Pattipati et al. (1984) and Weiss et al. (1984) defined a useful context and several useful analytical results, which provide a basis for the FDI design methodology developed here. A general decision structure which can take advantage of redundancy evaluation is presented, and examples of typical design considerations are discussed. The operation of the decision structure is then demonstrated for a sensor FDI application involving the F-100 jet engine. Author

A86-35402* Systems Control Technology, Inc., Palo Alto, Calif.
ROBUST DETECTION, ISOLATION, AND ACCOMMODATION FOR SENSOR FAILURES
A. EMAMI-NAEINI, M. M. AKHTER, and S. M. ROCK (Systems Control Technology, Inc., Palo Alto, CA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1129-1134. refs
(Contract NAS3-24079)

Recent advances in multivariable robust control system design are extended to sensor failure, detection, isolation, and accommodation (FDIA) and estimator design. A new concept called threshold selector is introduced. It represents a significant and innovative tool for the analysis and synthesis of FDIA algorithms. Analytical results are obtained for the SISO case to compute optimal thresholds and size of minimum detectable failures, and a computer-aided technique is developed for the multivariable case. The techniques have been applied to sensor FDIA for an aircraft turbine engine control system. Author

A86-35403* Scientific Systems, Inc., Cambridge, Mass.
BIFURCATION TECHNIQUES FOR NONLINEAR DYNAMIC ANALYSIS OF COMPRESSOR STALL PHENOMENA
H. C. RAZAVI and R. K. MEHRA (Scientific Systems, Inc., Cambridge, MA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1135-1142. refs
(Contract NAS3-24089; NSF CEE-81-00491)

Compressor stall phenomena is analyzed from nonlinear control theory viewpoint, based on bifurcation-catastrophe techniques. This new approach appears promising and offers insight into such well known compressor instability problems as surge and rotating stall; furthermore it suggests strategies for recovery from stall. Three interlocking dynamic nonlinear state space models are developed. It is shown that the problem of rotating stall can be viewed as an (induced) bifurcation of solution of the unstalled model. Hysteresis effect is shown to exist in the stall/recovery process. Surge cycles are observed to develop for some critical parameter values. It is shown that the oscillatory behavior is due to development of limit cycles, generated by Hopf bifurcation of solutions. Both stable and unstable limit cycles are observed. To further illustrate the usefulness of the methodology some partial computation of domains of attraction of equilibria is carried out, and parameter sensitivity analysis is performed. Author

A86-35412
SYNTHESIS OF SYSTEM RESPONSES - A NONLINEAR MULTIVARIABLE CONTROL DESIGN APPROACH
J. L. PECZKOWSKI (Allied-Bendix Aerospace, Bendix Energy Controls Div., South Bend, IN) and M. K. SAIN (Notre Dame, University, IN) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1181-1186. refs
(Contract NAS2-11877)

A unique feedback controller structure using coordinated feedforward and feedback dynamics is presented, with emphasis on the application aspects of system response. The control approach linearizes the plant at a finite number of points over the envelope of operation, applies linear transfer synthesis techniques about each point to obtain desired output responses and acceptable control responses, and systematically links and schedules all local

designs together into a global design over the envelope as a function of key plant variables within a broad nonlinear design strategy. The synthesis is illustrated by the design of nonlinear control systems for a turbojet engine. B.J.

A86-35472
PRACTICAL DIAGNOSTICS OF AIRCRAFT GAS TURBINES [PRAKTICHESKAIA DIAGNOSTIKA AVIATSIONNYKH GAZOTURBINNYKH DVIGATELEI]
L. P. LOZITSKII, V. P. STEPANENKO, V. A. STUDENIKIN, V. F. LAPSHOV, M. D. AVDOSHKO et al. Moscow, Izdatel'stvo Transport, 1985, 104 p. In Russian. refs

The methods and equipment used in the testing and troubleshooting of aircraft gas turbines are reviewed. In particular, attention is given to the principal types of faults and malfunctions and their diagnostic parameters; detectability of faults; and the organizational and technical aspects of diagnostic support. The discussion also covers particular diagnostic techniques based on flight data, vibration parameters, thermogasdynamic parameters, and wear products accumulating in oil. Finally, the automation of testing and troubleshooting and future prospects in this field are discussed. V.L.

A86-35612
APPLICATION OF CFD DESIGN TECHNOLOGY IN DEVELOPMENT OF THE JVX ENGINE INLET
G. C. PAYNTER, J. L. KONCSEK (Boeing Military Airplane Co., Seattle, WA), B. TURCZENIUK (Boeing Vertol Co., Philadelphia, PA), D. R. CLARK, and D. J. STRASH (Analytical Methods, Inc., Bellevue, WA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 163-174. refs

A joint services program is underway to develop a tilt rotor vertical lift aircraft, the V-22 Osprey, previously the JVX, for amphibious assault, combat search and rescue, special operations and electronic warfare. The engine inlets for this aircraft must supply air to the engines with high recovery and low distortion under all operational modes without an increase in overall aircraft drag at cruise due to inlet flow spillage. In addition, the inlet must prevent sand ingested into the inlet from passing through the engine. This paper describes the CFD based design procedure which was used to configure the engine inlet and the wind tunnel testing which was used to validate the design. Wind tunnel tests confirmed that the inlet would meet or exceed its performance goals. Author

A86-35614* General Electric Co., Lynn, Mass.
THE APPLICATION OF LQR SYNTHESIS TECHNIQUES TO THE TURBOSHAFT ENGINE CONTROL PROBLEM
W. H. PFEIL, G. DE LOS REYES (General Electric Co., Aircraft Engine Business Group, Lynn, MA), and G. A. BOBULA (NASA, Lewis Research Center; U.S. Army, Propulsion Laboratory, Cleveland, OH) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 189-196. refs
(Contract NAS3-22763)

A power turbine governor was designed for a recent-technology turboshaft engine coupled to a modern, articulated rotor system using Linear Quadratic Regulator (LQR) and Kalman Filter (KF) techniques. A linear, state-space model of the engine and rotor system was derived for six engine power settings from flight idle to maximum continuous. An integrator was appended to the fuel flow input to reduce the steady-state governor error to zero. Feedback gains were calculated for the system states at each power setting using the LQR technique. The main rotor tip speed state is not measurable, so a Kalman Filter of the rotor was used to estimate this state. The crossover of the system was increased to 10 rad/s compared to 2 rad/sec for a current governor. Initial computer simulations with a nonlinear engine model indicate a significant decrease in power turbine speed variation with the LQR governor compared to a conventional governor. Author

A86-35615
ADAPTIVE FUEL CONTROL TESTING
D. M. ACHGILL (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) and R. D. ZAGRANSKI (Colt Industries, Inc., Chandler Evans Control Systems Div., West Hartford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 197-211.
(Contract DAAK51-83-C-0038)

Closed loop bench tests, 250-C30 engine tests, man-in-the-loop S76 simulator sessions, and 206L helicopter flight tests, are being conducted as part of a U.S. Army program for the evaluation of full authority digital engine control-implemented concepts. The adaptive control laws encompass engine start sequence variation as a function of speed and acceleration, sensing of compressor discharge pressures, measuring engine deceleration rates, adding torsional mode damping to the rotor drive-train, and sensing rotor speed decay rate. Test results indicate that substantial engine and helicopter performance paybacks are achieved with these control features. O.C.

A86-35865#
VIBRATION CHARACTERISTICS OF AIRCRAFT ENGINE-BLADED-DISK ASSEMBLY
J. S.J RAO, C. B. SHAH, CH. L. GANESH (Indian Institute of Technology, New Delhi, India), and Y. V. K. S. RAO (Indian Space Research Organization, Vikram Sarabhai Space Centre, Trivandum, India) Defence Science Journal (ISSN 0011-748X), vol. 36, Jan. 1986, p. 9-26. Research supported by the Defence Ministry. refs

This paper is concerned with the vibration characteristics of a gas-turbine blade-disk assembly and a third stage of compressor blade-disk assembly of an orpheus aircraft engine. The assembly is analyzed by considering each component individually and then combining them together with a receptance coupling technique by matching forces and displacements at each junction point. The blade is modeled by number of free-free aerofoil section beams staggered at different angles to the plane of the disk, and the nonuniform disk is modeled as number of concentric annuli. The natural frequencies and mode shapes for each case have been obtained. Results obtained are verified by testing both the above assemblies on a microprocessor based vibration exciter and real time analyzer. The mode shape corresponding to each natural frequency was obtained by probing with hand held accelerometer Author

A86-35992
LIMITING VALUES OF THE SPECIFIC PARAMETERS OF A RAMJET ENGINE [O PREDEL'NYKH ZNACHENIIAKH UDEL'NYKH PARAMETROV PVRD]
V. I. BAZHANOV and A. A. STEPCHKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 77, 78. In Russian.

The parameters of a ramjet engine using a supersonic diffuser with 2, 3, and 4 shock waves are calculated in the Mach number range 4-8. It is shown that the engine parameters are improved with increasing flight velocity, this effect being particularly pronounced in the range Mach 4-6; only a slight improvement is observed at Mach greater than 6. An increase in the number of shock waves in the diffuser above three does not change the specific thrust or specific fuel consumption by more than 5 percent. V.L.

A86-36336
AIRCRAFT ENGINE TECHNOLOGY WINDOWS (LECTURE)
B. H. ROWE (General Electric Co., Aircraft Engine Business Group, Cincinnati, OH) Aerospace (UK) (ISSN 0305-0831), vol. 13, April 1986, p. 23-27.

The success or failure of a manufacturing company depends on the ability to recognize technological windows, a confluence of developments which can be exploited to realize a successful product. New propulsion systems are the key to smaller, lighter, lower-cost, higher efficiency aircraft aircraft. Improvements are largely made with refinements of existing technologies, those for which capital investments in plant can be amortized over sufficiently

short periods of time. In R&D, attention is currently focused on unducted fans (UDF) for subsonic flight, augmented turbo fans for supersonic flight, and combinations of the airbreathing engines and rocket power for military and commercial hypersonic flight. The UDF, as NASA tests have shown, offers a potential 25 percent greater efficiency than current turbofans due to less a high SFC and diameter and weight reductions from counterrotating configurations. Substantial materials properties improvements, along with new fuels, are needed to satisfy the requirements for future supersonic (up to Mach 4.0) aircraft. Hypersonic vehicles will need acceleration more than cruise, combined cycle, variable thrust operation, and reusability. A database is now being accumulated on relevant past efforts as a prelude to studies of hypersonic vehicle propulsion systems. M.S.K.

A86-36741
CALCULATION OF THE STEADY-STATE TRANSVERSE VIBRATIONS OF THE SYSTEM ROTORS-HOUSING OF A GAS-TURBINE ENGINE [K RASCHETU USTANOVIVSHIKHSIA POPERECHNYKH `KOLEBANII SISTEM ROTORY-KORPUS GTD]
L. E. LASTOVETSKII Raschety na Prochnost', no. 26, 1985, p. 209-214. In Russian. refs

A new approach to solving the vibration problem for systems of the type rotors-housing, containing in the general case nonlinearly elastic constraints, is proposed in the context of the theory of vibrations for systems with a finite number of degrees of freedom. It is shown that an exact steady-state solution can be obtained for axisymmetric and quasi-axisymmetric systems without imposing substantial constraints on the initial system as in the existing approaches. V.L.

A86-37079*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SURVEY OF SUPERSONIC COMBUSTION RAMJET RESEARCH AT LANGLEY
G. B. NORTHAM and G. Y. ANDERSON (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 27 p. refs
(AIAA PAPER 86-0159)

The Hypersonic Propulsion Branch at NASA Langley Research Center has maintained an active research program in supersonic combustion ramjet (scramjet) and high speed ramjet propulsion since the 1960s. The focus for this research has centered on propulsion for manned reuseable vehicles with cryogenic hydrogen fuel. This paper presents some highlights of this research. The design philosophy of the Langley fixed-geometry airframe-integrated modular scramjet is discussed. The component development and research programs that have supported the successful demonstration of the engine concept using subscale engine module hardware is reviewed and a brief summary of the engine tests presented. An extensive bibliography of research supported by the Langley program is also included. Author

A86-37096
FRONT-LINE POWER
J. MOXON Flight International (ISSN 0015-3710), vol. 129, April 12, 1986, p. 22-26.

The types of fighter aircraft engines manufactured by western nations are described, along with developmental goals to meet the requirements of new generations of fighter aircraft. In all cases government orders are the sole accounts of the manufacturers. Development is usually paid for by the government(s) ordering the engines. The F100, F110 and F404 engines are the only engines for the F-14, -15, -16, and -18 aircraft, with the government frequently encouraging competition for replacement engines from General Electric (GE) and Pratt and Whitney (PW), the only domestic suppliers. In Europe, SNECMA is frequently the only supplier for the Mirage 2000 engine. Rolls Royce, the only other European manufacturer, produces the RB.199, Mk 104 and Mk 103 engines for use in the Toronado. GE and PW are both developing Increased Performance Engines (IPE) for the USAF. The IPEs are expected to be installed in aircraft in 1990. The Joint Advanced Fighter Engine (Jafe), to produce 30,000-35,000 lb. thrust, 75 percent without afterburner, is requiring research on reducing the IR signature and employing composite parts. European engines under development are the XG-40, the M88, the M53, and the European Fighter Engine (EFA). Prime requirements for new engines for the USAF are substantially increased availability and increased performance. M.S.K.

N86-24692# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
PROPULSION AND ENERGETICS PANEL WORKING GROUP 14 ON SUITABLE AVERAGING TECHNIQUES IN NON-UNIFORM INTERNAL FLOWS [PANEL DE PROPULSION ET D'ENERGETIQUE GROUPE DE TRAVAIL 14 METHODES D'ESTABLISSEMENT DE CARACTERISTIQUES MOYENNES DANS LES ECOULEMENTS INTERNES HETEROGENES]
M. PIANKO, ed. and F. WAZELT, ed. (Technische Hochschule, Darmstadt, West Germany) Loughton, England Aug. 1983 183 p refs In FRENCH; ENGLISH summary
(AD-A133968; AGARD-AR-182(FR); ISBN-92-835-2110-2) Avail: NTIS HC A09/MF A01 CSCL 21E

The averaging techniques used for nonuniform internal flow of gas turbine systems, in which the actual flows are usually heterogeneous and three-dimensional was studied. The test analysis and performance prediction methods are based upon simple one-dimensional models. Current practices were reviewed and a theoretical analysis of the relations which may be correctly applied to steady flow was undertaken and known averaging methods were classified. Refinements to known methods and a new approach to averaging for use with engine components and propulsion system analysis are proposed. A variety of possible averaging techniques are identified and compared by preparing a number of sample calculations in ducted flows, turbojet components and a complete propulsion system. The merits and the limitations of the methods studied are outlined. One method is recommended for stagnation temperature averaging. E.A.K.

N86-24694*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LOW-SPEED PERFORMANCE OF AN AXISYMMETRIC, MIXED-COMPRESSION, SUPERSONIC INLET WITH AUXILIARY INLETS
C. J. TREFNY and J. W. WASSERBAUER Feb. 1986 63 p refs
(NASA-TP-2557; E-2771; NAS 1.60:2557) Avail: NTIS HC A04/MF A01 CSCL 21E

A test program was conducted to determine the aerodynamic performance and acoustic characteristics associated with the low-speed operation of a supersonic, axisymmetric, mixed-compression inlet with auxiliary inlets. Blow-in-auxiliary doors were installed on the NASA Ames P inlet. One door per quadrant was located on the cowl in the subsonic diffuser selection of the inlet. Auxiliary inlets with areas of 20 and 40 percent of the inlet capture area were tested statically and at free-stream Mach numbers of 0.1 and 0.2. The effects of boundary layer bleed inflow were investigated. A JT8D fan simulator driven by compressed air was used to pump inlet flow and to provide a characteristic noise signature. Baseline data were obtained at static free-stream conditions with the sharp P-inlet cowl lip replaced by a blunt lip. Auxiliary inlets increased overall total pressure recovery of the order of 10 percent. Author

N86-24695*# Beech Aircraft Corp., Wichita, Kans.
EVALUATION OF PROPFAN PROPULSION APPLIED TO GENERAL AVIATION
R. W. AWKER Mar. 1986 146 p refs
(Contract NAS3-24349)
(NASA-CR-175020; NAS 1.26:175020) Avail: NTIS HC A07/MF A01 CSCL 21E

Propfan propulsion on business aircraft was evaluated. Comparisons, in terms of cost and performance, were made between propfan propulsion systems and conventional turbofan propulsion systems on a typical business aircraft. In addition,

configuration and cost sensitivity studies were conducted to further assess the potential of propfan propulsion. Author

N86-24696# Federal Aviation Administration, Washington, D.C.
EVALUATING TURBINE ENGINE OPERATING CHARACTERISTICS
19 Mar. 1986 10 p
(FAA-AC-25.939-1) Avail: NTIS HC A02/MF A01

Guidelines for the evaluation of turbine engine (turbojet, turboprop, and turboshaft) operating characteristics for subsonic transport category aircraft are provided. The guidelines describe a method of demonstrating compliance with the applicable airworthiness requirements. Like all advisory circular material, these guidelines are not mandatory and do not constitute a regulation. Derived from Federal Aviation Administration experience in establishing compliance with the airworthiness requirements, they represent the means and methods found to be acceptable to all aircraft designs. Each design should be examined to determine whether the suggested methods of evaluation are adequate or if other methods in addition to these may be appropriate. Author

N86-24697*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A REAL-TIME SIMULATION EVALUATION OF AN ADVANCED DETECTION, ISOLATION AND ACCOMMODATION ALGORITHM FOR SENSOR FAILURES IN TURBINE ENGINES
W. C. MERRILL and J. C. DELAAT 1986 17 p refs Presented at the American Control Conference, Seattle, Wash., 18-20 Jun. 1986; sponsored by IEEE
(NASA-TM-87289; E-2995; NAS 1.15:87289) Avail: NTIS HC A02/MF A01 CSCL 21E

An advanced sensor failure detection, isolation, and accommodation (ADIA) algorithm has been developed for use with an aircraft turbofan engine control system. In a previous paper the authors described the ADIA algorithm and its real-time implementation. Subsequent improvements made to the algorithm and implementation are discussed, and the results of an evaluation presented. The evaluation used a real-time, hybrid computer simulation of an F100 turbofan engine. Author

N86-24698 Department of the Air Force, Washington, D.C.
ONE-PIECE HPTR BLADE SQUEALER TIP Patent
R. L. HORVATH, inventor (to Air Force) 10 Sep. 1985 4 p
(AD-D012003; US-PATENT-4,540,339;
US-PATENT-APPL-SN-616380; US-PATENT-CLASS-416-92)
Avail: US Patent and Trademark Office CSCL 21E

An improved high pressure turbine rotor blade and tip cap structure is provided which comprises a tip end closure for the blade bonded to the end wall of the blade casting. It includes a base plate member and a pair of upstanding side walls defining a peripheral contour coincidental with and faired to the cambered side walls of the casting. The base plate member has a plurality of radially outwardly opening passageways through it and disposed along the chord of the blade and communicating with a channel included in the radially outwardly facing surface of the casting along a chord of the blade. The passageways are disposed along axes at angles to the base plate whereby coolant fluid flowing through it is directed against the tip side wall surfaces. An opening is provided through the end wall of the casting in the form of a slit or a plurality of holes along the chord of the blade and intersecting the channel, to define an outlet through the end wall for passage of coolant fluid through the blade. GRA

N86-25342*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
DIGITAL ELECTRONIC ENGINE CONTROL (DEEC) FLIGHT EVALUATION IN AN F-15 AIRPLANE
Mar. 1984 243 p refs Symposium held in Edwards, Calif., 25-26 May 1983
(NASA-CP-2298; H-1201; NAS 1.55:2298) Avail: NTIS HC A11/MF A01 CSCL 21E

Flight evaluation in an F-15 aircraft by digital electronic engine control (DEEC) was investigated. Topics discussed include: system description, F100 engine tests, effects of inlet distortion on static pressure probe, flight tests, digital electronic engine control fault detection and accommodation flight evaluation, flight evaluation of a hydromechanical backup control, augmentor transient capability of an F100 engine, investigation of nozzle instability, real time in flight thrust calculation, and control technology for future aircraft propulsion systems. It is shown that the DEEC system is a powerful and flexible controller for the F100 engine.

N86-25343*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
DIGITAL ELECTRONIC ENGINE CONTROL F-15 OVERVIEW
B. KOCK *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 1-14 Mar. 1984
(PAPER-1) Avail: NTIS HC A11/MF A01 CSCL 21E

A flight test evaluation of the digital elctronic engine control (DEEC) system was conducted. An overview of the flight program is presented. The roles of the participating parties, the system, and the flight program objectives are described. The test program approach is discussed, and the engine performance benefits are summarized. A description of the follow-on programs is included. Author

N86-25344*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
DIGITAL ELECTRONIC ENGINE CONTROL HISTORY
T. W. PUTNAM *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 15-31 Mar. 1984
(PAPER-2) Avail: NTIS HC A11/MF A01 CSCL 21E

Full authority digital electronic engine controls (DEECs) were studied, developed, and ground tested because of projected benefits in operability, improved performance, reduced maintenance, improved reliability, and lower life cycle costs. The issues of operability and improved performance, however, are assessed in a flight test program. The DEEC on a F100 engine in an F-15 aircraft was demonstrated and evaluated. The events leading to the flight test program are chronicled and important management and technical results are identified. Author

N86-25345*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
F-15 DIGITAL ELECTRONIC ENGINE CONTROL SYSTEM DESCRIPTION
L. P. MYERS *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 33-53 Mar. 1984
(PAPER-3) Avail: NTIS HC A11/MF A01 CSCL 21E

A digital electronic engine control (DEEC) was developed for use on the F100-PW-100 turbofan engine. This control system has full authority control, capable of moving all the controlled variables over their full ranges. The digital computational electronics and fault detection and accomodation logic maintains safe engine operation. A hydromechanical backup control (BUC) is an integral part of the fuel metering unit and provides gas generator control at a reduced performance level in the event of an electronics failure. The DEEC's features, hardware, and major logic diagrams are described. Author

N86-25346*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
NASA LEWIS F100 ENGINE TESTING
R. A. WERNER, R. G. WILLOH, JR., and M. ABDELWAHAB *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 55-71 Mar. 1984 refs
(PAPER-4) Avail: NTIS HC A11/MF A01 CSCL 21E

Two builds of an F100 engine model derivative (EMD) engine were evaluated for improvements in engine components and digital electronic engine control (DEEC) logic. Two DEEC flight logics were verified throughout the flight envelope in support of flight clearance for the F100 engine model derivative program (EMPD). A nozzle instability and a faster augmentor transient capability was investigated in support of the F-15 DEEC flight program. Off schedule coupled system mode fan flutter, DEEC nose-boom pressure correlation, DEEC station six pressure comparison, and

a new fan inlet variable vane (CIVV) schedule are identified.
Author

N86-25347*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
EFFECTS OF INLET DISTORTION ON A STATIC PRESSURE PROBE MOUNTED ON THE ENGINE HUB IN AN F-15 AIRPLANE
D. L. HUGHES and K. G. MACKALL *In its* Digital Electronic Engine Control Flight Evaluation in an F-15 Airplane p 73-89 Mar. 1984 refs
(PAPER-5) Avail: NTIS HC A11/MF A01 CSCL 21E

Problems encountered in obtaining good engine face pressure data were studied. A single static measurement located upstream of the engine hub in the stream flow was found to provide a pressure signal suitable for engine control. Two identical probes for measuring fan inlet static (PS2) pressure were designed and mounted on the hub of the left F100-PW-100 turbofan engine installed in the F-15 test aircraft for flight evaluation. The probe is used as a static pressure sensor for a digital engine control system.
Author

N86-25348*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
FLIGHT TESTING THE DIGITAL ELECTRONIC ENGINE CONTROL IN THE F-15 AIRPLANE
L. P. MYERS *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 91-105 Mar. 1984
(PAPER-6) Avail: NTIS HC A11/MF A01 CSCL 21E

The digital electronic engine control (DEEC) is a full-authority digital engine control developed for the F100-PW-100 turbofan engine which was flight tested on an F-15 aircraft. The DEEC hardware and software throughout the F-15 flight envelope was evaluated. Real-time data reduction and data display systems were implemented. New test techniques and stronger coordination between the propulsion test engineer and pilot were developed which produced efficient use of test time, reduced pilot work load, and greatly improved quality data. The engine pressure ratio (EPR) control mode is demonstrated. It is found that the nonaugmented throttle transients and engine performance are satisfactory.
Author

N86-25349*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
DIGITAL ELECTRONIC ENGINE CONTROL FAULT DETECTION AND ACCOMMODATION FLIGHT EVALUATION
J. L. BAER-RUEDHART *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in n F-15 Airplane p 107-126 Mar. 1984
(PAPER-7) Avail: NTIS HC A11/MF A01 CSCL 21E

The capabilities and performance of various fault detection and accommodation (FDA) schemes in existing and projected engine control systems were investigated. Flight tests of the digital electronic engine control (DEEC) in an F-15 aircraft show discrepancies between flight results and predictions based on simulation and altitude testing. The FDA methodology and logic in the DEEC system, and the results of the flight failures which occurred to date are described.
E.A.K.

N86-25350*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
AIRSTART PERFORMANCE OF A DIGITAL ELECTRONIC ENGINE CONTROL SYSTEM ON AN F100 ENGINE
F. W. BURCHAM, JR. *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 127-139 Mar. 1984
(PAPER-8) Avail: NTIS HC A11/MF A01 CSCL 21E

The digital electronic engine control (DEEC) system installed on an F100 engine in an F-15 aircraft was tested. The DEEC system incorporates a closed-loop air start feature in which the fuel flow is modulated to achieve the desired rate of compressor acceleration. With this logic the DEEC equipped F100 engine can achieve air starts over a larger envelope. The DEEC air start logic, the test program conducted on the F-15, and its results are described.
Author

N86-25351*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
FLIGHT EVALUATION OF A HYDROMECHANICAL BACKUP CONTROL FOR THE DIGITAL ELECTRONIC ENGINE CONTROL SYSTEM IN AN F100 ENGINE
K. R. WALSH and F. W. BURCHAM *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 141-155 Mar. 1984
(PAPER-9) Avail: NTIS HC A11/MF A01 CSCL 21E

The backup control (BUC) features, the operation of the BUC system, the BUC control logic, and the BUC flight test results are described. The flight test results include: (1) transfers to the BUC at military and maximum power settings; (2) a military power acceleration showing comparisons bvetween flight and simulation for BUC and primary modes; (3) steady-state idle power showing idle compressor speeds at different flight conditions; and (4) idle-to-military power BUC transients showing where cpmpressor stalls occurred for different ramp rates and idle speeds. All the BUC transfers which occur during the DEEC flight program are initiated by the pilot. Automatic transfers to the BUC do not occur.
Author

N86-25352*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
BACKUP CONTROL AIRSTART PERFORMANCE ON A DIGITAL ELECTRONIC ENGINE CONTROL-EQUIPPED F100-ENGINE
J. B. JOHNSON *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 157-170 Mar. 1984 refs
(PAPER-10) Avail: NTIS HC A11/MF A01 CSCL 21E

The air start capability of a backup control (BUC) was tested for a digital electronic engine control (DEEC) equipped F100 engine, which was installed in an F-15 aircraft. Two air start schedules were tested. Using the group 1 start schedule, based on a 40 sec timer, an air speed of 300 knots was required to ensure successful 40 and 25% BUC mode spooldown airstarts. If core rotor speed (N2) was less than 40% a stall would occur when the start bleed closed, 40 sec after initiation of the air start. All jet fuel starter (JFS) assisted air starts were successful with the group 1 start schedule. For the group 2 schedule, the time between pressurization and start bleed closure ranged between 50 sec and 72 sec. Idle rps was lower than the desired 65% for air starts at higher altitudes and lower air speeds.
Author

N86-25353*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
AUGMENTOR TRANSIENT CAPABILITY OF AN F100 ENGINE EQUIPPED WITH A DIGITAL ELECTRONIC ENGINE CONTROL
F. W. BURCHAM, JR. and G. D. PAI *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 171-199 Mar. 1984
(PAPER-11) Avail: NTIS HC A11/MF A01 CSCL 21E

An F100 augmented turbofan engine equipped with digital electronic engine control (DEEC) system was evaluated. The engine was equipped with a specially modified augmentor to provide improved steady state and transient augmentor capability. The combination of the DEEC and the modified augmentor was evaluated in sea level and altitude facility tests and then in four different flight phases in an F-15 aircraft. The augmentor configuration, logic, and test results are presented.
Author

N86-25354*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
INVESTIGATION OF A NOZZLE INSTABILITY ON AN F100 ENGINE EQUIPPED WITH A DIGITAL ELECTRONIC ENGINE CONTROL
F. W. BURCHAM, JR. and J. R. ZELLER (NASA, Lewis Research Center, Cleveland, Ohio) *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 201-214 Mar. 1984
(PAPER-12) Avail: NTIS HC A11/MF A01 CSCL 21E

An instability in the nozzle of the F100 engine, equipped with a digital electronic engine control (DEEC), was observed during a flight evaluation on an F-15 aircraft. The instability occurred in the upper left hand corner (ULMC) of the flight envelope during augmentation. The instability was not predicted by stability analysis, closed-loop simulations of the the engine, or altitude testing of the engine. The instability caused stalls and augmentor blowouts. The nozzle instability and the altitude testing are described. Linear analysis and nonlinear digital simulation test results are presented. Software modifications on further flight test are discussed.
Author

N86-25355*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
REAL-TIME IN-FLIGHT THRUST CALCULATION ON A DIGITAL ELECTRONIC ENGINE CONTROL-EQUIPPED F100 ENGINE IN AN F-15 AIRPLANE
R. J. RAY (California Polytechnic State Univ., San Luis Obispo) and L. P. MYERS *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 231-247 Mar. 1984
(PAPER-13) Avail: NTIS HC A11/MF A01 CSCL 21E

Computer algorithms which calculate in-flight engine and aircraft performance real-time are discussed. The first step was completed with the implementation of a real-time thrust calculation program on a digital electronic engine control (DEEC) equiped F100 engine in an F-15 aircraft. The in-flight thrust modifications that allow calculations to be performed in real-time, to compare results to predictions, are presented.
Author

N86-25356*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
CONTROL TECHNOLOGY FOR FUTURE AIRCRAFT PROPULSION SYSTEMS
J. R. ZELLER, J. R. SZUCH, W. C. MERRILL, B. LEHTINEN, and J. F. SOEDER *In its* Digital Electronic Engine Control (DEEC) Flight Evaluation in an F-15 Airplane p 231-247 Mar. 1984
(PAPER-14) Avail: NTIS HC A11/MF A01 CSCL 21E

The need for a more sophisticated engine control system is discussed. The improvements in better thrust-to-weight ratios demand the manipulation of more control inputs. New technological solutions to the engine control problem are practiced. The digital electronic engine control (DEEC) system is a step in the evolution to digital electronic engine control. Technology issues are addressed to ensure a growth in confidence in sophisticated electronic controls for aircraft turbine engines. The need of a control system architecture which permits propulsion controls to be functionally integrated with other aircraft systems is established. Areas of technology studied include: (1) control design methodology; (2) improved modeling and simulation methods; and (3) implementation technologies. Objectives, results and future thrusts are summarized.
E.A.K.

N86-25360# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
DAMAGE TOLERANCE CONCEPTS FOR CRITICAL ENGINE COMPONENTS
Loughton, England Oct. 1985 295 p refs Presented in San Antonio, Tex., 22-26 Apr. 1985
(AGARD-CP-393; ISBN-92-835-0380-5) Avail: NTIS HC A13/MF A01

The proceedings of a specialist meeting called by the AGARD Structures and Materials Panel on damage tolerance concepts for critical engine components is presented. The meeting discussed the overall philosophy of damage tolerance as applied to aircraft engine parts, considered and refined the parameters important in DTC, reviewed specialist techniques needed for the support of DTC, and surveyed the prospects for and experiences of the implementation of DTC.

N86-25361# Rolls-Royce Ltd., Derby (England).
DAMAGE TOLERANCE CONCEPTS FOR CRITICAL ENGINE COMPONENTS
R. H. JEAL *In* AGARD Damage Tolerance Concepts for Critical Engine Components 12 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

The cost of failures in gas turbines has always been so high, both in human and financial terms, that it has been recognized since the earliest days that the behavior of components had to be fully characterized before the engines were used in service. The integrity of the gas turbine has therefore always been based upon two separate phases of development. The first has been the basic design itself where, as well as ensuring that the individual components meet their basic mechanical purpose, the designer attempts to match his understanding of the operating conditions to his perception of the capability of material chosen. The second has been the development phase where the actual behavior of the component has been assessed either as part of an operating engine - bench engine testing or as an individual component - rig testing - under conditions which are related to those the engine is expected to see in service. The results of this work are then used, together with prior experience, to identify the critical components of the engine, those that prejudice the safety of the aircraft if they fail. The development of damage tolerance concepts is traced from the earliest days, the current situation is examined in light of design needs and available technology, and possible directions are examined.
E.R.

N86-25362# Naval Air Propulsion Test Center, Trenton, N.J. Systems Development and Evaluation Group.
ENGINE CYCLIC DURABILITY BY ANALYSIS AND TESTING: HIGHLIGHTS OF THE SPRING 1984 PEP MEETING
A. A. MARTINO *In* AGARD Damage Tolerance Concepts for Critical Engine Components 13 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

Research on gas turbine engine development during the past decade in NATO nations has concentrated heavily on gaining better understanding of the relationship between material characteristics, failure mechanisms, structural analysis and validation testing for increased service life. Recognizing this intense interest and activity level the Propulsion and Energetics Panel (PEP) sponsored a specialists' meeting that surveyed the state-of-art technical areas related to improving engine life and considered the technical and economical problems and possibilities of advanced cyclic testing in the development of engines. Discussions focused on relationships between engine use and failure modes, accelerated mission testing (AMT) development, critical material characteristics, component life assessment methods, recent results of component and engine cyclic testing, and future requirements.
Author

N86-25365# Rolls-Royce Ltd., Derby (England). NDT Technology.
LIMITATIONS OF MANUAL NDT SYSTEMS AND THE NO EYES CONCEPT
R. G. TAYLOR *In* AGARD Damage Tolerance Concepts for Critical Engine Components 9 p Oct. 1985 refs Previously announced as N86-14215
Avail: NTIS HC A13/MF A01

Defect tolerant design, particularly of aircraft components, and its links with nondestructive testing (NDT) are discussed. Engineering of the NDT technique, defect detection requirements, and human factors in the inspection cycle are considered.
Author

N86-25368# Systems Research Labs., Inc., Dayton, Ohio. NDE Systems Div.
MANUFACTURING TECHNOLOGY FOR NONDESTRUCTIVE EVALUATION (NDE) SYSTEM TO IMPLEMENT RETIREMENT FOR CAUSE (RFC) PROCEDURES FOR GAS TURBINE ENGINE COMPONENTS
D. L. BIRX and D. G. DOOLIN *In* AGARD Damage Tolerance Concepts for Critical Engine Components 8 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

An automated NDE inspection system to detect surface flaws and inclusions in jet engine rotary parts was developed. The system implements the Air Force Retirement for Cause philosophy in which good, used engine parts are returned to service, and flawed components are retired for cause. Emphasis has thus been placed on improving current flaw detection and characterization techniques by using computer algorithms (removing the human decision process) and achieving basic inspection and predictive capabilities via automated eddy current and ultrasonic inspection techniques. Author

N86-25369# National Aerospace Lab., Amsterdam (Netherlands).
AGARD COOPERATIVE TEST PROGAMME ON TITANIUM ALLOY ENGINE DISC MATERIAL
A. J. A. MOM and M. D. RAIZENNE (National Research Council of Canada, Ottawa, Ontario) *In* AGARD Damage Tolerance Concepts for Critical Engine Components 15 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

In recent years a strong interest in the application of damage tolerance techniques for lifing of gas turbine engine discs has developed. Before the damage tolerance approach can be safely implemented it requires sensitive and reliable crack detection techniques, operational loading information and improved knowledge of fatigue crack growth and fracture under service conditions. This latter aspect is the main subject of an international test program, in which a number of laboratories from North America and Europe participate under AGARD coordination. The first phase of the program is directed to test and specimen standardization and calibration of the different laboratories. The second phase will specifically address parameters relevant for real service operation like mission loading, sequence and dwell effects, temperature, fatigue threshold, etc. The background and first phase of the program are discussed. Author

N86-25378# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
FRACTURE MECHANICS AND LCF-PROPERTIES OF ENGINE DISCS OF TI 6AL-4V, INCONEL 718 AND UDIMET 700 P/M-HIP
W. SCHUETZ and R. HEIDENREICH *In* AGARD Damage Tolerance Concepts for Critical Engine Components 13 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

Over the last decade IABG has carried out a large number of tests on gas turbine materials to determine the materials data necessary for the conventional lifing approach, that is LCF data, including dwell time effects and some HCF data. The data necessary for a damage tolerance approach as well as crack propagation properties were also determined. These tests were done at room and typical service temperatures. The materials were Ti 6A1 4V, Inconel 718 and Udimet 700 P/M-HIP. The specimens were machined from a number of nominally identical compressor discs of Ti A16 V4, from compressor discs of Inconel 718 and from disc-shaped 'pancakes' of Udimet 700 P/M-HIP. Constant amplitude tests under strain control with unnotched specimens and under stress control with notched specimens were carried out, as well as a number or relatively simple variable amplitude tests. Author

N86-25379# Technische Univ., Munich (West Germany). Materials Lab.
EVALUATION OF CYCLIC SPIN PIT TESTS FOR THE DAMAGE TOLERANCE OF DISKS
H. HUFF and G. W. KOENIG *In* AGARD Damage Tolerance Concepts for Critical Engine Components 13 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

In order to determine the damage tolerance at critical areas of nickelbase engine disks (bore, eccentric hole, blade slot) the crack propagation behavior was investigated. The experiments include cyclic spin pit tests on disks and fracture mechanics tests on small crack specimens. The results of the spin pit tests are compared with the crack propagation behavior predicted by fracture mechanics. The tolerance of engine disks with respect to small crack-like defects is estimated and the potential of the crack propagation life for application in service is discussed. It was found that at low and intermediate temperatures the crack propagation life is sufficient to cover a substantial portion of the life required for disks. With increasing temperature the influence of time dependent processes results in a very strong reduction of the defect tolerance. Author

08

AIRCRAFT STABILITY AND CONTROL

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

A86-33979#
ON THE VERTICAL TURNS SUSTAINING CORNER VELOCITY
K. KATO (Tokyo, University, Japan) and S. UENO (Toshiba Co., Ltd., Kawasaki, Japan) (Japan Society for Aeronautical and Space Sciences, Annual Conference, 15th, Tokyo, Japan, Apr. 1984) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 28, Feb. 1986, p. 175-184. refs

Minimum time pull-up maneuvers in the vertical plane are formulated and solved numerically as an optimal control problem. Restrictions due to thrust, load factor and angle of attack (or stall) are involved as the inequality constraints. It is shown that the intermediate thrust arc can be optimal and the exact necessary conditions are derived with the maximum-turn-rates sustained. A variety of the optimal pull-ups are also shown when the initial velocity is varied. Author

A86-34193
FLYING HANDS OFF TO A HOVER
J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, April 1986, p. 10-15.

Using microprocessors, multifunction CRT displays, and multiplex digital data buses, helicopter electric flight director systems are integrated with digital automatic flight control systems (DAFCS) to enable hands-off flying for IFR certification. Flight management systems (FMS), consolidate information from the communications, navigation, and performance subsystems. The electronic flight instrument system, using the EDZ-705 electronic flight instrument system, displays flight data such as airspeed and altitude on the electronic attitude director indicator (EADI), and data such as heading and bearing on the electronic horizontal situation indicator (EHSI). DAFCS is an integrated autopilot with a full range of horizontal and vertical flight guidance modes, including all radio guidance modes, hover mode, and coupled collective. An ILS approach can be flown, with navigation mode armed to capture the localizer, the ILS mode armed to capture glide slope, and the radio altimeter DH set to IFR minimum altitude. R.R.

A86-34194
GUIDANCE, NAVIGATION, AND CONTROL FOR 21ST CENTURY AIRCRAFT
J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, April 1986, p. 18-24.

Developments such as optical fault-tolerant buses, full digital fly-by-wire control, and active flutter suppression for military aircraft with stores, will make possible ultra fault-tolerant, reliable, high-integrity flight control systems and avionics architectures for the next generation civil and military aircraft. Multiple-redundant automatic flight control systems (AFCS) will enable maximum airframe and engine element performance by relaxing many traditional stability and control constraints. Local flow or vortex control over all lifting surfaces and parts of the fuselage, and integration of highly interactive subsystems like vectored thrust, will improve cruise performance, short field capability, and maneuverability. Other innovations foreseen include automated situational information management systems, the application of artificial intelligence, and local pressure, vibration, surface conditions, and deflection measurement sensors. R.R.

A86-34926#
AN APPLICATION OF SELF-TUNING REGULATOR TO GLA SYSTEM OF AN AIRCRAFT
M. KOBAYAKAWA, K. SAKURA, and H. IMAI (Setsunan University, Japan) Kyoto University, Faculty of Engineering, Memoirs (ISSN 0023-6063), vol. 48, Jan. 1986, p. 60-74. refs

In this paper, a Self-Tuning Regulator (STR), one of the adaptive control strategies, is applied to the gust load alleviation system of a large civil aircraft. Two types of STR are introduced. For algorithm 1, the restriction that the number of the inputs must be equal to that of the outputs is imposed. On the contrary, for algorithm 2, this restriction is released. These two algorithms are applied to alleviate the gust response of aircrafts, firstly a rigid aircraft and secondly a flexible one. In consequence of simulations, it is found that the STR can alleviate the gust response of aircrafts favorably. A STR is more effective to alleviate response to a discrete gust than to a continuous gust. In spite of the inaccurate estimation of system parameters, the STR works well. Generally, the proposed STRs show better performance for a rigid aircraft than for a flexible one. However, even for the latter, by choosing initial values of parameters appropriately, good results can be obtained. Author

A86-35153#
ROLL-DAMPING MEASUREMENTS ON TWO FLIGHT BODY CONFIGURATIONS IN THE GOETTINGEN DFVLR-AVA TRANSONIC WIND TUNNEL [ROLLDAEMPFUNGSMESSUNGEN AN ZWEI FLUGKOERPER-KONFIGURATIONEN IM TRANSKANAL DER DFVLR-AVA GOETTINGEN]
E. SCHMIDT (DFVLR, Aerodynamische Versuchsanstalt, Goettingen, West Germany) and H.-G. FUCHS (Dornier GmbH, Friedrichshafen, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 41 p. In German. refs
(DGLR PAPER 85-090)

Measurements carried out in the DFVLR-AVA transonic wind tunnel in Goettingen on flight body configurations using two new rolling components are discussed. Coefficients and derivatives of the rolling motion are used to obtain plots of the measured angles of attack as a function of Mach number and reduced frequency. The results are compared with those from a half-empirical procedure. C.D.

A86-35177#
LMR-83 - INERTIAL MEASUREMENT UNIT FOR FLIGHT REGULATION AND NAVIGATION [LMR-83 - EINE INERTIALE MESSEINHEIT FUER FLUGREGELUNG UND NAVIGATION]
G. SCHULZ (Litton Technische Werke Freiburg im Breisgau, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 14 p. In German. refs
(DGLR PAPER 85-132)

Based on the measurement data requirements of future high-performance aircraft, the design, operation, and output results of the inertial measurement unit LMR-85 are described. The quadruplex usage of this measurement device in a fly-by-wire aircraft is discussed. Modifications in this device made with regard to avionics systems considerations in high-performance aircraft are addressed. C.d.

A86-35342
NEW LINEAR TRACKING FILTERS
D. ANDRISANI, II (Purdue University, West Lafayette, IN) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 175-178. refs

A description is provided of linear tracking filters with superior ability to track maneuvering aircraft. The filters model both the vehicle rotation and translation degrees of freedom, and compute both the magnitude and direction of the vehicle acceleration. The estimation of attitude improves the filter's ability to estimate position and velocity, as a result of the correlation between aircraft acceleration and attitude. Some linearizing assumptions are needed on account of the nonlinearity of the relationship between attitude and acceleration. Attention is given to a mathematical model for the pitch rotation degree of freedom, the state equation model for vertical translation and pitch rotation, and the tracker model. G.R.

A86-35360* Minnesota Univ., Minneapolis.
APPLICATION OF EIGENSPACE TECHNIQUES TO DESIGN OF AIRCRAFT CONTROL SYSTEMS
B. S. LIEBST and W. L. GARRARD (Minnesota, University, Minneapolis) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 475-480. refs
(Contract NAG1-217)

Eigenspace techniques allow the control system designer to use feedback to place eigenvalues and shape eigenvectors so as to modify closed loop dynamic response characteristics to achieve performance objectives. In this paper the theory of eigenspace design is reviewed, extended and applied to several aircraft control problems. Author

A86-35370
ADAPTIVE FLUTTER SUPPRESSION IN THE PRESENCE OF TURBULENCE
A. CHAKRAVARTY, D. GANGSAAS (Boeing Co., Seattle, WA), and J. B. MOORE (Australian National University, Canberra, Australia) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 751-756.

This paper presents an application of adaptive control to flutter suppression for an aircraft flying in turbulence. The adaptive control law is integrated with a nominal constant gain controller and furnishes the equivalent of a 180 deg phase margin at the flutter frequency. The design approach blends the classical, linear quadratic Gaussian and adaptive synthesis techniques, so that each contributes at its point of strength to achieve a robust control law with good performance characteristics. It is shown that the adaptive controller stabilizes the flutter in the face of arbitrary initial parameter estimates, unmodeled stochastic inputs, and significant level of spillover dynamics. Author

A86-35383
TIME DOMAIN CONTROL DESIGN FOR ROBUST STABILITY OF LINEAR REGULATORS - APPLICATION TO AIRCRAFT CONTROL
R. K. YEDAVALLI (Stevens Institute of Technology, Hoboken, NJ) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 914-919. refs

This paper addresses the aspect of 'Stability Robustness' of linear systems in time domain. Upper bounds on the linear perturbation of an asymptotically stable linear system are obtained to maintain stability, both for 'structured' as well as 'unstructured' perturbations using Liapunov approach. A quantitative measure called 'Stability Robustness Index' is introduced and this measure

is used to design 'robust' controllers for Linear Quadratic (LQ) Regulators. The proposed control design algorithm can be used, for given set of perturbations, to select the range of control effort for which the system is stability robust. Conversely it can also be used, for given control effort, to determine the range of the size of allowable perturbations. The algorithm is illustrated with the help of an aircraft control example. The scope of the proposed research and its extension to LQG Regulators, dynamic compensator design and other applications are discussed.
Author

A86-35384
COORDINATED BANK-TO-TURN AUTOPILOT DESIGN
C.-F. LIN (Boeing Co., Seattle, WA) and W. R. YUEH (Northrop Corp., Electronics Div., Hawthorne, CA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 922-926. refs

Bank-to-turn (BTT) missile coordinated autopilot system design principle is presented. The general design concept, design objective and requirement, design approach, and performance analysis are discussed. The closed loop system of the resulting control law is stable for a wide range of flight conditions with little changes in the location of the closed loop eigenvalues. The control loop frequency responses of six flight conditions during the terminal phase are presented to show the robustness of a feedback controller design. Simulations of the time responses of the tracking system are also presented to demonstrate tracking autopilot with good turn coordination.
Author

A86-35404* Integrated Systems, Inc., Palo Alto, Calif.
FLIGHT TEST TRAJECTORY CONTROLLER SYNTHESIS WITH CONSTRAINED EIGENSTRUCTURE ASSIGNMENT
P. K. A. MENON, H. A. SABERI, R. A. WALKER (Integrated Systems, Inc., Palo Alto, CA), and E. L. DUKE (NASA, Flight Research Center, Edwards, CA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1181-1186. refs
(Contract NAS2-11877)

The design of a maneuver autopilot for flight test trajectory control using constrained eigenvalue/eigenvector assignment is examined. The aircraft considered was a high-performance fighter with a command augmentation system engaged in all three axes. Attention is given to difficulties encountered in the generation of the desired eigenvalues and eigenvectors. It is found that this approach demands several iterations to converge to a satisfactory result, and does not appear to easily yield suitable insight for the output feedback design of high-order multivariable systems which will be used at other operating points. It is concluded that this technique could be made more attractive by generating gradients of the eigensystem between flight conditions, and including this information in the single-point design technique.
B.J.

A86-35443
PILOT INTERFACE WITH FLY-BY-WIRE CONTROL SYSTEMS
W. W. MELVIN (Air Line Pilots Association International, Washington, DC) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 153-157. refs
(SAE PAPER 851836)

The problems of pilot interface with automatic fly-by-wire control systems are described. The differences between manual and automatic aircraft control are examined. The incorporation of stability augmentation systems with fly-by-wire automatic systems to enhance the stability of the aircraft is discussed.
I.F.

A86-35457
SR-71 DIGITAL AUTOMATIC FLIGHT AND INLET CONTROL SYSTEM
R. P. DEGREY, R. L. NELSON, and J. E. MEYER (Lockheed Corp., Burbank, CA) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 399-410.
(SAE PAPER 851977)

This paper presents a description and treats the integration of a new triple channel multi-rate Digital Automatic Flight and Inlet Control System (DAFICS) into the SR-71 aircraft. Predicted airframe longevity to the year 2000 and aging automatic flight control/air inlet control analog systems dictated a modernization program to insure supportability over the life span of the aircraft. Aerodynamic consideration and development rationale is provided. A functional system description identifies the systems being replaced. Simulation, hardware/software development, redundancy management and flight experience is presented. Finally, digital and analog control comparisons are made and improvements discussed.
Author

A86-35563#
FRONT SEAT ON THE FUTURE
B. ZIEGLER (Airbus Industrie, Blagnac, France) Aerospace America (ISSN 0740-722X), vol. 24, April 1986, p. 66-68, 70.

Design and performance features of the Airbus 320 cockpit and control systems are outlined. The aircraft, designed to be almost completely computer-controlled with no single-failure flight critical systems, is to always maintain a minimum pitch roll control. The conventional control surfaces will have a mix of electrical and hydraulic actuators, the mechanical systems being largely emergency back-ups. There will be no mechanical linkage between the cockpit and the control mechanisms. The conventional configuration wil provide a neutral static stability which aids the limited back-up control mechanisms. The various techniques being incorporated into the flight control system to enhance instructor-student interactions and permit pilot-first officer interactive control of the aircraft in low-altitude turbulent flight regimes are described. One innovative feature of the automated control system is the provision of a wind shear modes to compensate for pilot errors.
M.S.K.

A86-35602
HIGHER HARMONIC CONTROL - WIND TUNNEL DEMONSTRATION OF FULLY EFFECTIVE VIBRATORY HUB FORCE SUPPRESSION
J. SHAW, N. ALBION, E. J. HANKER, JR., and R. S. TEAL (Boeing Vertol Co., Philadelphia, PA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 1-15. refs

A dynamically scaled model of the three-bladed CH-47D helicopter rotor has successfully demonstrated closed loop Higher Harmonic Control (HHC) in wind tunnel tests, simultaneously suppressing vertical and in-plane 3/rev hub forces throughout the test envelope. HHC has accomplished this level of suppression by means of a fixed gain feedback control law that is simpler and faster than the adaptive control laws recently employed by others. The controller applied small amounts of oscillatory swashplate motion in order to generate multiharmonic blade pitch variations of up to + or - 3 deg at very high speed.
O.C.

A86-35604* Massachusetts Inst. of Tech., Cambridge.
HELICOPTER GUST ALLEVIATION, ATTITUDE STABILIZATION, AND VIBRATION ALLEVIATION USING INDIVIDUAL-BLADE-CONTROL THROUGH A CONVENTIONAL SWASH PLATE
N. D. HAM (MIT, Cambridge, MA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 33-45. NASA-sponsored research. refs

The novel active control system presented for helicopter rotor aerodynamic and aeroelastic problems involves the individual control of each blade in the rotating frame over a wide range of frequencies (up to the sixth harmonic of rotor speed). This Individual Blade Control (IBC) system controls blade pitch by means of broadband electrohydraulic actuators attached to the swash plate (in the case of three blades) or individually to each blade, using acceleratometer signals to furnish control commands to the actuators. Attention is given to IBC's application to blade lag, flapping, and bending dynamics. It is shown that gust alleviation, attitude stabilization, vibration alleviation, and air/ground resonance suppression, are all achievable with a conventional helicopter swash plate. O.C.

A86-35622* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
DIRECTIONAL HANDLING QUALITIES REQUIREMENTS FOR NAP OF THE EARTH (NOE) TASKS
C. C. BIVENS (NASA, Ames Research Center; U.S. Army, Aeromechanics Laboratory, Moffett Field, CA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 297-314. refs

A piloted simulator experiment has been conducted to ascertain the directional axis handling requirements of hover and below 40-kt tasks of a scout/attack helicopter, with attention to such light helicopter configurations as those being considered for the 'LHX' program. Two types of yaw stability and control augmentation system were implemented: one consisted of a washed-out yaw rate feedback and shaped control unit, while the other involved a yaw rate command heading-hold system. Experiment results indicate that rotorcraft configurations with high directional gust sensitivity require greater minimum yaw damping to maintain satisfactory handling qualities in nap of the earth flight. Yaw damping and control response are critical handling qualities parameters in air-to-air target acquisition and tracking. O.C.

A86-35623
ASSESSMENT OF ROTORCRAFT AGILITY AND MANEUVERABILITY WITH A PILOT-IN-THE-LOOP SIMULATION
L. S. LEVINE, F. W. WARBURTON (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT), and H. C. CURTISS, JR. (Princeton University, NJ) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 315-325.

Attention is given to an economical, minicomputer-based, six-degree-of-freedom piloted simulation for assessing the effect of rotorcraft design parameters on combat effectiveness. A pilot-directed vehicle is used whose agility and maneuverability characteristics can be varied for different flights against a computer-driven adversary. The effects of roll time constant, sideslip envelope, and auxiliary propulsion system are investigated for two combat scenarios employing forward firing guns; effectiveness is quantified in terms of the probabilities of target kill and of survival over combat time. The results obtained provide insight into the relationship between vehicle handling qualities and weapons pointing tasks during maneuvering flight. O.C.

A86-35625
HELICOPTER HANDLING REQUIREMENTS BASED ON ANALYSIS OF FLIGHT MANEUVERS
R. K. HEFFLEY and S. M. BOURNE (Manudyne Systems, Inc., Los Altos, CA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 339-344. refs

An approach is described for the direct examination of helicopter flight maneuvers in order to determine handling qualities requirements. A general procedure is outlined for relating closed-loop discrete maneuver performance features to conventional open-loop vehicle characteristics. Two of the main maneuver features analyzed are the maneuver aggressiveness and maneuver amplitude. Flight data results from a variety of roll-axis maneuvers are presented. It can be seen that maneuver aggressiveness is highest for low-amplitude maneuvers and, because of an apparent upper bound on peak roll rate, lessens for larger-amplitude commands. Author

A86-35626
A COMPARATIVE STUDY OF AN ARTICULATED INTEGRATED SIDE-ARM CONTROLLER IN A VARIABLE STABILITY HELICOPTER
J. M. MORGAN (National Aeronautical Establishment, Flight Research Laboratory, Ottawa, Canada) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 359-366. refs

A large amplitude displacement four degrees of freedom manipulator was flown in a piloted experiment as a fully integrated side-arm controller (SAC) in the NAE Airborne Simulator. The experimental tasks were flown by four evaluation pilots using (1) conventional helicopter controls, (2) the SAC configured with a spherical grip and (3) the SAC configured with a conformal vertically oriented grip. Cooper Harper data for a series of tasks at and around the hover suggest that the grip configured controller degrades the vehicle by approximately one half of a Cooper Harper point, but that the spherical interface leads to approximately 1.5 points degradation. The spherical grip was noted as being more prone to cross-coupling than the conformal grip. Author

A86-35984
LOCALLY OPTIMAL CONTROL IN SYSTEMS WITH DELAY [LOKAL'NO-OPTIMAL'NOE UPRAVLENIE V SISTEMAKH S ZAPAZDYVANIEM]
G. L. DEGTIAREV and S. A. TERENTEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 39-42. In Russian.

The problem of determining control parameters in flight vehicle stabilization systems with delay is analyzed for the case of incomplete measurements of the state. Optimal control is determined as a function of the current and previous measurements of the system state. The problem is reduced to that of solving a closed system of equations for the unknown parameters. V.L.

A86-36772#
PRELIMINARY DESIGN OF LOW AUTHORITY SAS. I
T. HACKER (Institute of Aviation, Bucharest, Rumania) and B. TEODORESCU (Bucuresti, Institutul Politehnic, Bucharest, Rumania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 30, Nov.-Dec. 1985, p. 565-576.

The early stage of preliminary synthesis is viewed from the flight dynamicist's standpoint. Specific eigenvalue requirements concerning damping, frequency, and initial response are directly mapped into control gain space. Time domain criteria are seen to influence selection of the system structure and the gain values. Problems caused by flight control system/airframe interaction are considered. Modal requirements currently assigned to airframe alone are extended to airframe/flight control system dynamics and feedbacks of airframe states are used to cure flight control system-induced instability. Author

A86-36871#
A COMPUTER CONTROLLED AUTOPILOT AND AN ANNUNCIATION SYSTEM FOR LIGHT AIRCRAFT
S. N. DWIVEDI (North Carolina, University, Charlotte) IN: Computers in engineering 1985; Proceedings of the International Computers in Engineering Conference and Exhibition, Boston, MA, August 4-8, 1985. Volume 3 . New York, American Society of Mechanical Engineers, 1985, p. 111-119. refs

A design is described for an integrated autopilot for a light aircraft, that not only flies the airplane but also monitors its systems. In the event of any malfunction, the onboard computer announces the problem and on command follows the remedial procedure. Features of the system include the use of a synthesized voice to prompt the pilot or announce malfunctions and the use of a microcomputer to monitor the aircraft systems. The system incorporates the best features of several existing autopilots and consists of nine different processors for the following functions: system controller, backup, autopilot, navigation, integrated data control, radio adapter unit, electronic horizontal situation indicator, Votrax speech units, and the hand-held computer. D.H.

A86-37061* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE INFLUENCE OF SAMPLING RATE ON THE DYNAMICS AND CONTROL OF AERONAUTICAL SYSTEMS
J. C. HOWARD and L. D. WEBSTER (NASA, Ames Research Center, Moffett Field, CA) IN: Annual Pittsburgh Conference *16th, University of Pittsburgh, PA, April 25, 26, 1985, Proceedings.* Research Triangle Park, NC, Instrument Society of America (Modeling and Simulation. Volume 16, Pt. 5), 1985, p. 1467-1478. refs

It is shown in the design of aeronautical control systems that sampling rate variations give rise to migrations of the discrete eigenvalues for both the plant and the controllers. In general, these migrations tend to degrade simulation fidelity and the overall performance of Ultrareliable Fault Tolerant Control Systems (UFTCS). These systems consist of a redundant asynchronous network of microprocessors which use sensor information to generate the servo commands that drive actuators, thrust linkages, etc. A change in the sampling period of a single microprocessor will, in addition to causing an eigenvalue shift, alter the magnitude of the servo command issued by the controller. The influence of these changes and the effect of initial conditions and skew are considered. Author

A86-37070*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ADAPTIVE CONTROL ROBUSTNESS IN FLEXIBLE AIRCRAFT APPLICATION
E. N. SANCHEZ (NASA, Langley Research Center, Hampton, VA) American Control Conference, Seattle, WA, June 18-20, 1986, Paper. 4 p. refs

This paper presents the application of a model reference adaptive control (MRAC) algorithm to flexible aircraft flight control. The algorithm is an adaptive version of the Command Generator Tracking (CGT) control technique. This technique forces a dynamic system to follow a reduced-order model, allowing it to cope with the problem of unmodeled dynamics. The studies were made via simulation, using for the plant an aircraft dynamic model similar to the B1 bomber. This model is of a large aircraft with a reasonable amount of structural flexibility. In particular, flight configurations were analyzed where the influence of the flexible modes make it difficult to control the aircraft. The results indicate that the algorithm has good robustness properties vis-a-vis unmodeled dynamics and can force the flexible aircraft to follow rigid body responses. Author

N86-24700*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SWASHPLATE CONTROL SYSTEM Patent Application
R. J. PEYRAN, inventor (to NASA) (Army Aviation Engineering Flight Activity, Edwards AFB, Calif.), G. H. LAUB, inventor (to NASA) (Army Aviation Engineering Flight Activity, Edwards AFB, Calif.), and H. A. MORSE, inventor (to NASA) (Army Aviation Engineering Flight Activity, Edwards AFB, Calif.) 31 Mar. 1986 13 p
(NASA-CASE-ARC-11633-1; NAS 1.71:ARC-11633-1; US-PATENT-APPL-SN-846439) Avail: NTIS HC A02/MF A01 CSCL 01C

A mechanical system to control the position of a rotating swashplate is developed. This system provides independent lateral cyclic, longitudinal cyclic and collective pitch control of a helicopter rotor attached to the swashplate, without use of a mixer box. The system also provides direct, linear readout of cyclic and collective swashplate positions. A swashplate control system has a first gimbal ring pivotally mounted along a longitudinal axis. A second gimbal ring is pivotally attached to the first gimbal ring along a lateral axis. A longitudinal cyclic actuator pivots the first gimbal ring along the longitudinal axis. A lateral cyclic actuator pivots the second gimbal ring along the lateral axis. The lateral cyclic actuator is mounted on the first gimbal ring. A swashplate is rotatably mounted on the second gimbal ring. Prior swashplate control systems required use of a mixer box to provide true decoupling of lateral and longitudinal cyclic input to the swashplate. Author

N86-24701# National Aeronautics and Space Administration, Washington, D.C.
EIGENSTRUCTURE ASSIGNMENT AND ITS APPLICATION IN DESIGN OF FLIGHT CONTROL SYSTEMS
Z. GENG and D. FU May 1986 15 p refs Transl. by SCITRAN, Santa Barbara, Calif.
(Contract NASW-4004)
(NASA-TM-88411; NAS 1.15:88411) Avail: NTIS HC A02/MF A01 CSCL 01C

The present paper is concerned with an extension of the basic concept and the algorithm of eigenstructure assignment. A general conclusion is drawn regarding the assignment of freedoms in the case of the eigenstructure, taking into account a completely controllable linear time-invariant system. The new algorithms are provided for assigning the eigenstructure with multiple eigenvalues and/or with complex conjugate eigenvalues. The application of the eigenstructure assignment method to the design of a flight control system is illustrated with the aid of a numerical example involving an aircraft flight control system. Author

N86-24702*# Georgetown Univ., Washington, D.C. School of Engineering and Applied Science.
A RESEARCH PROGRAM IN ACTIVE CONTROL/AEROELASTICITY Final Semiannual Status Report, May - Oct. 1985
Oct. 1985 15 p
(Contract NAG1-199)
(NASA-CR-176773; NAS 1.26:176773) Avail: NTIS HC A02/MF A01 CSCL 01C

In this research period a synthesis methodology for multifunctional robust aeroservoelastic systems was developed. The development consisted of the following stages: (1) development of an universal diagram to determine phase and gain margins of a multi-input multi-output (MIMO) system using singular value based stability margin criteria; (2) determination of singular value gradients with respect to design parameters and their application to improve stability margins of multiloop system; and (3) application of constrained optimization techniques to synthesize a low order robust controller for a high order MIMO aeroservoelastic system while satisfying several design constraints on the dynamic loads and responses and stability margins at the plant input and output. Overall research activities are summarized. Author

N86-24703*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LATERAL AND LONGITUDINAL AERODYNAMIC STABILITY AND CONTROL PARAMETERS OF THE BASIC VORTEX FLAP RESEARCH AIRCRAFT AS DETERMINED FROM FLIGHT TEST DATA
W. T. SUIT and J. G. BATTERSON Apr. 1986 38 p
(NASA-TM-87711; NAS 1.15:87711) Avail: NTIS HC A03/MF A01 CSCL 01C

The aerodynamics of the basic F-106B were determined at selected points in the flight envelope. The test aircraft and flight procedures were presented. Aircraft instrumentation and the data system were discussed. The parameter extraction procedure was presented along with a discussion of the test flight results. The results were used to predict the aircraft motions for maneuvers that were not used to determine the vehicle aerodynamics. The control inputs used to maneuver the aircraft to get data for the determination of the aerodynamic parameters were discussed in the flight test procedures. The results from the current flight tests were compared with the results from wind tunnel test of the basic F-106B. B.G.

N86-24705# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
EXPERIMENTAL STUDY OF APEX FENCES FOR LIFT ENHANCEMENT ON A HIGHLY SWEPT DELTA WING CONFIGURATION M.S. Thesis
M. STUART Dec. 1985 197 p refs
(AD-A163877; AFIT/GAE/AA/85D-14) Avail: NTIS HC A09/MF A01 CSCL 12A

The longitudinal stability characteristics of a 60 deg. delta wing/body model equipped with various types of apex fences were studied experimentally. The experimental effort used force balance instrumentation and oil flow visualization. The locations of the fence-generated vortices and leading-edge vortices associated with highly swept wings were also determined. Five major fence parameters (shape, surface area, cant, length-to-height, movement) were studied and the results are given in a qualitative analysis. Results indicate a favorable application of apex fences for STOL operations. The fences increase lift and positive pitching moment which dictates the use of trailing edge flaps, further increasing the available maximum lift for takeoff and landing. Accompanying this is a large increase in drag at low angles of attack and a marginal increase at moderate to high angles. The relative strength of nose-down pitching moments at high (above 35 deg.) angles of attack produced by apex fences is slight. Apex fences seem to be a technology whose time may have come. Further research of the lateral behavior of a fenced aircraft appears warranted. GRA

N86-24706# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
MULTIVARIABLE CONTROL LAW DESIGN FOR ENHANCED AIR COMBAT MANEUVERING. F-15/STOL (SHORT TAKE-OFF AND LANDING) DERIVATIVE FIGHTER M.S. Thesis
K. A. SHEEHAN Dec. 1985 378 p refs
(AD-A164017; AFIT/GE/EE/85D-38) Avail: NTIS HC A17/MF A01 CSCL 01B

Proportional plus integral controllers are designed for the longitudinal mode using a multivariable control law theory developed by Professor Brian Porter of the University of Salford, England. Control laws are formulated by use of a computer-aided multivariable design program entitled MULTI. In addition MULTI performs a digital closed-loop simulation for controller performance analysis. The aircraft model is developed from linearized data. Decoupling of the longitudinal output variables is achieved and demonstrated by four maneuvers (pitch-pointing, vertical translation, direct climb, and constant g pull-up). Plant parameter variation effects are also examined. Destabilizing effects to include actuator and sensor dynamics computational time delay random Gaussian sensor noise and simulation nonlinearities are included. Results show stable responses for all simulations. Except for the most demanding simulations (all destabilizing effects considered), controller responses are smooth and well behaved. Recommendations include proposed future work in thrust vector modeling and suggested improvements to the computer-aided design program, MULTI. GRA

N86-24707# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
AN LQG UP-AND AWAY FLIGHT CONTROL DESIGN FOR THE STOL F-15 AIRCRAFT M.S. Thesis
R. A. HOUSTON Dec. 1985 243 p refs
(AD-A164108; AFIT/GE/ENG/85D-21) Avail: NTIS HC A11/MF A01 CSCL 01D

A robust controller for the STOL F-15 aircraft is developed using the LQG/LTR (linear system model, quadratic cost, Gaussian models of uncertainty used for controller synthesis, with loop transfer recovery techniques of tuning the filter in the loop for control robustness enhancement) methods. Full state feedback controllers are synthesized using CGT/PI (Command Generator Tracking feedforward compensator to provide direct incoporation of flying qualities into the design process, with proportional plus integral feedback control) synthesis, using implicit model following techniques to improve full state robustness characteristics. Finally, a Kalman filter is used to replace the unrealistic assumption of full state availability with estimated states, using a LTR scheme to recover as much full state robustness characteristics as possible. GRA

N86-24708# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
LQG/LTR DESIGN OF A ROBUST FLIGHT CONTROLLER FOR THE STOL F-15 M.S. Thesis
G. L. GROSS Dec. 1985 182 p refs
(AD-A164111; AFIT/GAE/ENG/85D-1) Avail: NTIS HC A09/MF A01 CSCL 17G

A robust controller for the approach and landing phase of the Short Take-off and Landing (STOL) F-15 is developed via LQG/LTR (Linear System model, Quadratic cost, Gaussian models of uncertainty, used for controller synthesis, with Loop Transmission Recovery techniques of tuning the filter in the loop for control robustness enhancement) methods. Reduced-order full-state feedback controllers are synthesized using CGT/PT (Command Generator Tracking feedforward compensator to incorporate handling qualities, with Proportional plus Integral feedback) synthesis, specifically using implicit model following to provide good robustness characteristics in the full-state feedback case. The robustness is fully assessed using realistic simulations of the real-world system with meaningful deviations from design conditions. Once a Kalman filter is embedded into the loop to estimate states rather than assuming artificial access to all states, LTR methodology is used to preserve as much robustness as possible. A full assessment of performance and robustness of these final implementable designs is provided. GRA

N86-25384# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
AN LQG UP-AND AWAY FLIGHT CONTROL DESIGN FOR THE STOL F-15 AIRCRAFT M.S. Thesis
R. A. HOUSTON Dec. 1985 243 p refs
(AD-A164108; AFIT/GE/ENG/85D-21) Avail: NTIS HC A11/MF A01 CSCL 01D

A robust controller for the STOL F-15 aircraft is developed using the LQG/LTR (linear system model, quadratic cost, gaussian models of uncertainty used for controller synthesis, with loop transfer recovery techniques of tuning the filter in the loop for control robustness enhancement) methods. Full state feedback controllers are synthesized using CGT/PI (Command Generator Tracking feedforward compensator to provide direct incoporation of flying qualities into the design process, with proportional plus integral feedback control) synthesis, using implicit model following techniques to improve full state robustness characteristics. Finally, a Kalman filter is used to replace the unrealistic assumption of full state availability with estimated states, using a LTR scheme to recover as much full state robustness characteristics as possible. GRA

N86-25603# Joint Publications Research Service, Arlington, Va.
ROLE OF OPTIMIZATION METHODS IN IMPROVEMENT OF FLIGHT CONTROL FOR AIRPLANES Abstract Only
G. M. KASHIN *In its* USSR Report: Engineering and Equipment (JPRS-UEQ-86-002) p 10 7 Feb. 1986 Transl. into ENGLISH from Standarty i Kachestvo (Moscow, USSR), no. 12, Dec. 1984 p 15-18
Avail: NTIS HC A06/MF A01

While conventional computer aided automatic flight control alone improves the static and dynamic characteristics of aircraft, active automatic control can further improve the flight mechanics by means of reduction of takeoff mass. Such a control system is capable of performing other additional functions as well, namely relaxing the constraints on natural static stability, reducing the loads involved in maneuvers, increasing the stability margin under flutter, damping elastic vibrations in a turbulent atmosphere, direct control of lift and lateral forces, improving the flight aerodynamics, prevention of dives and spins, and improving passenger comfort. The stability margin is reduced by increasing the stability level. The design of such a system is based on analysis of surges and vibrations, requires inclusion of corrective filters, and calls for optimization of the control algorithm for the special application. One approach proposed is the approach taken for optimizing the parameters of standardization objects. Author

09

RESEARCH AND SUPPORT FACILITIES (AIR)

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

A86-35155#
SIMULATION AND MEASUREMENT OF ENGINE INFLUENCES IN A TWO-JET AIRCRAFT MODEL USING MODEL ENGINES [SIMULATION UND MESSUNG VON TRIEBWERKSEINFLUESSEN AN EINEM ZWEISTRAHLIGEN FLUGZEUGMODELL MIT HILFE VON MODELLTRIEBWERKEN]
D. ECKERT (Duits-Nederlandse Windtunnel Emmeloord, Netherlands) and W. BURGSMUELLER (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 16 p. In German.
(DGLR PAPER 85-092)

The calibration, simulation, a measurement technology used in the German-Dutch Wind Tunnel DNW to study engine influences in a two-jet aircraft model are described. The accuracy of the interference evaluation achieved in the DNW using pressure distribution and six-component power measurements on an Airbus model is reported. Potential improvements that could be made to improve design results antecedent to flight tests are discussed. C.D.

A86-35166#
HELICOPTER TEST INSTALLATION ROTEST IN DNW - APPLICATION AND RESULTS [HUBSCHRAUBER-VERSUCHSANLAGE ROTEST IM DNW - EINSATZ UND ERGEBNISSE]
H.-J. LANGER, G. BRAUN, and B. JUNKER (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 14 p. In German.
(DGLR PAPER 85-113)

The model standardization and functioning of the helicopter test installation RoTeSt in DNW is discussed. The choice of standardization factors for the different aspects of the installation is addressed, and a block diagram of the installation signal flow is given. Tests conducted on various rotors in the installation's wind tunnel are reviewed, showing results on the relation between model rotor operation points and flight states, on the derivative of the longitudinal angle of control as a function of velocity, on correction values for rotor angle of attack for various measuring section configurations and mast angles of inclination, and on the effect of tunnel temperature on the rotor thrust for constant rotational speed. Comparison results for various rotors are given, including accelerations, dynamic momentum behavior, and measurements of downwash. C.D.

A86-35213
REQUIREMENTS FOR SECOND GENERATION AIRCRAFT WEIGHING SYSTEMS
C. R. URSELL, II and R. L. WILBUR (Southwest Research Institute, San Antonio, TX) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 6 p.
(SAWE PAPER 1669)

Weighing of aircraft to determine weights, distribution and center of gravity is becoming more and more a critical and necessary operation. In order to achieve the desired goals, ten basic requirements have been set forth for the second generation of new weighting systems. These requirements involve accuracy, repeatability, linearity, simplicity, portability, ruggedness, size/weight, maintainability, calibration and temperature correction. These have been achieved in two prototype systems that have been in operation for the past five years. Author

A86-36941
ENGINEERING FLIGHT SIMULATION - A REVOLUTION OF CHANGE
T. L. FRASER and C. E. PHILLIPS (Boeing Computer Services Flight Systems Laboratory, Seattle, WA) IN: Flight simulation/simulators; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 11-17.
(SAE PAPER 851901)

Issues which require consideration when developing an engineering simulation facility are presented, with emphasis placed on the incorporation of a dynamic computing technology into short and long-term planning. The effects of the operation environment, simulation growth, and simulation payoff are discussed in relation to external influences of computer architecture, re-education of the programmer, and simulation user help. It is concluded that new simulation technology may include the application of a modular computing architecture in the form of multi-processors and engineering workstations, as well as extensive input/output and file networking systems. Moreover, it would include the selection and education of new programming languages and the development of adequate help systems. K.K.

A86-36944
CAPABILITIES OF AIRBORNE AND GROUND BASED FLIGHT SIMULATION
S. R. MARKMAN (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: Flight simulation/simulators; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 35-42.
(SAE PAPER 851944)

Major capabilities and limitations of ground based and in-flight simulation are discussed, and the unique role of in-flight simulation for test pilot training is demonstrated. Inherent advantages of ground-based simulation include unlimited flexibility, easy design modification, the absence of flight safety issues and the early evaluation of new systems and aerodynamic effects. However, motion and visual cues are insufficiently simulated but they are readily available in in-flight simulation, together with greater control precision. Disadvantages associated with this mechanism include a lack of control power, less flexibility in reconfiguring cock-pit equipment, and a psychological barrier connected to safety-pilot presence. It is concluded that the use of both types of simulators in a combined flight simulation program is justified and desirable. K.K.

A86-37087*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CURRENT WIND TUNNEL CAPABILITY AND PLANNED IMPROVEMENTS AT THE NASA LANGLEY RESEARCH CENTER
R. E. BOWER (NASA, Langley Research Center, Hampton, VA) AIAA, Aerodynamic Testing Conference, 14th, West Palm Beach, FL, Mar. 5-7, 1986. 65 p. refs
(AIAA PAPER 86-0727)

NASA Langley's major wing wind tunnels and the projected facilities planned to be completed by 1988 are presented. Special capabilities, uses, and the improvements done during the Langley's tunnel revitalization program are described for the following facilities: (1) the 30 x 60-ft subsonic tunnel, (2) the 4 x 7-m low-speed testing tunnel, (3) the Low-Turbulence Tunnel, (4) the Spin Tunnel, (5) the National Transonic Pressure Tunnel, (6) Transonic Cryogenic Tunnel, (7) the National Transonic Facility, (8) the 16-ft Transonic Tunnel, (9) the Transonic Dynamic Tunnel, (10) the Unitary Plan Wind Tunnel, and (11) a new 20-inch supersonic wind tunnel which is currently undergoing final checkout. The design concept of an extremely-low disturbance level supersonic tunnel, the upgrading plans for the hypersonic aerothermal complex, and the present and planned capabilities for testing the hydrogen-fueled Scramjet engines are also presented. In addition, uses of inexpensive simple-to-operate research wind tunnels are discussed. Tunnel diagrams and graphs of upgrade results are included. I.S.

A86-37090#
THE DEVELOPMENT AND CALIBRATION OF AN ACOUSTIC WALL TRANSONIC TEST SECTION
R. L. BENGELINK, R. P. DOERZBACHER, and A. J. KRYNYTZKY (Boeing Commercial Airplane Co., Seattle, WA) AIAA, Aerodynamic Testing Conference, 14th, West Palm Beach, FL, Mar. 5-7, 1986. 10 p. refs
(AIAA PAPER 86-0759)

The Boeing transonic wind tunnel has been equipped with an optional test section to allow near-field acoustic measurements for many types of models, including propfan-type propulsion simulators. Acoustic requirements led to a design using unventilated walls made of small cell, acoustic foam 12-in thick covered with a thin 50 percent porosity, perforated plate. In order to ensure maximum effectiveness of the sound material forward of the model noise-generating parts, a circumferential slot to reduce wall boundary layer momentum thickness is included in the configuration. Much of the test section development was accomplished using the 1/20-scale pilot transonic wind tunnel. Operational limits due to model blockage, wall divergence sensitivity, wall loads, and wall boundary layer slot performance were evaluated in the pilot facility. Also included in the development was a computational fluid dynamics Euler code analysis of a model with actuator disc for evaluation of wall interference due to propfan thrust. The code also addressed flow qualities around a propfan with wall boundary layer bleed. Author

N86-24710*# National Aeronautics and Space Administration, Washington, D.C.
WIND TUNNEL TECHNOLOGY FOR THE DEVELOPMENT OF FUTURE COMMERCIAL AIRCRAFT
J. SZODRUCH Mar. 1986 45 p refs Transl. into ENGLISH Conference Paper "Windkanaltechnologie fur die Entwicklung Zukunftiger Verkehrsflugzeuge" Hamburg, West Germany, DGLR Paper 84-127 Presented at the German Aerospace Society Annual Convention, Hamburg, West Germany, 1-3 Oct. 1984 Original language doc. was announced in IAA as A85-40340 Transl. by SCITRAN, Inc., Santa Barbara, Calif. Original doc. prep. by Deutsche Gesellschaft fur Luft- und Raumhafrt
(Contract NASW-4004)
(NASA-TM-88390; NAS 1.15:88390; DGLR-PAPER-84-127)
Avail: NTIS HC A03/MF A01 CSCL 14B

Requirements for new technologies in the area of civil aircraft design are mainly related to the high cost involved in the purchase of modern, fuel saving aircraft. A second important factor is the long term rise in the price of fuel. The demonstration of the benefits of new technologies, as far as these are related to aerodynamics, will,for the foreseeable future, still be based on wind tunnel measurements. Theoretical computation methods are very successfully used in design work, wing optimization, and an estimation of the Reynolds number effect. However, wind tunnel tests are still needed to verify the feasibility of the considered concepts. Along with other costs, the cost for the wind tunnel tests needed for the development of an aircraft is steadily increasing. The present investigation is concerned with the effect of numerical aerodynamics and civil aircraft technology on the development of wind tunnels. Attention is given to the requirements for the wind tunnel, investigative methods, measurement technology, models, and the relation between wind tunnel experiments and theoretical methods. F.M.R.

N86-25385# Drexel Univ., Philadelphia, Pa. Dept. of Civil Engineering.
MATERIALS FOR EMERGENCY REPAIR OF RUNWAYS Final Report, 1 Apr. 1984 - 14 Feb. 1985
S. POPOVICS 20 Mar. 1985 236 p refs
(Contract AF-AFOSR-0245-83)
(AD-A164225; REPT-001120-1; AFOSR-85-1229TR) Avail: NTIS HC A11/MF A01 CSCL 11B

The primary objective of this project was to identify or develop an inorganic cementing material that is suitable for emergency repair of damaged airport runways under war conditions. In the first half of the work several commercially available rapid hardening cements were screen-tested as presented in an earlier progress report. It was established on this basis that the SET-45 formulas and their modifications appeared to be the most promising for achieving the given objectives of this project. These objectives were: at least 2000 psi compressive strength at the age of 1 hour; adequately long setting time; good bond to old concrete; and minimum shrinkage under every weather condition. Since then both mechanical (compressive and flexural strengths, bond, shrinkage, etc.) and physicochemical tests (X-ray diffraction, scanning electron microscopy, infrared spectroscopy, etc.) were performed with these materials to see the technically important properties of these cements under various curing conditions and learn about the basic nature of these materials. GRA

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ASTRONAUTICS

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

A86-34112#
COMMERCIAL APPLICATIONS OF THE NAVSTAR GLOBAL POSITIONING SYSTEM
M. W. MILLER (Rockwell International Corp., Satellite Systems Div., Washington, DC) IN: U.S. Opportunities in Space Conference; Proceedings of the Second Annual Space Business Conference, Washington, DC, October 30-November 1, 1985 . London, Space Consultants International, Ltd., 1985, 10 p.

The characteristics and operation of the Global Positioning System (GPS) are described. The benefits GPS will provide to civilian air, sea, land, and space travel are discussed. Specific commercial applications for the satellite system, which include air traffic control, time synchronization, and oil exploration, are analyzed. I.F.

A86-34195
CAN WE DEVELOP THE 1.5 MILLION POUND AEROSPACE PLANE?
D. J. HOLT Aerospace Engineering (ISSN 0736-2536), vol. 6, April 1986, p. 26-30.

A technology readiness and economic feasibility evaluation is made of hypersonic, 'transatmospheric' aerospace vehicles; attention is given to the prospects for propulsion systems capable of attaining the Mach 25 escape velocity needed to reach low earth orbits and duplicating many of the functions currently undertaken by the Space Shuttle. Either two integrated propulsion systems or two 'staged' vehicles may be employed to yield the requisite operational capabilities. The claims of competing airbreathing and nonairbreathing (rocket) propulsion systems are evaluated. O.C.

A86-35217 National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
WEIGHTS ASSESSMENT FOR ORBIT-ON-DEMAND VEHICLES
I. O. MACCONOCHIE, J. A. MARTIN (NASA, Langley Research Center, Hampton, VA), C. A. BREINER, and J. A. CERRO (Kentron International, Inc., Hampton, VA) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 32 p. refs
(SAWE PAPER 1674)

Future manned, reusable earth-to-orbit vehicles may be required to reach orbit within hours or even minutes of a mission decision. A study has been conducted to consider vehicles with such a capability. In the initial phase of the study, 11 vehicles were sized for deployment of 5000 lbs to a polar orbit. From this matrix, two of the most promising concepts were resized for a modified mission and payload. A key feature of the study was the use of consistent mass estimating techniques for a broad range of concepts, allowing direct comparisons of sizes and weights. Author

N86-24722*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PASSIVE EDDY-CURRENT DAMPING AS A MEANS OF VIBRATION CONTROL IN CRYOGENIC TURBOMACHINERY
R. E. CUNNINGHAM Feb. 1986 14 p refs
(NASA-TP-2562; E-2762; NAS 1.60:2562) Avail: NTIS HC A02/MF A01 CSCL 13I

Lateral shaft vibrations produced by a rotating unbalance weight were damped by means of eddy currents generated in copper conductors that were precessing cyclicly in the gap formed by the pole faces of C-shaped, permanent magnets. The damper assembly, which was located at the lower bearing support of a vertically oriented rotor was completely immersed in liquid nitrogen during the test run. The test rotor was operated over a speed range from 800 to 10,000 rpm. Three magnet/conductor designs were evaluated. Experimental damping coefficients varied from 180 to 530 N sec/m. Reasonable agreement was noted for theoretical values of damping for these same assemblies. Values of damping coefficients varied from 150 to 780 N sec/m. The results demonstrate that passive eddy-current damping is a viable candidate for vibration control in cryogenic turbomachinery.
Author

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CHEMISTRY AND MATERIALS

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

A86-34650* Vrije Universiteit, Brussels (Belgium).
AN INTERNAL VARIABLE ASSISTED FORMULATION OF MOISTURE SORPTION MODELS FOR POLYMERS AND COMPOSITES
C. C. HIEL (Brussel, Vrije Universiteit, Brussels, Belgium) and M. J. ADAMSON (NASA, Ames Research Center, Moffett Field, CA) IN: 1985 SEM Spring Conference on Experimental Mechanics, Las Vegas, NV, June 9-14, 1985, Proceedings . Brookfield Center, CT, Society for Experimental Mechanics, Inc., 1985, p. 813-818. refs

The purpose of the paper is to demonstrate that constitutive equations for moisture sorption and swelling can be obtained with an internal variable method which is rooted in the theory of irreversible thermodynamics. Realism is injected into the model through the concept of free volume. The power of the method is illustrated by the solution of the formidable nonlinear boundary value problem for diffusion with swelling-stress dependent diffusivity. Author

A86-35179#
COMPARISON OF AL ALLOYS AND CARBON FIBER COMPOSITE MATERIALS IN AIRCRAFT CONSTRUCTION [VERGLEICH VON AL-LEGIERUNGEN UND CFK-WERKSTOFFEN IM FLUGZEUGBAU]
F. J. ARENDTS (Stuttgart, Universitaet, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 43 p. In German. refs
(DGLR PAPER 85-136)

A comparison is made between Al alloys and carbon fiber composite (CFC) materials in static loading, emphasizing the adaptability of the results to a variety of situations. Results are presented for tension, pressure, Euler bending, buckling, shear, and torsion. The notch impact strength of CFC is taken into consideration. The fatigue behavior of both materials is compared. The damage in metal sheets under tension is compared with a crack in aluminum-lithium and a pressure-loaded laminate is compared with delamination in CFC. Results of an extended study on weight-optimal materials for a spherical pressure cup in a commercial aircraft are presented. The inherent tendency of orthotropic materials to form elastomechanical couplings vic the elasticity law is discussed. C.D.

A86-35180#
ARALL (ARAMID REINFORCED ALUMINIUM LAMINATES), - A HYBRID COMPOSITE WITH A GREAT RESISTANCE AGAINST FATIGUE CRACK PROPAGATION
R. MARISSEN (DFVLR, Institut fuer Werkstoff-Forschung, Cologne, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 28 p. DFG-supported research. refs
(DGLR PAPER 85-137)

Modern aircraft structures are subjected to high-level fatigue stresses, and suitable structural materials with a high resistance to such stresses are needed. The present paper is concerned with such a material, taking into account the hybrid composite Arall (Aramid Reinforced Aluminum Laminates). Advantages of Arall are related to extremely low crack growth rates, even at high stress levels, and a large critical crack length. The material consists of thin aluminum alloy sheets (0.3 to 0.5 mm) and layers in which Aramid fibers are incorporated in a structural adhesive. Attention is given to a description of Arall, the statical properties of Arall, the technological properties of Arall, its potential applications, and the observed fatigue mechanisms. G.R.

A86-35226
STRAINING FOR WEIGHT SAVINGS IN ADVANCED COMPOSITES
L. J. LINNER (Lockheed-California Co., Burbank, CA) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 70 p. refs
(SAWE PAPER 1685)

The use of advanced composites in aircraft structures is discussed with emphasis on the possibility of increasing the potential levels of strain allowables for the composites. In particular, attention is given to the principal design criteria, test results for new toughened resin systems, an analysis of the primary failure modes, and estimation of weight savings resulting from the use of advanced composites. The study provides a realistic approach to the use of advanced composites in structural design by taking advantage of the high strain allowables while addressing nonoptimum constraints. V.L.

A86-35640* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFECT OF FIBER AND MATRIX MAXIMUM STRAIN ON THE ENERGY ABSORPTION OF COMPOSITE MATERIALS
G. L. FARLEY (NASA, Langley Research Center; U.S. Army, Structures Laboratory, Hampton, VA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 583-588. refs

Static crushing tests were conducted on graphite composite tubes to examine the influence of fiber and matrix maximum strain at failure on the energy absorption capability of graphite reinforced composite material. Fiber and matrix maximum strain at failure were determined to significantly effect energy absorption. The higher strain at failure composite material system, AS-4/5245, exhibited superior energy absorption capability compared to AS-4/934, T300/5245 or T300/934 composite material. Results of this investigation suggest that to achieve maximum energy absorption from a composite material a matrix material that has a higher strain at failure than the fiber reinforcement should be used. Author

A86-35641
PROCESS DEVELOPMENT AND TEST EVALUATION OF CAST, HIP AND HEAT TREATED TITANIUM UH-60A M.R. DAMPER BRACKET
J. KOPCHIK, M. M. SCHWARTZ, and S. SILVERSTEIN (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 589-593. Army-supported research.

Sikorsky Aircraft recently completed this U.S. Army funded program which produced and qualified a cast titanium Main Rotor Damper Bracket for the UH-60A helicopter to replace the existing forged and machined titanium bracket at a lower cost. The Ti-6Al-4V investment casting was HIP, heat treated, machined and full scale fatigue tested as a part of the acceptance of the material properties and processing techniques needed for production implementation. A series of tensile and fatigue tests also were performed (as well as non-destructive, dimensional, and chemical evaluation of the cast parts). The material for these small scale and the full scale tests came from the successful preproduction of forty-four (44) full scale damper bracket investment castings. Author

A86-36178
COMPARISON OF THE STRENGTH AND DAMAGE TOLERANCE OF ALUMINIUM ALLOYS
L. SCHWARMANN (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) International Journal of Fatigue (ISSN 0142-1123), vol. 8, April 1986, p. 73-77. refs

The static strengths, crack growth lives and residual strengths have been predicted for a variety of aluminum alloys used in aeronautical structures, and the influence of product form and heat treatment on these properties assessed. Recommendations are made concerning the best plate or sheet material to use when high strength or good fatigue performance is required. Author

A86-36335
STRUCTURAL MATERIALS IN AERONAUTICS - PROSPECTS AND PERSPECTIVES
G. G. POPE (Royal Aircraft Establishment, Farnborough, England) Aerospace (UK) (ISSN 0305-0831), vol. 13, April 1986, p. 16-22.

The factors influencing choices of materials for aircraft components are reviewed, along with recent advances in available materials and their applications. The primary concern is weight minimization, followed by maximized strength and stiffness, acceptable life cycle costs and fatigue resistance. The operational environment is of concern, especially near oceans due to corrosion for metals (which can be coated) and weakening of composites (due to water absorption). New aircraft propulsion system designs continually require higher operating temperatures with the concomitant desire for long-life materials. The features, performance and present and projected applications of various composites, Ti alloys, steels and Al alloys, particularly for military purposes, are examined. M.S.K.

A86-36750
WHAT IS THE CHOICE FOR PRIMARY AIRCRAFT STRUCTURES - COMPOSITE OR ALUMINUM MATERIALS? [QUE FAUT-IL CHOISIR POUR LES OEUVRES VIVES - LES MATERIAUX COMPOSITES OU L'ALUMINIUM?]
B. LIARD (Brochier, S.A., Nevilly-sur-Seine, France) Materiaux et Techniques (ISSN 0032-6895), vol. 74, Jan.-Feb. 1986, p. 37-39. In French.

Aluminum alloys have been the material of choice for aircraft structures for decades due to their light weight, strength and fatigue resistance. Composite materials, at first comprising glass fiber-reinforced polymers, have been used for radomes and secondary structures. The high strength, low weight and fatigue resistance of carbon fiber reinforced plastics (CFRP) have led to their consideration as replacements for aluminum. CFRP materials are at least as fatigue resistant and as stiff as steel and offer significant overall gains in weight reduction if used as aircraft primary structures relative to the same structures made from aluminum. CFRP helicopter blades have already lasted up to four times as long as metal blades, but must be proven to structually resist the separation, shocks and shear forces experienced by metallic aircraft components before being employed in wings and fuselages. The new PEEK-based CRFPs have satisfactory shock resistance, although no field-ready techniques have yet been developed for repairs. The large potential market for CFRPs of sufficient material properties is delineated, along with the properties of the competing Al-Li alloys for the next generations of aircraft. M.S.K.

A86-36874#
A TRANSPORT MODEL FOR FLAMMABILITY OF PREMIXED GASES
A. J. SABER (Concordia University, Montreal, Canada) IN: Computers in engineering 1985; Proceedings of the International Computers in Engineering Conference and Exhibition, Boston, MA, August 4-8, 1985. Volume 3 . New York, American Society of Mechanical Engineers, 1985, p. 177-181. refs
(Contract NSERC-A-4209)

Criteria for the prediction of flammability limits of premixed gases are presented. The model used incorporates gas phase diffusion in the case of a relatively low pressure, stationary, one-dimensional flow. No additional physio-chemical properties are assumed. Applications include the selection of minimum air/fuel ratios for synthetic aircraft fuels. The model can be extended by relaxing the assumptions and the approach leads directly to numerical solution. Author

A86-37068*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DROP TESTING AND ANALYSIS OF SIX-FOOT DIAMETER GRAPHITE-EPOXY FRAMES
R. L. BOITNOTT (NASA, Langley Research Center; U.S. Army, Aerostructures Directorate, Hampton, VA) and H. D. CARDEN (NASA, Langley Research Center, Hampton, VA) AHS, National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, Apr. 7-9, 1986, Paper. 10 p. refs

Graphite-epoxy frames were drop tested onto a concrete floor to simulate crash loadings. The frames have Z-shaped cross-sections typical of designs often proposed for fuselage structure of advanced composite transports. The 6-foot diameter of the frames was chosen to reduce specimen fabrication costs and to facilitate testing. Response of the frames from accelerometer, strain gage, and photographic measurements are presented which characterize the behavior under 25-30 fps vertical impact velocity onto concrete. Failure of the graphite-epoxy frames involved a complete separation through the cross section near the impact point. All damage to the composite frame was confined to an area close to the impact point. Failure of aluminum frames tested for comparison were different from the composite specimens. The aluminum frames yielded (plastic hinges formed) at several locations around the lower portion of the frame without failing completely across the section. Author

A86-37073* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NA2SO4 INDUCED CORROSION OF NICKEL AT HIGH TEMPERATURE
A. K. MISRA (NASA, Lewis Research Center, Cleveland, OH) ASM, International Conference on Surface Modifications and Coatings, Toronto, Canada, Oct. 14-16, 1985, Paper. 18 p. refs

Sodium sulfate-induced corrosion of nickel was studied at 900 C as a function of oxygen partial pressure. For high O2 partial pressures, accelerated corrosion during the first few minutes occurred by rapid penetration of the melt along the metal grain boundaries. A mechanism is proposed to explain this phenomenon. Repetitive scale metal detachment was observed for corrosion in lower O2 partial pressures and during the later period of corrosion in higher O2 partial pressures. The effect of preoxidation on the hot corrosion has also been studied. An induction period is observed before the onset of rapid corrosion for the preoxidized samples; the onset of rapid corrosion is associated with sudden cracking of the scale. The length of the induction period for the preoxidized samples is a function of the length of preoxidation, and appears to be related to the structure of the oxide scale after the preoxidation treatment. Author

A86-37118
COMPRESSIVE STRENGTH OF IMPACT DAMAGED GRAPHITE EPOXY LAMINATES
R. JONES and A. A. BAKER (Ministry of Defence, Aeronautical Research Laboratories, Melbourne, Australia) IN: Composite structures 3; Proceedings of the Third International Conference, Paisley, Scotland, September 9-11, 1985 . London, Elsevier Applied Science Publishers, 1985, p. 402-414. refs

A major long-term objective in the evolution of advanced fiber composites as aircraft structural materials must be the establishment of a damage tolerance methodology. The availability of this methodology would greatly aid the design of safe, efficient composite structures as well as their management in service. There are, however, many difficulties in meeting this objective, including the multiplicity of failure modes in the composites, the numerous types of potentially significant defects which may arise during manufacture or in service, and sensitivity to moisture and temperature. Author

A86-37134
METHOD TO DETERMINE THE COMPLETE THREE-DIMENSIONAL ELASTIC COMPLIANCE MATRIX OF COMPOSITE MATERIALS
A. RUEBBEN and G. SCHARR (Aachen, Rheinisch-Westfaelische Technische Hochschule, West Germany) IN: Composite structures 3; Proceedings of the Third International Conference, Paisley, Scotland, September 9-11, 1985 . London, Elsevier Applied Science Publishers, 1985, p. 760-773. refs

The use of composite materials has rapidly progressed in the past years. Especially in aircraft and aerospace structures, the percentage of components made from composite materials constantly increases, yet the knowledge of many fundamental material properties is still insufficient. The correct calculation of the stress-strain behavior of space structures requires the exact determination of the complete compliance matrix, i.e. of the three-dimensional coefficients of elasticity. The present paper describes an extended testing and computing method to determine all three-dimensional elastic coefficients of composite materials dependent on temperature. The experiments are isothermal, static, short-term tensile tests and short-term torsion tests with low loading to secure elastic behavior. The torsion testing machine was developed according to Krabbe (1960) and Neuhaus (1981). The applied computing method derives from studies by Hoerig (1957). Author

A86-37136
ADVANCED COMPOSITES - THE STRUCTURAL REVOLUTION
R. C. FORNEY (Du Pont de Nemours and Co., Wilmington, DE) Journal of Metals (ISSN 0148-6608), vol. 38, March 1986, p. 18-20.

An evaluation is made of the development status and development prospects of advanced composites, with attention to projected gains obtained by means of them in design practices, manufacturing methods, energy conservation, and product utility and diversity. Major performance improvements attributable to advanced composites are noted in the aerospace industry, where they have made possible such innovative aircraft configurations as the X-29 forward-swept wing aircraft, and in the automotive industry, where significant parts count reductions are expected from composites-based construction methods. Composites are also noted to lend themselves to automated production methods. Attention is given to the long term socioeconomic consequences of composite materials' increasing use. O.C.

A86-37137
ARAMID FIBER COMPOSITES FOR GENERAL ENGINEERING
D. TANNER, A. K. DHINGRA, and J. J. PIGLIACAMPI (Du Pont de Nemours and Co., Textile Fibers Dept., Wilmington, DE) Journal of Metals (ISSN 0148-6608), vol. 38, March 1986, p. 21-25. refs

The para-aramid known commercially as poly p-phenyleneterephthalamide (PPD-T) consists of liquid crystalline domains oriented in the direction of applied shear during fiber extrusion operations. This high degree of orientation accounts for PPD-T's exceptional fiber strength and stiffness. It is projected that aircraft applications of PPD-T will emphasize damage tolerance and crashworthiness for primary structures. Attention is given to ongoing development efforts to improve matrix interface bonding in composites, including those with novel thermoplastic resin matrices, as well as antiballistic armor, asbestos-replacing composites, and rubber-matrix composites. O.C.

N86-24760*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.
EVALUATION OF CAPILLARY REINFORCED COMPOSITES Contractor Report, Sep. 1984 - Sep. 1985
J. E. CAHILL, J. F. HALASE, W. K. SOUTH, and L. J. STOFFER Sep. 1985 141 p Original contains color illustrations
(Contract NAS3-24386)
(NASA-CR-175061; NAS 1.26:175061) Avail: NTIS HC A07/MF A01 CSCL 11D

Anti-icing of the inlet of jet engines is generally performed with high pressure heated air that is directed forward from the

compressor through a series of pipes to various manifolds located near the structures to be anti-iced. From these manifolds, the air is directed to all flowpath surfaces that may be susceptible to ice formation. There the anti-icing function may be performed by either heat conduction or film heating. Unfortunately, the prospect of utilizing lighweight, high strength composites for inlet structures of jet engines has been frustrated by the low transverse thermal conductivity of such materials. It was the objective of this program to develop an advanced materials and design concept for anti-icing composite structures. The concept that was evaluated used capillary glass tubes embedded on the surface of a composite structure with heated air ducted through the tubes. An analytical computer program was developed to predict the anti-icing performance of such tubes and a test program was conducted to demonstrate actual performance of this system. Test data and analytical code results were in excellent agreement. Both indicate feasibility of using capillary tubes for surface heating as a means for composite engine structures to combat ice accumulation.
Author

N86-24781# Pratt and Whitney Aircraft, West Palm Beach, Fla. Government Products Div.
ALTITUDE IGNITION/LEAN DECEL STUDY Final Report, Aug. 1983 - Jan. 1985
D. ANDREADIS Nov. 1985 88 p
(Contract F33615-83-C-2329)
(AD-A163052; P/W/GPD-FR-18710; AFWAL-TR-85-2054) Avail: NTIS HC A05/MF A01 CSCL 21B

Analytical tasks consisting of new or improved models for predicting altitude ignition and lean deceleration blowout are developed. The approach taken was to describe the ignition and flame stabilization limits in terms of characteristic time models. Characterisitic times associated with chemical kinetics, fuel evaporation and hot flow residence are quantified for ignition and lean deceleration blowout limits. These expressions were interrelated according to the criteria for successful ignition and flame stabilization. Statistical analysis was used to compare the various expressions and select the appropriate terms that formulate models which best fit the data for altitude ignition and lean deceleration blowout. The models linearly correlate variations in combustor pressure, inlet temperature, fuel-air ratio, fuel temperature, air velocity, pressure drop, combustor front end geometry and injector size using existing data from USAF, Navy, NASA and P&W sponsored programs on operability performance of military and commercial gas turbine combustors. These models have been based entirely on full scale engine test. GRA

N86-24788# National Bureau of Standards, Gaithersburg, Md. Center for Fire Research.
DATA SOURCES FOR PARAMETERS USED IN PREDICTIVE MODELING OF FIRE GROWTH AND SMOKE SPREAD
D. GROSS Sep. 1985 41 p
(PB86-130986; NBSIR-85/3223) Avail: NTIS HC A03/MF A01 CSCL 13L

Sources of data needed for predictive modeling of fire growth by FAST and ASET, two computer codes developed at the Center for Fire Research, are identified for a few selected materials. Data includes thermophysical properties of compartment lining materials and burning rates and combustion product generation rates for typical combustible contents. GRA

N86-24818*# Massachusetts Inst. of Tech., Cambridge. Dept. of Materials Science and Engineering.
THERMAL-MECHANICAL FATIGUE BEHAVIOR OF NICKEL-BASE SUPERALLOYS Final Report
R. M. PELLOUX and N. MARCHAND Mar. 1986 186 p refs
(Contract NAG3-280)
(NASA-CR-175048; NAS 1.26:175048; USAAVSCOM-TR-86-C-4)
Avail: NTIS HC A09/MF A01 CSCL 11F

The main achievements of a 36-month research program are presented. The main objective was to gain more insight into the problem of crack growth under thermal mechanical fatigue (TMF) conditions. This program was conducted at M.I.T. for the period of September 1982 to September 1985. The program was arranged into five technical tasks. Under Task I, the literature of TMF data was reviewed. The goal was to identify the crack propagation conditions in aircraft engines (hot section) and to assess the validity of conventional fracture mechanics parameters to address TMF crack growth. The second task defined the test facilities, test specimen and the testing conditions needed to establish the effectiveness of data correlation parameters identified in Task I. Three materials (Inconel X-750, Hastelloy-X, and B-1900) were chosen for the program. Task II was accomplished in collaboration with Pratt & Whitney Aircraft engineers. Under Task III, a computerized testing system to measure the TMF behavior (LCF and CG behaviors) of various alloys systems was built. The software used to run isothermal and TMF tests was also developed. Built around a conventional servohydraulic machine, the system is capable of push-pull tests under stress or strain and temperature controlled conditions in the temperature range of 25C to 1050C. A crack propagation test program was defined and conducted under Task IV. The test variables included strain range, strain rate (frequency) and temperature. Task V correlated and generalized the Task IV data for isothermal and variable temperature conditions so that several crack propagation parameters could be compared and evaluated. The structural damage (mode of cracking and dislocation substructure) under TMF cycling was identified and contrasted with the isothermal damage to achieve a sound fundamental mechanistic understanding of TMF. Author

N86-24821# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
CONSTANT-LOAD-AMPLITUDE FATIGUE CRACK GROWTH TESTING OF CAST ALUMINUM ALLOYS A201-T7 AND A357-T6 Final Report, Mar. 1983 - Apr. 1984
J. D. TIRPAK Nov. 1985 60 p refs
(AD-A163494; AFWAL-TR-85-4096) Avail: NTIS HC A04/MF A01 CSCL 11F

This report is a repository of constant-load-amplitude fatigue crack growth rate data for cast aluminum alloys A201-T7 and A357-T6. Conditions were R=0.1, room temperature, lab air, and growth rates were above .0000001 m/cycle. The data herein was published for use by the aerospace community. From this data, it appears as if cast aluminum alloys possess some variability with respect to fatigue crack growth rate. For the most part though, the data is to serve as a nucleus for evaluating fatigue and fracture data for aluminum casting alloys, and generating impetus for further evaluation of these alloys with respect to fracture. GRA

N86-25370# Cambridge Univ. (England). Dept. of Metallurgy and Materials Science.
ASPECTS OF SMALL CRACK GROWTH
M. N. JAMES and J. F. KNOTT *In* AGARD Damage Tolerance Concepts for Critical Engine Components 16 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

The nature of small defects which occur in engineering components and structures, and their subsequent growth to a size detectable by nondestructive inspection techniques are discussed. Consideration is given to fundamental aspects such as the modifying influence of residual stresses and crack closure on the growth of small cracks. Possible differences between laboratory test data and in-service crack growth are highlighted. Practical aspects are illustrated with specific reference to the example of the safety-critical high pressure turbine disc of an aeroengine.
Author

N86-25376# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Materials Lab.
ADVANCED QUANTITATIVE METHODS FOR NONDESTRUCTIVE EVALUATION
D. E. CHIMENTI and T. J. MORAN *In* AGARD Damage Tolerance Concepts for Critical Engine Components 17 p Oct. 1985 *refs*
Avail: NTIS HC A13/MF A01

Over the past decade and a half progress in nondestructive evaluation (NDE) methods which yield quantitative flaw information has been considerable and has sparked a revolution in the way industry and government view the capabilities and benefits of quality assurance or component integrity. Almost no NDE technique, new or established, is selected for research and development without examining its potential for providing accurate, quantitative defect information. Concurrent with this trend has been the increasing use of fracture mechanics in the design and life management of aircraft systems, placing in turn stringent requirements on quantitative nondestructive evaluation (QNDE). Nowhere are these demands heavier than in the case of advanced aircraft engine alloys where critical flaw sizes are measured in hundredths of an inch. Research in NDE, therefore, has concentrated on improving defect sensitivity and reliability and providing the quantitative information essential to the new system maintenance philosphies, such as Retirement-for-Cause. In addition to the well known quantitative capabilities of standard techniques like radiography, dye penetrant, and in some cases, eddy current, developments in quantitative ultrasonics, eddy current, thermal wave techniques and exploitation of new medicial X-ray imaging methods offer alternatives with enhanced capabilities and possibly reduced cost. The state of the art in QNDE is discussed, as well as advanced methods currently in development. Author

N86-25502*# Rensselaer Polytechnic Inst., Troy, N.Y. Dept. of Mechanical Engineering.
EMISSION FTIR ANALYSES OF THIN MICROSCOPIC PATCHES OF JET FUEL RESIDUES DEPOSITED ON HEATED METAL SURFACES Final Report
J. L. LAUER and P. VOGEL 30 May 1986 95 p refs
(Contract NAG3-205)
(NASA-CR-176786; NAS 1.26:176786) Avail: NTIS HC A05/MF A01 CSCL 21D

The relationship of fuel stability to fuel composition and the development of mechanisms for deposit formation were investigated. Fuel deposits reduce heat transfer efficiency and increase resistance to fuel flow and are highly detrimental to aircraft performance. Infrared emission Fourier transform spectroscopy was chosen as the primary method of analysis because it was sensitive enough to be used in-situ on tiny patches of monolayers or of only a few molecular layers of deposits which generally proved completely insoluble in any nondestructive solvents. Deposits of four base fuels were compared; dodecane, a dodecane/tetralin blend, commercial Jet A fuel, and a broadened-properties jet fuel particularly rich in polynuclear aromatics. Every fuel in turn was provided with and without small additions of such additives as thiophene, furan, pyrrole, and copper and iron naphthenates. B.G.

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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.

A86-33943
SHARP (STATIONARY HIGH ALTITUDE RELAY PLATFORMS) TELECOMMUNICATIONS MISSIONS AND SYSTEMS
G. W. JULL, A. LILLEMARK, and R. M. TURNER (Canadian Department of Communications, Communications Research Centre, Ottawa, Canada) IN: GLOBECOM '85 - Global Telecommunications Conference, New Orleans, LA, December 2-5, 1985, Conference Record. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 955-959. refs

The SHARP (Stationary High Altitude Relay Platform) system concept envisages use of microwave-powered airplanes, circling at an altitude of 21 km, as platforms to distribute telecommunications services within regions of up to about 600 km diameter. Various configurations of airplanes and power transmission systems have been examined. Studies have shown that SHARP would have the technical capability to distribute UHF mobile radio and radio telephone services along with SHF direct broadcast TV channels to rural regions. Unique features of SHARP were found to include capabilities to provide reliable radio telephone service to low power user sets and to permit frequency reuse to meet expanding traffic capacity requirements. Author

A86-33944
SHARP (STATIONARY HIGH ALTITUDE RELAY PLATFORM) - RECTENNA AND LOW ALTITUDE TESTS
J. J. SCHLESAK, A. ALDEN, and T. OHNO (Canadian Department of Communications, Communications Research Centre, Ottawa, Canada) IN: GLOBECOM '85 - Global Telecommunications Conference, New Orleans, LA, December 2-5, 1985, Conference Record. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 960-964. refs

This paper describes a planned low-altitude microwave-powered flight test to demonstrate several key features of the SHARP (Stationary High Altitude Relay Platform) concept. A small-scale airplane will be flown at an altitude of about 50 m, powered by microwave energy transmitted from the ground. RF power at a frequency of 2.45 GHz will be converted to dc by an array of rectennas mounted on the lower surfaces of the airplane's wings. A novel dual-polarized rectenna system has been developed for powering the scaled model. The RF to dc power conversion efficiency of this rectenna is about 60 percent. Author

A86-34407
INTERNATIONAL SYMPOSIUM ON LASER ANEMOMETRY, 2ND, MIAMI BEACH, FL, NOVEMBER 17-22, 1985, PROCEEDINGS
A. DYBBS, ED. (Case Western Reserve University, Cleveland, OH) and P. A. PFUND, ED. (Babcock and Wilcox Co., New York) Symposium sponsored by ASME. New York, American Society of Mechanical Engineers (Fluids Engineering Symposia Series. Volume FED-33), 1985, 311 p. For individual items see A86-34408 to A86-34441.

Recent developments in laser anemometry are discussed under the following headings: industrially relevant flows, optical techniques and new instrumentation, turbulent flows and boundary layers, signal processing techniques, and external and internal flows. Papers are presented on intrablade velocity mapping in transonic fan passages of gas turbine, velocity measurements within boundary layer roughness using index matching, laser-based method for analyzing speed and vorticity, and a technique to measure the size of particles in laser Doppler velocimetry applications. Other topics discussed include experiments in

polydisperse two-phase turbulent flows, filter induced errors in laser anemometry using counter-processor, and physical properties of separated flows behind two-dimensional bluff bodies in uniform flows. V.L.

A86-34410#
LASER ANEMOMETER MEASUREMENTS OF THE FLOW FROM A SIMULATED FUEL NOZZLE
D. R. ZIMMERMAN (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) IN:. International Symposium on Laser Anemometry, 2nd, Miami Beach, FL, November 17-22, 1985, Proceedings . New York, American Society of Mechanical Engineers, 1985, p. 13-18. Research supported by General Motors Corp.
(Contract N00140-83-C-8894)

Two-color, two-dimensional, laser anemometer measurements were made of the axis-symmetric, swirling flow from a gas-turbine-engine, fuel-nozzle model. The flow field is characterized by two concentric, swirling, annular jets with an enclosed centerbody. The three mean velocity components, three normal stresses and two shear stresses were measured as a function of radial and axial location and Reynolds number for five geometrical configurations. The two most distinctly different geometries, co-rotating and counter-rotating annular jets, are discussed. Author

A86-34442
ADVANCED TOPICS IN BOUNDARY ELEMENT ANALYSIS; PROCEEDINGS OF THE WINTER ANNUAL MEETING, MIAMI BEACH, FL, NOVEMBER 17-22, 1985
T. A. CRUSE, ED. (Southwest Research Institute, San Antonio, TX), A. B. PIFKO, ED., and H. ARMEN, ED. (Grumman Aerospace Corp., Bethpage, NY) Meeting sponsored by ASME. New York, American Society of Mechanical Engineers , 1985, 296 p. For individual items see A86-34443 to A86-34454.

The papers presented in this volume provide an overview of current developments in boundary element methodology. Topics discussed include stress analysis of gas turbine engine structures using the boundary element method, advanced three-dimensional dynamic analysis by boundary element methods, a recursive integration technique for boundary element methods in elastostaatics, and boundary element treatment of three-dimensional elastic fracture mechanics problems. Papers are also presented on error control in three-dimensional crack modeling using the boundary element method, adaptive mesh refinement techniques for boundary element methods, and parallel processing and the solution of boundary element equations. V.L.

A86-34444*# United Technologies Corp., East Hartford, Conn.
STRESS ANALYSIS OF GAS TURBINE ENGINE STRUCTURES USING THE BOUNDARY ELEMENT METHOD
R. B. WILSON, D. W. SNOW (United Technologies Corp., Engineering Div., Hartaford, CT), and P. K. BANERJEE (New York, State University, Buffalo) IN: Advanced topics in boundary element analysis; Proceedings of the Winter Annual Meeting, Miami Beach, FL, November 17-22, 1985 . New York, American Society of Mechanical Engineers, 1985, p. 45-63. refs
(Contract NAS3-23697)

The theory of the boundary element method is briefly reviewed with particular reference to the feasibility of elastic and inelastic three-dimensional stress analysis of complex structures characteristic of gas turbine engine components. Particular requirements of gas turbine analysis are defined, and examples of the use of a boundary element code designed for the three-dimensional stress analysis of turbine components are presented. It is shown that the general-purpose boundary element code can accurately and efficiently analyze many of the gas turbine engine structures. V.L.

A86-34636
757 MAJOR STATIC TEST INSTRUMENTATION SYSTEMS
J. P. WALLACE (Boeing Commercial Airplane Co., Seattle, WA) IN: 1985 SEM Spring Conference on Experimental Mechanics, Las Vegas, NV, June 9-14, 1985, Proceedings . Brookfield Center, CT, Society for Experimental Mechanics, Inc., 1985, p. 634-645.

Several instrumentation systems were designed and built to support the 757 Major Static Test Program. These systems included a 36 channel Sound Detection System, a 48 channel Inertia Detection System, an Airplane Attitude Display System and two large scale Data Acquisition and Display Systems capable of recording and displaying up to 1536 channels of data. Graphic displays were developed for plotting the test data on-line. CAD/CAM systems were used to produce strain gage location drawings. The supporting software that was developed and the graphic display systems resulted in significant cost savings over previous major test programs. Author

A86-34639
PHOTOGRAMMETRY AS A MEANS OF MAPPING POSTBUCKLED COMPOSITE SURFACES
T. S. GATES (Rockwell International Corp., Los Angeles, CA) IN: 1985 SEM Spring Conference on Experimental Mechanics, Las Vegas, NV, June 9-14, 1985, Proceedings . Brookfield Center, CT, Society for Experimental Mechanics, Inc., 1985, p. 667-674. refs

Experimental results are discussed which indicate that nontopographic photogrammetry (NTP) can provide accurate, meaningful data for experimentally analyzing aspects of postbuckled structures. In particular, it is shown that the capability of NTP to supply data on initial imperfections, buckle geometry, edge effects, and transverse displacements exceeds the capability of moire or displacement transducers. By combining NTP with moire, strain gauges, and LDVTs, a complete and comprehensive data base can be formed to verify the analytical methodology required for efficient composite aircraft design. C.D.

A86-34641
THE DEVELOPMENT OF A SYSTEM FOR THE STUDY OF FATIGUE CRACK GROWTH UP TO 2000 HZ
A. PETROVICH and W. BESSLER (Mechanical Technology, Inc., Latham, NY) IN: 1985 SEM Spring Conference on Experimental Mechanics, Las Vegas, NV, June 9-14, 1985, Proceedings . Brookfield Center, CT, Society for Experimental Mechanics, Inc., 1985, p. 682-687.

A system constructed for the study of fatigue crack growth under combined high/low cycle loading is described. Based on a voice coil electro-hydraulic servo-valve, the system was used to study fatigue crack growth in aircraft turbine disk alloy 718 under combined high and low cycle loading with a high cycle frequency up to 2000 Hz. A specimen was designed to minimize the frequency ranges over which dynamic stresses due to resonance are significant. The procedures for verifying the elimination of these dynamic stresses is described. The achievement of similar stress distributions over a range from 200 to 2000 Hz allowed observation of the frequency dependence of the transition from low cycle to high cycle dominated crack growth with varying high cycle stress intensity factor range. Author

A86-34642
THE EFFECT OF CENTER DELAMINATION ON THE INSTABILITY OF COMPOSITE CYLINDRICAL PANELS
A. PALAZOTTO (USAF, Institute of Technology, Wright-Patterson AFB, OH) and G. SEIFERT IN: 1985 SEM Spring Conference on Experimental Mechanics, Las Vegas, NV, June 9-14, 1985, Proceedings . Brookfield Center, CT, Society for Experimental Mechanics, Inc., 1985, p. 707-711. refs

The buckling loads of 8-ply graphite-epoxy delaminated cylindrical panels were determined experimentally. The study included two different ply orientations, two different aspect ratios (length/chord), two different delamination sizes, and one set of boundary conditions; clamped along the top and bottom edges and simply supported along the vertical sides. The experimental

test results were compared to the linear bifurcation loads obtained from the STAGSC-1 finite element computer code and the buckling loads of panels with square cutouts which were also obtained from STAGSC-1. Author

A86-35221
A WEIGHT METHOD FOR STRUCTUAL BOXES
A. H. SCHMIDT (Boeing Vertol Co., Philadelphia, PA) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 17 p. refs
(SAWE PAPER 1680)

A fast and relatively simple method is described to predict the weight of aluminum wing and tail structural boxes simultaneously loaded for bending and torsion. The basic data were derived from an extensive compression testing study on stiffened panels of NACA 24S-T and 75S-T aluminum (identifical to current use 2024-T3 and 7075-T6. There are two equations, one for Z-stiffened 24S-T, and one for 75S-T. A graphite composite material was estimated for one structural configuration using the ratios of the modulus of elasticity for aluminum and graphite and the aluminum stiffened sheet curves. The method, which has its primary application to subsonic aircraft, yields accurate results. As in most weight estimating methods, good judgement is required in selecting the values for the nonoptimum factor, the rib material factor, and the effective height factor. I.S.

A86-35225
AN OPTIMIZATION PROCEDURE FOR A REDUNDANT WING STRUCTURE
L. A. RIEDINGER (Northrop Corp., Advanced System Div., Pico Rivera, CA) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 14 p.
(SAWE PAPER 1684)

A procedure is described whereby a minimum-weight wing may be obtained by calculating the optimum bending moment of inertia for each of the two spars (or boxes). This is accomplished by forcing each spar to support a proportionate amount of bending moment resulting in the maximum Mc/I stress equal to the damage tolerance allowable for the critical loading condition. The procedure described involves two initial analyses whereby an equation is obtained for the percent of bending in each spar as a function of the ratio of the moments of inertia. From this, a particular ratio of moments of inertia of the two spars is calculated to ensure that each spar is working to its allowable stress. According to the optimal stress theory, any other ratio would result in greater spar weight for bending. Three cases are used in the examples provided: constant height, same allowable stress; different heights, same allowable stress; and different heights, different materials; therefore, different allowable stresses. This procedure can save at least four weeks of design sizing iterations since it determines the optimum ratio of moments of inertia of the spars without iterations.
Author

A86-35611
GEARBOX CONFIGURATION ANALYSIS
H. COCKING (Westland Helicopters, Ltd., Yeovil, England) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 153-161. refs

In the design of any new gearbox, a conflict arises as to whether the gearbox should have an epicyclic or parallel shaft output stage. A method is derived which enables the relative merits of the two systems to be compared and the weight of each accurately predicted in the design stage. The method shows the actual relationship between the various gear design variables and the gear weight. A new factor called the 'configuration factor' is identified, which dominates the prediction of gearbox weight. It is shown how this factor is used to assess gearbox designs and identifies three features common to any low-weight gearbox. Finally, combining these features in a semiskeletal case results in an Advanced Engineering Gearbox, with a weight of only 62 percent of the current comparable gearbox. Author

A86-35643
POSTBUCKLING AND CRIPPLING BEHAVIOR OF GRAPHITE/EPOXY THIN-WALLED AIRFRAME MEMBERS
A. D. REDDY and L. W. REHFIELD (Georgia Institute of Technology, Atlanta) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 609-615. Research supported by the United Technologies Corp. refs
(Contract DAAG29-82-K-0094)

Test specimens employing plain-woven C3000 graphite/epoxy with five different ply layup geometries are the bases of the present study of buckling, postbuckling and crippling behavior in graphite/epoxy thin walled I-section airframe structure members. Boundary conditions at the web/flange interface, postbuckling stiffnesses, and the crippling loads and modes are determined. Nondimensional crippling curves are presented, on the basis of the preliminary data obtained, which may be used for predicting the crippling strengths of similar material systems; these curves are compared with existing ones for metals. O.C.

A86-35651
ASSESSMENT OF STRUCTURAL DAMAGE IN COMPOSITES UTILIZING ACOUSTIC EMISSION TECHNOLOGY
W. C. BOYCE (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) and R. K. MILLER (United Technologies Research Center, East Hartford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 665-677. refs

AE can be used in the quantitative characterization of structural damage in composite structures by means of a nonresonant point contact transducer (PCT), together with broadband signal processing; experimental results thus obtained have revealed unique signatures for matrix failures, delaminations, and fiber breaks. Attention is presently given to the development status and prospects for the application of PCT-based AE to full scale fatigue testing of helicopter dynamic components, as well as to the development of signal processing algorithms for the evaluation and tracking of structural damage propagation in composites.
O.C.

A86-35658
ADVANCED STRUCTURAL CASTING APPLICATIONS FOR A GAS TURBINE ENGINE
E. F. BISHOP, J. N. FLECK, and T. M. REGAN (General Electric Co., Lynn, MA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 777-784.

Attention is given to the methods and results of a program to convert complex gas turbine engine structural elements into precision castings that do not compromise design function, weight, and performance characteristics. Significant cost reductions are noted to result from the obviation of materials and labor otherwise required for fabrication by other means; welding, brazing and other joining operations are eliminated, and the inventory of components and subassemblies is reduced. Illustrative examples are noted in the case of the T700 gas turbine helicopter engine family's investment castings. O.C.

A86-35659
APPLICATION OF CLOSED-LOOP MACHINING IN THE MANUFACTURE OF GAS TURBINES
S. M. BURGESS and M. H. WOLLOWITZ (General Electric Co., Aircraft Engine Business Group, Lynn, MA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 785-791.

The in-process adaptive control system designated 'closed loop machining' (CLM), which employs machine-mounted probes to automatically correct process and machine errors, is presently applied to the manufacture of gas turbine components to reduce both manufacturing losses and product costs. The CLM system is incorporated into computer numerical control lathes. Attention is

given to hardware concepts used in implementation, as well as to software design and programming requirements. The sources of probing system errors are discussed, together with comments on CLM systems obtained from machine operators, numerical control programmers, and production managers. O.C.

A86-35660
ROBOTICS IN AIRCRAFT MANUFACTURING
J. J. BARTO, JR. (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 793-800.

Attention is given to two robotic installations for the manufacture of helicopter airframe components: a small hole-drilling and deburring system, an assembly system for drill/wet-seal/rivet operations. The multistation drilling system employs a robot to drill pilot holes in a family of machined aluminum cabin frame structures, and also brush-deburrs the machined surfaces. The assembly system involves a track-mounted robot designed to drill, wet-seal, and rivet Kevlar and aluminum panels onto preassembled frames that are positioned in a work cell arrangement. O.C.

A86-35980
THE EFFECT OF THE ELECTRODE GAP GEOMETRY ON CURRENT DISTRIBUTION DURING ELECTROCHEMICAL ROUNDING OF EDGES [VLIIANIE GEOMETRII MEZHELEKTRODNOGO PROMEZHUTKA NA RASPREDELENIE TOKA PRI ELEKTROKHIMICHESKOM SKRUGLENII KROMOK]
IU. M. VAKHITOV and A. KH. KARIMOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 20-24. In Russian.

In order to increase the reliability and life of gas-turbine engines it is necessary that sharp edges on some parts be rounded and then polished. The objective of the present study was to investigate the possibility of controlling current density by varying the shape and size of the working surface of the electrode tool and of the insulating screen during the electrochemical rounding of edges. Analog modeling using an electrointegrator has made it possible to obtain a number of practical recommendations concerning the design of the electrode tool and instrumentation. V.L.

A86-35997
USING THE PERTURBATION METHOD FOR DETERMINING THE DIE FORGING PARAMETERS FOR AIRCRAFT PARTS [ISPOL'ZOVANIE METODA VOZMUSHCHENII PRI OPREDELENII TEKHNOLOGICHESKIKH PARAMETROV SHTAMPOVKI AVIATSIONNYKH DETALEI]
I. P. POPOV and V. D. MASLOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 93-96. In Russian.

The perturbation method with a series expansion of the solution in powers of the small operator is used to obtain simple analytical expressions for determining the principal process variables for the die forging of aircraft parts. The changes in the thickness of the part during the die forging operation are described in the form of a power-law function with allowance for the hardening of the material on the basis of the energy criterion of plasticity. The approach proposed here is demonstrated through an example. V.L.

A86-35998
THE POSSIBILITY OF USING ION IMPLANTATION FOR INCREASING THE LIFE OF THE COMPRESSOR BLADES OF GAS-TURBINE AIRCRAFT ENGINES [O VOZMOZHNOSTI ISPOL'ZOVANIIA IONNOI IMPLANTATSII DLIA POVYSHENIIA DOLGOVECHNOSTI LOPATOK KOMPRESSORA GAZOTURBINNYKH AVIATSIONNYKH DVIGATELEI]
A. V. FEDOROV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 96, 97. In Russian.

A86-35999
SOME CHARACTERISTICS OF STRUCTURE FORMATION IN FORGED SEMIFINISHED PRODUCTS OF V93PCH ALUMINUM ALLOY [O NEKOTORYKH ZAKONOMERNOSTIAKH FORMIROVANIIA STRUKTURY V KOVANYKH POLUFABRIKATAKH IZ ALIUMINIEVOGO SPLAVA V93PCH]
A. IA. CHERNIAK, E. L. SHIF, and A. G. KARAKOZOVA Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 4, 1985, p. 97-99. In Russian.

The formation of a local coarse-grained structure in forged semifinished products of V93pch, an Al-Zn-Mg-Cu alloy commonly used in aircraft engineering, is investigated as a function of the structure of the alloy (polygonized or recrystallized) prior to the final stage of forging, temperature, and the extent of deformation. It is found that the formation of coarse-grained zones in V93pch alloy is largely due to the nonuniformity of deformation and to the excessively wide temperature range of forging. In order to obtain a sufficiently fine-grained recrystallized structure, it is recommended that the temperature of the final stage of forging do not exceed 610 K. V.L.

A86-36176
SOME ASPECTS OF VARIABILITY IN FATIGUE CRACK INITIATION AND PROPAGATION IN THICK ALUMINIUM ALLOY SECTIONS
J. Y. MANN, R. A. PELL, and A. S. MACHIN (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) International Journal of Fatigue (ISSN 0142-1123), vol. 8, April 1986, p. 59-66. refs

As part of an investigation to extend the lives of wings of the Mirage IIIO aircraft, a fatigue testing program and extensive fractographic examination was undertaken on thick specimens representing the critical section of the spar to provide information on variability in fatigue crack initiation and propagation. A good linear relationship was found between the log life and log crack depth for individual specimens. At the smallest crack depth used for analysis (0.3 mm) no significant differences were found between the standard deviations of log life to crack initiation, for propagation or to final failure, nor in the corresponding standard deviations of arithmetic lives. However, in considering the more general question of whether the greater contribution to variability in total life comes from that in initiation life or that in propagation life, it is shown that account must be taken of the analytical basis of the assessment - whether arithmetic or logarithmic. Author

A86-36805
THERMAL SCENE GENERATORS
A. PRITCHARD (British Aerospace, PLC, Research Dept., Bristol, England) Aerospace Dynamics (ISSN 0263-2012), vol. 18, Winter 1986, p. 17-22.

Design and performance features are discussed for Thermal Scene Generators (TSG) for hardware flight simulation testing of heat seeking missiles. The TSG must match the seeker's field of view, have a suitable range and resolution for the seeker design envelope, and have a response speed suitable for the trials run. The Bly cell, a thin membrane with favorable light absorption, thermal conductivity and emissivity properties, can be image-heated in a vacuum to a temperature corresponding to a visible image. A massive monolithic transducer can be employed to provide closed loop moving imagery through resistance heating. Sample imagery and circuitry diagrams are provided from experimental testing of the latter method by means of the application of thin film hybrid technology. M.S.K.

A86-36887#
ON THE METHODOLOGY OF AN INTERACTIVE COMPUTER-AIDED OPTIMAL DESIGN OF A DUAL-VALVE LINKAGE
D. E. ARMY, JR. (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT), R. C. AZAR, and S. CHANDRASHEKHAR (Western New England College, Springfield, MA) IN: Computers in engineering 1985; Proceedings of the International Computers in Engineering Conference and Exhibition, Boston, MA, August 4-8, 1985. Volume 3 . New York, American Society of Mechanical Engineers, 1985, p. 339-345. refs

This paper presents a methodology for obtaining a set of on-line optimal dual-valve linkages using an interactive computer-aided design approach. The dual-valve linkage is used in aircraft environmental systems wherein airflow in two ducts is controlled using a common valve actuator. The throttle and the bypass valves must open or close a desired amount according to a design schedule, so an efficient synthesis method has to be employed. A least-squares method along with Freudenstein's equation is used to minimize an objective function and thereby reduce the difference between the desired output and the measured output over the domain of operation. The software package developed enables a user to interact with the computer to determine a number of alternative designs depending upon the weight, the torque ratios and the effective valve area. This allows the user to choose from a number of options in a relatively short period of time and thus significantly reduce the design time. Author

A86-37067*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
IMPLICIT, VECTORIZABLE SCHEMES FOR THE FLUX-DIFFERENCE SPLIT, THREE-DIMENSIONAL NAVIER-STOKES EQUATIONS
C. H. LIU, P.-M. HARTWICH, and C.-H. HSU (NASA, Langley Research Center, Hampton, VA) Chinese Aerodynamics Research Society, International Conference on Numerical Methods in Fluid Dynamics, 10th, Beijing, People's Republic of China, June 23-27, 1986, Paper. 4 p. refs

Two hybrid upwind models are defined for solving the Euler equations. The algorithms both employ approximate factorization (AF) in crossplane and symmetric block Gauss-Seidel relaxation in the third direction. One approach adds an additional factorization step to lower the number of required grid point operations for inversion of the block tridiagonal matrices; however, the move permits only one third of the operations to be vectorized. Finite difference solutions are calculated on a C-H-type grid, in this case enveloping a slender, sharp-edged delta wing. Sample data are provided for the calculated vortex flow for Re of 10,000, at a 20.5 deg angle of attack, represented in a crossflow velocity vector plot and in a spanwise pressure coefficient distribution. The AF scheme, without additional factorization, when used with a grid covering 51 x 51 x 72 points provides a convergent solution with no time step lasting longer than 0.00001 sec. M.S.K.

A86-37071*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
CHARACTERISTICS PERTAINING TO A STIFFNESS CROSS-COUPLED JEFFCOTT MODEL
K. L. SPANYER (NASA, Marshall Space Flight Center, Huntsville, AL) ASME, Conference and Exhibit on Mechanical Vibration and Noise, Cincinnati, OH, Sept. 10-13, 1985. 12 p. refs
(ASME PAPER 85-DET-144)

Rotordynamic studies of complex systems utilizing multiple degree-of-freedom analysis have been performed to understand response, loads, and stability. In order to understand the fundamental nature of rotordynamic response, the Jeffcott rotor model has received wide attention. The purpose of this paper is to provide a generic rotordynamic analysis of a stiffness cross-coupled Jeffcott rotor model to illustrate characteristics of a second order stiffness-coupled linear system. The particular characteristics investigated were forced response, force vector diagrams, response orbits, and stability. Numerical results were achieved through a fourth order Runge-Kutta method for solving differential equations and the Routh Hurwitz stability criterion. The numerical results were verified to an exact mathematical solution for the steady state response. Author

A86-37072*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TECHNIQUES FOR INCREASING THE UPDATE RATE OF REAL-TIME DYNAMIC COMPUTER GRAPHIC DISPLAYS
W. M. KAHLBAUM, JR. (NASA, Langley Research Center, Hampton, VA) Association for Computing Machinery, SIGGRAPH 86, Dallas, TX, Aug. 18-22, 1986, Paper. 22 p.

This paper describes several techniques which may be used to increase the animation update rate of real-time computer raster graphic displays. The techniques were developed on the ADAGE RDS 3000 graphic system in support of the Advanced Concepts Simulator at the NASA Langley Research Center. The first technique involves pre-processing of the next animation frame while the previous one is being erased from the screen memory. The second technique involves the use of a parallel processor, the AGG4, for high speed character generation. The description of the AGG4 includes the Barrel Shifter which is a part of the hardware and is the key to the high speed character rendition. The final result of this total effort was a four fold increase in the update rate of an existing primary flight display from 4 to 16 frames per second. Author

A86-37091*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE DEVELOPMENT OF LASER SPECKLE VELOCIMETRY FOR THE MEASUREMENT OF VORTICAL FLOW FIELDS
C. A. SMITH (NASA, Ames Research Center, Moffett Field, CA), L. M. M. LOURENCO, and A. KROTHAPALLI (Florida State University, Tallahassee) AIAA, Aerodynamic Testing Conference, 14th, West Palm Beach, FL, Mar. 5-7, 1986. 15 p. refs
(AIAA PAPER 86-0768)

A new velocity measurement technique is described that provides the simultaneous visualization of a two-dimensional streamline pattern and the quantification of the velocity field. The main advantage of this technique is that the velocity field can be measured with sufficient accuracy and spatial resolution so that the vorticity field can be readily obtained. This technique is ideally suited for the study of unsteady vortical flows, which occur in rotorcraft and in high-angle-of-attack aerodynamics. The technique, some of the important parameters that affect its use, and some recent examples are described. Author

A86-37106
THE MATERIAL DEVELOPMENT, COMPONENT MANUFACTURE AND POST-SERVICE EVALUATION OF RB 211-524 COWL DOORS UTILISING CARBON FIBRE COMPOSITE MATERIALS
G. A. OWENS (Rolls-Royce, Ltd., Derby, England) IN: Composite structures 3; Proceedings of the Third International Conference, Paisley, Scotland, September 9-11, 1985 . London, Elsevier Applied Science Publishers, 1985, p. 83-99. refs

A86-37112
POSTBUCKLING FAILURE OF COMPOSITE PANELS
N. BUSKELL, G. A. O. DAVIES, and K. A. STEVENS (Imperial College of Science and Technology, London, England) IN: Composite structures 3; Proceedings of the Third International Conference, Paisley, Scotland, September 9-11, 1985 . London, Elsevier Applied Science Publishers, 1985, p. 290-314. Sponsorship: Ministry of Defence. refs
(Contract MOD-2037/0230/XR/STR)

A series of postbuckling tests have been conducted on thin rectangular quasi-isotropic CFRP panels. The testing machine allowed careful control of panel loading and by using acoustic emission as a diagnosis it was possible to monitor the onset and progress of failure before compression collapse destroyed the evidence. The panels exhibited substantial postbuckled strength, safely supporting at least twice their buckling load. Inspection of damaged panels revealed that postbuckling failure was caused by

the rapid growth of edge delamination from positions corresponding to a node line in the buckled mode shape. Author

A86-37119
DAMAGE TOLERANT COMPOSITE DESIGN DEVELOPMENT
E. DEMUTS (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) and R. E. HORTON (Boeing Co., Seattle, CA) IN: Composite structures 3; Proceedings of the Third International Conference, Paisley, Scotland, September 9-11, 1985 . London, Elsevier Applied Science Publishers, 1985, p. 427-439. USAF-sponsored research. refs

A design development has been presented of a damage tolerant composite multirib wing structural box section. A gradual advancing of the design through testing, evaluation of results and potential design modification at various specimen complexity levels has been applied here. This traditional building block approach is found to be valid and valuable. The specimen complexity levels include flat, simple coupons of a wide range of sizes and built-up wing cover panels with three and five stiffeners. The design development tests have demonstrated adequate damage tolerance of the blade-stiffened and the RTD I-stiffened designs. Findings from investigation of a premature fatigue failure of a moisture preconditional I-stiffened panel may cause its design modification. This design is used in the large box component whose tests are to qualify the component design and verify the composite damage tolerance requirements applied in designing the box. Author

N86-24883# Army Aviation Systems Command, St. Louis, Mo.
VHF-FM COMMUNICATIONS ANTENNAS FOR PROJECT SINCGARS (UH-1 TAIL WHIP AND CABIN ROOF BENT WHIP EVALUATION)
J. CARALYUS, J. MILLER, C. GRATACOS, and F. CANSLER Dec. 1985 103 p refs
(AD-A163561; USAAVSCOM-TR-85-E-3) Avail: NTIS HC A06/MF A01 CSCL 17B

The American Electronics Laboratory (AEL), Allaire, NJ, was tasked by the U.S. Army Avionics Research and Development Laboratory (SAVAA-M), Fort Monmouth, NJ, to develop replacement breadband matching modules for the CU-942B and the FM 10-30-1 antenna to satisfy specified requirements for Project SINCGARS. AEL was further tasked to test various candidate antennas provided by commercial vendors that are mechanically interchangeable with the CU-942B and the FM 10-30-1. After completion of the AEL development/test program, AVRADA tasked an independent, non-based Government antenna test facility to conduct prescribed antenna verification tests in accordance with an agreed upon test plan. This technical report describes communications antenna systems provided by Dayton-Granger, Inc (DGI), American Electronics Lab (AEL), and Avionics Antenna Systems (AVANT). The test measurements were conducted at the Naval Air Development Center, Antenna Test Facility located in Warminster, PA. The information in this report provides, in part, the technical data for the protection data package of adequate VHF-FM Communications antennas for the UH-1 helicopter when used with the new SINCGARS Radio. Author (GRA)

N86-24897# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
REAL-TIME FLIGHT TEST PCM DATA ACQUISITION MONITOR M.S. Thesis
J. R. CROASDALE Sep. 1985 268 p refs
(AD-A164035; AFIT/GE/ENG/85S-1) Avail: NTIS HC A12/MF A01 CSCL 17B

A computer based system utilizing an inexpensive off-the-shelf personal computer and original interface design centered around a 68000 microprocessor for real-time monitoring of a time division multiplexed pulse code modulated (TDM/PCM) data stream was designed and constructed. This system is a prototype of a low-cost, portable PCM data acquistion monitor intended for use in flight test programs by the 4950th Test Wing at Wright-Patterson AFB, Oh. It will accept a single Armed Forces Instrumentation Standard NRZ or split-phase (Manchester) baseband data stream at rates up to 100 KBPS, display selected data words in graphical or numerical format, and alarm the user when data exceeds certain limits. It will provide a real-time verification that the data being generated and recorded during a test is of acceptable quality, allowing the option of continuation of the test, or termination. The system is capable of automatically determining the data rate and signaling format and synchronizing itself with the incoming signal. GRA

N86-24934*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
UNSTEADY HEAT TRANSFER AND DIRECT COMPARISON TO STEADY-STATE MEASUREMENTS IN A ROTOR-WAKE EXPERIMENT
J. E. OBRIEN, R. J. SIMONEAU, J. E. LAGRAFF (Syracuse Univ.), and K. A. MOREHOUSE Jan. 1986 21 p refs Presented at the 8th International Heat Transfer Conference, San Francisco, Calif., 17-22 Aug. 1986
(NASA-TM-87220; E-2757; NAS 1.15:87220) Avail: NTIS HC A02/MF A01 CSCL 20D

Circumferentially local and time-resolved heat transfer measurements were obtained for a circular cylinder in crossflow located downstream of a rotating spoked wheel wake generator in a steady flow tunnel. The unsteady heat transfer effects were obtained by developing an extension of a thin film gauge technique employed to date exclusively in short-duration facilities. The time-average thin film results and conventional steady-state heat transfer measurements were compared. Time-averaged wake-induced stagnation heat transfer enhancement levels above the nowake case were about 10% for the four cylinder Reynolds numbers. This enhancement level was nearly independent of bar passing frequency and was related directly to the time integral of the heat transfer spikes observed at the bar passing frequency. It is observed that the wake-induced heat transfer spikes have peak magnitudes averaging 30 to 40% above the interwake heat transfer level. E.A.K.

N86-24936# National Aeronautics and Space Administration, Washington, D.C.
AN EXPERIMENTAL INVESTIGATION ON LOCATION OF BOUNDARY LAYER TRANSITION ON THE NACA 0012 USING SURFACE HOT FILM GAGES
T. C. WANG Mar. 1986 10 p refs Transl. into ENGLISH from Acta Aeronautica et Astronautica Sinica, v. 5, no. 4, Dec. 1984 p 401-405 Original language document was announced in IAA as A85-43231 Transl. by SCITRAN, Inc., Santa Barbara, Calif. Original doc. was prep. by Nanjing Aeronautical Inst.
(Contract NASW-4004)
(NASA-TM-88285; NAS 1.15:88285) Avail: NTIS HC A02/MF A01 CSCL 20D

Hot film gages were attached flush to the upper surface of a NACA-type 0012 airfoil in order to locate the boundary layer transitions corresponding to a range of distances from the leading edge. The measurements were carried out in a low-speed wind tunnel at Nanjing Aeronautical Institute. During the wind-tunnel tests, Reynolds numbers were kept constant at 200,000 Re(b), while the angle of attack of the airfoil was varied continuously. The locations on the airfoil of boundary layer separation and turbulent boundary layer attachment are shown in a diagram. It is found that the location of boundary layer transitions using hot film gages is a feasible and practical technique. Author

N86-24944# Department of the Air Force, Washington, D.C.
DUAL MODE HEAT EXCHANGER Patent Application
F. E. ALTOZ, inventor (to Air Force) 3 Dec. 1985 18 p refs
(AD-D012156; US-PATENT-APPL-SN-804193) Avail: NTIS HC A02/MF A01 CSCL 20M

The invention comprises a compact, light weight, dual mode heat transfer device. The dual mode heat transfer device provides for air cooling of heat dissipating electronic components at moderate aircraft speeds and when available ambient air is below a preselected temperature. At elevated aircraft speeds when the ambient air temperature is above the preselected temperature a coolant liquid is converted to steam or vapor in order to cool the

heat dissipating electronic components. A preferred embodiment of the invention includes a cold plate for conducting heat away from the heat dissipating components and radiator fins for dissipating cold plate heat to a air cooling flow. GRA

N86-24955*# Kansas Univ. Center for Research, Inc., Lawrence.
REVIEW AND EVALUATION OF RECENT DEVELOPMENTS IN MELIC INLET DYNAMIC FLOW DISTORTION PREDICTION AND COMPUTER PROGRAM DOCUMENTATION AND USER'S MANUAL ESTIMATING MAXIMUM INSTANTANEOUS INLET FLOW DISTORTION FROM STEADY-STATE TOTAL PRESSURE MEASUREMENTS WITH FULL, LIMITED, OR NO DYNAMIC DATA Final Report
W. G. SCHWEIKHARD and S. R. DENNON Apr. 1986 257 p refs
(Contract NAG3-11)
(NASA-CR-176765; NAS 1.26:176765) Avail: NTIS HC A12/MF A01 CSCL 20D

A review of the Melick method of inlet flow dynamic distortion prediction by statistical means is provided. These developments include the general Melick approach with full dynamic measurements, a limited dynamic measurement approach, and a turbulence modelling approach which requires no dynamic rms pressure fluctuation measurements. These modifications are evaluated by comparing predicted and measured peak instantaneous distortion levels from provisional inlet data sets. A nonlinear mean-line following vortex model is proposed and evaluated as a potential criterion for improving the peak instantaneous distortion map generated from the conventional linear vortex of the Melick method. The model is simplified to a series of linear vortex segments which lay along the mean line. Maps generated with this new approach are compared with conventionally generated maps, as well as measured peak instantaneous maps. Inlet data sets include subsonic, transonic, and supersonic inlets under various flight conditions. Author

N86-24984 Department of the Air Force, Washington, D.C.
LASER BEAM DUCT PRESSURE CONTROLLER SYSTEM Patent
A. J. LADERMAN, inventor (to Air Force) and F. M. BERGTHOLD, JR., inventor (to Air Force) 3 Sep. 1985 5 p
(AD-D012017; US-PATENT-4,538,635;
US-PATENT-APPL-SN-539352; US-PATENT CLASS-137-114)
Avail: US Patent and Trademark Office CSCL 20D

Disclosed is a laser beam duct pressure controller system for maintaining a spatially uniform pressure in a flowing gas volume which is subjected to temporal pressure variations. This desired result is accomplished with cooperating structural components (and gases therein), which eliminate the axial flow of a conditioning gas within the laser beam duct by matching the time rate of change of the pressure of the flowing conditioning gas to the time rate of change of the pressure in the cavity of an operably associated laser beam turret. GRA

N86-24990*# Akron Univ., Ohio. Dept. of Mechanical Engineering.
SYSTEM LIFE AND RELIABILITY MODELING FOR HELICOPTER TRANSMISSIONS Final Report
M. SAVAGE and C. K. BRIKMANIS Washington Apr. 1986 202 p refs
(Contract NAG3-55)
(NASA-CR-3967; E-2889; NAS 1.26:3967) Avail: NTIS HC A10/MF A01 CSCL 05C

A computer program which simulates life and reliability of helicopter transmissions is presented. The helicopter transmissions may be composed of spiral bevel gear units and planetary gear units - alone, in series or in parallel. The spiral bevel gear units may have either single or dual input pinions, which are identical. The planetary gear units may be stepped or unstepped and the number of planet gears carried by the planet arm may be varied. The reliability analysis used in the program is based on the Weibull distribution lives of the transmission components. The computer calculates the system lives and dynamic capacities of the transmission components and the transmission. The system life is defined as the life of the component or transmission at an output torque at which the probability of survival is 90 percent. The dynamic capacity of a component or transmission is defined as the output torque which can be applied for one million output shaft cycles for a probability of survival of 90 percent. A complete summary of the life and dynamic capacity results is produced by the program. Author

N86-24991*# Irwin (Arthur S.) Co., Inc., Bemus Point, N.Y.
REVIEW AND CRITICAL ANALYSIS: ROLLING-ELEMENT BEARINGS FOR SYSTEM LIFE AND RELIABILITY Final Report
A. S. IRWIN, W. J. ANDERSON, and W. J. DERNER Mar. 1985 234 p
(Contract NAS3-23520)
(NASA-CR-174710; NAS 1.26:174710; USAAVSCOM-TR-85-F-1)
Avail: NTIS HC A11/MF A01 CSCL 13I

A ball and cylindrical roller bearing technical specification which incorporates the latest state-of-the-art advancements was prepared for the purpose of improving bearing reliability in U.S. Army aircraft. The current U.S. Army aviation bearing designs and applications, including life analyses, were analyzed. A bearing restoration and refurbishment specification was prepared to improve bearing availability. Author

N86-24992*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TESTING OF YUH-61A HELICOPTER TRANSMISSION IN NASA LEWIS 2240-KW (3000-HP FACILITY
A. M. MITCHELL, F. B. OSWALD, and F. T. SCHULLER Mar. 1986 28 p refs
(NASA-TP-2538; E-2801; NAS 1.60:2538) Avail: NTIS HC A03/MF A01 CSCL 01C

A helicopter transmission that was being considered for the Army's Utility Tactical Transport Attack System (UTTAS) was tested in the NASA Lewis 2240-kW (3000-hp) test facility to obtain the transmission's operational data. The results will form a vibration and efficiency data base for evaluation similar-class helicopter transmissions. The transmission's mechanical efficiency was determined to be 98.7 percent at its rated power level of 2080 kW (2792 hp). At power levels up to 113 percent of rated the transmission displayed 56 percent higher vibration acceleration levels on the right input than on the left input. Both vibration signature analysis and final visual inspection indicated that the right input spiral-bevel gear had poor contact patterns. The highest vibration meter level was 52 g's rms at the accessory gear, which had free-wheeling gearsets. At 113 percent power and 100 percent rated speed the vibration meter levels generally ranged from 3 to 25 g's rms. Author

N86-24997# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
AUTOMATING KNOWLEDGE ACQUISITION IN A FLIGHTLINE ROBOT M.S. Thesis
W. M. CLIFFORD Dec. 1985 170 p refs
(AD-A163829; AFIT/GE/ENG/85D-7) Avail: NTIS HC A08/MF A01 CSCL 06D

Robots enjoy widespread use in industry on simplistic repetitive tasks in a controlled environment. Tasks in the military domain, particularly the flightline, require mobility and intelligence. While the mobility issue is being addressed, the intelligence issue is not. By giving the robot the ability to learn from a novice, the robot could be placed on the flightline and learn what it needs to know from the domain experts. Rather than deal with a toy problem, this work takes the actual refueling Job Guides for two aircraft and shows how these can be used directly by a computer. The process involves three steps. First, the text is transformed into a common natural language processor form. Second, the forms are examined to allow the commonalty between the two refueling tasks to be extracted. The forms are expanded by applying expert system and planning techniques to include missing domain and world

knowledge. Finally, the forms are examined to allow the commanalty between the two refueling tasks to be extracted.
GRA

N86-25003*# Pratt and Whitney Aircraft, East Hartford, Conn. Engineering Div.
LIFE PREDICTION AND CONSTITUTIVE MODELS FOR ENGINE HOT SECTION ANISOTROPIC MATERIALS PROGRAM Annual Status Report
G. A. SWANSON, I. LINASK, D. M. NISSLEY, P. P. NORRIS, T. G. MEYER, and K. P. WALKER Feb. 1986 203 p refs
(Contract NAS3-23939)
(NASA-CR-174952; NAS 1.26:174952; PWA-5968-19) Avail: NTIS HC A09/MF A01 CSCL 14D

This report presents the results of the first year of a program designed to develop life prediction and constitutive models for two coated single crystal alloys used in gas turbine airfoils. The two alloys are PWA 1480 and Alloy 185. The two oxidation resistant coatings are PWA 273, an aluminide coating, and PWA 286, an overlay NiCoCrAlY coating. To obtain constitutive and/or fatigue data, tests were conducted on coated and uncoated PWA 1480 specimens tensilely loaded in the 100 , 110 , 111 , and 123 directions. A literature survey of constitutive models was completed for both single crystal alloys and metallic coating materials; candidate models were selected. One constitutive model under consideration for single crystal alloys applies Walker's micromechanical viscoplastic formulation to all slip systems participating in the single crystal deformation. The constitutive models for the overlay coating correlate the viscoplastic data well. For the aluminide coating, a unique test method is under development. LCF and TMF tests are underway. The two coatings caused a significant drop in fatigue life, and each produced a much different failure mechanism. Author

N86-25371# Royal Aircraft Establishment, Farnborough (England). Propulsion Dept.
CRACK GROWTH IN NEAR-ALPHA TITANIUM ALLOYS
C. R. GOSTELOW *In* AGARD Damage Tolerance Concepts for Critical Engine Components 5 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

Ever since the first gas turbine aero engine entered into service there has been pressure to develop more powerful yet more efficient and lightweight units. To this end manufacturers have endeavored to increase overall pressure ratios and maximum cycle temperatures while trying to limit engine size by using materials having higher strength-to-weight ratios and higher temperature capability. Two main material approaches were followed in order to help meet these requirements. These are the development of high strength, high temperature capability nickel base superalloys for extensive use in the turbine and the replacement of heavy steels and nickel alloys in the compressor by advanced lightweight titanium alloys. The latter approach was the driving force behind the development in the UK of a unique range of creep-resistant near-alpha titanium alloys suitable for use up to 600 C. A variety of parameters are described which can influence the crack growth characteristics of near-alpha titanium alloys, with particular reference to the UK alloy IMI685. The relevance of these laboratory data to actual engine operation is assessed. Author

N86-25373# Fiat Research Center, Orbassano, Turin (Italy).
SMALL DEFECT CHARACTERIZATION IN POWDER METALLURGY MATERIALS
S. R. FIORENTIN and H. WALTHER (Fiat Aviazione S.p.A., Turin, Italy) *In* AGARD Damage Tolerance Concepts for Critical Engine Components 12 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

Powder metallurgy nickel base superalloys are becoming important structural materials for the manufacturing of critical complex-shaped aircraft components (e.g. turbine disks). Since fatigue life is largely affected by the presence of defects, in order to extend the limit of application of PM materials as far as possible, the need is felt for a nondestructive technique capable of detecting defects of size down to approximately 50 micrometers. An ultrasonic technique is presented which allows the detection and characterization of such small defects. It is based on the analysis of the signals backscattered by the material lying in the focal region of a short pulse transducer. During a first overall inspection of the component a real time data processing allows both the detection of critical defects and the evaluation of average grain size. In successive local inspections, confined in the regions where inclusions have been detected, further information on their characteristics may be collected. Some experimental results obtained on powder metallurgy samples containing seeded inclusions are presented. Author

N86-25375# TRW, Inc., Cleveland, Ohio.
MULTIAXIAL AND THERMOMECHANICAL FATIGUE CONSIDERATIONS IN DAMAGE TOLERANT DESIGN
G. E. LEESE and R. C. BILL (Army Research and Technology Labs., Cleveland, Ohio) *In* AGARD Damage Tolerance Concepts for Critical Engine Components 17 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

In considering damage tolerant design concepts for gas turbine hot section components, several challenging concerns arise: Complex multiaxial loading situations are encountered; thermomechanical fatigue loading involving very wide temperature ranges is imposed on components; some hot section materials are extremely anisotropic; and coatings and environmental interactions play an important role in crack propagation. The effects of multiaxiality and thermomechanical fatigue are considered from the standpoint of their impact on damage tolerant design concepts. Recently obtained research results as well as results from the open literature are examined and their implications for damage tolerant design are discussed. Three important needs required to advance analytical capabilities in support of damage tolerant design become readily apparent: (1) a theoretical basis to account for the effect of nonproportional loading (mechanical and mechanical/thermal); (2) the development of practical crack growth parameters that are applicable to thermomechanical fatigue situations; (3) the development of crack growth models that address multiple crack failures. Author

N86-25380# National Aerospace Lab., Amsterdam (Netherlands).
TURBISTAN: A STANDARD LOAD SEQUENCE FOR AIRCRAFT ENGINE DISCS
A. J. A. MOM, W. J. EVANS (Royal Aircraft Establishment, Farnborough, England), and A. A. TENHAVE *In* AGARD Damage Tolerance Concepts for Critical Engine Components 12 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

The development of TURBISTAN is a joint international effort to derive a loading standard representative for fighter aircraft engine disc usage. A representative loading standard offers considerable potential advantages over the present zero-max type of loading used for disc material evaluation. This is because the standard incorporates the effects of subcycles, their number, magnitude and sequence, which are known to seriously affect disc life and for which current life prediction techniques only partly account. Therefore usage of the standard in fatigue tests provides an improved evaluation of material properties, structural details, fabrication techniques, surface quality and life prediction. The compilation of operational flight data is described along with their analysis and the the generation of a preliminary TURBISTAN sequence for 'cold' compressor discs. The sequence contains about 8000 cycles which represent 100 flights. In addition, the background and philosophy of a material testing program meant to assess the effectiveness of the standard and to explore the validity of the assumptions made in its derivation is described.
Author

N86-25381# Rolls-Royce Ltd., Derby (England).
AN ANALYSIS OF RIG TEST DISC FAILURES
G. ASQUITH *In* AGARD Damage Tolerance Concepts for Critical Engine Components 10 p Oct. 1985 refs
Avail: NTIS HC A13/MF A01

A major objective in gas turbine engineering is the design and manufacture of discs that are reliable in service. Much depends on the accurate prediction of safe total lives and inspection intervals. Accurate predictions come from a complete understanding of material behavior involving experimentation, interpretation and quantification, for which a balanced program of laboratory specimen and full sized disc evaluation is required. Cyclic testing of full size discs is essential, this allows each disc to do its own 'Monte Carlo' evaluation of the large number of variables that affect the final result. Where life can be predictd entirely by linear elastic fracture mechanics some simplification can be introduced; this encourages studies in the quantification of short crack propagation behavior. Author

N86-25555# Joint Publications Research Service, Arlington, Va.
NORMAL FORCE CHARACTERISTICS OF SHARP NOSED BODIES OF REVOLUTION AT HIGH ANGLES OF ATTACK IN SUBSONIC AND TRANSONIC FLOW Abstract Only
X. TU and W. WU *In its* China Report: Science and Technology (JPRS-CST-86-011) p 102 31 Mar. 1986 Transl. into ENGLISH from Kongqidonglixue Xuebao (Mianyang, China), no. 4, 1985 p 81-89
Avail: NTIS HC A07/MF A01

The normal force characteristics of sharp nosed bodies of revolution were investigated experimentally at high angles of attack in a Mack number range form 0.35 to 1.20. The test results were analyzed. It was shown that both the Mach number and the Reynolds number strongly influence the normal force characteristics. The calculation methods based on crossflow theory had not taken into account the effects of viscosity and compressibility, so the actual phenomenon could not be represented. The present research also investigated the effect of rolling orientation on the normal force characteristics experimentally. It was shown that the vortex pattern on the leeside surface has a considerable effect on the normal force coefficient. The difference of the normal force coefficient for different rolling orientations is approximately the same as the magnitude of the Mack number effect. For sharp nosed bodies of revolution the vortex pattern on the leeside surface cannot be predicted precisely. For the same model, at the same angle of attack, the vortex pattern is different with different rolling orientations. Therefore, we can predict that the aerodynamic characteristics of sharp nosed bodies of revolution at high angles of attack should not be unique, and they can vary within a certain range. Author

N86-25600# Joint Publications Research Service, Arlington, Va.
AN-124 AIRPLANE'S CARGO-HANDLING AND AUTOMATION EQUIPMENT
T. KUZNETSOVA *In its* USSR Report: Engineering and Equipment (JPRS-UEQ-86-002) p 1-2 7 Feb. 1986 Transl. into ENGLISH from Pravda Ukrainy (Kiev, USSR), 26 May 1985 p 1
Avail: NTIS HC A06/MF A01

Development of the wide-body transport aircraft AN-124 is described. The aircraft has a large payload capacity, an airspeed of 800 to 850 kilometers an hour at an altitude of 10 to 12 kilometers, one third the fuel consumption, and the ability to use runways that are not concrete. The AN-124 is equipped with the latest navigation and piloting equipment, as well as an automated electrohydromechanical control system with quadruple redundancy, which ensures a high degree of reliability. The aircraft is also equipped with an onboard automatic monitoring complex which oversees all parameters, runs a comparison check, and warns ground services in the event of a malfunction. B.G.

N86-25793*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
GENERATION OF SPIRAL BEVEL GEARS WITH ZERO KINEMATICAL ERRORS AND COMPUTER AIDED TOOTH CONTACT ANALYSIS
F. L. LITVIN (Illinois Univ., Chicago.), W. J. TSUNG, J. J. COY, and C. HEINE (Dana Corp., Fort Wayne, Ind.) Mar. 1986 21 p refs Presented at the 2nd World Congress on Gearing, Paris, France, 2-5 Mar. 1986
(Contract NAG3-48)
(NASA-TM-87273; E-2932; NAS 1.15:87273; USAAVSCOM-TR-86-C-2) Avail: NTIS HC A02/MF A01 CSCL 13I

Kinematic errors in spiral bevel gears are a major source of noise and vibrations in transmissions. A method for the generation of Gleason's spiral bevel gears which provides conjugated gear tooth surfaces and an improved bearing contact was developed. A computer program for the simulation of meshing, misalignment, and bearing contact was written. Author

N86-25823*# Computer Software Management and Information Center, Athens, Ga.
FOURTEENTH NASTRAN USERS' COLLOQUIUM
May 1986 337 p refs Colloquium held in San Diego, Calif. 5-9 May 1986
(Contract NASW-3247)
(NASA-CP-2419; NAS 1.55:2419) Avail: NTIS HC A15/MF A01; also available from COSMIC, Athens, Ga. CSCL 20K

The proceedings of a colloquium are presented along with technical papers contributed during the conference. Reviewed are general applications of finite element methodology and the specific application of the NASA Structural Analysis System, NASTRAN, to a variety of static and dynamic sturctural problems.

N86-25826*# Aerostructures, Inc., Arlington, Va.
DYNAMIC AND AEROELASTIC ANALYSES OF TURBOSYSTEMS IN NASTRAN
V. ELCHURI and P. R. PAMIDI (RPK Corp., Columbia, Md.) *In* Computer Software Management and Information Center Fourteenteh NASTRAN Users' Colloquium p 56-60 May 1986 refs
Avail: NTIS HC A15/MF A01; also available from COSMIC, Athens, Ga. CSCL 20K

Several new capabilities dealing with the dynamic and aeroelastic analyses of turbosystems have been added as standard features to the April 1986 release of NASTRAN. A brief description is given of these capabilities and their implementation in NASTRAN are outlined. Author

N86-25831*# Naval Ship Research and Development Center, Bethesda, Md.
EXPERIENCES WITH NASTRAN IN A MULTIDISCIPLINARY OPTIMIZATION ENVIRONMENT
M. M. HURWITZ *In its* Computer Software Management and Information Center Fourteenth NASTRAN Users' Colloquium p 145-153 May 1986 refs
Avail: NTIS HC A15/MF A01; also available from COSMIC, Athens, Ga. CSCL 20K

NASTRAN and COPES/CONMIN were used in the early-stage design optimization of a propeller and shaft. The work was undertaken, in part, to assess the performance of these programs for such a task. While the optimization was successful, some drawbacks to the approach surfaced and are discussed. Author

N86-25838*# Naval Ocean Systems Center, San Diego, Calif.
FLUTTER ANALYSIS OF LOW ASPECT RATIO WINGS
L. A. PARNELL *In* Computer Software Management and Information Center Fourteenth NASTRAN Users' Colloquium p 247-263 May 1986 refs
Avail: NTIS HC A15/MF A01; also available from COSMIC, Athens, Ga. CSCL 20K

Several very low aspect ratio flat plate wing configurations are analyzed for their aerodynamic instability (flutter) characteristics.

All of the wings investigated are delta planforms with clipped tips, made of aluminum alloy plate and cantilevered from the supporting vehicle body. Results of both subsonic and supersonic NASTRAN aeroelastic analyses as well as those from another version of the program implementing the supersonic linearized aerodynamic theory are presented. Results are selectively compared with the experimental data; however, supersonic predictions of the Mach Box method in NASTRAN are found to be erratic and erroneous, requiring the use of a separate program. Author

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GEOSCIENCES

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

A86-36308
AN INTERCOMPARISON OF TURBULENCE DATA OBTAINED BY TWO AIRCRAFT DURING KONTUR
A. GRANT (Meteorological Office, Bracknell, England) and S. ZANK (Hamburg, Universitaet, West Germany) Beitraege zur Physik der Atmosphaere (ISSN 0005-8173), vol. 59, Feb. 1986, p. 185-194. refs

To ensure that the data obtained by the two aircraft, the Falcon 20 and the Hercules C-130 which took part in the 1981 KonTur experiment, were compatible a number of side by side intercomparison runs were carried out. This paper concentrates on the results of a comparison of the turbulence data, to document the accuracy, as well as the limitations of aircraft measurements in present field studies. Agreement between velocity component power spectra is found to be within the limits of natural variability for independently measured data. Stress cospectra and covariances show good agreement. Agreement between corresponding temperature power spectra as well as between corresponding heat flux cospectra is poor. The corresponding humidity power spectra as well as flux cospectra show good qualitative agreement. Because of the lack of humidity fluxes from the intercomparisons the quantitative agreement is illustrated by humidity flux profiles. Author

A86-36448
THE IMPORTANCE OF DYNAMIC STALL IN AERODYNAMIC MODELING OF THE DARRIEUS ROTOR [IMPORTANCE DU DECROCHAGE DYNAMIQUE DANS LES CALCULS AERODYNAMIQUES DU ROTOR DARRIEUS]
P. FRAUNIE, C. BEGUIER (Aix-Marseille II, Universite, Marseille, France), and I. PARASCHIVOIU (Montreal, Universite, Montreal, Canada) Journal de Mecanique Theorique et Appliquee (ISSN 0750-7240), vol. 4, no. 6, 1985, p. 785-804. In French. refs

The CAARDEX program is defined for analyzing the behavior of Darrieus wind turbines in terms of the Reynolds number, the geometrical characteristics of the wind turbine and the spreading of the stream tubes traversing the rotor volume. It is demonstrated that the maximum power conversion efficiency of the Darrieus rotor is 0.4, with the energy capture being divided at a 4:1 ratio upstream to downstream rotor. The model shows that the velocity induced on the rotor is a function of the specific velocity and solidity, and that previous stream tube theories are valid only at low values of these parameters. CARDAAX treats the rotor disk in terms of horizontal slices of stream tubes modeled separately for the upstream and downstream segments. Account is taken of the velocity profile in the atmospheric boundary layer, which can vary significantly in the case of large wind turbines, i.e., several hundred feet high. When applied to predicting the performance of a 1 kW, 2.6 m diam prototype Darrieus wind turbine in a 10 mps flow, fair agreement is obtained for power capture/wind velocity and cyclic aerodynamic forces. Additional flow visualization data is provided to illustrate the production of turbulence in the form of vortices shed between the blades. M.S.K.

A86-36480
PROBABILISTIC MODELING OF FIELDS OF ATMOSPHERIC TURBULENCE AND SEA ROUGHNESS WITH REFERENCE TO THE STUDY OF COMPLEX SYSTEMS [VEROIATNOSTNOE MODELIROVANIE POLEI TURBULENTNOSTI ATMOSFERY I MORSKOGO VOLNENIIA PRI ISSLEDOVANII SLOZHNYKH SISTEM]
IU. I. PALAGIN, S. V. FEDOTOV, and A. S. SHALYGIN Radiotekhnika i Elektronika (ISSN 0033-8494), vol. 31, April 1986, p. 721-727. In Russian. refs

Simulation models of atmospheric turbulence and sea roughness are developed on the basis of parametric representations of random fields. The models do not exhibit errors in relation to the spectral-correlation characteristics, require a limited computation volume, and are convenient for implementation on both digital and analog processors. The present approach is applied to the statistical modeling of the motion-control system of a flight vehicle with a radar altimeter. Author

A86-37059*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPARISON OF ADVANCED TURBOPROP AND CONVENTIONAL JET AND PROPELLER AIRCRAFT FLYOVER NOISE ANNOYANCE - PRELIMINARY RESULTS
D. A. MCCURDY (NASA, Langley Research Center, Hampton, VA) ASA, Meeting, 110th, Nashville, TN, Nov. 4-8, 1985, Paper. 30 p. refs

A laboratory experiment was conducted to compare the flyover noise annoyance of proposed advanced turboprop aircraft with that of conventional turboprop and jet aircraft. The effects of fundamental frequency and tone-to-broadband noise ratio on advanced turboprop annoyance were also examined. A computer synthesis system was used to generate 18 realistic, time varyring simulations of propeller aircraft takeoff noise in which the harmonic content was systematically varied to represent the factorial combinations of six fundamental frequencies ranging from 67.5 Hz to 292.5 Hz and three tone-to-broadband noise ratios of 0, 15, and 30 dB. These advanced turboprop simulations along with recordings of five conventional turboprop takeoffs and five conventional jet takeoffs were presented at D-weighted sound pressure levels of 70, 80, and 90 dB to 32 subjects in an anechoic chamber. Analyses of the subjects' annoyance judgments compare the three categories of aircraft and examine the effects of the differences in harmonic content among the advanced turboprop noises. The annoyance prediction ability of various noise measurement procedures and corrections is also examined. Author

N86-25079# Naval Research Lab., Washington, D. C.
AN ASSESSMENT OF DATA QUALITY AND QUANTITY FROM AIRBORNE CLOUD PHYSICS PROJECTS FROM 1974 THROUGH 1984 Final Report, Apr. 1983 - Dec. 1984
R. K. JECK Dec. 1985 144 p refs
(Contract DTFA03-83-A-00309)
(DOT/FAA/CT-85/37; NRL-8951) Avail: NTIS HC A07/MF A01

Airborne cloud physics projects are reviewed to assess the quantity, quality, and availability of microphysical data from clouds above the freezing level. In particular, available information is analyzed to determine whether adequate data on supercooled liquid water content (SLWC) and snow currently exist for reliably characterizing aircraft icing conditions at altitudes up to 30,000 feet over the conterminous United States (CONUS). About 1700 flights in cold clouds over CONUS are documented, and the number and value of flights having data on SLWC, snow and other hydrometeors are tabulated. B.G.

N86-25954# National Weather Service, Silver Spring, Md. Techniques Development Lab.
AFOS (AUTOMATION OF FIELD OPERATIONS AND SERVICES) TERMINAL FORECAST DECODING
D. J. VERCELLI, G. A. NORMAN, and M. M. HEFFERNAN Oct. 1985 23 p
(PB86-147360; NOAA-NWS-TDL-CP-85-2) Avail: NTIS HC A2/MF A01 CSCL 04B

Terminal forecasts (FT's) are issued by Weather Service Forecast Offices (WSFO's) for approximately 500 airports nationwide. A regularly scheduled FT is valid for the 24-h period following its issuance. The FT's are prepared manually each day at WSFO's which have FT responsibilities. Once prepared, they are then stored in the local Automation of Field Operations and Services (AFOS) database and transmitted over the AFSO communications circuits. The information in the forecasts can also be used by various applications programs at the local office (e.g., Vercelli and Norman, 1985). To do this, however, the forecasts must first be decoded. The paper describes two formula translation (FORTRAN) subroutine programs which together with their subordinate subroutines can be used to decode FT's. GRA

N86-25956*# Chicago Univ., Ill. Satellite and Mesometeorology Research Project.
DFW (DALLAS-FT. WORTH) MICROBURST ON AUGUST 2, 1985
T. T. FUJITA 1986 162 p
(Contract NGR-14-001-008; NA85AA-DR-064; NSF ATM-81-09828)
(NASA-CR-176794; NAS 1.26:176794; PB86-131638; SMRP-RP-217; LC-85-52386) Avail: NTIS HC A08/MF A01 CSCL 04B

The features of the microburst on August 2, 1985, related to the Delta 191 accident during the approach to Runway 17L of the Dallas-Ft. Worth Airport is described. Both radar and satellite data, along with ground-based measurements, were used in determining the characteristics of the parent cloud which spawned the most complicated microburst winds ever analyzed by the author. The detailed reconstruction of the airflow and the aircraft's maneuver were made possible by a series of computer analyses of the Digital Flight Data Recorder (DFDR) readout. Both measured and computed values in color diagrams that can be evaluated readily by meteorologists, pilots, structural engineers, and other interested persons in preventing microburst-related accidents in future years are presented. Author

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LIFE SCIENCES

Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and planetary biology.

A86-33805
APPLICABILITY OF USING THE CAR-II MODEL IN DESIGN AND EVALUATION OF MULTIOPERATOR WORKSTATIONS WITH SHARED CONTROLS
S. J. MORRISSEY, B. E. HERRING (Auburn University, AL), and M. G. GENNETTI (Stanford University, CA) IN: Human Factors Society, Annual Meeting, 29th, Baltimore, MD, September 29-October 3, 1985, Proceedings. Volume 2 . Santa Monica, CA, Human Factors Society, 1985, p. 698-701.

This study was done to show how a computerized workstation design program could be used to design and evaluate workstations having multiple operators with shared or common controls. To do this the Computerized Assessment of Reach program (CAR) was used to evaluate the cockpit of the OH-58A (Huey) helicopter. This same program was then used to demonstrate methods of cockpit redesign. Author

A86-34923#
HELICOPTER FLIGHT CONTROL WITH ONE HAND
A. L. LIPPAY, M. KING, R. V. KRUK (CAE Electronics, Ltd., Montreal, Canada), and M. MORGAN (National Aeronautical Establishment, Ottawa, Canada) (CASI, Annual General Meeting, 32nd, Montreal, Canada, May 27, 1985) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 31, Dec. 1985, p. 335-345. refs

In a given control task, human error rate may increase in proportion to the number of control devices and mental transformations. A single device whose degrees of freedom coincide spatially with the principal task parameters, and whose dynamic characteristics provide a modicum of feedback representing the demands imposed on the system, should permit a reduction of the (human) control problem. A deflection-type side-arm controller developed in Montreal is described, which enables axis-by-axis or co-ordinated control in up to six degrees of freedom with one hand. The design minimizes unwanted inputs and cross-coupling between axes. Six-axis control was established in several spacecraft and manipulator simulations. A four-axis version has been installed in a research helicopter. Preliminary testing indicated good pilot acceptance, reduced training/familiarization requirements and - in some cases - significant improvement in control performance. A second generation engineering effort is currently in progress to produce high quality units for formal testing and eventual flight qualification. Author

A86-35431
COCKPIT AUTOMATION - DESIGN AND IMPLEMENTATION ISSUES
R. W. MOSS and J. M. REISING (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 41-45. refs
(SAE PAPER 851921)

The relationship between pilots and the electronic crew member (EC) is discussed. The use of automation for decision making and its reliability are examined; the roles of the pilot and EC in decision making are studied. The implementation of the EC is described. Three examples of EC/pilot interaction are presented. I.F.

A86-35432
PILOT VEHICLE INTERFACES WITH SMART AVIONICS SYSTEMS
L. D. POHLMANN, J. B. SHELNUTT, and J. D. GILMOUR (Boeing Military Airplane Co., Seattle, WA) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 47-53. refs
(SAE PAPER 851923)

Design goals for the development of smart pilot vehicle interfaces (PVIs) are examined. The basic characteristics of smart PVIs and the pilot's role in combat aircraft are described. The need for the PVIs to anticipate pilot-system communication requirements, and the pilot/PVIs interaction required for evaluating situations are studied. Methods of presenting and regulating the PVIs information for the pilots are discussed. The ability of the PVIs to discuss abstract ideas such as strategy, risk, and tactics, and the use of direct communication of the pilot's intent to the avionics systems are proposed. I.F.

A86-36175
AN INTEGRATED DISPLAY FOR VERTICAL AND TRANSLATIONAL FLIGHT EIGHT FACTORS AFFECTING PILOT PERFORMANCE
J. S. TATRO (Bell Helicopter Textron, Fort Worth, TX) and S. N. ROSCOE (New Mexico State University, Las Cruces) Human Factors (ISSN 0018-7208), vol. 28, Feb. 1986, p. 101-120. refs
(Contract N00014-81-K-0439)

As part of an overall research program to optimize both forward-looking and downward-looking tactical situation displays

for all-weather instrument flight in vertical takeoff and landing (VTOL) aircraft, an integrated horizontal situation display was developed for both vertical and translational flight. This paper covers the developed and initial experimentation of the downward-looking portion of the overall display and control system. The effects of eight factors on pilot performance were tested, and a multiple regression model of VTOL pilot performance as a function of those eight factors was derived for each of three dependent performance measures. Factors having important effects were position error magnification, control order, prediction time, control gain, tracking mode, and several of their interactions. Author

A86-36852#
THE USE OF ELLIPSOIDAL SOLIDS TO DISPLAY HUMAN BODY DYNAMIC RESPONSE
D. H. LAANANEN and D. KALITA (Arizona State University, Tempe) IN: Computers in engineering 1985; Proceedings of the International Computers in Engineering Conference and Exhibition, Boston, MA, August 4-8, 1985. Volume 2 . New York, American Society of Mechanical Engineers, 1985, p. 11-17. refs
(Contract DOT-FA03-84-P-01649)

An algorithm for displaying the human body modeled as a set of ellipsoids with hidden lines omitted is described. The algorithm is implemented as a post-processor for a dynamic simulation of an aircraft occupant and seat in a crash environment. It includes consideration of complete penetration of one ellipsoid into another and total obscuration of one by another, features which are desirable for display of the abnormal body positions that can result in a vehicle crash. Also, interaction of the ellipsoids with the polygonal representations of the restraint system and seat has been considered. Results are illustrated by examples of output produced for an aircraft crash simulation. Author

A86-36879#
SIMULATION OF AIRCRAFT SEAT RESPONSE TO A CRASH ENVIRONMENT
D. H. LAANANEN (Arizona State University, Tempe) IN: Computers in engineering 1985; Proceedings of the International Computers in Engineering Conference and Exhibition, Boston, MA, August 4-8, 1985. Volume 3 . New York, American Society of Mechanical Engineers, 1985, p. 241-246. refs
(Contract DOT-FA03-84-P-01649)

A three-dimensional mathematical model of an aircraft seat, occupant, and restraint system has been developed for use in analysis of light aircraft crashworthiness. Because of the significant role played by the seat in overall system crashworthiness, a finite element model of the seat structure is included. The seat model can accommodate large displacements, nonlinear material behavior, and local buckling of tubular elements. The occupant model consists of twelve segments whose dimensions and inertial properties have been determined from studies of human body anthropometry and kinematics and from measurements of anthropomorphic test dummies. The seat and occupant models are described, along with the simulation program, and some examples of output data are provided. Author

A86-36940
THE ROLE OF FLIGHT SIMULATION IN HELICOPTER CREW STATION DESIGN
J. N. DEMASI and H. P. HARPER (Sikorsky Aircraft, Stratford, CT) IN: Flight simulation/simulators; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1-10. refs
(SAE PAPER 851900)

The need for simulation is assessed in the context of changing missions and technology; and the helicopter simulation facilities at the Sikorsky Aircraft Division are described in detail. These facilities include the human factors engineering laboratory, the avionics laboratory, the fixed-base simulator, the motion base simulator, and an in-flight simulator. It has been shown that simulation, an essential part of the crew station design process, can be applied at many levels. Simulator capabilities must cover a broad spectrum of fidelity levels with the capability to tie real hardware with the software simulation. It is concluded that in-flight simulation is necessary to provide realism for critical mission elements and to provide a validation of anchor points. Block diagrams are included. K.K.

N86-25113# Defence and Civil Inst. of Environmental Medicine, Downsview (Ontario).
A REVIEW OF THE PILOT BACKACHE PROBLEM IN THE CH113 LABRADOR HELICOPTER
A. BEACH Dec. 1985 26 p refs
(AD-A164011; DCIEM-85-R-49) Avail: NTIS HC A03/MF A01
CSCL 06S

In response to an Unsatisfactory Condition Report, complaints of back pain and discomfort induced by the pilots' seat of the CH113 Labrador helicopter were investigated. Several published reports dealing with the problem are reviewed and summarized in terms of incidence and prevalence rates, frequency, intensity, duration, location and time to pain onset. A questionnaire was developed and distributed to CH113 Labrador helicopter pilots in order to determine how closely the backache characteristics of the pilots match the characteristics reported by the general population. In addition, an evaluation of the size and shape of the Labrador seat was conducted and results were compared to published seat design guidelines and recommendations. Questionnaire results indicate that the typical backache reported by Labrador pilots is similar to the backache reported by other helicopter pilots. It is usually a dull pain in the lumbar area, most often experienced during flight and usually lasting after the mission ends. Subjective results also indicate that backache may be negatively correlated with regular exercise. Based on the symptoms identified in the questionnaire and the causes identified by other investigators, design principles for an improved seat incorporating an inflatable lumbar support and a more effective load bearing seat cushion were established. GRA

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A86-34140
OPTIMAL CONTROL OF DETERMINISTIC SYSTEMS VIA SHIFTED LEGENDRE POLYNOMIALS
D.-H. SHIH and F.-C. KUNG (National Cheng Kung University, Tainan, Republic of China) IEEE Transactions on Automatic Control (ISSN 0018-9286), vol. AC-31, May 1986, p. 451-454. refs

The synthesis of an optimal control function for deterministic systems described by integrodifferential equations is investigated. By using the elegant operational properties of shifted Legendre polynomials, a direct computational algorithm for evaluating the optimal control and trajectory of deterministic systems is developed. An example is given to illustrate the utility of this method.
Author

A86-34635
A COMPLETELY INTEGRATED SYSTEM FOR THE TREATMENT OF CRACK GROWTH TEST DATA
B. J. SCHWARTZ and D. T. HUNTER (United Technologies Corp., Pratt and Whitney, Div., West Palm Beach, FL) IN: 1985 SEM Spring Conference on Experimental Mechanics, Las Vegas, NV, June 9-14, 1985, Proceedings . Brookfield Center, CT, Society for Experimental Mechanics, Inc., 1985, p. 606-611. USAF-supported research. refs

The process of recording, analyzing, and modeling experimental data needed for fracture mechanics calculations is typically both time consuming and expensive. This paper describes the features and operation of a computer-assisted system, that is capable of automatically performing complete engineering analysis and documentation of crack growth test data. Author

A86-35204
THE DEVELOPMENT OF AN ADVANCED WEIGHT ESTIMATION TECHNIQUE FOR AIRCRAFT CONCEPTUAL DESIGN
M. J. LOGAN (LTV Aerospace and Defense Co., Vought Aero Products Div., Dallas, TX) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 14 p. (SAWE PAPER 1645)

The development of an advanced weight estimation methodology is necessary to keep pace with ever changing aircraft technology. One such method uses state-of-the-art computer concepts to provide flexible, accurate and comprehensive weight estimation capability. Using the proposed method, structural and nonstructural weights can be computed from the actual geometry of the aircraft, the materials used, and the various design, mission, and customer requirements information. Systems and equipment weights can be accurately assessed from a data library showing actual component applications. Accuracy can be ensured through the use of only those equation which are appropriate to the aircraft type being analyzed. It is concluded that with the advent of a completely interactive, menu driven system, the weight engineer's function is significantly altered. K.K.

A86-35326
1985 AMERICAN CONTROL CONFERENCE, 4TH, BOSTON, MA, JUNE 19-21, 1985, PROCEEDINGS. VOLUMES 1, 2, & 3
Conference sponsored by the American Automatic Control Council. New York, Institute of Electrical and Electronics Engineers, 1985. Vol. 1, 699 p.; vol. 2, 557 p.; vol. 3, 576 p. For individual items see A86-35327 to A86-35424.

Subjects investigated are concerned with robot control, adaptive control, advances in robust multivariable design techniques, model-based analysis and control, filtering and estimation, industrial control methods and applications, directions in decentralized control, plant wide process control, and robot manipulator systems. Attention is also given to robustness considerations in time domain, eigenstructure assignment, estimation, industrial applications, decentralized control, recent developments in process control, aircraft guidance and flow management, direct-drive robot arms, control applications, robust control, and linear and multivariable systems. Other topics explored are related to missile guidance and control systems, multitarget tracking and data association, control of polymerization and fermentation reactors, the emergence of artificial intelligence in process control, the application of modern control/estimation theory to aircraft control, and nonlinear systems. G.R.

A86-35358
EIGENSTRUCTURE ASSIGNMENT: A TUTORIAL - I THEORY
K. M. SOBEL (Lockheed California Co., Burbank) and E. Y. SHAPIRO (HR Textron, Inc., Valencia, CA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 456-467. refs

A linear time invariant system and the output feedback eigenstructure problem are considered, taking into account a theorem which provides a solution to the problem. Attention is given to the problems of characterizing eigenvectors which can be assigned as closed-loop eigenvectors. Questions of feedback gain computation are explored, and aspects of constrained output feedback are discussed. A description of the application of eigenstructure assignment to flight control system design has been provided by Shapiro and Chung (1981), and by Andry et al. (1983). In this paper a review is presented of questions regarding the choice of eigenvectors for a stability augmentation system and for an autopilot for the lateral dynamics of an aircraft. The use of both output feedback and constrained output feedback is illustrated with the aid of an example. G.R.

A86-35409* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
HIGH-SPEED, AUTOMATIC CONTROLLER DESIGN CONSIDERATIONS FOR INTEGRATING ARRAY PROCESSOR, MULTI-MICROPROCESSOR, AND HOST COMPUTER SYSTEM ARCHITECTURES
S. A. JACKLIN, J. A. LEYLAND, and W. WARMBRODT (NASA, Ames Research Center, Moffett Field, CA) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1223-1232. refs

Modern control systems must typically perform real-time identification and control, as well as coordinate a host of other activities related to user interaction, online graphics, and file management. This paper discusses five global design considerations which are useful to integrate array processor, multimicroprocessor, and host computer system architectures into versatile, high-speed controllers. Such controllers are capable of very high control throughput, and can maintain constant interaction with the nonreal-time or user environment. As an application example, the architecture of a high-speed, closed-loop controller used to actively control helicopter vibration is briefly discussed. Although this system has been designed for use as the controller for real-time rotorcraft dynamics and control studies in a wind tunnel environment, the controller architecture can generally be applied to a wide range of automatic control applications. Author

A86-36208
OPTIMIZATION IN DESIGN PROCESSES - AN INFORMATICS POINT OF VIEW
R. F. VAN DEN DAM, J. W. BOERSTOEL, and H. A. M. DANIELS (Nationaal Luct- en Ruimtevaart Laboratorium, Amsterdam, Netherlands) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 22, Feb. 1986, p. 433-450. refs

The purpose of this paper is to outline the optimization-system development at NLR. The paper starts with a discussion of the potential of mathematical optimization techniques in aeronautical engineering. Subsequently, the main requirements to be met by a general-purpose optimization system are given. Following this, the implementation at NLR is described, and some examples of applications are presented to illustrate the optimization capabilities. Author

A86-36574
THE POSSIBILITY OF ACHIEVING HIGH PRODUCTIVITY WITH VECTOR-PIPELINE PROCESSORS IN SOLVING PROBLEMS OF MATHEMATICAL PHYSICS [O VOZMOZHNOSTIAKH DOSTIZHENIIA VYSOKOI PROIZVODITEL'NOSTI NA VEKTORNO-KONVEIERNYKH EVM PRI RESHENII ZADACH MATEMATICHESKOI FIZIKI]
A. V. BABAKOV, O. S. BATSUKOV, O. M. BELOTSERKOVSKII, and L. N. STOLIAROV Zhurnal Vychislitel'noi Matematiki i Matematicheskoi Fiziki (ISSN 0044-4669), vol. 26, April 1986, p. 601-613. In Russian. refs

The paper examines aspects of the analysis of algorithms for solving problems of mathematical physics (e.g., of flow around aircraft structures) with the aim of programming these algorithms on vector-pipeline processors. The proposed method makes it possible to match the algorithm with the machine architecture, and to obtain a high-efficiency program. The proposed approach is demonstrated on a difference scheme for solving the problem

of flow around a cylinder. The response-time characteristics of the program are evaluated, and it is shown that there is a five-fold increase in productivity as compared with a program obtained through translation from a high-level language. B.J.

A86-36894#
THE APPLICATION OF SYSTOLIC ARRAY PROCESSOR TECHNOLOGY TO REAL-TIME CONTROL
R. H. TRAVASSOS (Systolic Systems, Inc., San Jose, CA), K. A. FARRY (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), and H. C. BRIGGS (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) IN: Computers in engineering 1985; Proceedings of the International Computers in Engineering Conference and Exhibition, Boston, MA, August 4-8, 1985. Volume 3 . New York, American Society of Mechanical Engineers, 1985, p. 431-440. refs
(Contract F33615-82-C-3604; F33615-83-C-3619)

An account is given of work of the Flight Dynamics Laboratory, which is sponsoring research on the use of systolic array processor concepts for real-time control computations for aircraft and spacecraft. The motivation for the work is given and progress is documented. To date, most of the work has focused on linear multivariable control problems. Several different linear multivariable control schemes are being implemented for vibration damping in a low-frequency cantilevered beam, at sample rates up to 2000 Hz, using the PC-1000 Systolic Array Processor. Additional work has begun on a 32-processor array optimized to solve nonlinear two-point boundary value problems (such as those occurring in flight control gain optimization) in real time. D.H.

A86-36942
APPLICATION OF THE OPTIMAL CONTROL MODEL TO THE DESIGN OF FLIGHT SIMULATION EXPERIMENTS
W. H. LEVISON (BBN Laboratories, Inc., Cambridge, MA) IN: Flight simulation/simulators; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 19-28. refs
(SAE PAPER 851903)

The Optimal Control Model (OCM) for manually controlled systems is suggested as an aid to the design of manned flight simulation experiments. The structure of the OCM, and procedures for selecting operator-related model parameters, are reviewed. Applications of the model to the design of specific simulation experiments are summarized. Good correspondence between pre-experiment model predictions and experimental performance trends is shown, demonstrating the utility of the model in the design of simulator tasks that fall within the domain of model application. Examples presented include whole-body and tactile motion cuing, visual scene cuing, and aircraft handling qualities.
Author

A86-36943
TOO LITTLE TIME - TOO LITTLE MONEY
C. A. BOHN and B. J. LEIDEN (IBM Corp., Federal Systems Div., Owego, NY) IN: Flight simulation/simulators; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 29-34.
(SAE PAPER 851904)

An alternative to the high cost and long time associated with typical flight simulation efforts is proposed. A facility is described whereby low fidelity simulation is used early in a development program to provide empirical data for decision making in the design process. Five DOD mission tasks were identified for implementation: (1) assault, (2) antisubmarine warfare, (3) rescue, (4) scout, and (5) command and control. The underlying laboratory characteristic is reconfigurability, which is achieved in all areas via a modular approach and everything is simplified into basic components with flexibility in how the individual components are joined for any simulation. Computer operator crew station equipment and computer generation equipment together comprise the primary parts of the lab. A brief review of the experience gained in its first six months of use is provided with a simulation sample. K.K.

A86-36945
ADA FOR SIMULATORS
M. NAROTAM (Burtek, Inc., Software Systems Group, Tulsa, OK) and C. LAYTON (Rogers State College, Claremore, OK) IN: Flight simulation/simulators; Proceedings of the Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 43-50. refs
(SAE PAPER 851964)

This paper presents the impact of Ada on software engineering of simulation training equipment. The advantages of Ada as the programming language for Simulators are examined. The feasibility of the use of Ada for developing simulation software and the associated cost impact are discussed. Problem areas such as real-time issues, concurrency, data identification, multi-tasking, portability and reconfigurability of software are addressed.
Author

N86-25145*# Research Triangle Inst., Research Triangle Park, N.C. Software Research and Development.
AN EMPIRICAL STUDY OF FLIGHT CONTROL SOFTWARE RELIABILITY Final Report
J. R. DUNHAM and J. L. PIERCE Mar. 1986 46 p refs
(Contract NAS1-16489)
(NASA-CR-178058; NAS 1.26:178058; REPT-412U-2094-22)
Avail: NTIS HC A03/MF A01 CSCL 09B

The results of a laboratory experiment in flight control software reliability are reported. The experiment tests a small sample of implementations of a pitch axis control law for a PA28 aircraft with over 14 million pitch commands with varying levels of additive input and feedback noise. The testing which uses the method of n-version programming for error detection surfaced four software faults in one implementation of the control law. The small number of detected faults precluded the conduct of the error burst analyses. The pitch axis problem provides data for use in constructing a model in the prediction of the reliability of software in systems with feedback. The study is undertaken to find means to perform reliability evaluations of flight control software. E.A.K.

N86-25149# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
COMPARISON OF ABSORPTION AND RADIATION BOUNDARY CONDITIONS USING A TIME-DOMAIN THREE-DIMENSIONAL FINITE DIFFERENCE ELECTROMAGNETIC COMPUTER CODE M.S. Thesis
C. F. WILLIFORD Dec. 1985 186 p refs
(AD-A163828; AFIT/GE/ENG/85D-53) Avail: NTIS HC A09/MF A01 CSCL 20C

The Three-Dimensional Finite Difference (3DFD) computer code is compared using Absorption Boundary Conditions (ABS) versus Radiation Boundary Conditions (RBC). This comparison is made when the 3DFD code is used to study the interaction of lightning with an aircraft. The 3DFD computer code is a modified version of Rymes' 3DFD. The aircraft modeled for the paper is and F-16 Fighting Falcon. The ABC used simulates an infinite free-space by setting the conductivity of the boundary space to that of distilled water, to absorb the outgoing electromagnetic waves. The RBC simulates free-space by assigning the boundary fields to a previously calculated value. The value is calculated with a parabolic interpolation of three previous field values, which are offset in space. Therefore, the calculated value is also extrapolated to account for the time delay and position change. The results of incorporating RBC were dramatic. The ten locations sampled for the test showed marked improvement in the waveforms when using RBC's. Depending on the purpose of the analysis, this improved waveform output may be overshadowed by the 25% increase in CPU time that is needed for the more sophisticated RBC. GRA

N86-25151# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
USING ADA IN THE REAL-TIME AVIONICS ENVIRONMENT ISSUES AND CONCLUSIONS M.S. Thesis
D. J. WITT Dec. 1985 121 p refs
(AD-A163844; AFIT/GCS/MA/85D-6) Avail: NTIS HC A06/MF A01 CSCL 09B

This project involved studying the real-time avionics environment in which Ada will become the primary programming language in the near future. A set of issues of concern regarding the use of Ada within this environment was identified and described. Test programs, including the new Prototype Ada Compiler Evaluation Capability, were evaluated as to their applicability to these issues. The applicable test program were compiled and executed using two validated Ada compilers. Compile time and run time statistics were gathered to form a baseline against which other Ada compilers (preferably MIL-STD-1750a Ada compilers) may be compared. GRA

N86-25168*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THEORETICAL THREE-AND FOUR-AXIS GIMBAL ROBOT WRISTS
L. K. BARKER and J. A. HOUCK May 1986 38 p refs
(NASA-TP-2564; L-16042; NAS 1.60:2564) Avail: NTIS HC A03/MF A01 CSCL 09B

In high-performance flight simulations, a four-axis gimbal system allows all possible rotations with acceptable gimbal angle rates while it avoids the so-callled 'gimbal lock' that occurs when gimbal rotational axes are colinear. In this paper, pertinent equations (including quaternions) are assembled for a hypothetical robot wrist, functionally equivalent to this four-axis gimbal system, and also for a true three-axis gimbal robot wrist. These equations are used to simulate the rotation of a robot hand by the robot wrist in response to operator rotational velocity commands to the robot hand. Near gimbal lock (wrist singularity), excessive rotational rates occur. Scaling the rates, which is necessary for the three-gimbal robot wrist to prevent rate limiting, introduces an undesirable time delay in the robot hand rotation with respect to the commanded rotation. However, the merit of the four-gimbal robot wrist is that the fourth gimbal angle keeps the robot wrist away from the singularity so that the robot hand moves exactly as commanded. It appears that in a 'worst-type' maneuver of the robot hand, the fourth gimbal angle can be defined so that none of the gimbal angle rates exceed about twice the commanded rates. Author

N86-25169*# California Univ., Los Angeles.
AN APPLICATION OF ADAPTIVE LEARNING TO MALFUNCTION RECOVERY Final Report
R. E. CRUZ May 1986 46 p refs
(Contract NAG2-302)
(NASA-CR-166620; H-1325; NAS 1.26:166620) Avail: NTIS HC A03/MF A01 CSCL 09B

A self-organizing controller is developed for a simplified two-dimensional aircraft model. The Controller learns how to pilot the aircraft through a navigational mission without exceeding pre-established position and velocity limits. The controller pilots the aircraft by activating one of eight directional actuators at all times. By continually monitoring the aircraft's position and velocity with respect to the mission, the controller progressively modifies its decision rules to improve the aircraft's performance. When the controller has learned how to pilot the aircraft, two actuators fail permanently. Despite this malfunction, the controller regains proficiency at its original task. The experimental results reported show the controller's capabilities for self-organizing control, learning, and malfunction recovery. Author

N86-25174# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
STUDY OF THE EFFECTS OF DISCRETIZING QUANTITATIVE FEEDBACK THEORY ANALOG CONTROL SYSTEM DESIGNS M.S. Thesis
J. S. COUCOULES Dec. 1985 208 p refs
(AD-A164209; AFIT/GE/ENG/85D-10) Avail: NTIS HC A10/MF A01 CSCL 01C

This thesis examines the feasibility and a method of extending continuous domain Quantitative Feedback Theory (QFT) flight control system designs to the discrete domain. The results of two previous QFT analog design efforts are modified for a digital implementation. The first design effort is for the KC-135 transport aircraft. Robust analog fixed compensators are designed for three different flight conditions. The second design effort is for the AFTI/F-16 aircraft. In this design, parameter variation is due to both varying flight conditions and different aircraft configurations caused by failed surfaces. GRA

N86-26030# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
DEVELOPMENT AND EVALUATION OF MATH LIBRARY ROUTINES FOR A 1750A AIRBORNE MICROCOMPUTER M.S. Thesis
J. J. FRIED 4 Dec. 1985 150 p refs
(AD-A164050; AFIT/GCS/MA/85D-3) Avail: NTIS HC A07/MF A01 CSCL 09B

This project produced a run-time math library for the MIL-STD-1750A embedded computer architectures. The math library consists of the algebraic functions. In addition, the steps required for a performance analysis of the math library have been outlined. Several approximation methods were investigated. The Chebyshev Economization of Maclaurin series polynomials, and rational approximations derived from the second algorithm of Remes were determined to be the best methods available. Each function's implementation was designed to take advantage of features MIL-STD-1750A architectures. The recommended test procedures provide measures of the average and worst case generated errors within each approximation. Author (GRA)

N86-26074# Stevens Inst. of Tech.; Hoboken, N. J. Dept. of Mechanical Engineering.
TINE DOMAIN DESIGN OF ROBUST CONTROLLERS FOR LQG (LINEAR QUADRATIC GAUSSIAN); APPLICATION TO LARGE SPACE STRUCTURES Final Report, May 1984 - Aug. 1985
R. K. YEDAVALLI Dec. 1985 104 p
(Contract F33615-84-K-3606)
(AD-A163635; AFWAL-TR-85-3093) Avail: NTIS HC A06/MF A01 CSCL 20K

The aspect of Robustness for linear multivariable systems in time domain is the central theme of the research under the present contract. Upper bonds on the linear, structured, time varying perturbation of an asymptotically stable linear time invariant regulator are obtained to maintain both stability and acceptable regulation, using Lyapunov approach. Improvement of the proposed measures over existing measures is illustrated with the help of examples. It is shown that by employing a scaling transformation on the nominal system, it is possible to further improve the upper bound. The proposed Perturbation Round Analysis is used to design robust controllers for Linear Quadratic Regulators with structured uncertainity. Introducing quantitative measures called Stability Robustness Index and Performance Robustness Index, design algorithms are presented by which one can achieve a trade off between nominal performance, stability robustness and performance robustness. Applications considered include aircraft control problems, large space structure control problems having uncertain modal data and mode truncation as the perturbations. GRA

N86-26160# Joint Publications Research Service, Arlington, Va.
SIMULATION PROBLEM OF CONTROLLING LATERAL MOVEMENT OF AIRCRAFT DURING LANDING APPROACH Abstract Only
N. D. BOTKIN, V. M. KEYN, and V. S. PATSKO *In its* USSR Report: Physics and Mathematics (JPRS-UPM-86-001) p 69-70 21 Jan. 1986 Transl. into ENGLISH from Prikladnaya Matematika i Mekhanika (Moscow, USSR), v. 48, no. 4, Jul. - Aug. 1984 p 560-567
Avail: NTIS HC A05

The problem of controlling lateral movement of an aircraft in the final phase of landing under windy condition is investigated. A vector differential equation is derived to describe the lateral movement of an aircraft in linear approximation. The problem is formalized as an antagonistic positional differential close-end game between two players with a convex payoff function. The controlling parameter of the first player is a scalar, so that a universal stable optimum strategy exists for the first player. The movements of the initial system of equations are modeled for the initial conditions of one of the parameters at the moment T sub o = 0. It is found that a linear control principle does not guarantee a successful landing approach under extreme perturbation, but that a combined method does provide such a guarantee. Linear control likewise does not guarantee a successful landing in the absence of extreme perturbations if initial deviations, which the combined control principle can handle, are large. Author

N86-26161# Joint Publications Research Service, Arlington, Va.
PARAMETRIC OPTIMIZATION OF ALGORITHM FOR ESTIMATING VALUES OF ONE CLASS OF UNSTEADY RANDOM PROCESSES Abstract Only
G. A. KRYZHANOVSKIY and V. I. ALESHIN *In its* USSR Report: Physics and Mathematics (JPRS-UPM-86-001) p 71 21 Jan. 1986 Transl. into ENGLISH from Izvestiya Akademii Nauk Kazakhskoy SSR: Seriya Fiziko-Matematicheskaya (Alma Ata, USSR), no. 5, Sep. - Oct. 1984 p 77-81
Avail: NTIS HC A05

Optimization of the measurement processing algorithm employed in automated air traffic control systems is investigated with respect to such observation parameters as the number of measurements processed, the digitization interval and the weighted coefficients of the algorithm. The longitudinal and lateral components of the ground speed vector are calculated by the least squares method, using a linear approximation function. The variance of the approximating function in the region of the airport is defined as the efficiency indicator in the problem of parametric optimization of the traffic control algorithm. The approach employed makes it possible to make maximum use of the capabilities of existing automated air traffic control systems and to improve ground speed determination accuracy. Author

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PHYSICS

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

A86-35146
WEAKLY NONLINEAR ACOUSTIC AND SHOCK-WAVE THEORY OF THE NOISE OF ADVANCED HIGH-SPEED TURBOPROPELLERS
C. K. W. TAM (Florida State University, Tallahassee) and M. SALIKUDDIN (Lockheed-Georgia Co., Marietta) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 164, March 1986, p. 127-154. Research supported by the Lockheed-Georgia Independent Research and Development Program. refs

The problem of the acoustic field generated by a supersonic turbopropeller is formulated and solved as a boundary-value problem with the equations of motion of an inviscid compressible fluid used as the governing equations. In the blade-fixed cylindrical coordinate system used here, the disturbance field is time independent so that the solution is a function of the spatial coordinate alone; the problem is further simplified by adopting the thin-airfoil approximation. Weakly nonlinear propagation effects are incorporated into the solution following Whitham's (1974) nonlinearization procedure. Numerical results of the present theory are compared with the measurements of the Jetstar flight experiment and low-cruise Mach number open-wind-tunnel data, and good overall agreement is found. V.L.

A86-35165#
MEASUREMENTS REGARDING THE EMISSION ANGLE DEPENDENCE OF PROPELLER-ACOUSTIC PRESSURE/TIME SIGNALS, TAKING INTO ACCOUNT PASSING FLIGHT CONDITIONS [VORBEIFLUGMESSUNGEN ZUR EMISSIONSWINKEL-ABHAENGIGKEIT VON PROPELLER-SCHALLDRUCK/ZEITSIGNALEN]
M. KALLERGIS (DFVLR, Institut fuer Entwurfs-Aerodynamik, Brunswick, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 20 p. In German.
(DGLR PAPER 85-112)

An understanding of the relations between operative and blade-geometrical parameters, and the resulting acoustic pressure/time signal is of particular importance for the successful development of a quiet propeller drive. This report presents experimental data which can contribute to a solution of the considered problem. Studies on the basis of measurements utilizing passing flight conditions in the free atmosphere make it possible to avoid certain difficulties which arise in wind-tunnel investigations. Measurements regarding the remote acoustic radiation field were conducted with the aid of a research aircraft and a glider. The glider was employed for the storage of acoustic signals and distance measurements. Supplementary near-field measurements were performed with another research aircraft. In this case, a microphone-array system at the wing was utilized. Details regarding the employment of gliders in the considered acoustic investigations are discussed, and a description is given of the approach employed to separate engine noise and propeller noise in near-field measurements. G.R.

A86-35617
THE ROLE OF SCALE MODELS IN THE DESIGN OF 'LOW BVI NOISE' ROTORCRAFT
K. R. SHENOY (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 239-248. refs

Results from two scale model rotor acoustic tests conducted in the NASA 4mX7m wind tunnel and the United Technologies Acoustic Research Tunnel are presented to illustrate the effects of scale, blade tip shapes, thrust and flight parameters on the acoustic characteristics of helicopter rotors. The Blade-Vortex-Interaction noise is shown to be a discrete noise source which significantly affects the mid-frequency region. Further, the effect of Reynold's number at 1/20 scale is shown to be significant. The results also show that the Blade-Vortex-Interaction noise can be controlled by proper blade tip design and by undertaking proper flight procedures. Author

A86-35618* Cornell Univ., Ithaca, N.Y.
A COMPARATIVE STUDY OF TAIL ROTOR NOISE MECHANISMS
A. R. GEORGE (Cornell University, Ithaca, NY) and S.-T. CHOU IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 249-261. NASA-supported research. refs

A study was made of helicopter tail rotor noise, particularly that due to interactions with the wakes of the main rotor, hub, and fuselage, and with the engine exhaust. Both harmonic and broadband noise were analyzed. The disturbed flow into the tail

rotor was modeled using combinations of aerodynamic and acoustic flow codes along with some necessary estimates of turbulence properties. Representative calculations show that the main rotor wake is the strongest contributor to both harmonic and broadband tail rotor noise. The fuselage separation wake and the engine exhaust flow are also very important to both harmonic and broadband noise. The hub and hub-shaft wakes are important contributors to the broadband noise only. The tip vortices do not seem to be important to broadband noise, but their effects on harmonic noise were not modeled accurately enough to draw any conclusions from this study. Author

A86-35619
FAA/HAI HELICOPTER FLIGHT OPERATIONS NOISE TESTS AND INITIAL RESULTS
S. A. YOSHIKAMI (FAA, Washington, DC) and C. R. COX (Bell Helicopter Textron, Fort Worth, TX) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 263-275. refs

This paper discusses a noise test program of eight helicopters conducted jointly by the Federal Aviation Administration and the Helicopter Association International. The program emphasized the gathering of helicopter operational noise data and information appropriate to en route and heliport land use planning. The tests are described highlighting the extensive data acquisition systems used and the varied flight operations studied. Noise levels and acoustic directivity characteristics of the eight helicopters are presented for each flight operation. Trends in the data established by these characteristics are used to identify noise abatement operational procedures. Some of the procedures are shown to be applicable to all helicopter types, while others are configuration specific. Author

A86-35621* General Motors Corp., Detroit, Mich.
MODEL HELICOPTER BLADE SLAP AT LOW TIP SPEEDS - THEORETICAL AND EXPERIMENTAL CORRELATIONS
D. C.-L. CHAN (General Motors Corp., Detroit, MI) and J. E. HUBBARD, JR. (MIT, Cambridge, MA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 289-295. refs
(Contract NAG2-182)

A novel data acquisition system has been designed which allows a transfer of pressure transducer and hot film data from a rotating frame to a stationary one, while collecting both loading and far field acoustic measurements simultaneously; this permits correlations to be made between experimental and theoretical predictions of blade loads and the resulting far field acoustics. The comparison of predicted acoustic pulse with experimental measurements has verified the assumptions made in the Widnall and Wolf (1980) theory for the case of low speed incompressible flow. The theory is also shown to be very sensitive to the interaction geometry and trajectory of the blade trailing vortex. O.C.

A86-36467
MAXIMUM-RANGE PASSIVE FLIGHT [O PASSIVNOM POLETE NA MAKSIMAL'NUIU DAL'NOST']
M. V. ABULADZE Moskovskii Universitet, Vestnik, Seriia 1 - Matematika, Mekhanika (ISSN 0579-9368), Mar.-Apr. 1986, p. 102-105. In Russian.

The paper examines the plane-parallel motion of a rigid body with a vertical symmetry plane on a fixed vertical plane in an atmosphere of constant density and in a homogeneous gravitational field. Attention is given to the problem of determining the type of motion control near the center of mass for which the flight range at a fixed moment of time has a maximum value. A solution to the optimal problem is obtained which yields the precise upper-bound estimate of the maximum flight range for the body considered, as well as the upper-bound estimate for bodies of arbitrary shape. B.J.

A86-36710
THE EFFECT OF RANDOM FORCES ON NONLINEAR OSCILLATING SYSTEMS [O VOZDEISTVII SLUCHAINYKH SIL NA NELINEINYE KOLEBATEL'NYE SISTEMY]
IU. A. MITROPOLSKII and V. G. KOLOMIETS (AN USSR, Institut Matematiki, Kiev, Ukrainian SSR) Matematicheskaia Fizika i Nelineinaia Mekhanika (ISSN 0233-7568), no. 5, 1986, p. 23-34. In Russian. refs

The paper develops asymptotic methods which are connected with the averaging method and which can be applied in the theory of nonlinear stochastic differential equations and nonlinear random vibrations. The application to the random vibrations of aircraft is noted. B.J.

N86-25216*# United Technologies Research Center, East Hartford, Conn.
HELICOPTER ROTOR NOISE DUE TO INGESTION OF ATMOSPHERIC TURBULENCE Final Report
J. C. SIMONICH, R. K. AMIET, R. H. SCHLINKER, and E. M. GREITZER (Massachussetts Inst. of Technology, Cambridge) Washington NASA May 1986 150 p refs
(Contract NAS1-17096)
(NASA-CR-3973; NAS 1.26:3973) Avail: NTIS HC A07/MF A01 CSCL 20A

A theoretical study was conducted to develop an analytical prediction method for helicopter main rotor noise due to the ingestion of atmospheric turbulence. This study incorporates an atmospheric turbulence model, a rotor mean flow contraction model and a rapid distortion turbulence model which together determine the statistics of the non-isotropic turbulence at the rotor plane. Inputs to the combined mean inflow and turbulence models are controlled by atmospheric wind characteristics and helicopter operating conditions. A generalized acoustic source model was used to predict the far field noise generated by the non-isotropic flow incident on the rotor. Absolute levels for acoustic spectra and directivity patterns were calculated for full scale helicopters, without the use of empirical or adjustable constants. Comparisons between isotropic and non-isotropic turbulence at the rotor face demonstrated pronounced differences in acoustic spectra. Turning and contraction of the flow for hover and low speed vertical ascent cases result in a 3 dB increase in the acoustic spectrum energy and a 10 dB increase in tone levels. Compared to trailing edge noise, turbulence ingestion noise is the dominant noise mechanism below approximately 30 rotor harmonics, while above 100 harmonics, trailing edge noise levels exceed turbulence ingestion noise by 25 dB. Author

N86-25217*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN ESTIMATE OF THE ENROUTE NOISE OF AN ADVANCED TURBOPROP AIRPLANE NASA-TM-87302 E-3020 NAS 1.15:87302 HC A02/MF A01
J. H. DITTMAR Apr. 1986 24 p refs
(NASA-TM-87302; E-3020; NAS 1.15:87302) Avail: NTIS HC A02/MF A01 CSCL 20A

The enroute noise of an Advanced Turboprop powered aircraft was estimated. The measured noise levels were roughly equivalent in annoyance to the noise 15.24 m from an automobile traveling at 80 km/h. It is felt that these levels would not illicit noise complaints from urban areas during the day but might be a slight annoyance in rural areas or in urban areas at night. Although it is not felt that the enroute noise is a major problem, it is indicated that a reduction in the enroute noise could improve the acceptability of advance turboprop airplanes. Author

N86-25218*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN EXPERIMENTAL INVESTIGATION OF REDUCING ADVANCED TURBOPROP CABIN NOISE BY WING SHIELDING
J. H. DITTMAR 1986 37 p refs Presented at the 10th Aeroacoustics Conference, Seattle, Wash., 9-11 Jul. 1986; sponsored by AIAA
(NASA-TM-87112; E-2713; NAS 1.15:87112) Avail: NTIS HC A03/MF A01 CSCL 20A

An experimental investigation was undertaken to determine if wing shielding could reduce the noise impacting the fuselage of an advanced turboprop airplane. Four wings were tested behind two eight-bladed propeller models. Significant shielding of the propeller noise was observed and a particular wing-propeller geometry was identified to provide the most shielding. Specifically, an up-inboard rotation would be needed for a low-wing airplane and a down-inboard rotation for a high-wing airplane. As the axial Mach number was increased, the position where the shielding starts moved farther downstream. This shift in the start of shielding was roughly a straight line with respect to Mach number between $M = 0.7$ and $M = 0.8$. At $M = 0.85$ the start of shielding does not shift any farther downstream. A simple barrier noise-reduction model gave the same trends with transducer positions as did the data, and, if corrected for Mach number shift, the model might be used to provide estimates of the wing shielding. Besides providing a barrier to the noise reaching the shielded area, the wing also reflects some of the noise back onto the unshielded area. This can make the noise difference between the unshielded and shielded areas of the fuselage larger than would be expected by simple wind shielding. Author

N86-25220*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AIRCRAFT NOISE PREDICTION PROGRAM THEORETICAL MANUAL: PROPELLER AERODYNAMICS AND NOISE
W. E. ZORUMSKI, ed. and D. S. WEIR, ed. (PRC Kentron, Inc., Hampton, Va.) Jun. 1986 256 p refs 3 Vol.
(NASA-TM-83199-PT-3; L-15937; NAS 1.15:83199-PT-3) Avail: NTIS HC A12/MF A01 CSCL 20A

The prediction sequence used in the aircraft noise prediction program (ANOPP) is described. The elements of the sequence are called program modules. The first group of modules analyzes the propeller geometry, the aerodynamics, including both potential and boundary-layer flow, the propeller performance, and the surface loading distribution. This group of modules is based entirely on aerodynamic strip theory. The next group of modules deals with the first group. Predictions of periodic thickness and loading noise are determined with time-domain methods. Broadband noise is predicted by a semiempirical method. Near-field predictions of fuselage surface pressrues include the effects of boundary layer refraction and scattering. Far-field predictions include atmospheric and ground effects. Author

N86-26162*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXPERIMENTAL STUDY OF THE EFFECTS OF INSTALLATION ON SINGLEAND COUNTER-ROTATION PROPELLER NOISE
P. J. W. BLOCK Apr. 1986 33 p refs Original contains color illustrations
(NASA-TP-2541; L-16046; NAS 1.60:2541) Avail: NTIS HC A03/MF A01 CSCL 20A

Measurements which are required to define the directivity and the level of propeller noise were studied. The noise radiation pattern for various single-rotation (SR) propeller and counter-rotation (CR) propeller installations were mapped. The measurements covered + or - 60 deg from the propeller disk plane and + or - 60 deg in the cross-stream direction. Configurations examined included SR and CR propellers at angle of attack and an SR pusher installation. The increases in noise that arise from an unsteady loading operation such as an SR pusher or a CR exceeded 15 dB in the forward axial direction. Most of the additional noise radiates in the axial directions for unsteady loading operations of both the SR pusher and the CR tractor. E.A.K.

N86-26163*# Cornell Univ., Ithaca, N.Y. School of Mechanical and Aerospace Engineering.
HELICOPTER TAIL ROTOR NOISE ANALYSES Final Technical Report, 1 Jun. 1985 - 31 Jan. 1986
A. R. GEORGE and S. T. CHOU Jan. 1986 66 p refs
(Contract NAG1-590)
(NASA-CR-176829; NAS 1.26:176829) Avail: NTIS HC A04/MF A01 CSCL 20A

A study was made of helicopter tail rotor noise, particularly that due to interactions with the main rotor tip vortices, and with the fuselage separation mean wake. The tail rotor blade-main rotor tip vortex interaction is modelled as an airfoil of infinite span cutting through a moving vortex. The vortex and the geometry information required by the analyses are obtained through a free wake geometry analysis of the main rotor. The acoustic pressure-time histories for the tail rotor blade-vortex interactions are then calculated. These acoustic results are compared to tail rotor loading and thickness noise, and are found to be significant to the overall tail rotor noise generation. Under most helicopter operating conditions, large acoustic pressure fluctuations can be generated due to a series of skewed main rotor tip vortices passing through the tail rotor disk. The noise generation depends strongly upon the helicopter operating conditions and the location of the tail rotor relative to the main rotor. Author

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A86-35644
HELICOPTER CUSTOMER SUPPORT - ARE WE AWARE OF HOW GREAT IT CAN BE
J. J. ALEXANDER (Aerospatiale Helicopter Corp., Grand Prairie, TX) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 617-622. refs

Helicopter manufacturers' customer support services encompass the provision of spare parts, maintenance and repair equipment, and technical expertise, to customers on the basis of analyses of product histories. The manufacturer must address the service requirements of pilots, maintenance personnel, and spare parts inventory managers, in addition to members of administrative and financial departments. Attention is presently given to support service requirement information flowing from customers to manufacturers, typical product accident/incident cause analysis, and both obvious and hidden expenditures by customers that must be anticipated by support services. O.C.

A86-35645
THE FIELD REPRESENTATIVE 'FRONT LINE ACTIONEER'
W. G. TRIPP (United Technologies Corp., Sikorsky Aircraft Div., Stratford,, CT) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 623-627.

A helicopter manufacturer's field service representative must address the maintenance, operation and support requirements of customers operating one or several of the manufacturer's products. In addition to the technical expertise required to soundly advise operators on cost-minimizing procedures in operations, maintenance and repair, the representative must also possess and exercise evaluative judgment through which the manufacturer's staff can act on customers feedback. The degree to which a field service representative's work will enhance customer performance and satisfaction is presently assessed. O.C.

A86-35647
SPARE PARTS PRICING - IMPACT ON LOGISTICS SUPPORT
J. K. HANCOCK (Boeing Vertol Co., Ridley Park, PA) IN: American Helicopter Society, Annual Forum, 41st, Fort Worth, TX, May 15-17, 1985, Proceedings . Alexandria, VA, American Helicopter Society, 1985, p. 635-637.

A task force composed of management-level representatives from all major organizations of a military helicopter manufacturer was formed in response to a 10-point program, promulgated in July 1983 by the Secretary of Defense, in order to reform spare parts procurement practices. A corporate spares policy was duly formulated by October 1983. Attention is given to the effects of this policy on price lists, recommended minimum quantities, combined buy practices, low intrinsic value spares, ground support equipment, spare parts data tracking, and cost avoidance. O.C.

N86-25300# Army Aviation Systems Command, St. Louis, Mo.
COST ESTIMATING RELATIONSHIPS FOR FIXED WING AIRCRAFT: LIST PRICE VERSUS EMPTY WEIGHT Final Report
W. J. DITTO Sep. 1985 15 p refs
(AD-A164196; USAAVSCOM-TM-85-F-7) Avail: NTIS HC A02/MF A01 CSCL 15E

This Cost Estimating Relationship (CER) for fixed wing aircraft was developed to estimate the unit cost of a twin engine, commercial, turboprop aircraft procured off the shelf. The Army has a limited fixed wing capability and most of this capability is procured in a commercial environment instead of through a typical rotor wing procurement cycle. The list price in the commercial market includes both engines and standard avionics, while in a typical government rotor wing procurement these items are Government Furnished Equipment. Therefore, this CER was developed using the parameter of empty weight and aircraft commercial list price. The data collected were analyzed using the Statistical Analysis System (SAS) on the AVSCOM Scientific and Engineering Computer System. The program developed is a linear regression of the form ($y = a + bx$), and the results are shown in the report. GRA

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GENERAL

N86-26276*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LANGLEY AEROSPACE TEST HIGHLIGHTS, 1985
May 1986 100 p
(NASA-TM-87703; NAS 1.15:87703) Avail: NTIS HC A05/MF A01 CSCL 05A

The role of the Langley Research Center is to perform basic and applied research necessary for the advancement of aeronautics and space flight, to generate new and advanced concepts for the accomplishment of related national goals, and to provide research advice, technological support, and assistance to other NASA installations, other government agencies, and industry. Significant tests which were performed during calendar year 1985 in Langley test facilities, are highlighted. Both the broad range of the research and technology activities at the Langley Research Center and the contributions of this work toward maintaining United States leadership in aeronautics and space research, are illustrated. Other highlights of Langley research and technology for 1985 are described in Research and Technology-1985 Annual Report of the Langley Research Center. Author

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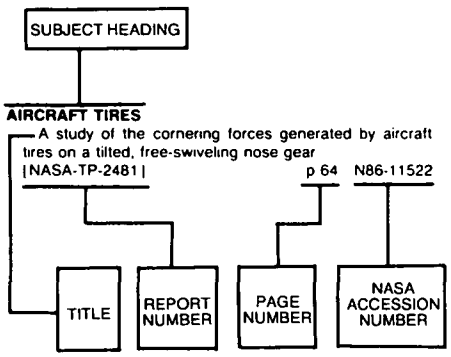

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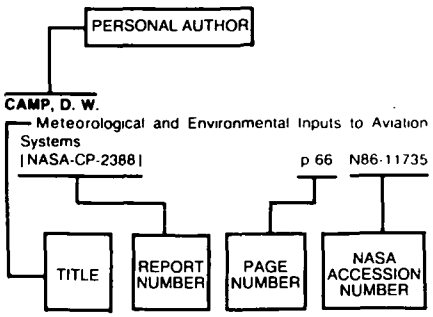

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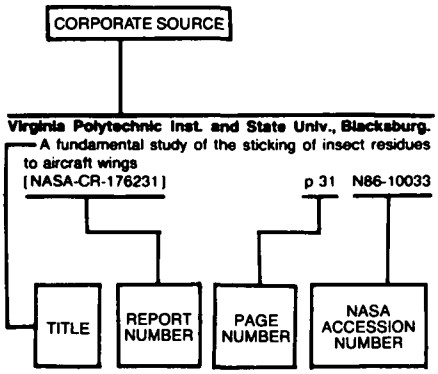

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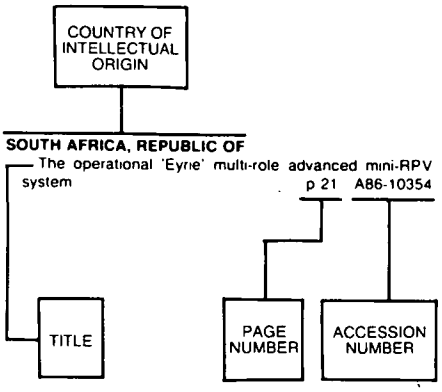

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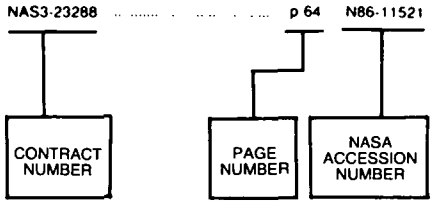

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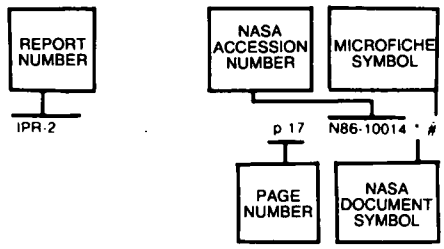

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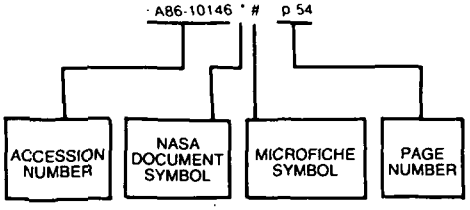

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