NASA

Aeronautical Engineering
A Continuing Bibliography with Indexes

NASA SP-7037(211)
March 1987

National Aeronautics and Space Administration

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NASA SP-7037(211)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 211)

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 February 1987 in

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

Scientific and Technical Information Branch 1986
National Aeronautics and Space Administration
Washington, DC

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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 519 reports, journal articles and other documents originally announced in February 1987 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

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

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

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

An annual cummulative index will be published.

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

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TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

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

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

PUBLICATION DATE

AVAILABILITY SOURCE

AUTHOR → D. R. SATRAN Oct. 1986 60 p

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

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

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

Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

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

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

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

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

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

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 211)

MARCH 1987

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AERONAUTICS (GENERAL)

A87-13062
IMPLEMENTATION OF A ROBOTIC ASSEMBLY CELL
R. J. MOLZ and R. PETERSON (Fairchild Republic Co., Farmingdale, NY) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 191-202.

The hardware design and software architecture of an automated robotic assembly cell is described. The integrated cell consists of an MV4000 Cell Controller, a GCA XR6100 gantry robot, an automated GEMCOR Driv-matic, a custom-designed flexible assembly station, several custom-designed and effectors, and various tooling fixtures. The use of MCL (Manufacturing Control Language), developed for the Air Force, in programming the cell off-line is also discussed. The cell is designed and programmed to assemble flat sheet metal parts, with or without flanges, into subassemblies for modern aircraft. No human intervention is required during the assembly process except for recoverable errors. Author

A87-13063
AUTOMATED FLEXIBLE ASSEMBLY OF AEROSPACE STRUCTURES
O. WEINGART (Rohr Industries, Inc., Riverside, CA) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 203-214.

The objective of the U.S. Air Force's Flexible Assembly Subsystem Program is the development and demonstration of the technologies required for the achievement of aerospace structures' automated assembly. Initial development efforts will concentrate on the configuration of a programmable robotic cell that will function as an 'island of automation' in an otherwise conventional aerospace assembly environment; the technologies thereby refined will subsequently be generalizable into a fully integrated automated manufacturing facility. The automated cell encompasses parts presenter, flexible assembly fixture, articulated arm robot, automatic fastening machine, vision system, and microcomputer components. O.C.

A87-13105
AUTOMATED ASSEMBLY-TRENDS, CONCEPTS AND REQUIREMENTS
T. F. W. HALL (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 795-809.

An attempt is made to identify the requirements for automated manufacturing of aircraft structures from advanced composite materials. First, attention is given to design considerations, including structure size and weight, self-aligning parts, tolerance, two-piece fasteners, adhesive bonding, repairabiilty and maintainability, and modular design. The use of robots is then discussed together with other requirements, such as standardization, a simplified human assembly system, integrated computer aided manufacturing, closed box internal assembly, flexible fixturing, and inspection. The need for artificial intelligence technology arising with the development of new and more sophisticated robots and sensors is emphasized. V.L.

A87-13157
COST DRIVERS AND DESIGN METHODOLOGY FOR AUTOMATED AIRFRAME ASSEMBLY
B. R. NOTON (Battelle Memorial Institute, Columbus, OH) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 1441-1455. refs

An evaluation is made of a design tool for the reduction of large aircraft discrete part acquisition and automated assembly costs, in light of cost drivers related to system performance, design configuration, structural materials and fabrication methods for both primary and secondary airframe structures. Emphasis is given to the need for developing a series of ground rules for cost driver analysis and the subsequent structural performance/acquisition cost tradeoff studies. Because of the high cost associated with the introduction of design changes in the course of a production run, the significance of decisions made during the conceptual design phase is stressed. It is noted that while assembly operations for airframe subassemblies can represent 50 percent of an aircraft's acquisition costs, secondary structures can represent fully 30 percent of the cost of a subassembly. O.C.

A87-13630
THE DEVELOPMENT OF BALANCE TUBES FOR DOWTY ROTOL COMPOSITE BLADED PROPELLERS
R. D. TIMMS (Courtaulds Research, Coventry, England) IN: Fibre reinforced composites 1986; Proceedings of the Second International Conference, Liverpool, England, April 8-10, 1986 . London, Mechanical Engineering Publications, Ltd., 1986, p. 199-202.

The successive stages in the development of a one-piece CFRP balance tube for use in a propeller blade assembly is described, together with the modifications made in the mold tool. The balance tubes, made of 40 percent Grafil/nylon, were tested to failure. The last version of the single-pocket tubes showed test failing loads ranging from 18.6 to 23.5 kN. The multipocket component, which has eight additional small pockets around the flange to make it possible to balance the blade about its two cross-sectional axes, showed failing loads ranging from 23.6 to 26.5 kN. Three variants of the balance tube are now being made for different size propellers. I.S.

A87-13635
ISRAEL ANNUAL CONFERENCE ON AVIATION AND ASTRONAUTICS, 27TH, HAIFA, ISRAEL, FEBRUARY 27, 28, 1985, COLLECTION OF PAPERS
Conference organized by Israel Society of Aeronautics and Astronautics; Supported by the Technion - Israel Institute of Technology, Tel Aviv University, Ministry of Defence of Israel, et al. Haifa, Israel, Technion - Israel Institute of Technology, 1986, 247 p. For individual items see A87-13636 to A87-13660.

Papers are presented on such topics as the parametric sizing of agricultural aircraft based on varying levels of technology; an analytical parametric investigation of numerical nonlinear vortex-lattice methods; equilibrium configurations of a cable drogue system towed in helical motion; the combination of suction and tangential blowing in boundary layer control for STOL aircraft; and a split canard configuration for improved control at high angles of attack. Consideration is also given to: pursuit-evasion games with finite detection ranges; the use of three-dimensional programs for aircraft design and development; the improvement of an expendable turbojet engine flight envelope; and the direct solution of flutter equations with an interactive graphics procedure. B.J.

A87-13911
AMES ACCELERATES RESEARCH ON HYPERSONIC TECHNOLOGY
J. T. MERRIFIELD Aviation Week and Space Technology (ISSN 0005-2175), vol. 125, Aug. 25, 1986, p. 85, 88, 92.

The recent announcement of program goals for a National Aerospace Plane has prompted an acceleration of hypersonic research at NASA's Ames Research Center. NASA hopes to be able to validate the technologies to be integrated in the aerospace plane's design by 1995, on the basis of an experimental flight research program. Ames hypersonic research focuses on computational fluid dynamics, trajectory analysis, and thermal protection materials, as well as such life support systems as an advanced pressure suit; in addition, aircraft flight and thermal load tests for structures, digital control of propulsion and other systems, and flight test plans for hypersonic vehicles are being developed. Such flight testing is rendered critical by the limitations of component size associated with ground test facilities. O.C.

A87-14015#
RESULTS OF RESEARCH ON MATERIALS AND CONSTRUCTION METHODS BY THE DFVLR [ERGEBNISSE DER WERKSTOFF- UND BAUWEISENFORSCHUNG IN DER DFVLR]
C.-J. WINTER BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 32 p. In German. refs

The research being conducted on materials and construction methods by four institutes of the DFVLR is reviewed. The general roles of the four institutes are reviewed, and work done in the areas of structural mechanics, optimization of structures, new materials, aeroelastics and structural dynamics are described in detail. Research on modern active flutter suppression systems and on the crushing behavior of construction techniques, on Al-Li alloys, on improving the fatigue behavior of high-strength titanium alloys, and on thermoplastic composites made of fiber-reinforced PEEK is emphasized. C.D.

A87-14034*# Kansas Univ., Lawrence.
STATIC TEST OF AN ULTRALIGHT AIRPLANE
H. W. SMITH (Kansas, University, Lawrence) AIAA, General Aviation Technology Conference, Anaheim, CA, Sept. 29-Oct. 1, 1986. 7 p. Research supported by the University of Kansas. refs
(Contract NAG1-345)
(AIAA PAPER 86-2600)

This paper describes all of the work necessary to perform the static test of an ultralight airplane. A steel reaction gantry was designed first, then all of the loading whiffletrees, the hydraulic actuation system, and instrumentation systems were designed. Loads and stress analyses were performed on the airplane and the gantry and whiffletrees. Components tested to date are: tubing samples, cables, and two-by-four whiffletrees. A hydraulic system consisting of a 3000-psi hand pump, 10,000-pound actuator, pressure gage and lines, and a Barksdale valve are described. Load cell calibration and pressure indicator calibration procedures are also described. A description of the strain and deflection measurement system is included. Preliminary data obtained to date are compared to the analytical predictions. Author

A87-14687
AUTOMATION OF SUPPORT PROCESSES FOR AIRCRAFT PRODUCTION USING COMPUTERS AND NUMERICAL CONTROL [AVTOMATIZATSIIA PROTSESSOV PODGOTOVKI AVIATSIONNOGO PROIZVODSTVA NA BAZE EVM I OBORUDOVANIIA S CHPU]
V. A. VAISBURG, B. A. MEDVEDEV, A. N. BAKUMSKII, G. M. MIKHAELIAN, V. IA. ELCHIBEKOV et al. Moscow, Izdatel'stvo Mashinostroenie, 1985, 216 p. In Russian. refs

Methods and means of the automated support of aircraft production using CAD and numerical control techniques are examined with particular reference to the design and manufacture of unique large components and parts of complex three-dimensional geometry. Specific topics discussed include the design of a manufacturing process involving the use of numerically controlled machine tools; software support for numerically controlled machine tools and automation of software development; and ways of increasing the precision of machining. The discussion also covers methods of increasing the efficiency of the generation and transmission of control information to numerically controlled machine tools using computers and the organizational aspects of programmed control. V.L.

A87-15414
MULTI-ECHELON REPAIR LEVEL ANALYSIS - MERLA
S. L. DEVRIES and S. A. WICKER (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: 1986 Annual Reliability and Maintainability Symposium, Las Vegas, NV, January 28-30, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 126-132.

Existing Repair Level Analysis (RLA) models were contrasted to the 'Air Force 2000' requirement and found inadequate in the areas of maintenance and basing scenario. A new RLA model, Multi-Echelon Repair Level Analysis (MERLA), was developed which provides for up to four alternative levels of support with a more comprehensive representation of support cost. Author

A87-15418
MD-80 SERVICE MATURITY PROGRAM
D. M. BLACKMORE and M. S. GEORGIADES (Douglas Aircraft Co., Long Beach, CA) IN: 1986 Annual Reliability and Maintainability Symposium, Las Vegas, NV, January 28-30, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 224-227.

This paper outlines the in-service reliability improvement program developed and implemented for McDonnell Douglas MD-80 airplane project. The key reasons for initiating such a program are summarized. The main objectives and goals are defined and the methods for achievement are explained. The paper shows that a closed-loop system of tracking malfunction-caused departure delays, and subsequent corrective action, are effective in increasing and maintaining high dispatch reliability. The key conclusion is that an in-service reliability improvement program be established for each new-airplane project to aid in the reduction of failures that delay airplanes from departing as scheduled. Author

A87-15419
F/A-18 HORNET RELIABILITY PROGRAM - STATUS REPORT
T. W. GORDON (McDonnell Douglas Corp., Saint Louis, MO) IN: 1986 Annual Reliability and Maintainability Symposium, Las Vegas, NV, January 28-30, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 228-231. refs

'New Look' steps inplemented to upgrade aircraft reliability during procurement of the F/A-18 fighter in 1976 and results from

4-yr tracking of reliability in the field are summarized. The efforts expended to identify and record component and system faults and to develop more reliable components and track their effectiveness are delineated. The aircraft required only a third the number of maintenance man-hours per hour of flight as did the aircraft it replaced. M.S.K.

A87-15436
DEMONSTRATION OF COMBAT DAMAGE REPAIR ESTIMATOR
D. H. KOVATCH (LTV Aerospace and Defense Co., Dallas, TX) and M. WEISENBACH (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: 1986 Annual Reliability and Maintainability Symposium, Las Vegas, NV, January 28-30, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 508-513.

This paper describes the results of an aircraft combat damage repair estimating procedure that was developed to evaluate the survivability and reparability of existing inventory aircraft and conceptual designs. Geometric modeling techniques and an aircraft battle damage repair data base form the nucleus of a simulation model that identifies items damaged, applicable repair concepts, repair time estimates, and resources required to return an aircraft to a combat ready status. Demonstration case results are presented for various threat/attack scenarios. Author

A87-16396
AEROSPACE PLANE - FACT OR FANTASY?
J. MOXON Flight International (ISSN 0015-3710), vol. 130, Aug. 30, 1986, p. 106, 107, 109, 110.

An evaluation is made of the technology development prospects, economic feasibility, and commercial and military usefulness of the proposed NASA aerospace plane. Attention is given to propulsion system-related questions, which hinge on the need for more than one powerplant to efficiently negotiate the low-speed (under Mach 6) and high-speed (up to Mach 25) phases of a single-stage flight to LEO. Ramjets, pulsejets, scramjets and rockets in various combinations are under consideration; an airturboramjet system that combines rockets, ramjet and turbojet features is noted to be promising. O.C.

A87-16397
THE INSPECTABLE STRUCTURE
J. M. RAMSDEN Flight International (ISSN 0015-3710), vol. 130, Aug. 30, 1986, p. 113-116.

An evaluation is made of the prospects for airliner-structure service-life extension through improved inspection, maintenance, materials choice, manufacturing quality control, and repair methods. Attention is given to the unique characteristics of composites, aluminum-lithium alloys, and bonded structures in this context. O.C.

A87-16398
US AIR TRANSPORT TECHNOLOGY - WHERE NEXT?
D. LEARMOUNT Flight International (ISSN 0015-3710), vol. 130, Aug. 30, 1986, p. 120-122, 124, 128.

An evaluation is made of the fuel-choice and thermodynamic-cycle-efficiency issues raised by the hypersonic airliner, as well as to the powerplant configuration and airframe materials choices under consideration for the next-generation subsonic airliners. The structural performance improvements and difficulties encountered to date with aluminum-lithium alloys and thermoplastic composite matrices are discussed. The strongest selling point of the 'Orient Express' hypersonic airliner is its completion of a Los Angeles-Sydney flight in less than 2.5 hr; the development cost and small production runs anticipated for this aircraft, however, are projected to make financing prohibitively expensive. O.C.

N87-11686# Transportation Systems Center, Cambridge, Mass.
GENERAL AVIATION ACTIVITY AND AVIONICS SURVEY Annual Summary Report, CY 1984
Oct. 1985 248 p
(AD-A168582; DOT-TSC-FAA-85-3; FAA-MS-85-5) Avail: NTIS HC A11/MF A01 CSCL 01B

This report presents and a description of the 1984 General Aviation Activity and Avionics Survey. The survey was conducted during 1985 by the FAA to obtain information on the activity and avionics of the United States registered general aviation aircraft fleet, the dominant component of civil aviation in the U.S. The survey was based on a statistically selected sample of about 12.7 percent of the general aviation fleet. A response rate of 59.5 percent was obtained. Survey results are based upon responses but are expanded upward to represent the total population. Survey results revealed that during 1984 an estimated 36.1 million hours of flying time were logged by the 220,943 active general aviation aircraft in the U.S. fleet, yielding a mean annual flight time per aircraft of 158 hours. The active aircraft represented about 82.6 percent of the registered general aviation fleet. The report contains breakdowns of these and other statistics by manufactured/model group, aircraft type, state and region of based aircraft, and primary use. Also included are fuel consumption, lifetime airframe hours, avionics, and engine hours estimates. In addition, tables are included for detailed analysis of the avionics capabilities of the general aviation fleet. Estimates of general aviation miles flown in 1984 have also been included in this report, broken down by aircraft type. GRA

N87-11687# Naval Postgraduate School, Monterey, Calif.
A DYNAMIC MODEL FOR AIRFRAME COST ESTIMATION M.S. Thesis
R. L. BROWN Mar. 1986 80 p
(AD-A168842) Avail: NTIS HC A05/MF A01 CSCL 14A

The Department of Defense has historically favored a relatively simple parametric approach to cost estimation. Economic theory has largely been ignored and the learning curve has become the customary analytical tool for relating production quantities to airframe costs. This thesis examines an effort to synthesize neoclassical economic theory with the traditional learning curve methodology. The proposed model implements a dynamic cost function that considers the effects of learning and production rate on the production process. To empirically test its validity, the model is applied to the F-4 Phantom II production program and parameters are estimated using historical production data. Author (GRA)

N87-11688# National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
A BRIEF INTRODUCTION TO THE HELICOPTER
H. J. G. C. VODEGEL 16 Sep. 1986 23 p Submitted for publication
(NLR-MP-85062-U; B8667019; ETN-86-98494) Avail: NTIS HC A02/MF A01

Helicopter geometrical configurations, means of control, and general design features are introduced. Characteristics of the helicopter which differ from those of fixed wing aircraft are described. ESA

N87-12533# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
THE EFFECT OF A WINGLET ON THE SPATIAL VORTEX OF A SLENDER BODY AT HIGH ANGLE OF ATTACK
W. ZIXING and W. GENXING 7 Jul. 1986 15 p Transl. into ENGLISH from Konggi Donglixue Xuebao (China), v. 3, no. 1, 1985 p 49-53
(AD-A169925; FTD-ID(RS)T-0267-86) Avail: NTIS HC A02/MF A01 CSCL 20D

The experimental investigation of the effect of a winglet on the spatial vortex of a slender body at a high angle of attack is presented. This investigation clearly shows that the circulation of the body vortex is minimized by the winglet and the vortex position is lower than that without the winglet, so that the asymmetric problem can be solved. GRA

N87-12534# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
THE PORTFOLIO MODEL OF TECHNOLOGICAL DEVELOPMENT IN THE AIRCRAFT INDUSTRY M.S. Thesis
D. M. SNYDER May 1986 56 p
(AD-A170832; AFIT/CI/NR-86-84T) Avail: NTIS HC A04/MF A01 CSCL 05C

The aircraft industry has long been considered the quintessential high technology industry. By examining the dynamics of technological change in this industry the portfolio model of technological advancement is developed. This model may be used to describe technological advancement in large sophisticated, technology intensive systems. The rapid advancement of individual technologies as measured by improvements in specific performance parameters is evident in the aircraft industry. However, the ability of a technology to improve performance in one or more key performance parameter may lead to adverse effects in other performance parameters or may not be compatible with other technological developments that are occurring in the industry. Individual technical improvements can be characterized as either portfolio reinforcing or portfolio shifting depending on whether or not they promote shift in the way the technologies are combined into a total system or portfolio. The commercially and economically successful products appear to be those that combine technologies into an optimum bundle of performance characteristics or portfolio. Technologies that flourish are not always the technologies on the leading edge of the performance frontier, but are those technologies that product the optimum portfolio. Author (GRA)

02

AERODYNAMICS

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

A87-13050
QUESTIONS AND PROBLEMS IN AERODYNAMICS [AERODINAMIKA V VOPROSAKH I ZADACHAKH]
N. F. KRASNOV, V. N. KOSHEVOI, A. N. DANILOV, V. F. ZAKHARCHENKO, E. E. BOROVSKII et al. Moscow, Izdatel'stvo Vysshaia Shkola, 1985, 760 p. In Russian. refs

The principal questions and problems related to the main fields of modern aerodynamics are formulated, and answers to these questions and problems are then supplied. Particular attention is given to the kinematics of a fluid medium; fluid and gas dynamics; the theory of shock waves; the method of characteristics; flow past airfoils, wings, and bodies of revolution; friction and heat transfer; aerodynamic interference; and the aerodynamics of a rarefied medium. In addition to stationary aerodynamics, attention is given to questions and problems related to nonstationary flow of a gas past isolated surfaces (wings and bodies) and aircraft as a whole. V.L.

A87-13499* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INTERACTION OF DECAYING TRAILING VORTICES IN GROUND SHEAR
C. H. LIU (NASA, Langley Research Center, Hampton, VA) and L. TING (New York University, NY) IN: Applied numerical modeling . San Diego, CA, Univelt, Inc., 1986, p. 646-655. refs
(Contract N00014-80-C-0324; NCC1-58)

The drift of trailing vortices in a cross wind near to the ground is modeled by an unsteady, two-dimensional, rotational flowfield with a concentration of large vorticity in spots having finite total strength. The problem is analyzed by a combination of the method of matched asymptotic analyses for the decay of the vortical spots and the Euler solution for the unsteady rotational flow. A primary feature of the numerical scheme is that the grid size and time step depend only the length and velocity scales of the background flow and is independent of the effective core size of a vortical spot which can be much smaller than the grid size. Numerical results are presented to demonstrated the strong interaction between the trajectjories of the vortical spots and the redistribution of vorticity in the background flowfield. Author

A87-13501
AN AERODYNAMIC ANALYSIS AND THE SUBSEQUENT MOTION OF EXTERNAL STORE
C.-M. LEE and S.-J. HSIEH (National Cheng Kung University, Tainan, Republic of China) IN: Applied numerical modeling . San Diego, CA, Univelt, Inc., 1986, p. 671-678. refs

A rational analytical method for the trajectory motion of an external store after separation from an aircraft is presented. The nonuniform flow field around the store and the resultant force and moment acting on the store are obtained with the panel method, and the theory of rigid body motion is used to predict the subsequent motion of the store. A computationally efficient iterative scheme is employed to treat the mutual interference effect among the wing, fuselage, and store. Results indicate that the displacement of the store from the aircraft is independent of its hanging position, while the angular momentum is significant when the store is released from the wing tip. R.R.

A87-13502
COMPUTATION OF TWO-DIMENSIONAL SUPERSONIC TURBULENT FLOW OVER A COMPRESSION CORNER
M.-S. LIOU and D.-V. WANG (National Cheng Kung University, Tainan, Republic of China) IN: Applied numerical modeling . San Diego, CA, Univelt, Inc., 1986, p. 679-684. refs

A two-layer equilibrium eddy-viscosity model is combined with mass-averaged Navier-Stokes equations to form a closed system of equations for the calculation of supersonic flow over a compression corner. The equations are solved by the fast and simple implicit numerical scheme of MacCormack (1981). Results demonstrate good prediction of the complicated shock/boundary layer interacting flow, and significant improvement in the prediction of upstream pressure propagation and separated flow. R.R.

A87-13503
SHOCK BOUNDARY LAYER INTERACTIONS IN LAMINAR TRANSONIC FLOW OVER AIRFOILS USING A HYBRID METHOD
S. N. TIWARI, C. S. VEMURU, and R. B. RAM (Old Dominion University, Norfolk, VA) IN: Applied numerical modeling . San Diego, CA, Univelt, Inc., 1986, p. 685-691. refs

A very economical method has been developed to investigate the laminar viscous-inviscid interaction over airfoils in transonic flows. The external flow over airfoil is obtained by using a finite-difference-relaxation technique and the method of integral relations is used to obtain the Euler solution near the shock. The laminar boundary-layer equations are solved by an integral method. The streamline angle is a common variable between the inviscid and viscous flows and accounts for the strong interaction. A new flow field is generated after the original airfoil is updated by adding the displacement thickness; the procedure is repeated until convergence occurs. The results obtained for a six percent circular-arc airfoil are found to be in good agreement with the experimental results. The results for a swept super-critical airfoil compare well with other available solutions. Author

A87-13504
NUMERICAL CALCULATION OF THREE-DIMENSIONAL INVISCID SUPERSONIC FLOWS
M.-S. LIOU (National Cheng Kung University, Tainan, Republic of China) and W.-C. HO IN: Applied numerical modeling . San Diego, CA, Univelt, Inc., 1986, p. 692-697. refs

An accurate and simple computational scheme for the space-marched solution of the three-dimensional Euler equations around bodies of varying shapes in supersonic flow is presented which uses a shock-capturing approach. The governing hyperbolic differential equations in cylindrical coordinates are normalized between the body and the bow shock, which completely surrounds the disturbed flow region, and the equations, in conservation-law formulations, are integrated from an initial data plane downstream over the body using the explicit scheme of MacCormack (1969). The bow shock is treated as a sharp discontinuity, and the shock-fitting technique is employed, while the embedded shocks are captured automatically. Computational results for cones, a complex forebody, and several projectiles show the flowfields generated by these bodies for different angles of attack and Mach numbers, and good agreement is found with experimental data obtained for small angles of attack. R.R.

A87-13638#
AN ANALYTICAL PARAMETRIC INVESTIGATION OF NUMERICAL NONLINEAR VORTEX-LATTICE METHODS
Z. RUSAK and A. SEGINER (Technion - Israel Institute of Technology, Haifa) IN: Israel Annual Conference on Aviation and Astronautics, 27th, Haifa, Israel, February 27, 28, 1985, Collection of Papers . Haifa, Israel, Technion - Israel Institute of Technology, 1986, p. 13-22. refs

The analytical equations of the discretized numerically model that describes the vortex-lattice methods (VLM), are analyzed parametrically. The analysis shows that the formulation of the computational grid and of the equations used for the numerical solution depends on two basic parameters of the method. One is the chord length of the vortex panel on the wing, which is the basic discretization length scale of the wing. The other is the ratio of the segment length of a free vortex in the wake (the basic wake-discreetization length) to wing-panel chord. This conclusion is independent of either the specific paneling scheme that is used on the wing or of the integration method of the trajectories of the free vortices in the wake. It is shown that the ratio of the two length scales governs the numerical uniqueness and the convergence characteristics of the VLM solution. This is also demonstrated by numerical examples for flow over several slender delta wings. Author

A87-13641#
COMBINATION OF SUCTION AND TANGENTIAL BLOWING IN BOUNDARY LAYER CONTROL
M. BOASSON (Ministry of Defence, Haifa, Israel) and J. L. LOTH (West Virginia University, Morgantown) IN: Israel Annual Conference on Aviation and Astronautics, 27th, Haifa, Israel, February 27, 28, 1985, Collection of Papers . Haifa, Israel, Technion - Israel Institute of Technology, 1986, p. 53-60. refs

The paper presents a method for finding the optimal blowing parameters for achieving the highest values of lift for a STOL aircraft. The airfoil is simulated as a flat plate with an adverse pressure gradient produced by a source type flow. The transformed boundary layer equations are solved numerically using a finite difference method until flow separation is reached. Suction can be incorporated through a boundary condition. A wall jet is added at the separation point, and calculations continue until separation occurs once again. Lift is then calculated as a function of the centerline velocity ratio and the blowing momentum or blowing power coefficients; and the optimal parameters are computed. B.J.

A87-13643#
A SPLIT CANARD CONFIGURAION FOR IMPROVED CONTROL AT HIGH ANGLES OF ATTACK
D. LEVIN (Technion - Israel Institute of Technology, Haifa), A. KATZ, and A. DAVIDOVITCH IN: Israel Annual Conference on Aviation and Astronautics, 27th, Haifa, Israel, February 27, 28, 1985, Collection of Papers . Haifa, Israel, Technion - Israel Institute of Technology, 1986, p. 65-73. refs

The ever growing demands for improving the performance of air-to-air missiles call for exploring the region of high angles of attack. In this range the common canard controlled missile configuration tends to lose its maneuverability. This effect is attributed to the failure to maintain a monotonically growing lift force on the control surfaces when positioned a high combined angles. A dual surface canard configuration is intended to overcome this problem, by extending the range of angles for which the lift force on the control surfaces grows monotonically. Initial experiments prove the potential of this solution and lead to further development possibilities. Author

A87-13652#
EXPERIMENTAL INVESTIGATION OF VORTEX FLOW OVER DOUBLE-DELTA WING AT HIGH ALPHA
D. MANOR (Saint Louis University, Cahokia, IL) IN: Israel Annual Conference on Aviation and Astronautics, 27th, Haifa, Israel, February 27, 28, 1985, Collection of Papers . Haifa, Israel, Technion - Israel Institute of Technology, 1986, p. 166-172. refs

The effects of large angles of attack, with and without sideslip, on the performance and stability of 65 deg/80 deg double-delta wing configuration were determined experimentally using six-component force measurements, surface oil flow, and wake total pressure surveys. The force measurement results are presented in graphical form, and flow-field photographs of the wake and surface oil flow are also included. Sideslip angle resulted in a decreased stall angle of attack, lower C(LMAX), enhancement of post-stall lift recovery, and increased upwind vortex sheet size and decreased downwind vortex size. The change in vortex size is believed to cause out of plane forces and moments. These adverse out of plane forces and moments are attributed to asymmetric vortex bursting and an increase in vortex spanwise spacing at prestall angles, observed in the wake surveys. As angle of attack increased, vortex merging caused a reduction in sideforce. The wake surveys color prints show that a narrow band at the edge of the vortex sheet has a very steep total pressure gradient present in all configurations. Interior gradients are not as steep. Author

A87-13653#
AERODYNAMIC COEFFICIENTS OF A CIRCULAR WING IN STEADY SUBSONIC FLOW
A. HAUPTMAN and T. MILOH (Tel Aviv University, Israel) IN: Israel Annual Conference on Aviation and Astronautics, 27th, Haifa, Israel, February 27, 28, 1985, Collection of Papers . Haifa, Israel, Technion - Israel Institute of Technology, 1986, p. 173-179. refs

An analytic solution is presented for the linearized lifting surface problem of a thin circular wing with arbitrary twist and camber in steady incompressible flow. The analysis is based on expansion of the acceleration potential in infinite series of spheroidal harmonics. Unlike previous analyses, which involve inversion of infinite sets of linear equations or numerically solving integral equations, the present method leads to rather simple explicit expressions for the lift and moment coefficients, as well as for the spanwise lift distribution and the induced drag. Author

A87-13788#
NOTES ON A GENERIC PARACHUTE OPENING FORCE ANALYSIS
W. P. LUDTKE (U.S. Navy, Naval Surface Weapons Center, Silver Spring, MD) IN: Aerodynamic Decelerator and Balloon Technology Conference, 9th, Albuquerque, NM, October 7-9, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 72-85. refs
(AIAA PAPER 86-2440)

This paper develops a generic opening shock analysis that permits calculation of velocity profiles, shock factors, maximum shock forces and their time of occurrence during deployment for many types of parachutes. Criteria are presented and methods of calculation developed. Application of the analysis to an apparent anomaly in solid cloth parachute finite mass deployment, verifies the parachute diameter effect shown in the test performance. This is illustrated by an example. Author

A87-13795#
ON THE UTILIZATION OF VORTEX METHODS FOR PARACHUTE AERODYNAMIC PREDICTIONS
J. H. STRICKLAND (Sandia National Laboratories, Albuquerque, NM) IN: Aerodynamic Decelerator and Balloon Technology Conference, 9th, Albuquerque, NM, October 7-9, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 132-139. refs
(Contract DE-AC04-76DP-00789)
(AIAA PAPER 86-2455)

The purpose of this paper is to provide a brief review of vortex methods with application to parachute aerodynamics. A somewhat generalized discussion of analysis techniques which are applicable to development of both two- and three-dimensional numerical solutions will be presented. A brief review of results from several bluff body simulations will also be presented. Author

A87-13796#
AXISYMMETRIC VORTEX LATTICE METHOD APPLIED TO PARACHUTE SHAPES
H. H. MCCOY and T. D. WERME (U.S. Navy, Recovery Systems Div., China Lake, CA) IN: Aerodynamic Decelerator and Balloon Technology Conference, 9th, Albuquerque, NM, October 7-9, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 140-146. refs
(AIAA PAPER 86-2456)

The Naval Weapons Center is developing a dynamic, unsteady aerodynamic model to investigate the dynamics of inflating parachutes. In this report, analysis of axisymmetric, rigid shapes is presented. The model replaces the body with a series of vortex rings. The generated vorticity is shed as discrete vortices and allowed to freely convect. The predicted drag and pressure distributions are compared to available data for ribbon parachutes. Wake interactive, apparent mass calculations are also presented. Author

A87-13798#
AERODYNAMIC CHARACTERISTICS AND FLOW ROUND CROSS PARACHUTES IN STEADY MOTION
C. Q. SHEN (Hongwei Machinery Factory, Xiangfan, People's Republic of China) and D. J. COCKRELL (Leicester, University, England) IN: Aerodynamic Decelerator and Balloon Technology Conference, 9th, Albuquerque, NM, October 7-9, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 157-165. Research supported by Irvin Great Britain, Ltd. refs
(AIAA PAPER 86-2458)

Making extensive force-measurement and flow-visualization tests in a wind tunnel and also conducting blockage-effect experiments under water, the authors considered the physical reasons for the aerodynamic characteristics of cross parachute canopies. The arm ratio of the canopy is a significant aerodynamic parameter in the determination of its drag and stability characteristics, but the porosity of the canopy fabric is equally important. Physical reasons are advanced for the importance of these two parameters, and recommendations are made as to their best choice in a given application. Author

A87-13805#
DRAG AND STABILITY IMPROVEMENTS OF A SQUARE PARACHUTE
C. T. CALIANNO (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: Aerodynamic Decelerator and Balloon Technology Conference, 9th, Albuquerque, NM, October 7-9, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 211-216.
(AIAA PAPER 86-2471)

A modified square parachute aimed toward producing a stable, low cost replacement for the cross-type parachute was evaluated. Wind tunnel tests were conducted to determine the drag and stability characteristics of square type parachutes modified by lowering their normal suspension line length/canopy diameter ratio from 1.0 to 0.45 and 0.60, or slotting the canopies. These parachutes were also flight tested to evaluate their opening and damping characteristics in a dynamic environment. The decelerators were configured to a maximum uninflated length of three feet for safety reasons. The results showed that the slotted square parachute was as stable and produced more drag, for a nominal surface area greater than 3.5 sq ft, compared to a cross-type parachute. Author

A87-13807#
IMPROVED MEASUREMENT OF THE DYNAMIC LOADS ACTING ON ROTATING PARACHUTES
Z. SHPUND and D. LEVIN (Technion Foundation for Research and Development, Wind Tunnel Laboratory, Haifa, Israel) IN: Aerodynamic Decelerator and Balloon Technology Conference, 9th, Albuquerque, NM, October 7-9, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 222-227.
(AIAA PAPER 86-2473)

An experimental apparatus for measuring the steady and non-steady aerodynamic loads acting on parachutes and decelerators has been designed and built in the wind tunnel laboratory in the Technion. This apparatus was installed in the subsonic wind tunnel. Calibration tests were carried out with both dead weights and a rigid body simulating the flow around a rotating parachute. Good agreement was obtained between the results of these tests and previously recorded data. The experiments with parachutes included both the static and rotating cases, of a cross type parachute, with W/L of .333. The measurements in the static case included all six component of the force and moment. In the rotating case five load components were measured plus the roll damping, and the roll transfer capability. The results obtained prove the ability of the modified system in measuring accurately the aerodynamic loads without interrupting the flow field of the parachute, as well as the versatility of the apparatus in obtaining dynamic data unobtainable in wind tunnel measurements before. Author

A87-13900
NUMERICAL SOLUTION OF TRANSONIC POTENTIAL FLOWS WITH FINITE ELEMENTS METHOD USING MULTIGRID TECHNIQUE
V. DANEK (Ceskoslovenska Akademie Ved, Ustav Termomechaniky, Prague, Czechoslovakia) Acta Technica CSAV (ISSN 0001-7043), vol. 31, no. 3, 1986, p. 359-373. refs

Techniques are presented for applying a multigrid finite element model (MFEM) to modeling steady transonic potential flows in channels and cascades. A full potential equation with Neumann boundary equation is defined and solved with an iterative successive line overrelaxation (SLOR) method. Interpolation expressions are formulated for generating connected multiple grids to decompose the partial differential equations for easier solution. Residual terms are restricted to an original coarse grid and accounted for over several SLOR iterations. The interpolation and restrictions operators necessary for transitions from a coarse grid to a fine mesh are described in detail. The flow around a NACA 0012 airfoil at Mach 0.8 is modeled to illustrate the effectiveness of the method in the presence of shock. M.S.K.

A87-13994#
THEORETICAL INVESTIGATIONS OF TRANSONIC ROTOR-BLADE AERODYNAMICS [THEORETISCHE UNTERSUCHUNGEN ZUR TRANSSONISCHEN ROTORBLATT-AERODYNAMIK]
J. HERTEL, E. KRAEMER, and S. WAGNER (Muenchen, Universitaet der Bundeswehr, Neubiberg, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 27 p. In German. refs

Techniques for computing the three-dimensional transonic flow around a helicopter rotor blade are developed and demonstrated. A number of theoretical approaches and spatial discretization schemes are characterized, and a procedure based on a finite-volume-method solution of the Euler equations is applied to the transonic flow around a wing profile using a modified H-type conforming grid. The results are presented graphically, and the accuracy obtained is shown to be equal to that of a C-type grid. The modification of the method to treat rotor-blade flows is described, and preliminary results (for an isolated nontwisted blade at tip Mach number 0.85, neglecting the effects of tip vortices) are presented and discussed. T.K.

A87-13995#
IMPROVEMENT OF MATHEMATICAL MODELS OF HELICOPTERS BY ANALYTICAL PRESENTATION OF NONLINEAR AERODYNAMICS [VERBESSERUNG DER MATHEMATISCHEN MODELLE VON HUBSCHRAUBERN DURCH ANALYTISCHE DARSTELLUNG NICHTLINEARER AERODYNAMIK]
U. LEISS and S. WAGNER (Muenchen, Universitaet der Bundeswehr, Munich, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 31 p. In German. refs

A new procedure has been developed for analyzing the steady and unsteady aerodynamic coefficients of helicopters. Arbitrary flow states on rotor blades are given as attached and separated flow, and a logical departure from steady and unsteady flow clarifies partial effects. The elimination of blade elements by analytic integration of the blade is an essential step to reducing the calculating time. C.D.

A87-14010#
NUMERICAL CALCULATION OF VISCOUS INTERNAL FLOWS [NUMERISCHE BERECHNUNG REIBUNGSBEHAFTETER INNENSTROEMUNGEN]
D. HAENEL, K. DORTMANN, W. SCHROEDER, and R. SCHWANE (Aachen, Rheinisch-Westfaelische Technische Hochschule, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 16 p. In German. refs

Calculative procedures using two different concepts were developed to evaluate viscous compressible flows. One procedure uses the boundary-layer concept and solves flow by coupling solutions of the flow with boundary-layer solutions, using both direct and inverse methods. The other procedure uses the Navier-Stokes equations and finite-difference methods to obtain a numerical solution. The first method provides solutions more economically, but its validity is lessened by the boundary layer approximation. The second method provides more comprehensive solutions, and its greater cost is partly offset by using improved solution methods. C.D.

A87-14022#
THEORETICAL STUDIES OF THE ETW DIFFUSER AND OF THE SECOND THROAT [THEORETISCHE ARBEITEN ZUM ETW-DIFFUSOR UND ZUR ZWEITEN VERENGUNG]
H. W. STOCK, W. HAASE, S. LEICHER, and W. SEIBERT (Dornier GmbH, Friedrichshafen, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 34 p. In German. refs

The flow fields in the diffuser and near the second throat of the modified configuration of the European Transonic Wind Tunnel (ETW) at inlet Mach numbers 0.54-0.6 are investigated theoretically using numerical simulations. The diffuser is treated in two ways, in two dimensions as an equivalent circular-cross-section diffuser and in three dimensions using an iterative method for compressible inviscid turbulent boundary-layer flows and a finite-volume scheme to solve the Euler equations; the throat flow is simulated by assuming it is inviscid and two-dimensional and applying the finite-volume Euler method. The results are presented in tables, diagrams, and graphs, compared with experimental data obtained in the ETW test-rig configuration, and characterized. It is found that the ETW configuration with the second throat is much more susceptible to separation than the test-rig configuration. A new throat geometry with two joints and more rounded contours is recommended to improve the flow characteristics. T.K.

A87-14028#
COMPARISON OF NUMERICAL SOLUTIONS OF LOWER ORDER AND HIGHER ORDER INTEGRAL EQUATION METHODS FOR TWO-DIMENSIONAL AEROFOILS
M. J. SHEU (National Tsing Hua University, Hsinchu, Republic of China) and D. R. CHENG AIAA, General Aviation Technology Conference, Anaheim, CA, Sept. 29-Oct. 1, 1986. 8 p. refs
(AIAA PAPER 86-2591)

A number of numerical solutions of lower-order and higher-order panel methods are presented and compared for predicting the properties of two-dimensional steady incompressible, inviscid flow past lifting airfoils. The effects of higher-order approximations (i.e., the use of the curved element and linear varying sigularity on the airfoils) are investigated. This paper presents the significance of the higher-order curved-panel models and the lower-order flat-panel models for the computational accuracy and for the numerical stability versus both the geometric shape and the effect of the distribution of the singularities. Author

A87-14035*# PRC Kentron, Inc., Hampton, Va.
EFFECT OF AN UPSTREAM WAKE ON A PUSHER PROPELLER
M. A. TAKALLU (PRC Kentron, Inc., Hampton, VA) AIAA, General Aviation Technology Conference, Anaheim, CA, Sept. 29-Oct. 1, 1986. 11 p. refs
(Contract NAS1-17993)
(AIAA PAPER 86-2602)

An analytical/computational study has been conducted to predict the effect of an upstream wake on an operating propeller. The upstream wing/pylon was modeled by a constant chord wing of NACA 0012 sections and was placed at a variable distance (0.1 - 0.3 chord) upstream of a scaled model propeller (SR-2). The wake model was a similarity formulation. The periodic behavior ofthe flow during the passage through the wake was formulated in terms of time-dependent variation of each blade section's angle of attack. It was found that the final expressions for the unsteady pressure distribution on each blade section are periodic and that the unsteady circulation and lift coefficieents exhibit a hysteresis loop. Author

A87-14038*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
WIND-TUNNEL INVESTIGATION OF THE OMAC CANARD CONFIGURATION
W. C. INGRAM, L. P. YIP (NASA, Langley Research Center, Hampton, VA), and E. L. COOK (OMAC, Inc., Albany, GA) AIAA, General Aviation Technology Conference, Anaheim, CA, Sept. 29-Oct. 1, 1986. 9 p. refs
(AIAA PAPER 86-2608)

Wind-tunnel tests were conducted on a 0.175-scale model of the OMAC Laser 300 canard configuration in the NASA Langley 12-Foot Low-Speed Wind Tunnel to determine its low-speed high angel-of-attack aerodynamic characteristics. The Laser 300 is a general aviation turboprop pusher aircraft utilizing a canard configuration. The design incorporates a low forward wing and a high main wing with a leading-edge droop installed on the outboard panel and tip fins mounted on the wing tips. The model was tested over a range of -6 to 50-deg angle-of-attack and 20 to -20 deg sideslip. Static force and moment data were measured, and the longitudinal and lateral-directional characteristics were determined. Author

A87-14095* Princeton Univ., N. J.
NUMERICAL SOLUTION OF THE EULER EQUATION FOR COMPRESSIBLE INVISCID FLUIDS
A. JAMESON (Princeton University, NJ) IN: Numerical methods for the Euler equations of fluid dynamics . Philadelphia, PA, Society for Industrial and Applied Mathematics, 1985, p. 199-245. refs
(Contract N00014-81-K-0379; NAG1-186)

An effort is made to develop a satisfactory numerical method for the calculation of steady solutions of the Euler equations for inviscid compressible gas flows. The intended application is the prediction of the aerodynamic properties of aircraft flying at transonic speeds. Particular consideration is given to the modification of the equations to improve convergence to a steady state; finite volume formulation; adaptive dissipation; schemes designed to improve the resolution of shock waves; hybrid multistage time stepping schemes; residual averaging; a multigrid scheme; and trials with Burgers' equation. Results clearly demonstrate that the convergence of a time-dependent hyperbolic system to a steady state can be substantially accelerated by the introduction of multiple grids. B.J.

A87-14096* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ACCELERATION TO A STEADY STATE FOR THE EULER EQUATIONS
E. TURKEL (NASA, Langley Research Center, Hampton, VA; Tel Aviv University, Israel) IN: Numerical methods for the Euler equations of fluid dynamics . Philadelphia, PA, Society for Industrial and Applied Mathematics, 1985, p. 281-311. Previously announced in STAR as N84-29852. refs
(Contract NAS1-16394; NAS1-17130)
A multistage Runge-Kutta method is analyzed for solving the Euler equations exterior to an airfoil. Highly subsonic, transonic and supersonic flows are evaluated. Various techniques for accelerating the convergence to a steady state are introduced and analyzed. Author

A87-14099
VORTEX-SHEET CAPTURING IN NUMERICAL SOLUTIONS OF THE INCOMPRESSIBLE EULER EQUATIONS
A. RIZZI and L.-E. ERIKSSON (Flygtekniska Forsoksanstalten, Bromma, Sweden) IN: Numerical methods for the Euler equations of fluid dynamics . Philadelphia, PA, Society for Industrial and Applied Mathematics, 1985, p. 437-469. refs
Numerical solutions to the Euler equations that contain vorticity appear qualitatively correct, but how the vorticity is generated is still an open question. The simpler case of incompressible flow where the only allowable discontinuity is a vortex sheet is a good model to use for studying this question. The present approach is the artificial compressibility method which leads to a hyperbolic system of equations that are solved by finite-volume differences centered in space and explicit multistage time stepping. The stability of this novel system is analyzed, its allowable discontinuities are described, and appropriate far-field and solid wall boundary conditions are introduced. Results are presented for both two- and three-dimensional flows. Whether vorticity is produced or not depends very strongly on the body geometry and the transient discontinuities that evolve in the flow field. The results are analyzed for the entropy produced in the flow-field, and for the difffusion of the vortex sheets. Author

A87-14101#
FINITE ELEMENT NAVIER-STOKES CALCULATION OF THREE-DIMENSIONAL TURBULENT FLOW NEAR A PROPELLER
D. H. PELLETIER (Montreal, Universite, Montreal, Canada) and J. A. SCHETZ (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 24, Sept. 1986, p. 1409-1416. Navy-supported research. Previously cited in issue 07, p. 844, Accession no. A85-19698. refs

A87-14102#
VORTEX PANEL CALCULATION OF WAKE ROLLUP BEHIND A LARGE ASPECT RATIO WING
A. PLOTKIN (San Diego State University, CA) and D. T. YEH AIAA Journal (ISSN 0001-1452), vol. 24, Sept. 1986, p. 1417-1423. Army-supported research. Previously cited in issue 19, p. 2737, Accession no. A85-40686. refs

A87-14104*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
COMPUTATION OF SHARP-FIN-INDUCED SHOCK WAVE/TURBULENT BOUNDARY-LAYER INTERACTIONS
C. C. HORSTMAN (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 24, Sept. 1986, p. 1433-1440. Previously cited in issue 17, p. 2466, Accession no. A86-38409. refs

A87-14105*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CONVERGENCE ACCELERATION FOR A THREE-DIMENSIONAL EULER/NAVIER-STOKES ZONAL APPROACH APPROACH
F. FLORES (NASA, Ames Research Center, Moffett Field, CA) (Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers, p. 75-86) AIAA Journal (ISSN 0001-1452), vol. 24, Sept. 1986, p. 1441, 1442. Abridged. Previously cited in issue 19, p. 2743, Accession no. A85-40934.

A87-14108*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TURBULENT FLOW AROUND A WING/FUSELAGE-TYPE JUNCTURE
L. R. KUBENDRAN (NASA, Langley Research Center, Hampton, VA), H. M. MCMAHON, and J. E. HUBBARTT (Georgia Institute of Technology, Atlanta) AIAA Journal (ISSN 0001-1452), vol. 24, Sept. 1986, p. 1447-1452. Previously cited in issue 07, p. 835, Accession no. A85-19475. refs
(Contract NAG1-40)

A87-14109*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPARISON OF FINITE VOLUME FLUX VECTOR SPLITTINGS FOR THE EULER EQUATIONS
W. K. ANDERSON, J. L. THOMAS (NASA, Langley Research Center, Hampton, VA), and B. VAN LEER (Delft, Technische Hogeschool, Netherlands) AIAA Journal (ISSN 0001-1452), vol. 24, Sept. 1986, p. 1453-1460. Previously cited in issue 07, p. 838, Accession no. A85-19533. refs

A87-14110*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPECTRAL METHODS FOR MODELING SUPERSONIC CHEMICALLY REACTING FLOWFIELDS
J. P. DRUMMOND, M. Y. HUSSAINI, and T. A. ZANG (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 24, Sept. 1986, p. 1461-1467. Previously cited in issue 07, p. 843, Accession no. A85-19651. refs

A87-14111*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TWO-DIMENSIONAL BLADE-VORTEX FLOW VISUALIZATION INVESTIGATION
E. R. BOOTH, JR. and J. C. YU (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 24, Sept. 1986, p. 1468-1473. Previously cited in issue 01, p. 2, Accession no. A85-10858. refs

A87-14117*# Washington Univ., Seattle.
EXPERIMENTAL AND NUMERICAL INVESTIGATION OF SUPERSONIC TURBULENT FLOW THROUGH A SQUARE DUCT
D. O. DAVIS, F. B. GESSNER (Washington, University, Seattle), and G. D. KERLICK (NASA, Ames Research Center; Informatics General Corp., Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 24, Sept. 1986, p. 1508-1515. Previously cited in issue 19, p. 2739, Accession no. A85-40728. refs
(Contract NCA2-IR-850-401)

A87-14119#
EFFECT OF TWO ENDWALL CONTOURS ON THE PERFORMANCE OF AN ANNULAR NOZZLE CASCADE
S. H. MOUSTAPHA (Pratt and Whitney Canada, Longueuil) and R. G. WILLIAMSON (National Research Council of Canada, Gas Dynamics Laboratory, Ottawa) AIAA Journal (ISSN 0001-1452), vol. 24, Sept. 1986, p. 1524-1530. Previously cited in issue 18, p. 2610, Accession no. A85-39661. refs

A87-14125#
INFLUENCE OF TRAILING-EDGE MESHES ON SKIN FRICTION IN NAVIER-STOKES CALCULATIONS
W. HAASE (Dornier GmbH, Friedrichshafen, West Germany) AIAA Journal (ISSN 0001-1452), vol. 24, Sept. 1986, p. 1557-1559. Sponsorship: Bundesministerium der Verteidigung. refs
(Contract BMVG-T/R41/D0007/D1407)

Calculations at a Mach number of 0.73, Reynolds number of 6.5 million, and an angle of attack of 3.19 deg are performed to interpret the trailing-edge skin-friction distribution with respect to the mesh structure in the trailing-edge vicinity of the RAE 2822 airfoil. Results for skin friction and pressure distributions were obtained in the case of aligning the trailing edge mesh with the flow direction, and additional tests showed the results to be independent of mesh type, finite approach, filtering technique and turbulence model. Wakeline-adapted meshes are shown to overcome some trailing edge problems, and make possible the performance of physically plausible flowfield predictions even in highly viscous interaction regions. R.R.

A87-14127#
CONSTANT-DENSITY APPROXIMATION TO TAYLOR-MACCOLL SOLUTION
C. S. MOORTHY (Indian Institute of Technology, Kanpur, India) AIAA Journal (ISSN 0001-1452), vol. 24, Sept. 1986, p. 1561-1563. refs

The Taylor-Maccoll equation is arranged with the nonlinearities grouped into one term which is zero on the cone surface as well as at the oblique shock, and it is shown that the constant-density approximation may be accurately employed in the supersonic range by neglecting this term. The transonic and hypersonic similarity parameters for conical flow are derived from the wedge flow parameters, and a Newtonian approximation is obtained at high Mach numbers. Shock detachment is found to occur at the shock angle at which the density ratio across the shock is maximized, for a given half-angle of the wedge or cone. R.R.

A87-14129#
COMMENT ON 'COMPUTATION OF CHOKED AND SUPERSONIC TURBOMACHINERY FLOWS BY A MODIFIED POTENTIAL METHOD'
T. C. ADAMSON, JR., J. MACE, and A. F. MESSITER (Michigan, University, Ann Arbor) AIAA Journal (ISSN 0001-1452), vol. 24, Sept. 1986, p. 1566; Author's Reply, p. 1566, 1567. refs

A87-14261#
AN IMPLICIT TIME-MARCHING SCHEME FOR TRANSONIC FLOW
H. DAIGUJI (Tohoku University, Sendai, Japan) and M. KUZUHARA (Mitsubishi Research Institute Inc., Tokyo, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 29, July 1986, p. 2032-2035. refs

An implicit time-marching finite-difference scheme is developed for computing steady two-dimensional inviscid transonic flows with arbitrary shaped boundaries. Most of the existing implicit time-marching schemes, including the Beam-Warming scheme, are unconditionally stable according to Neumann's stability criterion, but actually cannot take a sufficiently large Courant number because the diagonally dominant condition of the coefficient matrix is lost. In the present scheme, in order to remove this restriction of the Courant number, the Robert-Weiss convective-difference scheme is applied in place of the Crank-Nicholson scheme in the Beam-Warming delta-form approximate-factorization algorithm. As a numerical example, shocked flows through a nozzle are calculated, and the results are compared with the one-dimensional theory. Author

A87-14263#
STUDY OF A BOUNDED JET FLOW CONSIDERING THE INITIAL TURBULENCE. II - IN THE CASE OF RELATIVELY LARGE NOZZLE ASPECT RATIO
M. NAKASHIMA (Kagoshima National College of Technology, Japan), T. NOZAKI (Kagoshima University, Japan), and K. HATTA (Chubu University, Kasugai, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 29, July 1986, p. 2042-2048. refs

For an approximate calculation of the bounded jet flow, a velocity distribution function on the bounded jet center-plane is proposed, considering the effects of the wall turbulence and the free turbulence. Also, in order to determine the empirical parameter contained in this function, experiments were carried out using a nozzle having an aspect ratio of 16 with the initial turbulence intensity prescribed. As a result, the velocity distributions of the bounded jet flow are well expressed by the proposed function, regardless of the initial turbulence intensity. Furthermore, the variation of the flow patterns towards downstream can be shown by means of the parameter contained in the function. Author

A87-14360#
AERODYNAMIC FORCE CALCULATIONS OF AN ELLIPTICAL CIRCULATION CONTROL AIRFOIL
I. CHOPRA (Maryland, University, College Park), M. SUN, and S. I. PAI Journal of Aircraft (ISSN 0021-8669), vol. 23, Sept. 1986, p. 673-680. refs
(Contract N00167-85-C-0077)

A method is developed to predict the aerodynamic forces on a circulation control elliptical airfoil in a two-dimensional flow environment. By distributing source panels on the airfoil surface in the separation region and using conformal mapping techniques, a simple solution for the potential flow including effects of separated wake is obtained. The development of boundary layers and wall-jet is calculated by a finite difference method. The potential flow with separated wake effect calculations and boundary layer and wall-jet calculations are combined in an iterative process to determine the aerodynamic forces under given jet momentum coefficient and freestream condition. The effect of separated wake is found significant for a cylinder. The correlation of the calculation results with the available experimental data appears reasonable. Author

A87-14362#
SPANWISE VARIATION OF LAMINAR SEPARATION BUBBLES ON WINGS AT LOW REYNOLDS NUMBER
W. G. BASTEDO, JR. and T. J. MUELLER (Notre Dame, University, IN) Journal of Aircraft (ISSN 0021-8669), vol. 23, Sept. 1986, p. 687-694. Research supported by the University of Notre Dame. Previously cited in issue 19, p. 2738, Accession no. A85-40706. refs
(Contract N00014-83-K-0239)

A87-14363*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
IMPACT OF AIRFOIL PROFILE ON THE SUPERSONIC AERODYNAMICS OF DELTA WINGS
R. M. WOOD and D. S. MILLER (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, Sept. 1986, p. 695-702. Previously cited in issue 01, p. 4, Accession no. A86-11038. refs

A87-14365#
DIRECT-INVERSE TRANSONIC WING ANALYSIS-DESIGN METHOD WITH VISCOUS INTERACTION
L. A. CARLSON (Texas A & M University, College Station) and R. A. WEED (Lockheed-Georgia Co., Marietta) Journal of Aircraft (ISSN 0021-8669), vol. 23, Sept. 1986, p. 711-718. Research supported by the Lockheed-Georgia Co. and Texas A & M Research Foundation. Previously cited in issue 01, p. 5, Accession no. A86-11040. refs
(Contract N00167-81-C-0078-P00004)

A87-14370#
VISUALIZATION OF WING TIP VORTICES IN ACCELERATING AND STEADY FLOW
P. FREYMUTH, W. BANK (Colorado, University, Boulder), and F. FINAISH Journal of Aircraft (ISSN 0021-8669), vol. 23, Sept. 1986, p. 730-733. Previously cited in issue 17, p. 2469, Accession no. A86-38457. refs

A87-14372#
LOWER-SIDE NORMAL FORCE CHARACTERISTICS OF DELTA WINGS AT SUPERSONIC SPEEDS
E. S. LARSON (Flygtekniska Forsoksanstalten, Bromma, Sweden) Journal of Aircraft (ISSN 0021-8669), vol. 23, Sept. 1986, p. 735, 736. Sponsorship: Forsvaret Materielverk. refs
(Contract FMV-AU-2154)

A simplified analytical model is presented for the lower-side normal force characteristics of flat, sharp leading-edge delta wings at supersonic speeds. The model is based on a two-term formulation for estimating the normal force on slender bodies. Mach number effects are shown to decrease with increasing sweep. Results are provided from sample calculations for Mach number vs. angle of attack, lift curve slope vs. Mach number and normal force vs. angle of attack. Good agreement was found with model predictions and experimental results for Mach numbers above the threshold of conical flow and below the threshold of supersonic leading-edge flow. M.S.K.

A87-14652*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
VECTORIZABLE MULTIGRID ALGORITHMS FOR TRANSONIC-FLOW CALCULATIONS
N. D. MELSON (NASA, Langley Research Center, Hampton, VA) Applied Mathematics and Computation (ISSN 0096-3003), vol. 19, 1986, p. 217-238. refs

The analysis and the incorporation into a multigrid scheme of several vectorizable algorithms are discussed. von Neumann analyses of vertical-line, horizontal-line, and alternating-direction ZEBRA algorithms were performed; and the results were used to predict their multigrid damping rates. The algorithms were then successfully implemented in a transonic conservative full-potential computer program. The convergence acceleration effect of multiple grids is shown, and the convergence rates of the vectorizable algorithms are compared with those of standard successive-line overrelaxation (SLOR) algorithms. Author

A87-14771
PERFORMANCE EVALUATION OF AN INVERSE INTEGRAL EQUATION METHOD APPLIED TO TURBOMACHINE CASCADES
D. MARTIN (Brown Boveri et Cie. AG, Dietlikon, Switzerland) and M. RIBAUT (Brown Boveri et Cie. AG, Wettingen, Switzerland) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 6, Aug. 1986, p. 573-583. refs

An improved formulation of the inverse integral equation method proposed by Ribaut and Martin (1986) which allows, in particular, a well-posed problem to be ensured is presented. The corresponding computation code is tested in an exhaustive manner for axial and radial compressor and turbine cascades. The agreement between the velocity field obtained with the inverse method and that resulting from a direct calculation is examined for subsonic, transonic, and supersonic flows. The accuracy and reliability of the solution to the boundary condition problem are excellent for the subsonic and transonic flows. However, for the supersonic flow, the application of the method seems to be limited by the use of elementary solutions of the Laplace operator. Author

A87-15189#
THE USE OF MATHEMATICAL MODELS IN AERODYNAMICS (THE W. RUPERT TURNBULL LECTURE)
P. MANDL (Carleton University, Ottawa, Canada) (CASI, Annual General Meeting, Vancouver, Canada, May 12, 1986) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 32, June 1986, p. 113-121. refs

The interactions which are required between experimental aerodynamicists and applied mathematicians for fruitful progress to be made in research are illustrated with several design evaluation results. The discussion covers the characterization of potential flow around suction airfoils with split flaps, an application of rotating parachute shape theory, and analysis of inviscid hypersonic flow around a conical, flat-top wing-body configuration. A rotating parachute is shown to be superior to a similarly-shaped non-rotating parachute in terms of drag per unit weight and per unit volume. Finally, numerical modeling efforts are employed to predict a shape which achieve an optimum L/D for a hypersonic wing-body configuration. M.S.K.

A87-15206
START-UP OF A WIND TUNNEL WITH A MULTICHANNEL DIFFUSER [ZAPUSK AERODINAMICHESKOI TRUBY S MNOGOKANAL'NOM DIFFUZOROM]
I. IU. VASILEV, N. N. ZAKHAROV, E. S. IVANOV, V. IU. NIKOLENKO, and K. N. PICHKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1986, p. 28-32. In Russian. refs

The effect of the principal geometrical parameters of the test section on the pressure gradient during the start-up of a supersonic wind tunnel with a short multichannel vaned diffuser is investigated experimentally in the Mach range 3.8-4.5. An analysis of experimental results indicates that multichannel vaned diffusers of wind tunnels can be made much shorter than monodiffusers but are somewhat less efficient. The pressure gradient during the start-up of wind tunnels with a multichannel diffuser can be reduced by improving flow structure in the outer channels, which can be achieved, for instance, by using a boundary layer control system. V.L.

A87-15216
THE EFFECT OF RANDOM WIND GUSTS ON THE STABILITY OF A PARACHUTE SYSTEM [O VLIIANII SLUCHAINYKH PORYVOV VETRA NA USTOICHIVOST' PARASHIUTNOI SISTEMY]
V. M. CHURKIN and A. E. PRAVOTOROV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1986, p. 72-76. In Russian. refs

The theory of high-frequency random processes is used to determine stability conditions for the motion of a geometrically invariable parachute system subjected to the effect of random wind gusts. The predictions of the theory are found to be in good agreement with the results of a numerical integration of the initial equations of motion of the parachute system. V.L.

A87-15223
DETERMINATION OF DYNAMIC STRESSES IN THE HEAT-INSULATING COATINGS OF FLIGHT VEHICLES DURING AERODYNAMIC HEATING [OPREDELENIE DINAMICHESKIKH NAPRIAZHENII V TEPLOZASHCHITNYKH POKRYTIIAKH LETATEL'NYKH APPARATOV PRI AERODINAMICHESKOM NAGREVE]
L. I. KUDRIASHEV, N. L. MENSHIKH, and A. F. FEDCHEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1986, p. 92-95. In Russian.

The paper is concerned with the thermoelasticity problem for a two-layer thin-walled shell of the type commonly used in the structures of aircraft and engines. Under conditions of aerodynamic heating, when the dilatation term characterizing the mutual effect of the temperature and strain fields can be neglected, the thermoelasticity problem is solved in two stages. First, the heat conduction equation is solved for given boundary and initial conditions; after this, the stresses are determined. V.L.

A87-15229
CALCULATION OF AERODYNAMIC FORCE COEFFICIENTS [K RASCHETU KOEFFITSIENTOV AERODINAMICHESKIKH SIL]
O. P. SIDOROV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1986, p. 109-112. In Russian.
The graphic relationships based on experimental and theoretical data which have been used in several earlier studies to determine the aerodynamic characteristics of flight vehicles are presented here in analytical form. In particular, analytical expressions are given for the friction coefficient of the fuselage, aerodynamic braking coefficients in the region of the front and tail lifting surfaces, Mach number at the front and tail lifting surfaces, profile drag coefficient of the lifting surfaces, and wave-drag coefficient of the tail unit. V.L.

A87-15451* Florida State Univ., Tallahassee.
RECENT ADVANCES IN AERODYNAMICS
A. KROTHAPALLI, ED. (Florida State University, Tallahassee) and C. A. SMITH, ED. (NASA, Ames Research Center, Moffett Field, CA) New York, Springer-Verlag, 1986, 767 p. For individual items see A87-15452 to A87-15469.
Papers are presented on unsteady transonic aerodynamics and aeroelasticity, the unsteady separation phenomenon, and a wind tunnel method for V/STOL testing. Also considered are vortex-edge interactions, jet instability theory, large-scale organized motions in jets and shear layers, and the evolution of adaptive-wall wind tunnels. Other topics include advances in ejector thrust augmentation, multiple jet impingement flowfields, and recent advances in prediction methods for jet-induced effects on V/STOL aircraft. R.R.

A87-15452
ADVANCES IN THE UNDERSTANDING AND COMPUTATION OF UNSTEADY TRANSONIC FLOW
A. R. SEEBASS (Colorado, University, Boulder), K. Y. FUNG, and S. M. PRZYBYTKOWSKI (Arizona, University, Tucson) IN: Recent advances in aerodynamics . New York, Springer-Verlag, 1986, p. 3-37. refs
Numerical calculations of the effect of small unsteady motions on unsteady transonic flows around airfoils are presented, and the effect of wind-tunnel walls on unsteady transonic flows whose steady state is free from interference is considered. It is demonstrated that the resonances of linear theory remain in the nonlinear flow and can cause substantial discrepancies between unbounded flow and the flow in the wind tunnel, even for tunnel heights in excess of five times the wingspan and 20 times its chord. The results suggest that wind tunnel walls be acoustically treated to further reduce wall reflections during unsteady testing. R.R.

A87-15453
UNSTEADY TRANSONIC AERODYNAMICS AND AEROELASTICITY
E. H. DOWELL (Duke University, Durham, NC) IN: Recent advances in aerodynamics . New York, Springer-Verlag, 1986, p. 39-98. refs
(Contract AF-AFOSR-81-0213A)
Aeroelastic applications of unsteady transonic aerodynamics are considered. It is suggested that the aerodynamic forces will be linear functions of the airfoil motion for sufficiently small airfoil motions, which lead to sufficiently small shock motions, and that the field panel method of Hounjet (1981) is a viable alternative solution technique to finite difference methods. Flutter analysis in the frequency domain and simultaneous time integration of the fluid-dynamical and structural-dynamical equations of motion are considered for determination of the aeroelastic response, and methods for generating the frequency-domain aerodynamic forces are discussed. R.R.

A87-15454* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
MODELING OF TURBULENT SEPARATED FLOWS FOR AERODYNAMIC APPLICATIONS
J. G. MARVIN (NASA, Ames Research Center, Moffett Field, CA) IN: Recent advances in aerodynamics . New York, Springer-Verlag, 1986, p. 99-164. Previously announced in STAR as N83-33849. refs
Steady, high speed, compressible separated flows modeled through numerical simulations resulting from solutions of the mass-averaged Navier-Stokes equations are reviewed. Emphasis is placed on benchmark flows that represent simplified (but realistic) aerodynamic phenomena. These include impinging shock waves, compression corners, glancing shock waves, trailing edge regions, and supersonic high angle of attack flows. A critical assessment of modeling capabilities is provided by comparing the numerical simulations with experiment. The importance of combining experiment, numerical algorithm, grid, and turbulence model to effectively develop this potentially powerful simulation technique is stressed. S.L.

A87-15459
THE INDUCED AERODYNAMICS OF JET AND FAN POWERED V/STOL AIRCRAFT
R. E. KUHN IN: Recent advances in aerodynamics . New York, Springer-Verlag, 1986, p. 337-373. refs
The flow phenomena encountered in the hovering and low-speed flight of jet- and fan-powered V/STOL and STO/VL aircraft are examined, with attention to empirically based methods for the estimation of aerodynamic characteristics. While the design principles required to minimize adverse effects and to take advantage of favorable ones are well known, the current ability to make accurate estimates of many of the induced effects is limited. Expensive experimental programs are accordingly required at the outset of any aircraft development effort in order to obtain the accurate data required for design finalization. O.C.

A87-15461* McDonnell Aircraft Co., St. Louis, Mo.
MULTIPLE JET IMPINGEMENT FLOWFIELDS
D. R. KOTANSKY (McDonnell Aircraft Co., Saint Louis, MO) IN: Recent advances in aerodynamics . New York, Springer-Verlag, 1986, p. 435-469. Research supported by McDonnell Aircraft Co. refs
(Contract N62269-76-C-0086; N62269-81-C-0717; NAS2-9646; NAS2-10184; N00014-79-C-0130)
Attention is given to the prediction of lift-system-induced aerodynamic effects in lift-jet VTOL aircraft, considering both analytical fluid-dynamics models and an empirical database. The methodology takes into account the effects of aircraft geometry and orientation as well as height above ground, lift-jet vector and splay directions, jet exit-flow conditions, and nozzle exit geometry. O.C.

A87-15462
RECENT ADVANCES IN PREDICTION METHODS FOR JET-INDUCED EFFECTS ON V/STOL AIRCRAFT
R. K. AGARWAL (McDonnell Douglas Corp., Saint Louis, MO) IN: Recent advances in aerodynamics . New York, Springer-Verlag, 1986, p. 471-521. Research supported by the McDonnell Douglas Independent Research and Development Program. refs
This paper summarizes the currently used methodologies in aircraft industry for predicting forces and moments on a V/STOL aircraft in hover and transition modes of flight. These methodologies are based on a synthesis of various flow regions each of which accommodates a specific flow phenomena such as jet-ground-interactions, jet-in-crossflow, and fountain-airframe impingement. The progress made in recent years in theoretical modeling of the flowfield of representative jet-flow configurations: single-jet impingement, twin-jet impingement with fountain formation, and jet-in-crossflow is surveyed. The prediction methods ranging from semiempirical approaches to the solution of Reynolds-averaged Navier-Stokes equations are discussed. Author

A87-15467* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
LASER VELOCIMETRY FOR TRANSONIC AERODYNAMICS
D. A. JOHNSON (NASA, Ames Research Center, Moffett Field, CA) IN: Recent advances in aerodynamics . New York, Springer-Verlag, 1986, p. 631-655. refs

Applications of laser velocimetry to the measurement of turbulent flow properties of strong transonic viscous-inviscid interactions are reviewed. The data resulting from these studies are then discussed in relation to their importance in the development of improved viscous-flow calculation methods. Also considered are the current limitations of laser velocimetry, the need for further improvements in the method, and potential future applications. Author

A87-15468
THE AERODYNAMICS AND DYNAMICS OF ROTORS - PROBLEMS AND PERSPECTIVES
R. H. MILLER (MIT, Cambridge, MA) IN: Recent advances in aerodynamics . New York, Springer-Verlag, 1986, p. 659-722. refs

Rotary wing aircraft blades trail intense tip vortices, generate a curved, spiraling wake that initially remains close to a rotor and causes strong blade/vortex interaction, are subject to a high centrifugal force field, and have large steady state displacements out of the plane of rotation. The vibration reduction, blade stability and hovering flight control problems thus posed are noted to strongly depend on a precise, and as yet unaccomplished definition of blade aerodynamics; the dynamics of such rotor systems has, however, been formulated to a high degree of precision, furnishing valuable guidelines for design and for flight development. O.C.

A87-15469* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SPECIAL OPPORTUNITIES IN HELICOPTER AERODYNAMICS
W. J. MCCROSKEY (NASA, Ames Research Center, Moffett Field, CA) IN: Recent advances in aerodynamics . New York, Springer-Verlag, 1986, p. 723-752. Previously announced in STAR as N84-16138. refs

Aerodynamic research relating to modern helicopters includes the study of three dimensional, unsteady, nonlinear flow fields. A selective review is made of some of the phenomenon that hamper the development of satisfactory engineering prediction techniques, but which provides a rich source of research opportunities: flow separations, compressibility effects, complex vortical wakes, and aerodynamic interference between components. Several examples of work in progress are given, including dynamic stall alleviation, the development of computational methods for transonic flow, rotor-wake predictions, and blade-vortex interactions. Author

A87-15553
SOME ASYMPTOTIC TYPES OF TRANSONIC VORTEX FLOWS [NEKOTORYE ASIMPTOTICHESKIE TIPY TRANSZVUKOVYKH VIKHREVYKH TECHENII]
A. G. KUZMIN Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), April 1986, p. 61-65. In Russian. refs

Steady-state plane parallel vortex flows of an ideal gas are investigated analytically. In particular, a study is made of the qualitative flow patterns in the vicinity of a point where the sonic line is orthogonal with respect to the velocity vector and in the vicinity of a point on the sonic line where acceleration is equal to zero. Together with the results of Shifrin (1966), the results obtained here provide information on all possible flow patterns near the point where the sonic line is orthogonal to the velocity vector and demonstrate a large variety of possible flow patterns near the zero acceleration point. V.L.

A87-15561
DETERMINATION OF THE REGIME COEFFICIENTS IN THE LOCAL THEORY OF INTERACTION FROM PLATE DATA [OPREDELENIE KOEFFITSIENTOV REZHIMA LOKAL'NOI TEORII VZAIMODEISTVIIA PO DANNYM O PLASTINE]
I. I. KHOLIABIN Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), April 1986, p. 125-128. In Russian. refs

Regime coefficients are calculated on the basis of the aerodynamic characteristics of the plate, with particular attention given to the effect of the Mach number on the regime coefficients at angles of attack of 20 deg or greater. The regime coefficients are determined as a function of the Knudsen number over a wide range of Knudsen numbers with varying accuracy with respect to the Mach number. It is shown that satisfactory results are obtained even if no allowance is made for the Mach number. V.L.

A87-15761
COMPUTATION OF OPTIMUM-OPTIMORUM WING-FUSELAGE CONFIGURATION FOR FUTURE GENERATION OF SUPERSONIC AIRCRAFT
A. NASTASE (Aachen, Rheinisch-Westfaelische Technische Hochschule, West Germany) IN: Integral methods in science and engineering; Proceedings of the First International Conference on Global Techniques, Integral Methods in Science and Engineering, Arlington, TX, March 18-21, 1985 . Washington, DC, Hemisphere Publishing Corp., 1986, p. 259-279. refs

Two computational methods for the design of optimum optimorum integrated wing-fuselage configurations are presented: an analytical method and a hybrid graphic-analytical method. The design of optimum optimorum integrated wing-fuselage configuration using the graphic-analytical method requires computer time of about 5 seconds on Cyber 175. Author

N87-11691 ESDU International Ltd., London (England).
PITOT AND STATIC ERRORS IN STEADY LEVEL FLIGHT
Jul. 1986 42 p
(ESDU-86006; ISBN-0-85679-558-5; ISSN-0141-4054) Avail: ESDU

This Data Item ESDU 86006 is an addition to the Aircraft Performance Sub-series. All contributions to pressure errors and the implications of the various tests needed to determine the errors in steady level flight are considered. Typical magnitudes of the various contributions are tabulated for typical installations and, where appropriate, estimation methods are given for particular effects for Mach numbers up to 4 at altitudes up to 120,000 ft (36,000 m). ESDU 85011 deals with corrections for nonsteady flight and ESDU 83029 introduces the overall process of correcting for all error sources in flight-test analysis and, in particular, the need for a proper sequence of error correction. ESDU

N87-11695*# Georgia Inst. of Tech., Atlanta. Center for Roatary Wing Aircraft Technology.
SOME OBSERVATIONS ON THE BEHAVIOR OF THE LANGLEY MODEL ROTOR BLADE Semiannual Status Report
L. W. REHFIELD and A. R. ATILGAN Jul. 1986 49 p
(Contract NAG1-638; PROJ. E16-668)
(NASA-CR-179880; NAS 1.26:179880) Avail: NTIS HC A03/MF A01 CSCL 01A

The design of the model rotor and the comparative study of coupled beam theory and the finite element analysis performed earlier at the Aerostructures Directorate by Robert Hodges and Mark Nixon is examined. Attention is focused upon two matters: (1) an examination of the small discrepancies between twist angle predictions under pure torque and radial loading, and (2) an assessment of nonclassical effects in bending behavior. The primary objective is understanding, particularly with regard to cause and effect relationships. Understanding, together with the simple, affordable nature of the coupled beam analysis, provides a sound basis for design. Author

N87-11699*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
TIP VORTICES OF WINGS IN SUBSONIC AND TRANSONIC FLOW: A NUMERICAL SIMULATION
G. R. SRINIVASAN (JAI Associates, Mountain View, Calif.) and W. J. MCCROSKEY Jul. 1986 7 p Original contains color illustrations
(Contract DAAG29-85-C-0002)
(NASA-TM-88334; A-86415; NAS 1.15:88334; USAAVSCOM-TM-86-A-4) Avail: NTIS HC A02/MF A01 CSCL 01A

Thin layer Navier-Stokes and Euler equations are numerically solved using a multi-block zonal approach to simulate the formation and roll up of tip vortices of wings in subsonic and transonic flows. Several wing planforms were considered to examine the influence of tip-cap shape, planform geometry and free stream Mach number on the formation process. A good definition of the formation and qualitative roll up of tip vortices was achieved. Author

N87-11700*# Iowa State Univ. of Science and Technology, Ames. College of Engineering.
APPLICATION OF VISCOUS-INVISCID INTERACTION METHODS TO TRANSONIC TURBULENT FLOWS Final Report
D. LEE and R. H. PLETCHER Nov. 1986 292 p
(Contract NAG2-152)
(NASA-CR-179900; NAS 1.26:179900; HTL-42; CFD-16; ISU-ERI-AMES-87055) Avail: NTIS HC A13/MF A01 CSCL 01A

Two different viscous-inviscid interaction schemes were developed for the analysis of steady, turbulent, transonic, separated flows over axisymmetric bodies. The viscous and inviscid solutions are coupled through the displacement concept using a transpiration velocity approach. In the semi-inverse interaction scheme, the viscous and inviscid equations are solved in an explicitly separate manner and the displacement thickness distribution is iteratively updated by a simple coupling algorithm. In the simultaneous interaction method, local solutions of viscous and inviscid equations are treated simultaneously, and the displacement thickness is treated as an unknown and is obtained as a part of the solution through a global iteration procedure. The inviscid flow region is described by a direct finite-difference solution of a velocity potential equation in conservative form. The potential equation is solved on a numerically generated mesh by an approximate factorization (AF2) scheme in the semi-inverse interaction method and by a successive line overrelaxation (SLOR) scheme in the simultaneous interaction method. The boundary-layer equations are used for the viscous flow region. The continuity and momentum equations are solved inversely in a coupled manner using a fully implicit finite-difference scheme. Author

N87-11701*# Ohio State Univ., Columbus. Dept. of Aero- and Astro-Engineering.
AN EXPERIMENTAL STUDY OF THE AERODYNAMICS OF A NACA 0012 AIRFOIL WITH A SIMULATED GLAZE ICE ACCRETION Interim Technical Report
M. B. BRAGG Nov. 1986 318 p
(Contract NAG3-28; RF PROJ. 712620/762009)
(NASA-CR-179897; NAS 1.26:179897) Avail: NTIS HC A14/MF A01 CSCL 01A

An experimental study was conducted in the Ohio State University subsonic wind tunnel to measure the detailed aerodynamic characteristics of an airfoil with a simulated glaze ice accretion. A NACA 0012 model with interchangeable leading edges and pressure taps every one percent chord was used. Surface pressure and wake data were taken on the airfoil clean, with forced transition and with a simulated glaze ice shape. Lift and drag penalties due to the ice shape were found and the surface pressure clearly showed that large separation bubbles were present. Both total pressure and split-film probes were used to measure velocity profiles, both for the clean model and for the model with a simulated ice accretion. A large region of flow separation was seen in the velocity profiles and was correlated to the pressure measurements. Clean airfoil data were found to compare well to existing airfoil analysis methods. Author

N87-11702*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FORWARD-SWEPT WING CONFIGURATION DESIGNED FOR HIGH MANEUVERABILITY BY USE OF A TRANSONIC COMPUTATIONAL METHOD
M. J. MANN and C. E. MERCER Nov. 1986 185 p
(NASA-TP-2628; L-16120; NAS 1.60:2628) Avail: NTIS HC A09/MF A01 CSCL 01A

A transonic computational analysis method and a transonic design procedure have been used to design the wing and the canard of a forward-swept-wing fighter configuration for good transonic maneuver performance. A model of this configuration was tested in the Langley 16-Foot Transonic Tunnel. Oil-flow photographs were obtained to examine the wind flow patterns at Mach numbers from 0.60 to 0.90. The transonic theory gave a reasonably good estimate of the wing pressure distributions at transonic maneuver conditions. Comparison of the forward-swept-wing configuration with an equivalent aft-swept-wing-configuration showed that, at a Mach number of 0.90 and a lift coefficient of 0.9, the two configurations have the same trimmed drag. The forward-swept wing configuration was also found to have trimmed drag levels at transonic maneuver conditions which are comparable to those of the HiMAT (highly maneuverable aircraft technology) configuration and the X-29 forward-swept-wing research configuration. The configuration of this study was also tested with a forebody strake. Author

N87-11704# Max-Planck-Institut fuer Stroemungsforschung, Goettingen (West Germany).
VORTEX SHEDDING OF A SQUARE CYLINDER IN FRONT OF A SLENDER AIRFOIL AT HIGH REYNOLDS NUMBERS. PART 2: COMPRESSIBILITY EFFECT
T. NAKAGAWA, G. E. A. MEIER, R. TIMM, and H. M. LENT Oct. 1985 33 p Sponsored by Minna-James-Heinemann Foundation, Hannover, West Germany
(MPIS-24/1985; ISSN-0436-1199; ETN-86-98222) Avail: NTIS HC A03/MF A01; Fachinformationszentrum, Karlsruhe, West Germany DM 28

The compressibility effect on vortex shedding behind a square cylinder in front of a NACA 0018 airfoil was visualized. The mean pressure decreases with increasing Mach number (or Reynolds number). There is a tendency for the amplitude of the pressure fluctuations and the fundamental frequency (or vortex shedding frequency) to increase with increasing Mach number (or Reynolds number) except in the very high subsonic Mach number range. When the spacing between the square cylinder and the airfoil is fixed, the Strouhal number behind the square cylinder is kept at an almost constant value up to $M=0.63$. If the Mach number exceeds a critical value the Strouhal number either decreases or increases suddenly. With increasing Mach number (or Reynolds number), the formation region behind the square cylinder becomes smaller and more asymmetric, and the separating shear layers become more corrugated. ESA

N87-11738*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CALCULATED EFFECTS OF VARYING REYNOLDS NUMBER AND DYNAMIC PRESSURE ON FLEXIBLE WINGS AT TRANSONIC SPEEDS
R. L. CAMPBELL *In its* Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 (date] 19 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01A

A computational method is described that includes the effects of static aeroelastic wing deflections in steady transonic aerodynamic calculations. This method, known as the Transonic Aero-elastic Program System (TAPS), interacts a 3D transonic computer code with boundary layer and a linear finite element structural analysis codes to calculate wing pressures and deflections. The nonlinear nature of the transonic flow makes it necessary to couple the aerodynamic and structures codes in an iterative manner. TAPS has been arranged in a modular fashion so that different aerodynamic or structures programs may be used with a minimum of coding changes required. Results obtained using two different aerodynamic codes in TAPS are given, and those results are correlated with experimental data. Author

N87-12535 Texas Univ., Austin.
VISCOUS-INVISCID INTERACTION IN TRANSONIC SEPARATED FLOW OVER SOLID AND POROUS AIRFOILS AND CASCADES Ph.D. Thesis
C. R. OLLING 1985 185 p
Avail: Univ. Microfilms Order No. DA8609621

Viscous-inviscid interaction is used to compute steady two-dimensional, transonic separated flows for cascades and isolated airfoils. The full-potential code of Dulikravich is coupled with both a laminar/transition/turbulent integral boundary-layer/tubulent wake code written by the author and the finite-difference boundary-layer code of Drela using the semi-inverse method of Carter or Wigton. The transpiration coupling concept is applied. An option for a porous airfoil with passive physical transpiration is also included. Examples are presented which demonstrate that such flows can be calculated with engineering accuracy by the present code. The equivalent transpiration velocity can be larger in cascades than for isolated airfoils. Carter's update formula gives smoother solutions for a strong shock than Wigton's update formulas, although Wigton's formulas are preferred in the early coupling cycles for cascades. The computations show that passive physical transpiration can lead to a lower drag coefficient and higher lift coefficient, a weaker shock and elimination of shock-induced separation. The extent of the porous region and permeability factor distribution of the porous region must be chosen carefully if these improvements are to be achieved. Dissert. Abstr.

N87-12536 ESDU International Ltd., London (England).
INTRODUCTION TO AERODYNAMICS DERIVITIVES, EQUATIONS OF MOTION AND STABILITY
Oct. 1986 64 p Supersedes ESDU-Aero-A.00.00.02, ESDU-Aero-A.00.00.03, ESDU-Aero-A.00.00.04, and ESDU-67039
(ESDU-86021; ISBN-0-85679-573-9; ISSN-0141-397X) Avail: ESDU

This Data Item ESDU 86021 is an addition to the Aerodynamics Sub-series. It is a comprehensive introduction to the concept and use of derivatives in determining aircraft stability. After explaining a systematic method for expressing aerodynamic forces, moments, and derivatives in dimensionless form, the equations of motion for an aircraft treated as a rigid body are developed and the linearized small-perturbation form introduced. The conditions are outlined for the separation of the equations into a lateral and a longitudinal set, and a detailed study is made of the behavior of an aircraft disturbed with controls fixed from straight symmetric level flight. A comprehensive practical worked example illustrates the use of the techniques. A comparison is made between the ISO notation for derivatives used by ESDU, and the most widely used notation in the US, equations are given for deriving the longitudinal derivatives from the force and moment coefficients, and reference is included to all the ESDU validated data for lateral derivatives. Also included is the traditional treatment for static stability leading to the definitions of static and maneuver margins, and the relation between static stability and dynamic stability is discussed. Finally, a description is given in simple physical terms of commonly occurring lateral modes of an aircraft following a small disturbance. ESDU

N87-12537 ESDU International Ltd., London (England).
PROPELLAR/BODY INTERACTION FOR THRUST AND DRAG
Aug. 1986 20 p
(ESDU-86017; ISBN-0-85679-569-0; ISSN-0141-397X) Avail: ESDU

Available as part of the ESDU Sub-series on Aerodynamics, this document gives a simple method of estimating the thrust decrement and drag increment due to the interaction of propeller flow with a body (or nacelle) at zero incidence. It applies to smoothly contoured bodies with a tractor propeller at or near the nose or a pusher propeller at or near the tail and the propellers may be counter-rotating. It applies to Mach numbers up to 80 per cent of critical for the spinner-body combination. The method predicts the propulsive thrust in terms of the shaft thrust developed to within 2 or 3 per cent of thrust. A detailed discussion of the factors affecting the interaction effects is included. A comprehensive worked example shows how the method is used in combination with the method of ESDU 83001 for the propeller free-air thrust and of ESDU 78019 for the body drag propeller-off. ESDU

N87-12538*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MACH 6 EXPERIMENTAL AND THEORETICAL STABILITY AND PERFORMANCE OF A FINNED CYLINDRICAL BODY AT ANGLES OF ATTACK UP TO 65 DEG
E. R. HARTMAN and P. J. JOHNSTON Sep. 1986 45 p
(NASA-TM-89050; NAS 1.15:89050) Avail: NTIS HC A03/MF A01 CSCL 01A

A theoretical and experimental investigation of the longitudinal and lateral-directional stability and control of a finned cylindrical body has been conducted at Mach 6. The angle-of-attack range extended from 20 to 65 deg. to encompass maximum lift. Stability, performance, and trim could be accurately predicted with the fins in the + arrangement but this was not the case when the fins were in the x orientation where windward fin choking occurred at angles of attack above 50 deg. reducing their effectiveness and causing pitch up. Author

N87-12539*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
AN EXPERIMENTAL INVESTIGATION OF FREE-TIP RESPONSE TO A JET
L. A. YOUNG Sep. 1986 56 p
(NASA-TM-88250; A-86234; NAS 1.15:88250) Avail: NTIS HC A04/MF A01 CSCL 01A

The aerodynamic response of passively oscillating tips appended to a model helicopter rotor was investigated during a whirl test. Tip responsiveness was found to meet free-tip rotor requirements. Experimental and analytical estimates of the free-tip aerodynamic spring, mechanical spring, and aerodynamic damping were calculated and compared. The free tips were analytically demonstrated to be operating outside the tip resonant response region at full-scale tip speeds. Further, tip resonance was shown to be independent of tip speed, given the assumption that the tip forcing frequency is linearly dependent upon the rotor rotational speed. Author

N87-12540# Royal Aircraft Establishment, Farnborough (England).
AN APPROXIMATE METHOD OF ESTIMATING THE AERODYNAMIC INTERFERENCE BETWEEN TWO PARALLEL BODIES IN A SUPERSONIC FLOW (AXIAL FORCE)
H. KONDO Mar. 1985 28 p Transl. into ENGLISH from Technical Report of National Aerospace Laboratory, TR-751, 1983
(BR-100271; RAE-TRANS-2131) Avail: NTIS HC A03/MF A01

An approximate method of estimating the aerodynamic interference between two parallel bodies in a supersonic flow is discussed. The formulae are derived from linearized theory. The formulae for calculating the wave drag on one body are obtained as functions of Mach number, cone semi-vertex angle, and the relative distances between bodies. Theoretical calculations are compared with wind tunnel test results, and fairly good agreement is noted. It is pointed out that the present method can easily be applied to a combination of more than two bodies. Author

N87-12541*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFECT OF PORT CORNER GEOMETRY ON THE INTERNAL PERFORMANCE OF A ROTATING-VANE-TYPE THRUST REVERSER
B. L. BERRIER and F. J. CAPONE Dec. 1986 51 p
(NASA-TP-2624; L-16135; NAS 1.60:2624) Avail: NTIS HC A04/MF A01 CSCL 01A

An investigation has been conducted in the static-test facility of the Langley 16-Foot Transonic Tunnel to determine the effects of reverser port geometry on the internal performance of a nonaxisymmetric rotating-vane-type thrust reverser. Thrust reverser vane positions representing a spoiled-trust (partially deployed) position and a full-reverse-thrust (fully deployed) position were tested with each port geometry variable. The effects of upstream port corner radius and wall angle on internal performance were determined. In addition, the effect of the length of a simulated cooling liner (blunt-base step) near the reverser port entrance was investigated; five different lengths were tested. All tests were conducted with no external flows, and nozzle pressure ratio was varied from 1.2 to 5.0. Author

N87-12542*# Queensland Univ., St. Lucia (Australia). Dept. of Mechanical Engineering.
FURTHER SHOCK TUNNEL STUDIES OF SCRAMJET PHENOMENA
R. G. MORGAN, A. PAULL, N. A. MORRIS, and R. J. STALKER 12 May 1986 112 p
(Contract NAGW-674)
(NASA-CR-179937; NAS 1.26:179937; RR-10-86) Avail: NTIS HC A06/MF A01 CSCL 01A

Scramjet phenomena were studied using the shock tunnel T3 at the Australian National University. Simple two dimensional models were used with a combination of wall and central injectors. Silane as an additive to hydrogen fuel was studied over a range of temperatures and pressures to evaluate its effect as an ignition aid. The film cooling effect of surface injected hydrogen was measured over a wide range of equivalence. Heat transfer measurements without injection were repeated to confirm previous indications of heating rates lower than simple flat plate predictions for laminar boundary layers in equilibrium flow. The previous results were reproduced and the discrepancies are discussed in terms of the model geometry and departures of the flow from equilibrium. In the thrust producing mode, attempts were made to increase specific impulse with wall injection. Some preliminary tests were also performed on shock induced ignition, to investigate the possibility in flight of injecting fuel upstream of the combustion chamber, where it could mix but not burn. B.G.

N87-12543# Department of the Air Force, Washington, D.C.
LENGTH ADJUSTABLE STRUT LINK WITH LOW AERODYNAMIC DRAG Patent
D. O. NASH and J. A. CROWLEY, inventors (to Air Force) 25 Feb. 1986 8 p Supersedes AD-D011851
(AD-D012279; US-PATENT-4,571,936;
US-PATENT-APPL-SN-753462; US-PATENT-CLASS-60-39.31)
Avail: US Patent and Trademark Office CSCL 13E

This invention relates to a low aerodynamic drag structural link suitable for use within the housing of a turbofan jet engine. The link includes length adjustment capability, pivotal end mounting provision, maintained airstream orientation capability, low mass and jam nut length and orientation locking. Several variations in link construction including a single ball and socket arrangement, varying link cross-section along its longitudinal length and the use of fairing nose and tail inserts are disclosed. GRA

N87-12544# JAI Associates, Mountain View, Calif.
NUMERICAL SIMULATION OF TIP VORTICES OF WINGS IN SUBSONIC AND TRANSONIC FLOWS
G. R. SRINIVASAN, W. J. MCCROSKEY, J. D. BAEDER, and T. A. EDWARDS 1986 26 p
(Contract DAAG29-85-C-0002)
(AD-A169116; ARO-21731.1-EG) Avail: NTIS HC A03/MF A01 CSCL 20D

The formation and roll up process of the tip vortices of wings in subsonic and transonic flows is numerically simulates using a hybrid scheme of solving a zonal algorithm for thin layer Navier Stokes/Euler equations. The results are in good agreement with the available limited experimental data including the tip vortex strength. GRA

N87-12545# Analytical Methods, Inc., Redmond, Wash.
A SUMMARY OF THE DEVELOPMENT OF INTEGRAL AERODYNAMIC METHODS FOR THE COMPUTATION OF ROTOR WAKE INTERACTIONS Final Report, 1 Aug. 1981 - 30 Aug. 1984
J. M. SUMMA Mar. 1986 13 p
(Contract DAAG29-81-C-0032)
(AD-A169254; AMI-8605; ARO-18391.3-EG-S) Avail: NTIS HC A02/MF A01 CSCL 20D

The purpose of the research reported here is to develop basic methodology for a generalized forward flight aerodynamic analysis method for isolated rotors. All of the work thus far has been concerned with the development of integral methods. Efforts have concentrated on analytical modeling studies and code development for fundamental vortex/blade interactions that occur in forward flight. Calculations show that vortex core deformations can be simulated but that numerical errors in the core growth should be removed in order to study such phenomena as bursting. The computed trajectory of a tip vortex passing another wing is also validated with experiment as well as the prediction of vortex induced separations. The calculation of the rotor wake in hover has been improved and the importance of secondary vortex roll ups for a modern rotor is discussed. Finally, a time stepping panel method has been formulated and verified by application to impulsively started wings. A pilot code version for unsteady rotor motions is described along with its preliminary application to a two bladed rotor. GRA

N87-12547 Stanford Univ., Calif.
AN ANALYSIS OF BLADE VORTEX INTERACTION AERODYNAMICS AND ACOUSTICS Ph.D. Thesis
D. J. LEE 1985 176 p
Avail: Univ. Microfilms Order No. DA8602500

The impulsive noise associated with helicopter flight due to blade-vortex interaction, sometimes called blade slap, is analyzed especially for the case of a close encounter of the blade-tip vortex with a following blade. Three parts of the phenomena are considered: the tip-vortex structure generated by the rotating blade, the unsteady pressure produced on the following blade during the interaction, and the acoustic radiation due to the unsteady pressure field. To simplify the problem, we confine our analysis to the situation where the vortex is aligned parallel to the blade span in which case the maximum acoustic pressure results. The 2-dimensional incompressible flow is assumed with uniform motion of the blade. The tip-vortex is modelled so that the circulation near the tip is rolled into a concentrated vortex and the extreme case of the interaction is studied when the following blade cuts through the center of this vortex core, which is turbulent and viscous. It is further assumed that during the interaction, there is no distortion of the vortex path or of the vortex itself, in other words the interaction occurs only through the boundary condition on the blade giving an unsteady pressure on the blade surface. Acoustic radiation due to the interaction is analyzed in space-fixed coordinates and in the time domain with the unsteady pressure on the blade surface as the source of chordwise compact, but spanwise noncompact radiation. Maximum acoustic pressure is related to the vortex core size and Reynolds number which are in turn functions of the blade-tip aerodynamic parameters. Finally noise reduction and performance are considered. Dissert. Abstr.

03

AIR TRANSPORTATION AND SAFETY

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

A87-13186
FIRE SAFETY SCIENCE; PROCEEDINGS OF THE FIRST INTERNATIONAL SYMPOSIUM, GAITHERSBURG, MD, OCTOBER 7-11, 1985
C. E. GRANT, ED. and P. J. PAGNI, ED. (California, University, Berkeley) Symposium supported by the University of California. Washington, DC, Hemisphere Publishing Corp., 1986. 1241 p. For individual items see A87-13187 to A87-13189.
A symposium of papers discussing various aspects of fire research and their application to solving problems posed by destructive fire is presented. The invited lecture concerns fluid dynamic aspects of room fires. The rest of the papers are grouped into ten technical topics, including: fire physics; structural behavior; fire chemistry; people-fire interactions; translation of research into practice; detection; specialized fire problems; statistics, risk, and system analysis; smoke toxicity hazard; and suppression. C.D.

A87-13187
TURBULENT BUOYANT FLOW AND PRESSURE VARIATIONS AROUND AN AIRCRAFT FUSELAGE IN A CROSS WIND NEAR THE GROUND
H. S. KOU, K. T. YANG (Notre Dame, University, IN), and J. R. LLOYD (Michigan State University, East Lansing, MI) IN: Fire safety science; Proceedings of the First International Symposium, Gaithersburg, MD, October 7-11, 1985 . Washington, DC, Hemisphere Publishing Corp., 1986, p. 173-184. FAA-supported research. refs
(Contract NBS-NB-81-NADA-2000)
Two-dimensional numerical finite-difference calculations have been carried out to study the effects of cross wind speeds and the elevation of the fuselage on turbulent buoyant flow and pressure variations around an aircraft fuselage engulfed in a simulated fire in a uniform cross wind near the ground. Detailed velocity, temperature, smoke concentration, and pressure fields have been obtained and it is found that a major influence on the physical phenomena is the relative strength of the cross flow and the buoyant flow. Author

A87-13578
AIRCRAFT ACCIDENT INVESTIGATION
R. R. MCMEEKIN (U.S. Armed Forces Institute of Pathology, Washington, DC) IN: Fundamentals of aerospace medicine . Philadelphia, PA, Lea and Febiger, 1985, p. 762-814. refs
Aircraft accident investigations are described, emphasizing post-mortem examinations and administrative planning. The NTSB has the authority to perform autopsies on all victims of civil aircrat accidents. Attention is given to community and municipality planning for disasters and the necessity of drills for identifying weak areas in planning. M.S.K.

A87-13581
AIRCRAFT ACCIDENTS, SURVIVAL, AND RESCUE
R. L. DEHART (Industrial Medicine Employer's Service of Oklahoma, Inc.; Hillcrest Occupational Medicine Services, Tulsa; Oklahoma, University, Norman) and K. N. BEERS (Wright State University, Dayton, OH) IN: Fundamentals of aerospace medicine . Philadelphia, PA, Lea and Febiger, 1985, p. 862-887. refs
The database on air accidents is reviewed, with emphasis on survivability and the chances for rescue. The discussion covers civil transport, general aviation and military aircraft crashes. Takeoff and landing are identified as the most hazardous flight phases, and pleasure flying is shown to be the most significant contributer to general aviation accidents. M.S.K.

A87-13627
AIRWORTHINESS OF COMPOSITE STRUCTURES - SOME EXPERIENCES FROM CIVIL CERTIFICATION
J. W. BRISTOW (Civil Aviation Authority, Redhill, England) IN: Fibre reinforced composites 1986; Proceedings of the Second International Conference, Liverpool, England, April 8-10, 1986 . London, Mechanical Engineering Publications, Ltd., 1986, p. 147-152. refs
In this paper details are given of the guidance material used in the application of airworthiness requirements to primary structure in composite material in recent years. Some experience gained from the application of these requirements from the viewpoint of an airworthiness authority is also presented. Author

A87-13684
REALISTIC CIVIL HELICOPTER CRASH SAFETY
R. G. FOX (Bell Helicopter Textron, Fort Worth, TX) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 14 p. refs
Realistic crashworthiness criteria established by the Rotorcraft Airworthiness Requirement Committee of AIA for the seats, restraints, and fuel systems of future civil helicopters are discussed. Energy attenuating seats with shoulder harnesses and the Crash Resistant Fuel System are recommended as future requirements, which should be introduced into the initial design concept to minimize the weight increase.Furthermore, these requirements must be realistic for the civil helicopter crash environment and not suffer the severe weight penalties of military requirements. I.S.

A87-13685
ANALYSIS OF U.S. CIVIL ROTORCRAFT ACCIDENTS FOR DEVELOPMENT OF IMPROVED DESIGN CRITERIA
J. W. COLTMAN (Simula, Inc., Phoenix, AZ) and L. M. NERI (FAA Technical Center, Atlantic City, NJ) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 8 p. refs
A review was conducted of U.S. civil helicopter accidents occurring between 1974 and 1978 to determine typical impact conditions. A total of 311 accident cases were evaluated out of 1351 accidents which occurred during the five year period. Accident reconstruction techniques were used to determine the impact velocities and aircraft orientation at impact. This paper presents a summary of the important impact parameters and discusses six typical 'crash scenarios' for civil rotorcraft. Also, a comparison is made between the severity of injuries received by occupants with lap-belt only restraint, and those wearing a lap belt and shoulder harness. The data developed in this study provides a basis for formulating design criteria for future civil rotorcraft. Author

A87-13686
ACQUISITION AND USE OF DATA FOR CRASHWORTHINESS IMPROVEMENTS IN U.S. ARMY AIRCRAFT
B. H. ADAMS (U.S. Army Safety Center, Fort Rucker, AL) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 9 p. refs
Mishap data continue to serve as one of the principal foundations for the establishment of crashworthiness criteria for U.S. Army aircraft. This paper reviews the Army process for gathering the data and discusses its use in demonstrating the cost effectiveness of crashworthiness enhancements for future Army aircraft. This paper discusses the need for the data to support management decisions in the area of remedying crashworthiness deficiencies in existing aircraft systems. Author

A87-13687
IMPACT SEVERITY AND POTENTIAL INJURY PREVENTION IN GENERAL AVIATION ACCIDENTS
F. A. SHERERTZ (National Transportation Safety Board, Washington, DC) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 9 p.

The National Transportation Safety Board examined 535 general aviation accidents in order to determine the limits of real-world survivable crash loads and to determine the potential benefits of occupant restraints and energy-absorbing seats in survivable accidents. The data developed suggest that the survivable envelope is defined by impact speeds of 45 knots at 90 degrees of impact angle, 60 knots at 45 degrees, and 75 knots at zero degrees. Data are presented which demonstrate that if all occupants wore shoulder harnesses, fatalities could be expected to be reduced by 20 percent. Author

A87-13776
AERODYNAMIC DECELERATOR AND BALLOON TECHNOLOGY CONFERENCE, 9TH, ALBUQUERQUE, NM, OCTOBER 7-9, 1986, TECHNICAL PAPERS
Conference sponsored by AIAA. New York, American Institute of Aeronautics and Astronautics, 1986, 338 p. For individual items see A87-13777 to A87-13818.

The present conference discusses such topics a flight risk index, balloon flight mechanics in homothermic and nonhomothermic conditions, parachute design for supersonic and subsonic payload recovery, NASA wind-tunnel testing of supersonic ribbon parachutes, and the prediction of decelerator behavior with CFD. Also considered are the controlled terminal descent and recovery of large aerospace components, the degradation of nylon and Kevlar materials, a computer design code for conical ribbon parachutes, and a two-stage parachute system for the delivery of troops from high speed aircraft. O.C.

A87-13777#
TECHNICAL-HISTORICAL DEVELOPMENT OF PARACHUTES AND THEIR APPLICATIONS SINCE WORLD WAR I
T. W. KNACKE IN: Aerodynamic Decelerator and Balloon Technology Conference, 9th, Albuquerque, NM, October 7-9, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 1-10. refs
(AIAA PAPER 86-2423)

A development history is presented for parachute designs and applications, with attention to several highly specialized parachute types. Also noted are effects on parachute development due to the requirement of ejection-seat escape systems aboard high-speed aircraft and to the need for recovery of spacecraft after reentry. Parachute types treated include ribbon parachutes, extended skirt parachutes, airfoil/annular parachutes, ram air-inflated 'ballute' decelerators, ringsail parachutes, parafoil maneuverable parachutes, and Rogallo wing maneuverable parachutes. O.C.

A87-13784#
AUTOMATIC VARIABLE REEFING OF PARACHUTES BY APPLICATION OF INFLATION FORCES
D. B. WEBB (Irvin Industries Canada, Ltd., Fort Erie, Canada) IN: Aerodynamic Decelerator and Balloon Technology Conference, 9th, Albuquerque, NM, October 7-9, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 44-48.
(AIAA PAPER 86-2434)

The automatic inflation modulation concepts presented for automatic parachute reefing employ a small, Webb-type auxiliary parachute inside the mouth of the main parachute canopy to exert a controlled, circular opening force on the main canopy mouth. The reefing action of the main parachute is obtained by using the force generated at its crown to restrain the main canopy lines. This restraining force diminishes as the dynamic pressure in the canopy crown decays, so that the canopy can inflate slowly to its fully open state. O.C.

A87-13794#
AVERAGE LANDING FORCE DEPENDENCE ON LENGTH AND DIRECTION OF LANDING, PARACHUTE VELOCITY COMPONENTS AND WIND SPEED
J. MEYER (Arizona, University, Tucson) IN: Aerodynamic Decelerator and Balloon Technology Conference, 9th, Albuquerque, NM, October 7-9, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 127-131.
(AIAA PAPER 86-2452)

Average landing forces were calculated in the present paper by applying work-kinetic energy principles to a pilot landing under a parachute on solid level ground. The landing event started when the pilot's feet first touched the ground and stopped when the pilot came to rest on the ground. The dragging of a pilot by a wind-inflated parachute was not considered. Parachute velocity components, landing direction and distance, and wind speed were varied to determine their effects on average landing forces. Results, in the form of average net force contour plots, were used to find optimal parachute velocity components for a sample scenario. The contour plots showed that an optimal ground speed exists for each descent rate, longer landing distances lowered landing forces, landing along the parachute's glide path minimized landing forces and slightly off heading landings increase the landing forces by a small amount. Author

A87-13806#
LOW COST AERIAL TESTING OF PARACHUTES
J. V. HOGAN (Irvin Industries Canada, Ltd., Fort Erie, Canada) IN: Aerodynamic Decelerator and Balloon Technology Conference, 9th, Albuquerque, NM, October 7-9, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 217-221.
(AIAA PAPER 86-2472)

The methods used by Irvin Canada for instrumented aerial testing of parachutes are described. It has been found that through the use of a digital data logger onboard a simple air launched C.T.V. (Cylindrical Test Vehicle), sustained testing at the notably low labor level of 10 man-hours per drop is attainable. A live jump installation of virtually the same equipment yields similar data collection economy. Typical results from both C.T.V. and live jump tests are provided. Author

A87-13809#
PERFORMANCE PREDICTION FOR FULLY-DEPLOYED PARACHUTE CANOPIES
T. YAVUZ (Erciyes University, Kayseri, Turkey) IN: Aerodynamic Decelerator and Balloon Technology Conference, 9th, Albuquerque, NM, October 7-9, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 231-238. refs
(AIAA PAPER 86-2475)

In this paper, introducing experimentally determined apparent mass terms into the equations of motion the performance characteristics of a descending parachute-store system have been determined to resemble those observed, so as to give an appropriate basis for performance prediction. Using phase lag instead of the variable apparent mass terms in the equations, the dynamic stability of the system has also been analysed. It was found that, for a parachute which has high value of d(C) sub N/d(alpha) about the equilibrium angle, the influences of the apparent masses and the phase lag on the performance characteristics of the system are not significant. Author

A87-13815#
A COMPARISON OF MEASURED AND CALCULATED STRESS IN SOLID AND RIBBON PARACHUTE CANOPIES
W. L. GARRARD, M. L. KONICKE, and K. S. WU (Minnesota, University, Minneapolis) IN: Aerodynamic Decelerator and Balloon Technology Conference, 9th, Albuquerque, NM, October 7-9, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 299-309. Research supported by Sandia National Laboratories. refs
(AIAA PAPER 86-2488)

This paper reports the results of a study of measured and calculated stress distributions in solid, ribbon, and simulated ring-slot parachutes. Stress measurements were accomplished using Omega sensors and the stresses were calculated using a finite element stress analysis code called CANO. In the case of the ribbon parachute the inflated shape was measured and compared with the shape predicted using CANO. Author

A87-13818#
DESIGN AND DEVELOPMENT OF A TWO-STAGE PARACHUTE SYSTEM FOR DELIVERY OF TROOPS FROM A HIGH-SPEED AIRCRAFT
J. W. WATKINS (U.S. Army, Natick Research, Development and Engineering Center, MA) IN: Aerodynamic Decelerator and Balloon Technology Conference, 9th, Albuquerque, NM, October 7-9, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 327-334.
(AIAA PAPER 86-2448)

A two-stage parachute system has been designed to meet U.S. Army requirements for the parachute dropping of small groups of special troops behind enemy lines in a high-threat environment, from aircraft that approach the drop zone at high speed and low altitude. In the first system stage, a small drogue parachute decelerates and stabilizes the jumper. A time-delay pyrotechnic cutter then initiates deployment of the second stage, or main recovery parachute. Extremely high reliability is made a critical consideration by the preclusion of a reserve parachute in this system's requirements; it must also not generate forces that could injure a jumper. Attention is presently given to first stage parachute and staging component modifications conducted on the basis of initial test results. The modified system has successfully completed preliminary testing. O.C.

A87-13823#
THE ANNULAR PARACHUTE - AN APPROACH TO A LOW ALTITUDE PERSONNEL PARACHUTE
E. J. FALLON, J. WATKINS (U.S. Army, Natick Research, Development and Engineering Center, MA), and E. D. VICKERY (Pioneer Parachute Co., Manchester, CT) AIAA, Aerodynamic Decelerator and Balloon Technology Conference, 9th, Albuquerque, NM, Oct. 7-9, 1986. 18 p. refs
(AIAA PAPER 86-2449)

This paper discusses the use of the Annular Parachute for a low altitude personnel parachute. The discussion includes a historical narrative as well as current research on the Annular Parachute. Based upon the historical narrative and flight tests at this time, the Annular Parachute shows a high drag efficiency and good stability making it a good candidate for a low altitude personnel parachute. Author

A87-14371*# Michigan Technological Univ., Houghton.
AIRPLANE FLIGHT THROUGH WIND-SHEAR TURBULENCE
G. TREVINO (Michigan Technological University, Houghton) Journal of Aircraft (ISSN 0021-8669), vol. 23, Sept. 1986, p. 733-735. NASA-supported research. refs

An analytical model is developed for the interaction between wind shear and turbulence to improve the database for realistic flight simulator programming. Shear is treated as a spatially nonconstant mean flow, with consideration given to the associated anisotropy which can be a critical factor in landing approaches and take-offs during microburst events. A two-point velocity correlation is defined for anisotropic turbulence and the dynamical implications are analyzed. Emphasis is placed on turbulence conditions and scale lengths during a microburst, when turbulence is nonhomogeneous. M.S.K.

A87-14620
NOW HEAR THIS
H. HOPKINS Flight International (ISSN 0015-3710), vol. 130, Aug. 23, 1986, p. 26-28.

The need for distinctive warning sounds which are matched to the level of cockpit noise is discussed. The problems of warning loudness and of having numerous auditory warnings were studied. It is determined that pilots can quickly learn between four to six different sounds and confusion occurs between different sounds with similar repetition rates. The development and testing of warning sets for civil and military helicopters are examined. The use of auditory signals composed of bursts to warn of problems is described. I.F.

A87-14861#
GROUND-BASED DETECTION OF AIRCRAFT ICING CONDITIONS USING MICROWAVE RADIOMETERS
I. A. POPA FOTINO, M. T. DECKER (Cooperative Institute for Research in Environmental Sciences, Boulder, CO), and J. A. SCHROEDER (NOOA, Wave Propagation Laboratory, Boulder, CO) (1985 International Geoscience and Remote Sensing Symposium /IGARSS '85/, Amherst, MA, Oct. 7-9, 1985) IEEE Transactions on Geoscience and Remote Sensing (ISSN 0196-2892), vol. GE-24, Nov. 1986, p. 975-982. refs
(Contract DOT-FA01-84-Z-02021)

The potential role of ground-based remote sensors in the detection of atmospheric conditions conducive to aircraft icing is evaluated. Zenith measurements of liquid water and profiles of atmospheric temperature were made by microwave radiometers located at Stapleton International Airport, Denver, CO. Radiometer data and sky cover observations for a two-year period were correlated with icing occurrences reported by aircraft pilots in the area. Given certain limitations, it is concluded that the liquid measurement makes a critical contribution to the detection of icing conditions. This measurement is not generally available (e.g., from radiosondes), except from sensors like the radiometer. Author

A87-15001
INTERNATIONAL AEROSPACE AND GROUND CONFERENCE ON LIGHTNING AND STATIC ELECTRICITY, 11TH, DAYTON, OH, JUNE 24-26, 1986, TECHNICAL PAPERS
Conference sponsored by the National Interagency Coordination Group. Fairborn, OH, National Interagency Coordination Group, 1986, 390 p. For individual items see A87-15002 to A87-15041.

The present conference on the status of research activities, theoretical characterizations, and practical measures related to atmospheric electricity effects on aerospace systems gives attention to the prediction of temperature rises in conductors carrying impulse currents, results from NASA's storm hazards lightning research in 1980-1985, a threat-level lightning simulator, lightning strikes to German military aircraft, and EM measurements on an aircraft from direct lightning attachment. Also discussed are a comparison between aircraft lightning-induced transient test data and predictions, the corona from simulated aircraft surfaces and their contribution to the triggered discharge, lightning current redistributions, and intercloud discharges. O.C.

A87-15003*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SUMMARY OF NASA STORM HAZARDS LIGHTNING RESEARCH, 1980-1985
B. D. FISHER, P. W. BROWN (NASA, Langley Research Center, Hampton, VA), and J. A. PLUMER (Lightning Technologies, Inc., Pittsfield, MA) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 4-1 to 4-16. refs

Lightning swept-flash attachment patterns and the associated flight conditions were recorded from 1980-1985 during 1378 thunderstorm penetrations and 690 direct strikes with a NASA

F-106B research airplane. The individual lightning attachment spots, along with crew comments and onboard photographic data have been used to identify lightning swept-flash attachment patterns and the orientations of the lightning channels with respect to the airplane. The altitudes, ambient temperatures, and the relative turbulence and precipitation levels at which the strikes occurred also are summarized and discussed, with an emphasis on the differences between high and low altitude strikes. Author

A87-15004*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

F-106 DATA SUMMARY AND MODEL RESULTS RELATIVE TO THREAT CRITERIA AND PROTECTION DESIGN ANALYSIS

F. L. PITTS, G. B. FINELLI (NASA, Langley Research Center, Hampton, VA), R. A. PERALA, and T. H. RUDOLPH (Electro Magnetic Applications, Inc., Lakewood, CO) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 5-1 to 5-20. refs

The NASA F-106 has acquired considerable data on the rates-of-change of EM parameters on the aircraft surface during 690 direct lightning strikes while penetrating thunderstorms at altitudes from 15,000 to 40,000 feet. The data are presently being used in updating previous lightning criteria and standards. The new lightning standards will, therefore, be the first which reflect actual aircraft responses measured at flight altitudes. Author

A87-15005*# Military Academy, West Point, N. Y.

INTERPRETATION OF A CLASS OF IN-FLIGHT LIGHTNING SIGNATURES

T. F. TROST (U.S. Army, Military Academy, West Point, NY) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 6-1 to 6-9. refs

(Contract NAG1-28)

Data recorded on the NASA F-106B research aircraft during lightning strikes often reveals electric field waveforms which begin with a series of abrupt changes and end in an exponential variation. A possible interpretation of such events is that an ionized channel is completed to the aircraft during the time of the abrupt changes, and the charge on the aircraft dumps into this channel during the time of the exponential. An analysis of measured waveforms assuming a simple RC-circuit model has been carried out for one event, and the results include $I = 1000$ A, $V = -650$ kV, $R = 1000$ Ohms, and $W = 100$ J. Author

A87-15008#

LIGHTNING STRIKES TO AIRCRAFT OF THE GERMAN FEDERAL ARMED FORCES

W. ZIEGLER (Bundesamt fuer Wehrtechnik und Beschaffung, Coblenz, West Germany) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 10-1 to 10-6.

A survey is given of the lightning strikes from 1973 through 1985. About 80 percent of the more than 345 lightning strikes reported involved the following four types of aircraft: F-104G, F-4, C-160, and BR-1150. For these four aircraft the lightning strike rates per year and the average rates for the whole period of 13 years are shown. The hazard to the respective aircraft at the time of the lightning strike is assessed with respect to each incident of damage and classified according to four hazard severity categories, as specified: catastrophic, critical, tolerable and negligible. Author

A87-15013#

SPATIAL AND TEMPORAL DESCRIPTION OF STRIKES TO THE FAA CV-580 AIRCRAFT

J. S. REAZER and A. V. SERRANO (Technology/Scientific Services, Inc., Dayton, OH) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 15-1 to 15-11. refs

An analysis is made of lightning strike waveforms recorded digitally by the wideband EM sensors and current shunts of the FAA CV-580 research aircraft, during thunderstorm flights at 2000 to 18,000 ft. The waveforms were recorded at a sample rate of 5 nsec in order to yield 10-microsec windows with a 100-MHz frequency response. Current paths on the wings and fuselage are illustrated for several strikes. The inferred attachment points are correlated with recordings from the four video cameras installed on the aircraft. O.C.

A87-15014#

SIMULTANEOUS AIRBORNE AND GROUND MEASUREMENT OF LOW ALTITUDE CLOUD-TO-GROUND LIGHTNING STRIKE ON CV-580 AIRCRAFT

J. S. REAZER (Technology/Scientific Services, Inc., Dayton, OH) and R. D. RICHMOND (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 16-1 to 16-4.

The instrumented CV-580 aircraft used during the 1984-1985 Airborne Lightning Characterization Program was struck three times while flying at low altitude. Attention is presently given to one event, during which simultaneous ground measurements of the electric and magnetic fields were made; these are used to estimate peak channel current at the point of impact, in order to predict the current encountered at the aircraft altitude of 600 m. The results obtained are compared with aircraft data, and the current amplitudes, polarities, and paths, as well as the predicted currents, are used to determine the portion of the cloud-to-ground lightning stroke that was intercepted by the aircraft. O.C.

A87-15015#

COMPARISON OF ELECTROMAGNETIC MEASUREMENTS ON AN AIRCRAFT FROM DIRECT LIGHTNING ATTACHMENT AND SIMULATED NUCLEAR ELECTROMAGNETIC PULSE

H. D. BURKET (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 17-1 to 17-17. refs

The FAA CV-580 aircraft was flown in Florida thunderstorms during 1984-1985 in order to measure aircraft response to direct lightning attachment; the EM field and current levels continuously recorded with a 28-channel analog recorder were time-synchronized with ten-microsec windows of digital data having 5-nsec sample intervals. The aircraft was then subjected to simulated nuclear EMP. Comparisons are presently made between the EM field levels recorded aboard the aircraft during simulated nuclear EMP, scale-model extrapolations based on responses from scale model tests, and responses from two direct lightning attachments. O.C.

A87-15016#

ANALYSIS OF THE FIRST MILLISECONDS OF AIRCRAFT LIGHTNING ATTACHMENT

J. P. MOREAU and J. C. ALLIOT (ONERA, Chatillon-sous-Bagneux, France) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 18-1 to 18-6. DRET-supported research. refs

This paper presents a characterization of the lightning attachment to an aircraft based on the study of field and current measurements made during the first milliseconds of the phenomenon. The data have been collected during the CV-580 1984 program (20 strikes), the C-160 program (12 strikes) and the CV-580 1985 program (30 strikes). The parameters being characterized are the current and the electric and magnetic field on the aircraft surface. It is shown how the pulse-repetition rate of the electromagnetic pulses found during this first period indicates that the aircraft sustains different physical processes. This phenomenology will be the one encountered in a laboratory experiment, using a 6 MV generator sparking over a floating 4-m cylinder. All these studies lead to some conclusions about lightning simulation for indirect effects on aircraft. Author

A87-15017#

CURRENT LEVELS AND DISTRIBUTIONS ON AN AIRCRAFT DURING GROUND LIGHTNING SIMULATION TESTS AND IN-FLIGHT LIGHTNING ATTACHMENTS

J. L. HEBERT (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), J. S. REAZER, J. G. SCHNEIDER, M. D. RISLEY, and A. V. SERRANO (Technology/Scientific Services, Inc., Dayton, OH) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 19-1 to 19-21. refs

The current levels and distributions obtained during lightning strikes on the FAA CV-580 aircraft are compared with those gathered by means of ground simulation tests employing two generators and two return path configurations. It is found that the choice of lightning simulation generators and return path configurations has a pronounced effect on the current levels and distributions experienced on the aircraft, as is demonstrated by the transfer functions generated by each configuration. O.C.

A87-15021#

ATMOSPHERIC ELECTRICITY HAZARDS PROTECTION (AEHP) DEMONSTRATION

R. C. BEAVIN and M. P. HEBERT (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 24-1 to 24-5.
(Contract F33615-82-C-3406)

The Wright Laboratory Atmospheric Electricity Hazards Projection (AEHP) advanced development program has demonstrated AEHP schemes for fighter, transport/bomber, helicopter and cruise missile classes using the modified F-14 and All-Composite Airframe Program testbeds. Various protection concepts will be applied to configure additional demonstrator testbeds; the concepts encompass circuit shielding, terminal protection, conducting floors, and cable protection methods. AEHP investigations also address the problems of physical and thermal damage as a result of direct attachment to both composite and metallic airframes. The application of both swept-frequency CW and time-domain pulses to the AEHP program is discussed. O.C.

A87-15022#

AIRCRAFT LIGHTNING-INDUCED TRANSIENT TEST AND PROTECTION COMPARISON

M. M. SIMPSON (Boeing Military Airplane Co., Seattle, WA) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 25-1 to 25-6. refs
(Contract F33615-82-C-3406)

Attention is given to the features and results of a distributed parameter network model, consisting of both transmission line models and lumped parameter networks, for calculating the moderate level current pulse responses of a modified F-14A testbed in order to evaluate its lightning protection design. Ten transfer function and nine moderate level pulse comparisons were made between test responses. It is noted that the moderate level peak amplitude predictions selected for these comparisons were from 1.2 to 7.4 times greater than the measured peak amplitudes, and that the predicted responses were more oscillatory than the measured response. O.C.

A87-15024#

CORONA FROM SIMULATED AIRCRAFT SURFACES AND THEIR CONTRIBUTION TO THE TRIGGERED DISCHARGE

R. W. SHELTON and J. A. BICKNELL (University of Manchester Institute of Science and Technology, England) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 28-1 to 28-9. refs
(Contract AF-AFOSR-83-0083)

Evidence that aircraft may trigger an high current discharge, including the lightning strike, has been accumulating in recent years. The results of some experiments designed to simulate this type of breakdown suggest that a crucial part of the mechanism involves the interaction of positive corona streamers with the precipitation. Based on this idea the required breakdown fields have been estimated experimentally as a function of altitude. Author

A87-15033#

IMPLEMENTATION OF GEMACS FOR LIGHTNING INTERACTIONS ANALYSIS

E. L. COFFEY (Advanced Electromagnetics, Albuquerque, NM) and J. L. HEBERT (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 42-1 to 42-9. refs

The General Electromagnetic Model for the Analysis of Complex Systems (GEMACS), presently implemented for the analysis of lightning-aircraft interactions in the specific case of skin current distributions on an advanced composite helicopter testbed, incorporates the method of moments and the geometrical theory of diffraction, as well as a hybrid solution technique. The emphasis of the present GEMACS predictions of lightning-aircraft coupling is on ease of use, including the generation of structure geometry, physics, and surface current computations. Examples considered include free field and direct attachment coupling, as well as perfectly conducting versus finite conduction airframes. O.C.

A87-15034#

COMPARISON OF ABSORPTION AND RADIATION BOUNDARY CONDITIONS IN A TIME-DOMAIN THREE-DIMENSIONAL FINITE-DIFFERENCE CODE

C. F. WILLIFORD, R. JOST (USAF, Institute of Technology, Wright-Patterson AFB, OH), and J. L. HEBERT (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 44-1 to 44-10. refs

Three three-dimensional finite difference codes have been used to furnish effective time-domain predictions of skin current distributions due to an aerospace vehicle's interaction with nearby and direct lightning strikes. The use of absorption and radiation boundary conditions in these codes is analyzed, and the codes are validated in light of airborne lightning strike data for a nose-to-tail strike on an F-16. These predictions are compared with data from a CV-580 instrumented aircraft during an actual wing-to-wing lightning strike event. The results, advantages, and disadvantages of the use of each type of boundary condition are discussed. O.C.

A87-15038#
MINIMUM IGNITION LEVELS OF AIRCRAFT FUEL CONSTITUENTS TO LIGHTNING RELATED IGNITION SOURCES
K. E. CROUCH (Lightning Technologies, Inc., Pittsfield, MA) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 48-1 to 48-17. refs

Three basic ignition sources were investigated to establish conditions leading to the minimum ignition of mixtures of fuel vapors and air. A 200 microjoule spark was found to have an ignition probability of 0.01 to 0.1 percent. Sparks of 600 to 700 microjoules represent a 50-percent ignition probability. Hot spots of 1 sq cm required temperatures of greater than 800 C to ignite. Corona (glow discharge) was found incapable of ignition until the discharge transitioned into an arc. Author

A87-15180
AIRLINES LOOK AT 150-SEATERS
B. SWEETMAN and D. WOOLLEY Exxon Air World, vol. 38, no. 2, 1986, p. 12-15, 30.

The effects of economic changes and deregulation on the structuring of airlines are considered. The rebalancing of airline fleets from large aircraft to 150-seaters due to changing interest rates and lower fuel cost is examined. The conversion of turbofan-powered aircraft to propeller-powered aircraft is proposed. I.F.

N87-11706# National Transportation Safety Board, Washington, D. C.
NATIONAL TRANSPORTATION SAFETY BOARD SAFETY RECOMMENDATION
16 Jan. 1986 12 p
Avail: NTIS HC A02/MF A01

On November 3, 1984, a Cessna T210L, with a commercial pilot and a private pilot on board, was involved in a flight control malfunction incident during a takeoff ground run at Palwaukee Airport, Wheeling, Illinois. The commercial pilot stated that during the preflight and just before takeoff, the flight controls operated normally. After adding power to take off, he attempted to apply back pressure to rotate, but was unable to move the control yoke. The takeoff was aborted without further incident. A postincident inspection of the airplane revealed that the ribbon wire, Cessna Part No.1570308-1, for the control yoke electrical switches had jammed under the control column bearings, thus restricting the movement of the yoke. When the ribbon wire was removed from under the bearings, but while still installed in the airplane, investigators found an excessive amount of slack in the wire. When the flight controls were moved to their full extension limit, some slack still remained in the ribbon wire. On May 14, 1979, the Cessna Aircraft Corporation issued Service Information Letter No. SE 79-26, regarding 1978 and 1979 Cessna 210 and P210 models. The letter recommended that guides be installed under two of the four bearings to prevent the ribbon wire from becoming caught under the bearings. However, the letter did not address Cessna 210 models manufactured between 1970 and 1977, serial numbers (SN's) 59200 through 62273, or four other Cessna airplanes which incorporate the same ribbon wire arrangement. Author

N87-11707# Arinc Research Corp., Annapolis, Md.
GROUND AIRCRAFT DEICING TECHNOLOGY REVIEW Final Report, Sep. 1984 - Mar. 1986
D. MAYER, J. MICHITSCH, and R. YU Mar. 1986 116 p
(Contract DTFA03-84-C-00086)
(DOT/FAA/CT-85/21; REPT-3038-01-1-3985) Avail: NTIS HC A06/MF A01

A review and update of operational, procedural, and system information regarding on-ground deicing of aircraft prior to flight is presented. It reflects current practices of the different segments of aviation with the preponderance of information addressing the ground deicing operations and procedures employed by the airlines. Survey results presented in this report reflect the airlines' adherence to the clean aircraft concept as presented in Advisory Circular 20-117, and also indicates the need for a better understanding of the different types of deicing fluids and facilities currently available. Author

N87-11708# RMS Technologies, Inc., Trevose, Pa.
CRASH DYNAMICS PROGRAM TRANSPORT SEAT PERFORMANCE AND COST BENEFIT STUDY Final Report, Mar. 1984 - Oct. 1985
M. R. CANNON and R. E. ZIMMERMANN Oct. 1986 97 p
Prepared in cooperation with Simula, Inc., Tempe, Ariz.
(Contract DTFA03-81-C-00040)
(DOT/FAA/CT-85/36; TR-85433) Avail: NTIS HC A05/MF A01

Work performed to support the Federal Aviation Administration's Crash Dynamics Program is described. An element of the program was the Controlled Impact Demonstration (CID) of a Boeing 720 aircraft. Work related to the CID involved developing modifications of commercial transport seats to improve their structural crashworthiness, then installing them alongside standard, unmodified seats aboard the test aircraft. This was followed by posttest analyses of the CID data and examination of the test specimens. Other supporting work included a literature review of the development of transport seats from the 1950's to the present, an investigation of the elements affecting transport seats' performance in a crash environment, and recommended changes that would improve the seats' survival. Additionally, a study was performed of severe survivable transport accidents between 1970 and 1983 to determine the effect transport seat performance had on passenger survival, and to identify instances where an improved seat/restraint system might have been beneficial. Author

N87-11709# European Space Agency, Paris (France).
COMPARATIVE FLIGHT MEASUREMENT OF ICING PARAMETERS FOR THE DO 28 D2 PROPELLER-DRIVEN AIRCRAFT OF THE GERMAN ARMY TESTING OFFICE 61 AND FOR DFVLR'S FALCON 20 E JET AIRCRAFT IN STRATUS CLOUDS
K. P. SCHICKEL and K. UWIRA Sep. 1985 54 p Transl. into ENGLISH from "Vergleichende Flukgmessung der Vereisungsparameter des Propellerflugzeugs DO 28 D2 der Erprobungsstelle 61 der Bundeswehr und des Strahlflugzeugs Falcon 20 E der DFVLR in Stratiformen Wolken" (Oberpfaffenhofen, W. Germany Original language document was announced as N86-10720
(ESA-TT-941; DFVLR-FB-85-16; ETN-86-98240) Avail: NTIS HC A04/MF A01; original German version available at DFVLR, Cologne, West Germany DM 15.50

Two aircraft of different types and instrumentation were compared during a flight operation in icing stratus clouds. The results of the measurements are comparable. It is established that differences between icing and nonicing stratus clouds can be detected in infrared satellite pictures; possible causes of these differences are given. The improvement of forecasts of icing stratus clouds is planned. ESA

N87-11710# National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
AIRCRAFT ACCIDENT REPORTS: BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 5 OF 1985 ACCIDENTS
2 Jun. 1986 412 p
(PB86-916919; NTSB/AAB-86/19) Avail: NTIS HC A18/MF A01; also available on subscription, North American Continent HC $230.00/year, all others write for quote CSCL 01B

The publication contains selected aircraft accident reports in Brief Format occurring in U.S. civil and foreign aviation operations during Calendar Year 1985. Approximately 200 General Aviation and Air Carrier accidents contained in the publication represent a random selection. The publication is issued irregularly, normally eignteen times each year. The Brief format represents the facts, conditions, circumstances and probable cause(s) for each acci]dent. GRA

N87-11711# National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
RUNWAY INCURSIONS AT CONTROLLED AIRPORTS IN THE UNITED STATES Special Investigation Report, 1985 - 1986
6 May 1986 109 p
(PB86-917003; NTSB/SIR-86/01) Avail: NTIS HC A06/MF A01; also available on subscription, North American Continent HC $60.00/year, all others write for quote CSCL 01B

A special investigation discusses the problem of runway incursions based on the results of the Safety Board investigations of 26 selected incidents. Details of the 26 incursions are summarized in an appendix to the report. The report discusses the issues that the Safety Board found most relevant to the runway incursion problem at controlled airports in the United States. The report includes a review of previous runway incursion incidents and accidents that led to recommendations to the Federal Aviation Administration for remedial actions. The effectiveness and status of the remedial actions are evaluated in the report, which concludes with new safety recommendations for actions that the Board believes would significantly reduce the frequency of runway incursions. GRA

N87-11712# National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
AIRCRAFT ACCIDENT REPORTS: BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 4 OF 1985 ACCIDENTS
3 Jun. 1986 406 p
(PB86-916918; NTSB/AAB-86/18) Avail: NTIS HC A18/MF A01 CSCL 01B

Selected aircraft accident reports in Brief Format occurring in U.S. civil and foreign aviation operations during Calendar Year 1985 are given. Approximately 200 General Aviation and Air Carrier accidents contained in the publication represent a random selection. The Brief Format represents the facts, conditions, circumstances and probable cause(s) for each accident. GRA

N87-11713# National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
AIRCRAFT ACCIDENT REPORTS: BRIEF FORMAT, US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 3 OF 1985 ACCIDENTS
30 Apr. 1986 416 p
(PB86-916917; NTSB/AAB-86/17) Avail: NTIS HC A18/MF A01 CSCL 01B

Selected aircraft accident reports in Brief Format occurring in U.S. civil and foreign aviation operations during Calendar Year 1985 are given. Approximately 200 General Aviation and Air Carrier accidents contained in the publication represent a random selection. The Brief Format represents the facts, conditions, circumstances and probable cause(s) for each accident. GRA

N87-11714# National Transportation Safety Board, Washington, D. C. Bureau of Safety Programs.
REVIEW OF ACCIDENT DATA: US GENERAL AVIATION CALENDAR YEAR 1982 Annual Report
16 Feb. 1986 246 p
(PB86-201910; NTSB/ARG-86/01) Avail: NTIS HC A11/MF A01 CSCL 01B

A statistical compilation and review of general aviation accidents which occurred in 1982 in the United States, its territories and possessions, and in international waters are given. The accidents reported are all those involving U.S. registered aircraft not conducting air carrier revenue operations under 14 CFR 121, 14 CFR 125, 14 CFR 127, or 14 CFR 135. A review of a subset of all general aviation accidents is given. Each subset represents aircraft of similar types or aircraft being operated for particular purposes. Several tables present accident parameters for 1982 only, and each section includes tabulations which present comparative statistics for 1982 and for the five-year period 1977 to 1981. GRA

N87-11746*# Kentron International, Inc., Hampton, Va.
MULTIDISCIPLINARY OPTIMIZATION APPLIED TO A TRANSPORT AIRCRAFT
G. L. GILES and G. A. WRENN (Kentron International, Inc., Hampton, Va.) *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 15 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

Decomposition of a large optimization problem into several smaller subproblems has been proposed as an approach to making large-scale optimization problems tractable. To date, the characteristics of this approach have been tested on problems of limited complexity. The objective of the effort is to demonstrate the application of this multilevel optimization method on a large-scale design study using analytical models comparable to those currently being used in the aircraft industry. The purpose of the design study which is underway to provide this demonstration is to generate a wing design for a transport aircraft which will perform a specified mission with minimum block fuel. A definition of the problem; a discussion of the multilevel composition which is used for an aircraft wing; descriptions of analysis and optimization procedures used at each level; and numerical results obtained to date are included. Computational times required to perform various steps in the process are also given. Finally, a summary of the current status and plans for continuation of this development effort are given. Author

N87-12549# National Transportation Safety Board, Washington, D. C.
AIRCRAFT ACCIDENT/INCIDENT SUMMARY REPORTS: ERIE, PENNSYLVANIA, OCTOBER 14, 1984; ALBUQUERQUE, NEW MEXICO, FEBRUARY 11, 1985
30 Sep. 1986 17 p
(PB86-910407; NTSB-AAR-86-02-SUM) Avail: NTIS HC A02/MF A01

This publication is a compilation of the reports of two separate aircraft accidents investigated by the National Transportation Safety Board. The accident locations and their dates are as follows: Erie, Pennsylvania, October 14, 1984; and Albuquerque, New Mexico, February 11, 1985. Author

N87-12550# National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
AIRCRAFT ACCIDENT REPORT: BAR HARBOR AIRLINES FLIGHT 1808, BEECH BE-99, N300WP, AUBURN-LEWISTON MUNICIPAL AIRPORT, AUBURN, MAINE, AUGUST 25, 1985
30 Sep. 1986 77 p
(PB86-910408; NTSB-AAR-86-06) Avail: NTIS HC A05/MF A01

About 2205 e.d.t. on August 25, 1985, Bar Harbor Airlines Flight 1818, a Beech Aircraft Corporation Model 99 crashed about 1 mile southwest of the Auburn-Lewiston Municipal Airport at Auburn, Maine, while making an instrument landing system (ILS) approach to runway 4. The weather was indefinite 300-foot ceiling, sky obscured, visibility 1 mile in light drizzle and fog. The flight was a regularly scheduled commuter flight between Boston-Logan International Airport and Bangor, Maine, with intermediate stops at Auburn, Augusta, and Waterville, Maine. All six passengers and the two flightcrew members were killed in the accident. The airplane was destroyed by impact forces and postcrash fire. The National Transportation Safety Board determined that the probable cause of the accident was the captain's continuation of an unstabilized approach which resulted in a descent below glidescope. Contributing to the unstabilized approach was the radar controller's issuance and the captain's acceptance of a nonstandard air traffic control radar vector resulting in an excessive intercept with the localizer. Author

N87-12551# Sverdrup Technology, Inc., Arnold Air Force Station, Tenn.
ANALYSIS AND VERIFICATION OF THE ICING SCALING EQUATIONS. VOLUME 1: REVISION Final Report, 1 Aug. 1981 - 31 Mar. 1984
G. A. RUFF Mar. 1986 80 p Prepared in cooperation with Arnold Engineering Development Center, Arnold AFS, Tenn.
(AD-A167976; AEDC-TR-85-30-VOL-1-REV) Avail: NTIS HC A05/MF A01 CSCL 08L

Study objectives were to evaluate the equations governing the ice-accretion process to identify proposed scaling parameters and to conduct tests to determine which, is any, of the proposed methods produced scale ice accretions. Study results include: (1) A set of equations that can be used to calculate test conditions so that scaled ice shapes are produced on geometrically similar bodies was developed and experimentally verified. (2) Posttest evaluation of the scaling parameters based on the actual test conditions was necessary for accurate evaluation of test results. (3) An icing similitude computer code, SIMICE, was developed to calculate similitude conditions using the verified scaling equations. (4) The equations were applicable over the range of meteorological conditions found in natural icing, with the possible exception of velocity. (5) Velocity is the primary limitation of the scaling equations. To maintain scaled flow fields and droplet impingement characteristics, both the model and full-scale velocities must yield a Reynolds number > or = 200,000 and < the velocity giving the critical Mach number of the body geometry. (6) At values of dynamic pressure of approximately 1.6 psia, shedding characteristics of the ice accretion were observed to affect the final ice shape. GRA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A87-13362* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
TIME-BASED AIR TRAFFIC MANAGEMENT USING EXPERT SYSTEMS
L. TOBIAS and J. L. SCOGGINS (NASA, Ames Research Center, Moffett Field, CA) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 693-700. refs

A prototype expert system has been developed for the time scheduling of aircraft into the terminal area. The three functions of the air-traffic-control schedule advisor are as follows: (1) for each new arrival, it develops an admisible flight plan for that aircraft; (2) as the aircraft progresses through the terminal area, it monitors deviations from the aircraft's flight plan and provides advisories to return the aircraft to its assigned schedule; and (3) if major disruptions such as missed approaches occur, it develops a revised plan. The advisor is operational on a Symbolics 3600, and is programmed in MRS (a logic programming language), Lisp, and Fortran. Author

A87-13438
IN-FLIGHT TRANSFER ALIGNMENT/CALIBRATION OF A STRAPDOWN INS THAT EMPLOYS CAROUSELED INSTRUMENTS AND IMU INDEXING
C. JOHNSON (Delco Electronics Corp., Goleta, CA) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 1572, 1573.

An in-flight transfer alignment/calibration technique has been developed for the new Delco Electronics low cost inertial navigation system (LCINS). In-flight transfer alignment/calibration makes accurate guidance possible for a vehicle launched from a carrier aircraft without performing a preflight field alignment/calibration. The carrier aircraft possesses a master navigator which provides the reference information for LCINS operating as a slave navigator during the alignment/calibration process. Delco's alignment/calibration implementation employs a 25-state Kalman estimator that uses carousel-induced modulation and IMU indexing to optimally estimate the IMU attitude and calibrate the unknown instrument coefficients. Author

A87-13532
ION, NATIONAL TECHNICAL MEETING, LONG BEACH, CA, JANUARY 21-23, 1986, PROCEEDINGS
Meeting sponsored by ION, Bell Aerospace Textron, Northrop Corp., et al. Washington, DC, Institute of Navigation, 1986, 134 p. For individual items see A87-13533 to A87-13547.

Papers are presented on GPS satellite buildup strategy, PGS user equipment, the USAF Standard RLG INU program, navigation systems for multiple target formulation flight control, and differential GPS in the range application program. Also considered are GPS/JITDS compatibility, PGS application for air defense, weather safety aspects in future civil air navigation, satellite based position determination systems and concepts for air traffic surveillance, and GPS/Inmarsat. Other topics include a vehicle tracking system, improving LORAN coverage at minimum cost, precision point target tracking, and ring laser gyros for space precision pointing and navigation applications. Papers are also presented on reduction of missile impact CEP via carouseling for a two- or three-gimbaled platform during free-fall, GPS/Doppler processing for precise positioning in dynamic applications, and an evaluation of the GPS single frequency user ionospheric time-delay model. R.R.

A87-13533#
NAVSTAR GLOBAL POSITIONING SYSTEMS COLLINS USER EQUIPMENT - AN EVOLUTIONARY ASSESSMENT
G. J. HUDAK (Rockwell International Corp., Collins Government Avionics Div., Cedar Rapids, IA) IN: ION, National Technical Meeting, Long Beach, CA, January 21-23, 1986, Proceedings . Washington, DC, Institute of Navigation, 1986, p. 5-13.

The evolution of Collins GPS Receiver architecture, beginning with the Phase I concept validation, and the development of user equipment such as a Generalized Development Model, High and Medium Dynamics sets, and manpacks, are described. Phase II Life Cycle Cost trade studies suggested changes including the deletion of high risk LSI (RF) and Bubble Memory (processor), and the inclusion of custom LSI for code generators. The resultant receiver design has a 75 percent hardware commonality figure, with software commonality extending across 84 percent of all Host Vehicle (HV) applications. Software implementation minimized the hardware required, utilized an efficient HOL, and minimized logistics. Phase II changes were geared towards accommodating the requirements of the 120 candidate HVs planned for integration, and involved the standardizing of interfaces while allowing for necessary flexibility. R.R.

A87-13540#
WEATHER SAFETY ASPECTS IN FUTURE CIVIL AIR NAVIGATION
P. R. MAHAPATRA (Indian Institute of Science, Bangalore, India) and D. S. ZRNIC (NOAA, National Severe Storms Laboratory, Norman, OK) IN: ION, National Technical Meeting, Long Beach, CA, January 21-23, 1986, Proceedings . Washington, DC, Institute of Navigation, 1986, p. 57-64. refs

Weather factors affecting civil aviation are reviewed, and present and future approaches to obtain weather information and integrate it into ATC procedures are discussed. Topics examined include wind shear and its effects, turbulence and gusts, precipitation, ground-based and airborne in situ sensors and radars, satellite sensing, and the future potential of Doppler radars and frequency and polarization diversity radars. Consideration is given to software and system-integration aspects such as multiparameter displays; cell, mesocyclone, divergence, and gust-front detection; wind-field, multimoment, and composite displays; and expert systems. Graphs, diagrams, and a sample multimoment display are provided. T.K.

A87-13543#

IMPROVING LORAN COVERAGE AT MINIMUM COST

W. N. DEAN (ARNAV Systems, Inc., Portland, OR) IN: ION, National Technical Meeting, Long Beach, CA, January 21-23, 1986, Proceedings . Washington, DC, Institute of Navigation, 1986, p. 95-99.

Measures to extend Loran-C coverage of the continental U.S. are discussed and illustrated with diagrams, graphs, maps, and tables. It is shown that dual-rating of one station in Alaska and one in Texas would improve service there remarkably. A minimum-cost joint U.S.-Canadian expansion plan involving only six new stations and successfully filling the midcontinent gap over the U.S. and Canada (up to 60 deg N) is proposed. T.K.

A87-13544#

COMBINING LORAN AND GPS - THE BEST OF BOTH WORLDS

P. BRAISTED, R. ESCHENBACH, and A. TIWARI (Trimble Navigation, Mountain View, CA) IN: ION, National Technical Meeting, Long Beach, CA, January 21-23, 1986, Proceedings . Washington, DC, Institute of Navigation, 1986, p. 101-104.

The use of the current Loran-C network and the future GPS for marine navigation is described, and their use in combination (now planned for the period before GPS becomes fully operational in 1988) is shown to offer significant advantages over either system alone. Loran provides GPS initialization and continuous coastal coverage when GPS is out of sight, while GPS improves Loran by aiding cycle selection, ambiguity treatment, and ASF-factor calibration. Graphs and diagrams are included. T.K.

A87-14004#

DEVELOPMENT AND TESTING OF NEW TECHNOLOGIES FOR FLIGHT OPERATION AND SAFETY [ENTWICKLUNG UND ERPROBUNG NEUER TECHNOLOGIEN FUER DIE FLUGFUEHRUNG UND FLUGSICHERUNG]

H. WINTER (DFVLR, Institut fuer Flugfuehrung, Brunswick, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 45 p. In German.

Recent technological advances in flight operation and safety are reviewed. Advances in ring-laser technology are addressed, and research on resonator geometry and on possibilities for a low-cost ring laser is reviewed. The use of helicopters as test beds for avionics systems is examined, including the HETAS project and the DISCUS system. C.D.

A87-14140#

OPTIMAL GUIDANCE LAW WITH FIRST ORDER LAG LOOP AND NORMAL CONSTRAINT

Z. ZHAN (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, June 1986, p. 291-297. In Chinese, with abstract in English. refs

An optimal guidance law based on the maximum principle is discussed in this paper. It is assumed that the kinetic characteristics of 'vehicle-target' are that of a first order lag loop, the performance index is the minimum control energy consumption, the terminal states belong to a intercept curved surface with control cut-off, and the terminal acceleration of the vehicle equals zero. Based on these assumptions, an analytical form of the closed loop optimal intercept guidance law has been deduced. Author

A87-15427

FAULT-TOLERANT C3I SYSTEM A(0), A(I), MTBF ALLOCATIONS

R. FLEMING, J. JOSSELYN, and R. DEHOFF (Systems Control Technology, Inc., Palo Alto, CA) IN: 1986 Annual Reliability and Maintainability Symposium, Las Vegas, NV, January 28-30, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 352-357.

A generic technique is discussed for allocation of command, control, communications, and intelligence (C3I)) system availability and MTBF to subsystems, projects, or equipment. The technique can be used both for allocations and for reliability, maintainability, availability (RMA) design evaluations. Once set up, the methodology permits easily updated analyses, evalutions, or reallocations as the design evolves. Such analyses can support or form the basis for design changes, and the methodology can also be used to support specific project or subsystem designs. This analysis technique forms the first step in the establishment and automation of the link between RMA subsystem equipment design/requirements and fault-tolerant C3I system operational RMA requirements throughout the system development or acquisition process. An air traffic control system forms a good testbed for fault-tolerant C3I system RMA allocation because of its complexities. The procedure for allocation of mission operational availability requirements to the subsystem level is demonstrated using a generic air traffic control system example. Author

A87-15563

SYNTHESIS OF DEVICES FOR THE OPTIMAL PROCESSING OF PULSED RADIO SIGNALS IN LORAN SYSTEMS [SINTEZ USTROISTV OPTIMAL'NOI OBRABOTKI IMPUL'SNYKH RADIOSIGNALOV V RADIOTEKHNICHESKIKH SISTEMAKH DAL'NEI NAVIGATSII]

P. P. FILATOV Radiotekhnika (ISSN 0033-8486), July 1986, p. 16-19. In Russian. refs

A87-15569

RADIO-NAVIGATION METERS BASED ON THE K588 SERIES MICROPROCESSOR UNIT [RADIONAVIGATSIONNYE IZMERITELI NA OSNOVE MPK SERII K588]

G. N. GROMOV, V. V. GAVRISHCHUK, R. V. DROZDOV, IU. T. KRIVORUCHKO, B. V. PONOMARENKO et al. Radiotekhnika (ISSN 0033-8486), July 1986, p. 77-80. In Russian. refs

It is demonstrated that a unified family of onboard radio-navigation search-tracking meters can be built on the basis of the K588 series microprocessor unit. These meters provide for real-time signal processing and meet modern requirements on the organization of aircraft navigation instruments and the standardization of engineering solutions and software. The design of meters on the basis of a microcomputer with a parallel pipeline interface makes possible the independent improvement of the meter modules while retaining the appropriate sequence of engineering solutions by changing the software. B.J.

A87-16027#

MOBILE COMMUNICATIONS, NAVIGATION AND SURVEILLANCE

C. ROSETTI (ESA, Paris, France) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 20 p. (IAF PAPER 86-333)

The possible developments and changes in mobile communications and navigation in terms of traffic density, composition, technical requirements, and institutional organization by the year 2000 are discussed. In particular, it is noted that the whole structure and organization of air traffic as well as communications, navigation, and surveillance networks will have to be redefined; the shift from ground-based technologies to space is unavoidable, for reasons of both operational efficiency for the user and economy for the provider of the system. V.L.

N87-11715# Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
MODE S BEACOM SYSTEM: FUNCTIONAL DESCRIPTION
V. A. ORLANDO and P. R. DROUILHET 29 Aug. 1986 159 p
(Contract DOT-FA72WAI-261; F19628-85-C-0002)
(DOT/FAA/PM-86/19; ATC-42-REV-D) Avail: NTIS HC A08/MF A01

Provided is a functional description of the Mode S beacon System, a combined secondary surveillance radar (beacon) and ground-air-ground data link system capable of providing the aircraft surveillance and communications necessary to support ATC automation in future traffic environments. Mode S is capable of common-channel interoperation with the current ATC beacon system, and may be implemented over an extended transition period. Mode S will provide the surveillance and communication performance required by ATC automation, the reliable communications needed to support data link services, and the capability of operating with a terminal or enroute, radar digitizer-equipped, ATC surveillance radar. This material updates that presented in Mode S Beacon System: Functional Description, DOT/FAA/PM-83/8, 15 July 1983. Author

N87-11716# Department of the Air Force, Washington, D.C.
ELECTROLUMINESCENT (EL) REMOTELY-CONTROLLED LANDING ZONE MARKER LIGHT SYSTEM Patent
C. S. PIEROWAY, A. BLOUNT, G. L. BRITTON, and D. J. KRILE, inventors (to Air Force) 20 May 1986 10 p Supersedes AD-D010858
(AD-D012386; US-PATENT-4,590,471; US-PATENT-APPL-SN-566351; US-PATENT-CLASS-340-825.69)
Avail: US Patent and Trademark Office CSCL 17G

A remotely-controlled lighting system for austere landing zone lighting includes a plurality of light units each having dual electroluminescent light panels, a plurality of remote controllers each having an electrical receiver, and a separate electrical transmitter. The light panel units and remote controllers, attached electrically, may also be attached physically and placed along the sides of a landing zone, while the separate transmitter is located at a remote, covert place, such as a foxhole. The transmitter and receivers of the remote controllers are capable of being preset to respectively transmit and receive a first sequence of coded pulses for turning on the light panel units and a second sequence for turning off the light units. Also, the transmitter may be operated to repeatedly transmit one of the first or second sequence without transmitting the other sequence between one sequence to ensure that all of the light units are either turned on or turned off. GRA

N87-12552*# Douglas Aircraft Co., Inc., Long Beach, Calif.
GUIDANCE LAW SIMULATION STUDIES FOR COMPLEX APPROACHES USING THE MICROWAVE LANDING SYSTEM (MLS)
J. B. FEATHER Nov. 1986 80 p
(Contract NAS1-18028)
(NASA-CR-178182; NAS 1.26:178182) Avail: NTIS HC A05/MF A01 CSCL 17G

This report documents results for MLS guidance algorithm development conducted by DAC for NASA under the Advance Transport Operating Systems (ATOPS) Technology Studies program (NAS1-18028). The study consisted of evaluating guidance laws for vertical and lateral path control, as well as speed control, by simulating an MLS approach for the Washington National Airport. This work is an extension and generalization of a previous ATOPS contract (NAS1-16202) completed by DAC in 1985. The Washington river approach was simulated by six waypoints and one glideslope change and consisted of an eleven nautical mile approach path. Tracking performance was generated for 10 cases representing several different conditions, which included MLS noise, steady wind, turbulence, and windshear. Results of this simulation phase are suitable for use in future fixed-base simulator evaluations employing actual hardware (autopilot and a performance management system), as well as crew procedures and information requirements for MLS. Author

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A87-13101
ADVANCED COMPOSITES APPLICATIONS FOR THE B-1B BOMBER - AN OVERVIEW
L. G. HANSEN, D. LOSSEE, and W. L. OBRIEN (Rockwell International Corp., Pittsburgh, PA) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 712-724.

An overview of the advanced composites applications for the production B-1B Bomber is given. The applications cover the total gamut of complexity from wing type spar/cover construction used in the overwing movable fairings to full depth sandwich structure with varying cover thickness from minimum gage to thick laminates for such applications as the weapons bay and avionics doors, structural mode control vane and preloaded pivot fairings, plus thick filament wound application used in the development of a 180 inch long rotary launcher. This paper covers design configurations, manufacturing methods and structural certification as they apply to the production program. Author

A87-13151
DESIGN CONSIDERATIONS FOR SUPERPLASTICALLY FORMED COMPLEX AIRCRAFT STRUCTURES
H. ZAMANI, M. M. RATWANI, R. VASTAVA (Northrop Corp., Aircraft Div., Hawthorne, CA), and J. TUSS (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 1350-1361. USAF-supported research.

A research program has been conducted in order to assess the effect of the geometry of the structure, the forming parameters of the selected material, and the component-forming feasibility on the final design of complex superplastically formed structures. Particular emphasis is placed on ways to avoid such problems as subminimum thickness and cavitation. The design of the F-5F lower avionics deck and the F-5F leading edge extension, used as demonstration parts in this program, is reviewed. V.L.

A87-13354
OPTIMAL STOCHASTIC OBSERVERS APPLIED TO HYDRAULIC ACTUATION SYSTEMS
H. V. PANOSSIAN (HR Textron, Inc., Valencia, CA) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 602-604. refs

Fault detection and isolation in supersonic aircraft electrohydraulic servosystems is normally carried out by the flight control computer (FCC). A technique is presented for relieving the computational load on the FCC by inserting a linearly programmed microprocessor into the loop between a control surface actuator and the FCC. The linear stochastic observer features a state equation which includes an expression for white Gaussian noise. Simulation results show that the piston measurement is sufficient data for calculating the acceleration, velocity and position of the actuator, along with leakage along the piston seal. M.S.K.

A87-13360* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
IMPACT OF MISMODELED IDLE ENGINE PERFORMANCE ON CALCULATION AND TRACKING OF OPTIMAL 4-D DESCENT TRAJECTORIES
D. H. WILLIAMS (NASA, Langley Research Center, Hampton, VA) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 681-686. refs

Advanced flight management systems are being developed which are capable of calculating optimal 3-D and 4-D flight trajectories for arbitrary fuel and time costs. These systems require mathematical models of airplane performance in order to compute the optimal profiles. Mismodeled idle engine characteristics can result in descent trajectories requiring excessive throttle and/or speedbrake activity in order to achieve the desired end conditions. This paper evaluates the cost and fuel penalties, trajectory variations, and flight control requirements associated with typical idle engine modeling errors for a twin-jet transport airplane. Variations in idle power setting, thrust, fuel flow, and surge bleed operation were evaluated for a cruise/descent flight segment. The results of this analysis provide insight into the penalties associated with uncertainties in idle engine performance and suggest methods of modeling which minimize these penalties. Author

A87-13361* Boeing Commercial Airplane Co., Seattle, Wash.
SENSITIVITY STUDIES OF 4D DESCENT STRATEGIES IN AN ADVANCED METERING ENVIRONMENT
K. H. IZUMI (Boeing Commercial Airplane Co., Seattle, WA) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 687-692.
(Contract NAS1-17635)

An investigation of utilizing various 4D airplane descent strategies in an advanced time-based metering environment was conducted. The three strategies considered were clean-idle Mach/CAS, constant flight path angle (CFPA) Mach/CAS, and fuel-optimal. Traffic inputs consisted of all combinatory pairs of three types of commercial turbojets (B737-300, B747-200, and B767-200) and two weight classes for each airplane type. Sensitivities of traffic throughput and fleet fuel to descent strategies, both among themselves and in combination, for different assigned meter fix times and traffic pairings were studied under controlled initial conditions. Author

A87-13596* Virginia Polytechnic Inst. and State Univ., Blacksburg.
COMPARISON OF TWO PROPELLER SOURCE MODELS FOR AIRCRAFT INTERIOR NOISE STUDIES
J. R. MAHAN and C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) IN: Aero- and hydro-acoustics; Proceedings of the Symposium, Ecully, France, July 3-6, 1985 . Berlin and New York, Springer-Verlag, 1986, p. 135-143. refs
(Contract NAG1-493; NAG1-390)

The sensitivity of the predicted synchrophasing (SP) effectiveness trends to the propeller source model issued is investigated with reference to the development of advanced turboprop engines for transport aircraft. SP effectiveness is shown to be sensitive to the type of source model used. For the virtually rotating dipole source model, the SP effectiveness is sensitive to the direction of rotation at some frequencies but not at others. The SP effectiveness obtained from the virtually rotating dipole model is not very sensitive to the radial location of the source distribution within reasonable limits. Finally, the predicted SP effectiveness is shown to be more sensitive to the details of the source model used for the case of corotation than for the case of counterrotation. B.J.

A87-13628
AV-8B/GR MK 5 AIRFRAME COMPOSITE APPLICATIONS
B. L. RILEY (McDonnell Douglas Corp., Saint Louis, MO) IN: Fibre reinforced composites 1986; Proceedings of the Second International Conference, Liverpool, England, April 8-10, 1986 . London, Mechanical Engineering Publications, Ltd., 1986, p. 153-172. refs

Applications of composites (carbon/epoxy, fiberglass/epoxy, carbon/BMI, and fiberglass/BMI) to the AV-8B/GR Mk 5 airframe are described. Primary structural applications include the wing torque box and control surfaces, horizontal tail, and forward fuselage; secondary applications are the gun and ammo pods, strakes, LIDs fence, ventral fin, rudder, engine bay doors, nose cone, overwing fairing, and outrigger fairing. The use of composite materials for 25 percent of the airframe weight resulted in a weight saving of 525 lbs per aircraft. The design philosophy, test programs, interpretation and evaluation of test results, and the aspects of repairs and manufacturing defects are discussed. Multiple design diagrams are included. I.S.

A87-13637#
THE EQUIVALENT MASSES AT NOSE LANDING-GEARS DURING LANDING-IMPACTS AND WHEN TAXIING OVER RUNWAY PERTURBATIONS
D. H. CHESTER (Israel Aircraft Industries, Ltd., Lod) IN: Israel Annual Conference on Aviation and Astronautics, 27th, Haifa, Israel, February 27, 28, 1985, Collection of Papers . Haifa, Israel, Technion - Israel Institute of Technology, 1986, p. 7-12. refs

The problem of analysis of landing impacts at the nose-gear on aircraft having a tricycle landing-gear arrangement is considered. The main-gears are assumed to be landed and the reaction on them is mainly due to the proportion of the total weight normally acting there. During nose-gear landing impact, the vertical acceleration of both translational and pitching motions of the rigid aircraft. Expressions are found for the equivalent mass at the nose-gear, including an allowance for elasticity of the tires and shock-absorbers. Using realistic aircraft mass properties it is seen that the equivalent masses are between two and three times the mass fraction under static conditions. It is concluded that the equivalent mass at the nose-gear applies during landing-impact, but for calculating obstacle crossing loads it should be used with certain reservations. Author

A87-13646#
UTILIZATION OF 3-D PROGRAMS FOR AIRCRAFT DESIGN AND DEVELOPMENT
H. ROSS (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) IN: Israel Annual Conference on Aviation and Astronautics, 27th, Haifa, Israel, February 27, 28, 1985, Collection of Papers . Haifa, Israel, Technion - Israel Institute of Technology, 1986, p. 99-107.

This paper describes a three dimensional computer program which is being used as a mathematical tool for the geometric definition of air vehicles. The graphic interactive program allows the surface definition of irregular bodies and the analysis of kinematic problems as well as the analysis of installation problems. Typical examples of the application of a three-dimensional program for the design and development of high-performance fighter aircraft are given. The software- and hardware characteristics are discussed. Problems associated with the introduction of the system are described and the relative cost of the system is identified. Author

A87-13662

NATIONAL SPECIALIST'S MEETING ON CRASHWORTHY DESIGN OF ROTORCRAFT, GEORGIA INSTITUTE OF TECHNOLOGY, ATLANTA, APRIL 7-9, 1986, PROCEEDINGS

D. P. SCHRAGE, ED., S. V. HANAGUD, ED., and S. A. MEYER, ED. (Georgia Institute of Technology, Atlanta) Meeting sponsored by AHS and Georgia Institute of Technology. Alexandria, VA, American Helicopter Society, 1986, 263 p. For individual items see A87-13663 to A87-13687.

The topics discussed include crashworthy design criteria, specific aircraft and component crashworthy designs, structural crashworthiness research and analytical techniques, human tolerance and crashworthy seating systems, testing and instrumentation, materials and material properties related to crashworthy designs, and accident investigations and analysis of crash sequences. Papers are presented on the status of crashworthiness design criteria, design of aircraft structures for crash impact, landing gear performance simulation by the KRASH program, and crashworthy crewseat limit load optimization through dynamic testing. Consideration is given to Kane's method for analyzing crash sequences and crashworthy design, the role of fiber and matrix in the crash energy absorption of composite materials, correlation of the experimental static and dynamic response of simple structural components, the analysis of civil rotorcraft accidents for the development of improved design criteria, and impact severity and potential injury prevention in general aviation accidents. I.S.

A87-13663

EVOLUTION OF MIL-STD-1290A, LIGHT FIXED AND ROTARY-WING AIRCRAFT CRASHWORTHINESS

L. T. BURROWS (U.S. Army, Aviation Applied Technology Directorate, Fort Eustis, VA) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 8 p. refs

Modern-day training and tactical employment requirements for the U.S. Army helicopter dictate that a large percentage of operations occur in the low-speed, low altitude flight regime, with reduced margins of safety normally associated with higher airspeed and higher altitude operations in case of emergency. This increased probability of accident occurrence, coupled with the lack of an in-flight egress capability, makes design for crashworthiness essential for Army helicopters. The evolution of crash survival design criteria, its influence on the formulation of a U.S. Army military standard for rotary-wing aircraft crashworthiness, and its application to current and new-generation Army helicopters is discussed. Emphasis is given to the need for a total systems' approach in design for crashworthiness and the necessity for considering crashworthiness early in the design phase of a new aviation weapon systems development effort. The actual application of crashworthiness to Army helicopters is presented with statistics that show dramatic reductions in fatalities and injuries with implementation of a crashworthy fuel system. Author

A87-13664

THE STATUS OF CRASHWORTHINESS DESIGN CRITERIA

J. C. WARRICK and S. P. DESJARDINS (Simula, Inc., Phoenix, AZ) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 11 p. refs

The development of aircraft crashworthiness criteria is described with reference to military helicopters (e.g., The Black Hawk). The dangers of permitting either an increase or a decrease in the severity of the criteria are discussed. Special consideration is given to the hazard of misinterpreting the crashworthiness scenario data. It is shown that the selection of a new 85-percentile survivable crash velocity magnitude (instead of the old 95-percentile requirement) could result in protection for only about 55 percent of the survivable crashes. The disproportionate share of the injuries and fatalities occurs between the 85th-percentile and the 95th-percentile velocity levels because of the large increase in velocities within this range of percentiles and the even larger increase in the energy content. I.S.

A87-13665

SURVIVABILITY AND CRASHWORTHINESS DESIGN CRITERIA

J. K. SEN (McDonnell Douglas Helicopter Co., Culver City, CA) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 7 p.

Crashworthiness design criteria, determined for a helicopter in terms of vertical speed and helicopter attitude at crash impact, were established for the lightest helicopter encompassing the highest cumulative frequency of occurrence of survivable accidents. The weight trade-off study was based on the results of the crash-impact analysis by Sen et al. (1985) of a 10,000-lb crashworthy utility helicopter, conducted for a maximum vertical velocity of 42 ft/s, maximum roll angle of +/-15 deg, and pitch angles ranging between -5 and +15 deg, using the KRASH program. The conclusions from the weight trade-off study are compared to accident kinematics and survivability data of U.S. Army Utility Helicopters from 1975 to 1980. I.S.

A87-13666

THE DEVELOPMENT OF DYNAMIC PERFORMANCE STANDARDS FOR CIVIL ROTORCRAFT SEATS

J. H. MAJOR (FAA, Fort Worth, TX) and S. J. SOLTIS (FAA, Long Beach, CA) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 13 p. refs

Civil aircraft seats have traditionally been designed to comply with static strength requirements. Dynamic performance standards which address both seat strength and the occupant impact protection characteristics of the seat have recently been defined for aircraft seats. The FAA has funded a program to research U.S. rotorcraft accidents. Accident scenarios were developed from this research. Further analysis of the results of those data led to the formulation of new dynamic performance standards for rotorcraft seats and occupant restraint. The FAA has proposed that those newly developed seat dynamic performance criteria be incorporated into Parts 27 and 29 of the Federal Aviation Regulations. The development of those standards is reviewed. Author

A87-13667

STATE-OF-THE-ART CRASHWORTHY CARGO RESTRAINT SYSTEMS FOR MILITARY AIRCRAFT

R. L. HATE (U.S. Navy, Naval Air Development Center, Warminster, PA), R. F. CAMPBELL (Boeing Vertol Co., Philadelphia, PA), H. L. GEORGE (U.S. Naval Air Systems Command, Washington, DC), and J. SHEFRIN IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 11 p. refs

The aspects of designing cargo restraint systems by matching the cargo restraint's structural strength to the actual crash conditions of shipboard and land-based transports are discussed. Special attention is given to advanced technology materials, cargo-related accidents, design and system integration, cargo crash simulation testing, and energy management. The user benefits established by this cargo crash energy management program are: (1) the use of one crash pulse criterion, MIL-STD-1290, for all Navy cargo transports, rotary or fixed wing; (2) work load reduction in restraining cargo; (3) the use of energy absorbers in any cargo aircraft, old or new; (4) upgraded crash survivability in cargo transport during combat, during a peacetime mission, and when augmenting 463L restraint; and (5) reduced weight of mission equipment and the associated restraint structure in new aircraft. I.S.

A87-13668
DESIGN OF AIRFRAME STRUCTURES FOR CRASH IMPACT
J. D. CRONKHITE (Bell Helicopter Textron, Fort Worth, TX) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 13 p. refs

Due to recent trends in helicopter design, vertical impact has been identified as the primary determinant of crashworthiness for airframes. This factor has prompted the development of energy-absorbing fuselage underfloor structure concepts that have been demonstrated by full scale structure tests under the aegis of both NASA and the U.S. Army. The results obtained by these test programs are presented together with previously obtained data based on the comparison of KRASH and DYCAST nonlinear structural crash simulations with several other full scale crash tests. An attempt is made to identify the most important design parameters, the most promising energy-absorbing structure concepts, and those existing crash analysis methods that may prove most useful in the design of efficient crash impact-response helicopter airframes. O.C.

A87-13669
CREW SEAT STROKE REQUIREMENTS FOR HELICOPTER ROLLED ATTITUDE IMPACT CRASHWORTHINESS
L. C. LAMBORN (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 5 p.

The systems approach to crashworthiness is applied to a study of crew seat stroke sensitivity for varied crash impact attitudes. Using the computer program 'KRASH' as a preliminary design tool, two three-dimensional helicopter models were created to develop seat stroke trends for vehicle impact attitudes including pitch and roll. Due to the reduced energy absorbed by the landing gear and fuselage during impact conditions combining pitch and roll, the crew seat stroke requirements were found to be highly sensitive to vehicle attitude at impact. The maximum crew seat stroke was found to be approximately two and one-half times the stroke for the no pitch, no roll crash. This trend becomes a design driver for the cockpit and crew seat, and allowing for the 'extra' stroke is an absolute necessity for crashworthy helicopter design. Author

A87-13670
LANDING GEAR PERFORMANCE SIMULATION BY KRASH PROGRAM
M. B. PRAMANIK and B. L. CARNELL (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 6 p.

A computer program, KRASH-85, was used to simulate the dynamic performance of helicopter landing gear. To demonstrate the validity of the method, several landing gears used on Sikorsky helicopters have been modeled for the program. A retractable, conventional oleo landing gear was simulated at 8 ft/s; a crashworthy, swinging arm gear with dual-oleo shock strut was simulated at 34.5 ft/s; and an articulating gear with both an oleo and a crushable honeycomb shock strut was simulated at 20 ft/s. A comparison of ground loads, drop mass displacements, and impact velocities has demonstrated good correlation between the predicted and actual results. The KRASH program also predicts the loads on all the structural members of the landing gear and makes it possible to improve the accuracy of design and stress analysis. I.S.

A87-13671
COMPUTER MODELING OF CRASHWORTHY SEATING SYSTEMS
A. O. BOLUKBASI (Simula, Inc., Phoenix, AZ) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 8 p. refs

The purpose of this paper is to describe the application of Program SOM-LA (Seat/Occupant Model - Light Aircraft) to modeling of crashworthy seating systems. Program SOM-LA combines a three-dimensional dynamic model of the human body with a model of the seat structure. The specific seating system modeled is a guided energy-absorbing helicopter seat. The model predictions are compared with measured data from dynamic tests of the seat. Author

A87-13672
PROGRAM KRASH - THE EVOLUTION OF AN ANALYTICAL TOOL TO EVALUATE AIRCRAFT STRUCTURAL CRASH DYNAMICS RESPONSE
G. WITTLIN (Lockheed-California Co., Burbank, CA) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 12 p. refs

The evolution of program KRASH, developed under the sponsorships of the U.S. Army and the FAA, is described. The program, referred to as 'hybrid', presents an approach which incorporates experimental data as input and provides for approximate representations of complex structures and nonlinear behavior. The program's applicability to rotary-wing, light fixed-wing, and large transport aircraft is demonstrated. The updated version of the program was used to support the Controlled Impact Demonstration test performed by the FAA and NASA. The new program's features, analytical models, and comparisons with test data are presented. The use of the program in the course of developing design criteria and evaluating new material designs is also addressed. I.S.

A87-13673
MODELLING STRATEGIES FOR FINITE ELEMENT CRASH SIMULATION OF COMPLETE VEHICLES
R. WINTER and A. B. PIFKO (Grumman Corporate Research Center, Bethpage, NY) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 6 p.

This paper will discuss strategies and procedures for preparing finite element models for full vehicle crash simulation using nonlinear structural dynamic finite element computer codes. The limitations imposed on such models by existing computer systems, and the overall and specific procedures used to model full vehicles is outlined, based on experience with actual automobile and helicopter structures, using the DYCAST computer code. Results are shown for a particular helicopter impact in comparison with test data. Author

A87-13674
KRASH ANALYSIS CORRELATION WITH FULL SCALE YAH-63 HELICOPTER CRASH TEST
V. L. BERRY and J. D. CRONKHITE (Bell Helicopter Textron, Fort Worth, TX) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 14 p. refs

A full scale crash test of the YAH-63 prototype Advanced Attack Helicopter, designed to requirements similar to MIL-STD-1290, is described, and the test results on the crashworthiness performance are compared with those obtained using KRASH-simulated analysis. It is shown that the crashworthy landing gear, crushable structure, stroking seats, crashworthy fuel system, and high mass component retention all functioned successfully. The overall sequence of events and structural response time histories from the KRASH analysis agreed well with the measured test data. I.S.

A87-13675

CRASHWORTHY CREWSEAT LIMIT LOAD OPTIMIZATION THROUGH DYNAMIC TESTING

J. W. COLTMAN, C. VAN INGEN (Simula, Inc., Phoenix, AZ), and K. F. SMITH (U.S. Army, Aviation Applied Technology Directorate, Fort Eustis, VA) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 10 p. refs

The objective of this research was to experimentally determine a limit-load setting for energy-absorbing seating systems that would minimize the incidence of spinal injury. The threshold of spinal injury for seated humans subjected to vertical (+Gz) decelerative loading was investigated. The +Gz loading was induced by simulating impact conditions typically found in helicopter crashes and was modified by the incorporation of energy-absorbing mechanisms in the seat structure. Fifteen dynamic tests were conducted with unembalmed cadavers at various limit-load settings to identify the load threshold causing spinal injury. Vertebral strength test results were used to normalize the data from the dynamic test program. A correlation was derived relating the frequency of spinal injury to the energy absorber limit-load factor. The results are applicable to the design of military and civilian crashworthy seating systems. Comparison of the incidence of spinal injury between the experimental cadaver data and field performance data on production energy-absorbing seats is discussed. Author

A87-13678

FULL SCALE CRASH TEST OF A BK117 HELICOPTER

M. ONISHI and T. YOSHIMURA (Kawasaki Heavy Industries, Ltd., Airframe Engineering Section, Gifu, Japan) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 9 p. refs

A full scale crash test of a BK117 helicopter was performed by dropping the helicopter from a height of 15 m above the ground and using the original pendulum method of crash testing. The instrumentation for obtaining data on the dynamic behavior of the helicopter structure and dummies consisted of the onboard accelerometer, high-speed motion picture cameras, and video cameras. External coverage of the crash sequence was provided by ground-based fixed cameras. The analysis has established the actual resultant impact velocity of 75.5 m/sec and the actual attitude at the impact of 5.7-deg pitch up, 0.9-deg roll right, 2.2-deg yaw left. The results showed that the helicopter has a good protective shell and provides sufficient (by the criteria of the MIL-STD-1290) occupiable volume during severe crash loading. The maximum dynamic response index for the occupants was 35, as opposed to the value of 21 recommended by Sen et al. (1985). I.S.

A87-13679

THE DESIGN AND QUALIFICATION TESTING OF AN ENERGY-ABSORBING SEAT FOR THE NAVY'S H-53 A/D HELICOPTERS

S. J. SHANE (Simula, Inc., Phoenix, AZ) and B. L. CARNELL (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 10 p. refs

The design and qualification testing of an armored energy-absorbing crewseat for retrofit to the U.S. Navy's H-53 A/D helicopters are described. Design aspects described include the composite armor system and the energy absorption systems. Energy absorption in the vertical direction is used to limit the forces on the occupant and in the forward direction to limit the loads on the seat attachments to not exceed the floor strength of the existing aircraft. Qualification testing of the seat included operational, static, ballistic, environmental and dynamic tests. Data presented from the static testing includes performance of both the vertical and forward energy-absorbing systems. The dynamic tests series included three vertical tests using 5th-, 50th-, and 95th-percentile anthropomorphic dummies, and a single horizontal test, using a 95th-percentile dummy. Author

A87-13821#

STATUS REPORT OF A NEW RECOVERY PARACHUTE SYSTEM FOR THE F111 AIRCRAFT CREW ESCAPE MODULE

D. W. JOHNSON (Sandia National Laboratories, Albuquerque, NM) AIAA, Aerodynamic Decelerator and Balloon Technology Conference, 9th, Albuquerque, NM, Oct. 7-9, 1986. 6 p.
(Contract AF PROJECT 84-10A-71)
(AIAA PAPER 86-2437)

A new recovery parachute system for the F111 aircraft crew escape module was designed at the Sandia National Laboratories in Albuquerque, New Mexico with the support of the U.S. Air Force. The design of the proposed system is presented, and the results of six proof-of-design tests are discussed. Test results indicate that the parachute system will meet the 25 ft/sec at 5000 ft altitude descent velocity requirement specified in the draft Mil-Specs. The development program for the new recovery parachute consists of 20 drop tests and one sled-launched ejection test. The former will use a U.S. Air Force test vehicle that will be released from the NASA operated B52 aircraft. Testing is scheduled to start in January 1987. K.K.

A87-13987#

RESULTS OF HELICOPTER RESEARCH AT DFVLR [ERGEBNISSE DER HUBSCHRAUBERFORSCHUNG IN DER DFVLR]

B. GMELIN (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) and H. HELLER (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-20, 1986, Paper. 34 p. In German. refs

Results obtained in the DFVLR middle-term (1985-1990) helicopter-technology program are summarized, with a focus on the program areas flight simulation, wind-tunnel simulation, and rotor aeroacoustics. Consideration is given to the conversion of the BO 105-S3 to an Advanced Technology Testing Helicopter System (ATTHeS) with model-following control system, the ground simulation testing of the control system at NASA Ames, ATTHeS simulations of roll damping and roll control moments, wind-tunnel tests of optimized rotor blades and higher-harmonic rotor-control systems, and aeroacoustic wind-tunnel tests. T.K.

A87-13992#

THE AMPHIBIAN TECHNOLOGY TEST VEHICLE - SUMMARY AND RESULTS [AMPHIBISCHER TECHNOLOGIETRAEGER (ATT) - ZUSAMMENFASSUNG UND ERGEBNISSE]

G. KRIECHBAUM (Dornier GmbH, Friedrichshafen, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 29 p. In German.

The development and testing of an experimental amphibian aircraft (ATT) based on the Do 24 are described, summarizing the results obtained in phases I (1979-1980) and II (1980-1984) of the R&D program. Consideration is given to land tests, inland-water and high-sea tests (demonstrating the improved seaworthiness of the ATT vis a vis amphibians now in service), the ATT advanced-technology wing (using the Do A-5 profile employed in the Do 228), the performance of turboprop engines with inertial water/ice separators, the use of corrosion-resistant materials and anticorrosion treatment, and tests of CFRP and GFRP structural components. Graphs, drawings, and photographs are provided, and the implications of the results for the cost-effective design of future amphibians are discussed. T.K.

A87-13993#

DEVELOPMENT OF A GFRP WING IN ACCORDANCE WITH FAR PART 23 [ENTWICKLUNG EINES GLASFASERTRAGFLUEGELS NACH FAR PART 23]

H. LUCAS (Claudius Dornier Seastar GmbH und Co., Oberpfaffenhofen, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 31 p. In German. refs
(Contract BMFT-LFK-8531)

The design and fabrication of a GFRP wing for the 4.2-tonne Seastar amphibian aircraft are reported. The cost advantages (in material and processing) of GFRP systems (hardening at 0.7-0.9-bar air pressure) over CFRP systems (requiring autoclave processing) are explained; the ability of a GFRP wing to meet the FAR Part 23 requirements is discussed; and the development of a damage-tolerant three-spar sandwich-skin wing structure with projected service life 30,000 h is described and illustrated with drawings. The static and fatigue tests of the wing planned for summer 1986 are listed, and consideration is given to the fabrication of the GFRP-forming tools. T.K.

A87-13997#

DEVELOPMENT AND TESTING OF CRITICAL COMPONENTS FOR THE TECHNOLOGICAL PREPARATION OF A CFK OUTER WING [ENTWICKLUNG UND ERPROBUNG VON KRITISCHEN KOMPONENTEN ZUR TECHNOLOGISCHEN VORBEREITUNG EINES CFK-AUSSENFLUEGELS]

H. SCHNELL (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 22 p. In German.
(Contract BMFT-LFK-85508)
(MBB-UT-224-86)

The most important technological issues concerning the development of a CFK outer wing box and corresponding solution approaches are discussed. Components developed and perfected in order to manage the problem of highly loaded joints in the disconnection area between metal and CFK wings and the problem of the stability behavior of stiffened shells with high load characteristic values are presented and discussed. First results from load tests are reported. C.D.

A87-14002#

LOAD LIGHTENING AND FLUTTER DAMPING FOR FUTURE AIRBUS PROJECTS [LASTMINDERUNG UND FLATTERDAEMPFUNG FUER ZUKUENFTIGE AIRBUSPROJEKTE]

W. KOLANDER (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 50 p. In German. refs
(Contract BMFT-LFK-8360)
(MBB-UT-004-86)

Existing rudders, flaps, and spoilers are investigated in order to determine their suitability as control surfaces, and existing systems are studied to see how they could be used as components in load-lightening and flutter-damping systems. Advances made to achieve greater flight economies are reviewed, and their significance for Airbus technology is considered. C.D.

A87-14003#

ATTAS - THE NEW TEST BED [ATTAS - DER NEUE ERPROBUNGSTRAEGER]

P. HAMEL (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) and H. KRUEGER (DFVLR, Cologne, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 47 p. In German. refs

The ATTAS (Advanced Technologies Testing Aircraft System) is discussed. The energy supply is addressed, including the hydraulics, electronics, and orientation system. The fly-by-wire light system is described, including terminal functions and computer. The measurement system and avionics are discussed, and the economics of ATTAS are briefly addressed. C.D.

A87-14008#

MODELS FOR ROTOR AND HELICOPTER DESIGN [MODELLE ZUR ROTOR- UND HUBSCHRAUBERBERECHNUNG]

G. REICHERT, K. LIESE, and J. EWALD (Braunschweig, Technische Universitaet, Brunswick, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 59 p. In German. refs

The use of models to calculate parameters of interest in rotor and helicopter design is discussed. The influence of models on the trim and performance values is addressed with regard to rotor geometry, blade degree of freedom, rotor downwash and tip loss, and measurement polarities for rotor blade and airframe. Data reduction in flight performance measurements for hover flight and forward flight is discussed. C.D.

A87-14012#

TESTING OF FIBER-REINFORCED CONSTRUCTION ELEMENTS - SIMULATION OF MECHANICAL LOADS AND ENVIRONMENTAL INFLUENCES [PRUEFUNG VON FASERVERBUNDBAUTEILEN - SIMULATION VON MECHANISCHEN BELASTUNGEN UND UMWELTEINFLUESSEN]

K. WOITHE (Industrieanlagen-Betriebsgesellschaft mbH, Munich, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 17 p. In German.

A test facility for fiber-reinforced construction elements is described, and its application is demonstrated. The systems for air circulation, tempering, moistening, control, and loading are described, and important design data are given. Illustrative tests on the fiberglass fuselage of the Seastar amphibious aircraft and on the fiberglass wings of the Speed Canard, a two-seater canard airplane, are described, and results are presented. C.D.

A87-14014#

ESSY - AN ELECTROMECHANICAL ADJUSTMENT SYSTEM FOR AIRCRAFT CONTROL SURFACES [ESSY - EIN ELEKTROMECHANISCHES STELLSYSTEM FUER STEUERFLAECHEN VON FLUGZEUGEN]

G. QUANDT (Teldix GmbH, Heidelberg, West Germany) and E. PIEPKA (Zahnradfabrik Friedrichshafen AG, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 32 p. In German.
(Contract BMFT-LFL-8571-0)

The electromechanical adjustment system ESSY, a future-oriented alternative to hydraulic adjustment actuation of aircraft control surfaces, is described. The system specifications are summarized, and the adjustment actuation and its components are described, including the requirements and dimensioning of the brushless direct-current motor, the actuator layout, the brake, the actuator electronics, and the monitor. The test facilities for the system are summarized, the testing of the system is described, and the adjustments made due to the test results are reviewed. C.D.

A87-14016#

TESTING A TAIL ROTOR SYSTEM IN FIBER-REINFORCED CONSTRUCTION MANNER [ERPROBUNG EINES HECKROTORSYSTEM IN FASERVERBUNDBAUWEISE]

V. KLOEPPEL and B. ENENKL (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 25 p. In German. refs

A fiber-reinforced experimental version of a bearingless tail rotor was developed in order to improve aerodynamic effectiveness, structural simplicity, weight, and costs. A four-bladed, soft inplane bearingless rotor was selected. An extended ground test program is described using results based on precessional motion and simulation of ground resonance conditions. Finally, ground and flight tests performed on a BK 117 are reviewed. C.D.

A87-14017#

DEVELOPMENT OF A NEW TYPE OF BEARINGLESS ROTOR SYSTEM [ENTWICKLUNG NEUARTIGER LAGERLOSER ROTORSYSTEME]

H. STREHLOW and H. FROMMLET (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 44 p. In German. refs.

Work being done to develop an efficient, bearingless main rotor system for a light multipurpose helicopter is discussed. Two bearingless rotors with different designs and blade angle steering were tested on a test stand and on the BO 105 helicopter in flight. Corresponding constructive and theoretical investigations including necessary component tests were conducted. The results are used to define a final prototype, stressing the aerodynamic and structural system optimization. The eventual bearingless rotor will have a new blade form and the DM-H3 and DM-H4 profiles. C.D.

A87-14018#

ACTUATING SYSTEM WITH DIGITAL SIGNAL CONVERTERS AND FIBER-OPTIC CONTROL [STELLANTRIEB MIT DIGITALEN SIGNALWANDLERN UND LICHTLEITERANSTEUERUNG]

TH. ANNESER and H. MANG (Liebherr-Aero-Technik GmbH, Lindenberg im Allgaeu, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 29 p. In German.

Preliminary results of developmental studies on advanced aircraft actuating systems are summarized. The limitations of conventional electrohydraulic systems are reviewed; the fiber-optic transmission of control signals to the actuator is discussed; actuators with piezoelectric bending elements are described; and the principles of digital control are explained. Graphs, drawings, tables of numerical data, and flow charts are provided, and the results of computer simulations of the control performance are included. T.K.

A87-14025#

A REDUNDANT ACTUATING SYSTEM WITH SERVO VALVES OF LOW HYDRAULIC LOSS [REDUNDANTES STELLANTRIEBSSYSTEM MIT SERVOVENTILEN NIEDRIGER HYDRAULISCHER VERLUSTLEISTUNG]

G. DIESSEL and H. MUELLER (Feinmechanische Werke Mainz GmbH, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 35 p. In German.

The operating principle, design, development status, and preliminary performance of a redundant electrohydraulic actuating system for transport-aircraft ailerons are presented. The system employs two identical actuating systems (comprising single-stage linear-motor-driven servo valves, bypass and anticavitation valves, actuating cylinders with two displacement pickups, and electrical control and monitoring hardware), each supplying 75 percent of the required actuating force. Active, passive, and damped operating modes; signal flow; fly-by-wire system architecture; preflight and inflight monitoring; options evaluated in designing the individual components; and test procedures and results are described and illustrated with drawings, circuit diagrams, graphs, and tables of numerical data. Preliminary results indicate actuating force 650 and 720 N at current 4 and 6 A, respectively, with internal leakage less than 0.15 1/min at flow rate 13.8 1/min and supply pressure 210 bar. T.K.

A87-14026#

DESIGN AND MANUFACTURING OF A CFRP TAIL FIN FOR THE A300 [BAUWEISE UND FERTIGUNGSVERFAHREN DES A300-SEITENLEITWERKS IN KOHLEFASERBAUWEISE]

K.-H. HEIDTMANN (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 41 p. In German.
(MBB-UT-006-86)

The design, manufacture, and testing of a CFRP tail fin for the A300-310 transport aircraft are described and illustrated with photographs, drawings, diagrams, graphs, and tables of numerical data. Consideration is given to the selection of materials; the modular fabrication techniques used on the shells, ribs, spars, and fittings of the prototype fins (and taken over, for the most part, into the series manufacturing); and the procedures and results of static, dynamic, environmental, lightning-strike, and flight testing. After loading equivalent to three times the normal life of the aircraft, no damage to the CFRP box-spar structure and no growth of the artificially induced damage-zones were observed. The CFRP fin has been in use on line aircraft since December 1985. T.K.

A87-14027#

NEW FUSELAGE TECHNOLOGIES FOR GENERAL-AVIATION AIRCRAFT [NEUE RUMPFTECHNOLOGIEN FUER FLUGZEUGE DER ALLGEMEINEN LUFTFAHRT]

K. H. DOST, D. WELTE, and B. WAGNER (Dornier GmbH, Friedrichshafen, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 47 p. In German. refs

The current status of a BMFT R&D program begun in 1985 to extend advanced design principles and fabrication techniques to the fuselages of light passenger aircraft is reported, and wind-tunnel tests on two fuselage models are discussed. Primary goals of the present phase of the fuselage program (to be completed in 1988) are improved aerodynamics, cost-effective structural realization (low fabrication costs, low weight, and high reliability with little maintenance), and reduced internal noise. Two-abreast and three-abreast versions of a 19-passenger aircraft based on the Do-228 have been designed, and mechanical testing of a CFRP front half is underway. The definition, construction, and wind-tunnel testing of 1:8 models of these two configurations are described and illustrated with drawings, photographs, and graphs; and the determination of fabrication tolerances on the basis of both aerodynamic considerations and technical limitations is considered. T.K.

A87-14033#

GUST AND MANEUVER SPECTRA FOR GENERAL AVIATION AIRCRAFT

W. M. REYER and J. OGG (Kansas, University, Lawrence) AIAA, General Aviation Technology Conference, Anaheim, CA, Sept. 29-Oct. 1, 1986. 6 p. refs
(AIAA PAPER 86-2599)

Gust- and maneuver-induced loading spectra are presented for various aircraft operations in the general aviation category. These spectra depict the cumulative frequency of incremental acceleration (departure from 1-g flight condition) occurrence as a function of incremental acceleration magnitude. The spectra were derived from the data base collected in the NASA VGH General Aviation Program. The information represented by the gust and maneuver spectra can be used in the analytical determination of aircraft fatigue life. The cumulative frequency of occurrence gives the number of cycles the aircraft structure experiences. The incremental acceleration magnitude is a factor in determining the magnitude of the alternating stresses in the structure. Comparisons are made with existing gust and maneuver spectra, with the conclusion made that the gust and maneuver environments which contribute to aircraft fatigue are more severe that previously indicated. Author

A87-14036*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
POTENTIAL INFLUENCES OF HEAVY RAIN ON GENERAL AVIATION AIRPLANE PERFORMANCE
R. E. DUNHAM, JR. (NASA, Langley Research Center, Hampton, VA) AIAA, General Aviation Technology Conference, Anaheim, CA, Sept. 29-Oct. 1, 1986. 8 p. refs
(AIAA PAPER 86-2606)

Recent NASA wind tunnel tests of airfoils in a simulated rain environment under extremely heavy rain conditions have shown reductions in maximum lift and increases in drag. Conventional airfoils were tested with and without high lift devices and tests of laminar-flow airfoils without high-lift devices were conducted. Both types of airfoils indicated performance decrements when exposed to a simulated heavy rain environment. For the laminar flow airfoil, the rain influence was observed to occur throughout the angle of attack range, whereas for the conventional airfoil in a high lift configuration, the rain influence occurred mostly at the higher angles of attack. The performance decrement for the laminar-flow airfoil appeared to be a result of laminar-to-turbulent boundary-layer transition whereas the performance penalty for the conventional airfoil appeared to be the result of premature separation. The results of these tests are presented and the implication of the results to general aviation airplanes are discussed. Author

A87-14103*# California Univ., Los Angeles.
APPLICATION OF TIME-DOMAIN UNSTEADY AERODYNAMICS TO ROTARY-WING AEROELASTICITY
M. A. H. DINYAVARI and P. P. FRIEDMANN (California, University, Los Angeles) (Structures, Structural Dynamics and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 522-535) AIAA Journal (ISSN 0001-1452), vol. 24, Sept. 1986, p. 1424-1432. Previously cited in issue 13, p. 1849, Accession no. A85-30380. refs
(Contract NAG2-209)

A87-14368#
AEROELASTIC DIVERGENCE OF TRIMMED AIRCRAFT
L. T. NIBLETT (Royal Aircraft Establishment, Farnborough, England) Journal of Aircraft (ISSN 0021-8669), vol. 23, Sept. 1986, p. 727, 728.

A set of equations for an aircraft with unswept wings in an idealized trimmed shallow pullout is subjected to static analysis to identify the speed at which the equations become indeterminate. The speed, which corresponds to the unconstrained divergence speed of the aircraft, is found to be high relative to the fixed-root divergence speed (FDS). Control problems may, however, arise at the lower FDS speed because the pitch angle is negative near the FDS, thus constraining lift to be obtained from the angle of attack due to torsion alone. The equations and the analytical techniques can be easily extended to forward-swept and tapered wing aircraft. M.S.K.

A87-14369*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMIC LOADS ON TWIN JET EXHAUST NOZZLES DUE TO SHOCK NOISE
T. D. NORUM and J. G. SHEARIN (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, Sept. 1986, p. 728, 729. refs

Acoustic near field data were collected with model single and twin jet nozzles to determine if closely spaced nozzles produce higher acoustic loading than do single nozzles. The tests were spurred by structural failure of the B-1 exhaust nozzle external flaps and similar damage on the F-15. The test was performed using two 5/8 in. ID pipes machined and placed side-by-side to mimic B-1 nozzles. A microphone mounted on the internozzle fairing measured acoustic levels near the nozzle exit plane. The nozzles oscillated significantly more than did a single nozzle over a wide range of nozzle pressure ratios. Acoustic levels in the dual jets exceeded single jet noise by as much as 20 dB, making acoustic resonance a definite candidate for structural damage in the twin jet configuration. M.S.K.

A87-14717
A STUDY OF THE EFFECT OF SURFACE ROUGHNESS ON THE HEAD RESISTANCE OF AN AIRCRAFT [ISSLEDOVANIE VLIIANIIA SHEROKHOVATOSTI POVERKHNOSTI NA LOBOVOE SOPROTIVLENIE SAMOLETA]
R. I. ZUKAKISHVILI, A. M. ILLARIONOV, and V. IA. BELIAEV (Gruzinskii Politekhnicheskii Institut, Tbilisi, Georgian SSR) Akademiia Nauk Gruzinskoi SSR, Soobshcheniia (ISSN 0132-1447), vol. 122, May 1986, p. 357-360. In Russian.

The effect of the roughness of a painted surface on the head resistance of an aircraft is investigated by using a physical model of flow past such a surface. It is found that a surface roughness of 2-10 microns has a noticeable effect on the head resistance of the aircraft and that the density of the surface projections determines the friction coefficient increment. It is further shown that the use of polyurethane coatings, rather than paint coatings, makes it possible to reduce the head resistance of the aircraft and its fuel consumption by 2 percent. V.L.

A87-14925* Virginia Polytechnic Inst. and State Univ., Blacksburg.
ANALYTICAL MODEL FOR INVESTIGATION OF INTERIOR NOISE CHARACTERISTICS IN AIRCRAFT WITH MULTIPLE PROPELLERS INCLUDING SYNCHROPHASING
C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Sound and Vibration (ISSN 0022-460X), vol. 109, Aug. 22, 1986, p. 141-156. refs
(Contract NAG1-390)

A simplified analytical model of transmission of noise into the interior of propeller-driven aircraft has been developed. The analysis includes directivity and relative phase effects of the propeller noise sources, and leads to a closed form solution for the coupled motion between the interior and exterior fields via the shell (fuselage) vibrational response. Various situations commonly encountered in considering sound transmission into aircraft fuselages are investigated analytically and the results obtained are compared to measurements in real aircraft. In general the model has proved successful in identifying basic mechanisms behind noise transmission phenomena. Author

A87-15009
ZONING OF AIRCRAFT FOR LIGHTNING ATTACHMENT AND CURRENT TRANSFER
C. C. R. JONES (British Aerospace, PLC, Military Aircraft Div., Warton, England), G. A. M. ODAM (Royal Aircraft Establishment, Farnborough, England), and A. W. HANSON IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 11-1 to 11-13. Research supported by Culham Laboratory and British Aerospace, PLC. refs

Currently accepted zonings of aircraft into regions of differing susceptibility to lightning attachment and current transport were originally determined on the basis of data on lightning strikes to fixed-wing aircraft. It is presently suggested that the observations used in the original zoning work may have overlooked vital evidence more recently noted in tests tracing natural lightning attachment. Attention is also given to zoning criteria applicable to helicopters, VTOL aircraft, and delta-planform wing aircraft. An alternative set of zones based on incident threat rather than the lightning component at an attachment point is presented. O.C.

A87-15011
SIMULATED LIGHTNING CURRENT TESTS ON A LYNX HELICOPTER
C. J. HARDWICK, V. P. DUNKLEY (Culham Laboratory, Abingdon, England), R. H. EVANS, J. S. P. HARDY, and R. A. HOBBS (Royal Aircraft Establishment, Farnborough, England) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 13-1 to 13-9.

Simulated lightning tests were carried out jointly by RAE and Culham Laboratory on a Lynx helicopter, involving the application of test current pulses up to 90 kA peak. The test current was applied by discharging a capacitor bank into the rotor head in two alternative configurations to provide a current path from the rotor head to either the tail or the wheels, corresponding to the most likely paths for a lightning strike. Extensive measurements of skin current densities on the helicopter for both configurations were made. Measurement of transient-induced currents in seven wiring looms showed good linearity against amplitude of fuselage current; extrapolation to full-threat levels indicated somewhat higher levels than those previously experienced. Author

A87-15012#
PREDICTION OF SKIN CURRENTS FLOWING ON A LYNX HELICOPTER DUE TO A SIMULATED LIGHTNING STRIKE
A. MALLIK (Kimberley Communications Consultants, Nottingham, England), C. CHRISTOPOULOS (Nottingham University, England), and J. M. THOMSON (Royal Aircraft Establishment, Farnborough, England) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 14-1 to 14-7. Research supported by the Ministry of Defense (Procurement Executive). refs

A simulated lightning strike on a Lynx helicopter is presently modeled by means of a three-dimensional transmission line modeling program which has proved capable of identifying the origin of the three principal resonances reported in measurements elsewhere. All three resonances are noted to be affected by the charging circuit, which is constituted by the return conductor, the ground plane, and the capacitor bank; the configuration of the experimental facility will accordingly strongly affect the three principal resonances. O.C.

A87-15018*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
JOINT THUNDERSTORM OPERATIONS USING THE NASA F-106B AND FAATC/AFWAL CONVAIR 580 AIRPLANES
B. D. FISHER, P. W. BROWN (NASA, Langley Research Center, Hampton, VA), A. J. WUNSCHEL, JR. (USAF, Systems Command, Andrews AFB, MD), H. D. BURKET (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), and J. S. TERRY (FAA, Technical Center, Atlantic City, NJ) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 20-1 to 20-10. refs

During the 1985 thunderstorm season, three joint thunderstorm research flights were conducted within 100 n.mi. of NASA Langley by the NASA Storm Hazards F-106B and the FAA/USAF CV-580 research airplanes with ground-based weather radar measurements by NASA Wallops. This paper discusses the thunderstorm penetration capabilities of each airplane and the techniques used to safely place the two airplanes into the same thunderstorm cell for collection of correlated EM data. It is concluded that joint thunderstorm research operations of two aircraft with significantly dissimilar thunderstorm penetration capabilities are counterproductive to both airplanes. Author

A87-15027#
EFFECT OF E-FIELD MILL LOCATION ON ACCURACY OF ELECTRIC FIELD MEASUREMENTS WITH INSTRUMENTED AIRPLANE
V. MAZUR (NOAA, National Severe Storms Laboratory, Norman, OK), L. H. RUHNKE (U.S. Navy, Naval Research Laboratory, Washington, DC), and T. RUDOLPH (Electromagnetic Applications, Inc., Denver, CO) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 31-1 to 31-7. refs

It is common in airborne observations to measure the ambient electric field and self-charge of the instrumented airplane with four field mills. In this case, the sensors' locations on the airplane are critical for accurate measurement. It is shown that positioning sensors on or near crossing points of the lines of the airplane's electrical symmetry (neutrality) decreases significantly the amplification of errors in the signal processing system that are transferred into errors in the ambient field estimates. The calculations are made using the computer simulated model of the NASA F-106B research airplane placed in a uniform electric field. Two new calibration procedures for the net charge on the airplane are suggested. Author

A87-15037#
ELECTROSTATIC FIELD MEASUREMENTS IN A FOAM FILLED C-130 FUEL TANK DURING FUEL SLOSHING
A. R. BIGELOW, M. P. HEBERT, H. JIBILIAN (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), and J. S. REAZER (Technology/Scientific Services, Inc., Dayton, OH) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 47-1 to 47-6.

The electric field inside a C-130 external fuel tank has been measured during fuel sloshing by means of five flush plate dipole sensors, in order to ascertain the electrostatic charging characteristics of the tank's explosion-suppressant foam. Two foam configurations were tested: the currently operational nonconductive foam and an experimental conductive foam. Electric fields as high as 136 kV/m were recorded during slosh tests with the nonconductive foam at 600-gal fuel levels; no measurable fields were recorded with the conductive foam. Two electrostatic discharges and ignitions occurred during testing of the nonconductive foam, while none occurred during the conductive-foam testing. O.C.

A87-15181
MANUFACTURERS PLAN NEW LONG-RANGE AIRCRAFT
B. SWEETMAN and P. CONDOM Exxon Air World, vol. 38, no. 2, 1986, p. 16-19.

The development of long-range aircraft with increased-thrust low-fuel-consumption engines is discussed. Twin-engine aircraft are being permitted to travel new routes, and aircraft with increased range are being manufactured. The designs of twin aircraft with 10,600-km and 11,300-12,050-km ranges are examined. Long-range trijets with capabilities of 12,400 and 13,900 km are being constructed. I.F.

A87-15205
MATHEMATICAL MODELING OF THE MOTION OF A STATICALLY DEFORMED DELTA-SHAPED GLIDER [MATEMATICHESKOE MODELIROVANIE DVIZHENIIA STATICHESKI DEFORMIRUEMOGO DEL'TAPLANA]
I. I. BUKHTOIAROV, V. I. MOROZOV, and A. I. PONOMAREV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1986, p. 24-28. In Russian. refs

Nonlinear equations are presented which describe the three-dimensional motion of a power version of the delta-shaped glider with allowance for the static deformation of the structure and balancing control. The elastic displacements of the glider frame are determined by using the finite element method; the changes in the shape of the fabric covering are considered in an approximate manner; the nonlinear stationary aerodynamic characteristics are calculated by using the discrete vortex method. V.L.

A87-15214

A SYSTEM MODEL, A LOGIC DESIGN DIAGRAM, AND A GENERAL SYNTHESIS ALGORITHM FOR OPTIMAL SYSTEMS OF ONBOARD ELECTRICAL EQUIPMENT IN COMPUTER-AIDED DESIGN [SISTEMNAIA MODEL', LOGICHESKAIA SKHEMA PROEKTIROVANIIA I OBSHCHII ALGORITM SINTEZA OPTIMAL'NYKH SISTEM BORTOVOGO KOMPLEKSA ELEKTROOBORUDOVANIIA V SAPR]

V. S. TERESHCHUK Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1986, p. 62-68. In Russian.

The structure of an onboard electrical complex is described by a model based on the geometrical and structural aspects of the system. The structural model consists of a tree of components based on the geometrical decomposition of the system and trees of external and internal circuits. A system model is implemented by formalizing the solution of interrelated design problems in the form of a logical design scheme. V.L.

A87-15220

A SIMULATION OF THE DYNAMICS OF THE MECHANISMS OF THE AIRCRAFT LANDING GEAR [MODELIROVANIE DINAMIKI MEKHANIZMOV SHASSI SAMOLETA]

V. V. BERDNIKOV and I. P. IAKUPOVA Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1986, p. 86, 87. In Russian.

A simulation of the dynamics of landing gear mechanisms is carried out using a set of application software for modeling the kinematics and kinestatics of the landing gear mechanisms, with an additional module used for modeling the operation of the mechanisms during the lowering and retraction of the landing gear. Since the dynamic characteristics of the mechanisms depend to a large degree on the characteristics of the hydraulic drive and its feed system, the simulation uses a sufficiently accurate mathematical model of the hydraulic drive. The dynamic simulation of the landing gear mechanisms makes it possible to identify the operating conditions that involve particularly high stresses and then use the results to improve the performance of the landing gear. V.L.

A87-15424

ASSESSING THE R&M ATTRIBUTES OF ADVANCED STRUCTURES

T. N. COOK (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) and T. E. CONDON (U.S. Army, Aviation Applied Technology Directorate, Fort Eustis, VA) IN: 1986 Annual Reliability and Maintainability Symposium, Las Vegas, NV, January 28-30, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 312-317.

A methodology has been developed to assess the R&M attributes of advanced composite structures. The method begins with a definition of the impact-related hazards to which the structure will be exposed in service and the frequency and intensity of the impact exposures. The frequency and severity of the inflicted damage are predicted on the basis of empirically-developed damage vs. impact energy curves. These predictions are used to derive damage rates and repair costs for use in life-cycle cost studies and design tradeoffs. The reparability attributes of an advanced structure are assessed through an analysis of four key design variables: type of structure, design loading condition, margin of safety, and repair access. A mapping procedure is used to quantify the reparability of small-area and large-area damage. Author

A87-16394

A320 - FLY-BY-WIRE AIRLINER

G. WARWICK Flight International (ISSN 0015-3710), vol. 130, Aug. 30, 1986, p. 86-90, 93, 94.

An account is given of the design features, performance capabilities and market prospects of the A320, with attention to the fly-by-wire system it incorporates to improve handling qualities and reduce pilot workload. The A320's pitch-control law is a g-control law with pitch-rate feedback originally developed by NASA. As a whole, the most significant capability of the A320 flight control system is its ability to protect the aircraft from stalling, overspeeding, overloading, excessive attitudes, and windshear conditions. O.C.

A87-16400

V-22 OSPREY - MULTI-SERVICE WORKHORSE

J. MOXON Flight International (ISSN 0015-3710), vol. 130, Aug. 30, 1986, p. 154-157.

An account is given of the development history and existing deployment plans for the V-22 tilt-rotor VTOL aircraft; these services will employ it as an assault troop transport, ASW platform, supply transport and field hospital. Attention is given to the extensive use of commposites to maintain minimum weight, the performance advantages of the T406 powerplant, the projected flight envelope, and the wing/rotor blade stowage feature for shipboard use. O.C.

A87-16408

A REVIEW OF THE TECHNICAL DEVELOPMENT OF CONCORDE

C. S. LEYMAN (British Aerospace, PLC, Civil Div., Bristol, England) Progress in Aerospace Sciences (ISSN 0376-0421), vol. 23, no. 3, 1986, p. 185-238. refs

The technical problems encountered during the development and certification of Concorde are reviewed. The topics covered are mainly associated with aerodynamics, but other areas are discussed where they interact with the aerodynamic design or if there were conditions peculiar to supersonic transportation which had to be considered. Author

N87-11717*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

RECENT EXPERIENCES IN MULTIDISCIPLINARY ANALYSIS AND OPTIMIZATION, PART 1

J. SOBIESKI, comp. 1984 517 p Symposium held in Hampton, Va., 24-26 Apr. 1984

(NASA-CP-2327-PT-1; NAS 1.55:2327-PT-1) Avail: NTIS HC A22/MF A01 CSCL 01C

Papers presented at the NASA Symposium on Recent Experiences in Multidisciplinary Analysis and Optimization held at NASA Langley Research Center, Hampton, Virginia April 24 to 26, 1984 are given. The purposes of the symposium were to exchange information about the status of the application of optimization and associated analyses in industry or research laboratories to real life problems and to examine the directions of future developments. Information exchange has encompassed the following: (1) examples of successful applications; (2) attempt and failure examples; (3) identification of potential applications and benefits; (4) synergistic effects of optimized interaction and trade-offs occurring among two or more engineering disciplines and/or subsystems in a system; and (5) traditional organization of a design process as a vehicle for or an impediment to the progress in the design methodology.

N87-11719*# Lockheed-Georgia Co., Marietta.

OPTIMIZATION IN THE SYSTEMS ENGINEERING PROCESS

L. A. LEMMERMAN *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 16 p 1984

Avail: NTIS HC A22/MF A01 CSCL 01C

The objective is to look at optimization as it applies to the design process at a large aircraft company. The design process at Lockheed-Georgia is described. Some examples of the impact that optimization has had on that process are given, and then some areas that must be considered if optimization is to be successful and supportive in the total design process are indicated. Optimization must continue to be sold and this selling is best done by consistent good performance. For this good performance to occur, the future approaches must be clearly thought out so that the optimization methods solve the problems that actually occur during design. The visibility of the design process must be maintained as further developments are proposed. Careful attention must be given to the management of data in the optimization process, both for technical reasons and for administrative purposes. Finally, to satisfy program needs, provisions must be included to supply data to support program decisions, and to communicate with design processes outside of the optimization process. If designers fail to adequately consider all of these needs, the future acceptance of optimization will be impeded. Author

N87-11720*# Douglas Aircraft Co., Inc., St. Louis, Mo.
PRACTICAL CONSIDERATIONS IN AEROELASTIC DESIGN
B. A. ROMMEL and A. J. DODD *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 12 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

The structural design process for large transport aircraft is described. Critical loads must be determined from a large number of load cases within the flight maneuver envelope. The structural design is also constrained by considerations of producibility, reliability, maintainability, durability, and damage tolerance, as well as impact dynamics and multiple constraints due to flutter and aeroelasticity. Aircraft aeroelastic design considerations in three distinct areas of product development (preliminary design, advanced design, and detailed design) are presented and contrasted. The present state of the art is challenged to solve the practical difficulties associated with design, analysis, and redesign within cost and schedule constraints. The current practice consists of largely independent engineering disciplines operating with unorganized data interfaces. The need is then demonstrated for a well-planned computerized aeroelastic structural design optimization system operating with a common interdisciplinary data base. This system must incorporate automated interfaces between modular programs. In each phase of the design process, a common finite-element model for static and dynamic optimization is required to reduce errors due to modeling discrepancies. As the design proceeds from the simple models in preliminary design to the more complex models in advanced and detailed design, a means of retrieving design data from the previous models must be established. Author

N87-11721*# McDonnell Aircraft Co., St. Louis, Mo.
FLUTTER OPTIMIZATION IN FIGHTER AIRCRAFT DESIGN
W. E. TRIPLETT *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 17 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

The efficient design of aircraft structure involves a series of compromises among various engineering disciplines. These compromises are necessary to ensure the best overall design. To effectively reconcile the various technical constraints requires a number of design iterations, with the accompanying long elapsed time. Automated procedures can reduce the elapsed time, improve productivity and hold the promise of optimum designs which may be missed by batch processing. Several examples are given of optimization applications including aeroelastic constraints. Particular attention is given to the success or failure of each example and the lessons learned. The specific applications are shown. The final two applications were made recently. Author

N87-11722*# Lockheed-Georgia Co., Marietta.
APPLICATION OF THE GENERALIZED REDUCED GRADIENT METHOD TO CONCEPTUAL AIRCRAFT DESIGN
G. A. GABRIELE *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 21 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

The complete aircraft design process can be broken into three phases of increasing depth: conceptual design, preliminary design, and detail design. Conceptual design consists primarily of developing general arrangements and selecting the configuration that optimally satisfies all mission requirements. The result of the conceptual phase is a conceptual baseline configuration that serves as the starting point for the preliminary design phase. The conceptual design of an aircraft involves a complex trade-off of many independent variables that must be investigated before deciding upon the basic configuration. Some of these variables are discrete (number of engines), some represent different configurations (canard vs conventional tail) and some may represent incorporation of new technologies (aluminum vs composite materials). At Lockheed-Georgia, the sizing program is known as GASP (Generalized Aircraft Sizing Program). GASP is a large program containing analysis modules covering the many different disciplines involved fin defining the aricraft, such as aerodynamics, structures, stability and control, mission performance, and cost. These analysis modules provide first-level estimates the aircraft properties that are derived from handbook, experimental, and historical sources. Author

N87-11723*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXPERIENCES PERFORMING CONCEPTUAL DESIGN OPTIMIZATION OF TRANSPORT AIRCRAFT
P. D. ARBUCKLE and S. M. SLIWA *In its* Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 15 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

Optimum Preliminary Design of Transports (OPDOT) is a computer program developed at NASA Langley Research Center for evaluating the impact of new technologies upon transport aircraft. For example, it provides the capability to look at configurations which have been resized to take advantage of active controls and provide and indication of economic sensitivity to its use. Although this tool returns a conceptual design configuration as its output, it does not have the accuracy, in absolute terms, to yield satisfactory point designs for immediate use by aircraft manufacturers. However, the relative accuracy of comparing OPDOT-generated configurations while varying technological assumptions has been demonstrated to be highly reliable. Hence, OPDOT is a useful tool for ascertaining the synergistic benefits of active controls, composite structures, improved engine efficiencies and other advanced technological developments. The approach used by OPDOT is a direct numerical optimization of an economic performance index. A set of independent design variables is iterated, given a set of design constants and data. The design variables include wing geometry, tail geometry, fuselage size, and engine size. This iteration continues until the optimum performance index is found which satisfies all the constraint functions. The analyst interacts with OPDOT by varying the input parameters to either the constraint functions or the design constants. Note that the optimization of aircraft geometry parameters is equivalent to finding the ideal aircraft size, but with more degrees of freedom than classical design procedures will allow. Author

N87-11725*# Boeing Commercial Airplane Co., Seattle, Wash.
PIAS: A PROGRAM FOR AN ITERATIVE AEROELASTIC SOLUTION
M. E. MANRO *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 15 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

A Program for an Iterative Aeroelastic Solution (PIAS) is discussed. This will be a modular computer program that combines the use of a finite-element structural analysis code with any linear or nonlinear aerodynamic code. At this point in time, PIAS has been designed but the software has not been written. The idea for this development originated with P. J. (Bud) Bobbitt of the NASA Langley Research Center. There was initial interest in an aeroelastic solution for a separation-induced leading-edge vortex. Some examples of the flow patterns for a low aspect ratio wing are shown. The Leading-Edge Vortex Program, which calculates pressure distributions including the effects of a separation-induced leading-edge vortex, uses an iterative solution method. This led to the concept of an iteration cycle on configuration shape external to the aerodynamic code. Author

N87-11726*# Hughes Helicopters, Culver City, Calif.
OPTIMIZATION PROCESS IN HELICOPTER DESIGN
A. H. LOGAN and D. BANERJEE *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 19 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

In optimizing a helicopter configuration, Hughes Helicopters uses a program called Computer Aided Sizing of Helicopters (CASH), written and updated over the past ten years, and used as an important part of the preliminary design process of the AH-64. First, measures of effectiveness must be supplied to define the mission characteristics of the helicopter to be designed. Then CASH allows the designer to rapidly and automatically develop the basic size of the helicopter (or other rotorcraft) for the given mission. This enables the designer and management to assess the various tradeoffs and to quickly determine the optimum configuration. Author

N87-11737*# Kansas Univ., Lawrence. Dept. of Aerospace Engineering.
APPLICATIONS OF CONMIN TO WING DESIGN OPTIMIZATION WITH VORTEX FLOW EFFECT
C. E. LAN *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 12 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

Slender wings on supersonic cruise configurations are expected to be thin and highly swept. As a result, edge-separated vortex flow is inevitable and must be accounted for in aerodynamic analysis and design. The present method is based on the method of suction analogy to calculate the total aerodynamic characteristics. The method requires the solution of the attached flow problem, the latter being solved by a low-order panel method in subsonic and supersonic flow. In essence, the lifting pressure is calculated by using a pressure-doublet distribution satisfying the Prandtl-Glauert equation. From the pressure distribution, the leading-edge suction is calculated. The latter is assumed to be the vortex lift through the method of suction analogy. For a cambered wing, the location of vortex-lift action point is important in predicting the aerodynamic characteristics. It is also seen that the effect of camber shape appears nonlinearly in all aerodynamic expressions. To design the camber shape, the camber slope is represented by a cosine Fourier series at each of several spanwise stations. The Fourier coefficients are the design variables. To design a leading-edge flap in the vortex flow (i.e., a vortex flap), the coordinates of corner points and the deflection angle are the design variables. The process of wing design is to determine the camber shape and twist distribution such that an objective function, typically the drag, is minimized, subject to various constraints. Author

N87-11739*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INFLUENCE OF ANALYSIS AND DESIGN MODELS ON MINIMUM WEIGHT DESIGN
M. SALAMA, R. K. RAMANATHAN (Northrop Corp., Hawthorne, Calif.), L. A. SCHMIT (California Univ., Los Angeles), and I. S. SARMA *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 14 p 1984
(Contract NAS7-918)
Avail: NTIS HC A22/MF A01 CSCL 01C

The results of numerical experiments designed to illustrate how the minimum weight design, accuracy, and cost can be influenced by: (1) refinement of the finite element analysis model and associated load path problems, and (2) refinement of the design variable linking model are examined. The numerical experiments range from simple structures where the modelling decisions are relatively obvious and less costly to the more complex structures where such decisions are less obvious and more costly. All numerical experiments used employ the dual formulation in ACCESS-3 computer program. Guidelines are suggested for creating analysis and design models that predict a minimum weight structure with greater accuracy and less cost. These guidelines can be useful in an interactive optimization environment and in the design of heuristic rules for the development of knowledge-based expert optimization systems. Author

N87-11743*# Kentron International, Inc., Hampton, Va.
AIRCRAFT CONFIGURATION OPTIMIZATION INCLUDING OPTIMIZED FLIGHT PROFILES
L. A. MCCULLERS *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 18 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

The Flight Optimization System (FLOPS) is an aircraft configuration optimization program developed for use in conceptual design of new aircraft and in the assessment of the impact of advanced technology. The modular makeup of the program is illustrated. It contains modules for preliminary weights estimation, preliminary aerodynamics, detailed mission performance, takeoff and landing, and execution control. An optimization module is used to drive the overall design and in defining optimized profiles in the mission performance. Propulsion data, usually received from engine manufacturers, are used in both the mission performance and the takeoff and landing analyses. Although executed as a single in-core program, the modules are stored separately so that the user may select the appropriate modules (e.g., fighter weights versus transport weights) or leave out modules that are not needed. Author

N87-11747*# Lockheed-California Co., Burbank.
SOME EXPERIENCES IN AIRCRAFT AEROELASTIC DESIGN USING PRELIMINARY AEROELASTIC DESIGN OF STRUCTURES (PAD)
N. A. RADOVCICH *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 49 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

The design experience associated with a benchmark aeroelastic design of an out of production transport aircraft is discussed. Current work being performed on a high aspect ratio wing design is reported. The Preliminary Aeroelastic Design of Structures (PADS) system is briefly summarized and some operational aspects of generating the design in an automated aeroelastic design environment are discussed. Author

N87-11749*# Northrop Corp., Hawthorne, Calif. Aircraft Div.
THE AUTOMATED STRENGTH-AEROELASTIC DESIGN OF AEROSPACE STRUCTURES PROGRAM Progress Report
E. H. JOHNSON and V. B. VENKAYYA (Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio) *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 11 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

An ongoing program whose goal is to develop an automated procedure that can assist in the preliminary design of aircraft and space structures is described. The approach and capabilities that are to be included in the final procedures are descussed. By using proven engineering software as a basis for the project, a reliable and interdisciplinary procedure is developed. The use of a control language for module sequencing and execution permits efficient development of the procedure and gives the user significant flexibility in altering or enhancing the procedure. The data base system provides reliable and efficient access to the large amounts of interrelated data required in an enterprise of this sort. In addition, the data base allows interfacing with existing pre- and post-processors in an almost trivial manner. Altogether, the procedure promises to be of considerable utility to preliminary structural design teams. Author

N87-11750*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

RECENT EXPERIENCES IN MULTIDISCIPLINARY ANALYSIS AND OPTIMIZATION, PART 2

J. SOBIESKI, comp. 1984 509 p Symposium held in Hampton, Va., 24-26 Apr. 1984
(NASA-CP-2327-PT-2; L-15830; NAS 1.55:2327-PT-2) Avail: NTIS HC A22/MF A01 CSCL 01C

The papers presented at the NASA Symposium on Recent Experiences in Multidisciplinary Analysis and Optimization held at NASA Langley Research Center, Hampton, Virginia, April 24 to 26, 1984 are given. The purposes of the symposium were to exchange information about the status of the application of optimization and the associated analyses in industry or research laboratories to real life problems and to examine the directions of future developments.

N87-11751*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

OVERVIEW: APPLICATIONS OF NUMERICAL OPTIMIZATION METHODS TO HELICOPTER DESIGN PROBLEMS

H. MIURA *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 2 13 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

There are a number of helicopter design problems that are well suited to applications of numerical design optimization techniques. Adequate implementation of this technology will provide high pay-offs. There are a number of numerical optimization programs available, and there are many excellent response/performance analysis programs developed or being developed. But integration of these programs in a form that is usable in the design phase should be recognized as important. It is also necessary to attract the attention of engineers engaged in the development of analysis capabilities and to make them aware that analysis capabilities are much more powerful if integrated into design oriented codes. Frequently, the shortcoming of analysis capabilities are revealed by coupling them with an optimization code. Most of the published work has addressed problems in preliminary system design, rotor system/blade design or airframe design. Very few published results were found in acoustics, aerodynamics and control system design. Currently major efforts are focused on vibration reduction, and aerodynamics/acoustics applications appear to be growing fast. The development of a computer program system to integrate the multiple disciplines required in helicopter design with numerical optimization technique is needed. Activities in Britain, Germany and Poland are identified, but no published results from France, Italy, the USSR or Japan were found. Author

N87-11753*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

HELICOPTER ROTOR BLADE AERODYNAMIC OPTIMIZATION BY MATHEMATICAL PROGRAMMING

J. L. WALSH, G. J. BINGHAM, and M. F. RILEY (Kentron International, Inc., Hampton, Va.) *In its* Recent Experiences in Multidisciplinary Analysis and Optimization, Part 2 12 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

Formal mathematical programing was applied to the aerodynamic rotor blade design process. The approach is to couple hover and forward flight analysis programs with the general-purpose optimization program CONMIN to determine the blade taper ratio, percent taper, twist distribution, and solidity which minimize the horsepower required at hover while meeting constraints on forward flight performance. Designs obtained using this approach for the blade of a representative Army helicopter compare well with those obtained using a conventional approach involving personnel-intensive parametric studies. Results from the present method can be obtained in 2 days as compared to 5 weeks required by the conventional procedure. Also the systematic manipulation of the design variables by the optimization procedure minimizes the need for the researcher to have a vast body of past experience and data in determining the influence of a design change on the performance. Author

N87-11756*# United Technologies Research Center, East Hartford, Conn.

OPTIMIZATION OF HELICOPTER ROTOR BLADE DESIGN FOR MINIMUM VIBRATION

M. W. DAVIS *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 2 17 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

The optimization approach discussed is part of an ongoing effort to develop a general automated procedure for rotor blade design. This procedure can be used to determine the necessary geometric, structural, and material properties of a rotor system to achieve desired objectives relating to vibration, stress, and aerodynamic performance. The approach used for helicopter vibration is emphasized. Based on analytical studies performed at the United Technologies Research Center (UTRC), a simplified vibration analysis was developed to be used in conjunction with a forced response analysis in the optimization process. This simplified analysis improves the efficiency of the design process significantly. Results of applying this approach to the design of an existing rotor blade model are presented. Author

N87-11757*# Army Research and Technology Labs., Fort Eustis, Va.

APPLICATION OF NUMERICAL OPTIMIZATION TO ROTOR AERODYNAMIC DESIGN

W. A. PLEASANTS, III and T. J. WIGGINS *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 2 15 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

Based on initial results obtained from the performance optimization code, a number of observations can be made regarding the utility of optimization codes in supporting design of rotors for improved performance. (1) The primary objective of improving the productivity and responsiveness of current design methods can be met. (2) The use of optimization allows the designer to consider a wider range of design variables in a greatly compressed time period. (3) Optimization requires the user to carefully define his problem to avoid unproductive use of computer resources. (4) Optimization will increase the burden on the analyst to validate designs and to improve the accuracy of analysis methods. (5) Direct calculation of finite difference derivatives by the optimizer was not prohibitive for this application but was expensive. Approximate analysis in some form would be considered to improve program response time. (6) Program developement is not complete and will continue to evolve to integrate new analysis methods, design problems, and alternate optimizer options. Author

N87-11758*# Army Research and Technology Labs., Fort Eustis, Va. Applied Technology Lab.

AEROELASTIC-AERODYNAMIC OPTIMIZATION OF HIGH SPEED HELICOPTER-COMPOUND ROTOR

L. R. SUTTON and R. L. BENNETT *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 2 20 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

Several problems related to the aeroelastic/aerodynamic optimization of a high speed helicopter compound rotor are discussed. The helicopter fuselage vibration problem, the effects of fuselage vibrations, the source of external and periodic air loads, typical airfoil environments and configurations, rotor dynamics, vibration reduction, and requirements for the rotor design optimization analysis are among the topics covered. R.J.F.

N87-11759*# Sikorsky Aircraft, Stratford, Conn.
THE STRUCTURAL OPTIMIZATION OF A SPREADER BAR FOR TWIN LIFT HELICOPTER OPERATIONS
A. DOBYNS *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 2 12 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

An optimization study was performed to develop a minimum weight spreader bar to allow two helicopters to lift the same payload. With this arrangement, the maximum payload that can be lifted is almost doubled without the expense of designing and building a new helicopter. The concept has had some limited use by civil helicopter operators using small helicopters and has been demonstrated in large scale by two CH-54's which successfully lifted a total load of 20 ton. To this point, rather heavy available beams or tower structures have been used for the spreader bar. Since the weight of the bar not only detracts from payload but also adds to the logistics problem, there are more than the usual incentives to minimize weight. Since the design requirement is for classic beam column with uniform side loads resulting from bar weight and aerodynamic drag, the design problem is particularly amenable to optimization. A study has been performed at Sikorsky to establish the minimum weight for a spreader bar sized to carry a load equal to the capacity of two Army BLACK HAWK helicopters. Toward this end, a computer program was written to analyze the spreader bar deflections and stresses and coupled to the NASA developed CONMIN optimization routines. Author

N87-11781*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE PREDICTION OF TRANSONIC LOADING ADVANCING HELICOPTER ROTORS
R. STRAWN and C. TUNG Apr. 1986 17 p
(AD-A168217; NASA-TM-88238; A-86198; NAS 1.15:88238; AVSCOM-TM-86-A-1) Avail: NTIS HC A02/MF A01 CSCL 01C

Two different schemes are presented for including the effect of rotor wakes on the finite-difference prediction of rotor loads. The first formulation includes wake effects by means of a blade-surface inflow specification. This approach is sufficiently simple to permit coupling of a full-potential finite-difference rotor code to a comprehensive integral model for the rotor wake and blade motion. The coupling involves a transfer of appropriate loads and inflow data between the two computer codes. Results are compared with experimental data for two advancing rotor cases. The second rotor wake modeling scheme in this paper is a split potential formulation for computing unsteady blade-vortex interactions. Discrete vortex fields are introduced into a three-dimensional, conservative, full-potential rotor code. Computer predictions are compared with two experimental blade-vortex interaction cases. GRA

N87-11782# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
A CHECK OF CRACK PROPAGATION PREDICTION MODELS AGAINST TEST RESULTS GENERATED UNDER TRANSPORT AIRCRAFT FLIGHT SIMULATION LOADING
H. H. VANDERLINDEN 30 Dec. 1985 112 p Sponsored by Netherlands Agency for Aerospace Programs
(NLR-TR-84005-U; B8667272; GARTEUR/TP-008; ETN-86-98497)
Avail: NTIS HC A06/MF A01

Thirteen variations of the F-27 transport spectrum were evaluated by 7 institutes and companies using in total 13 crack propagation prediction methods and models. It is shown that the predictions range from very conservative through accurate to unconservative. ESA

N87-12556 ESDU International Ltd., London (England).
SIMPLIFIED FORMS OF PERFORMANCE EQUATIONS. ADDENDUM A: EFFECT ON AEROPLANE LEVEL SPEED OF SMALL CHANGES IN THRUST, DRAG, WEIGHT, POWER
May 1986 14 p Supersedes ESDU-EG2/1
(ESDU-86004-ADD-A; ISBN-0-85679-556-9; ISSN-0141-4054)
Avail: ESDU

This Data Item ESDU 86004 is an addition to the Aircraft Performance Sub-series. Equations and curves are given for a method that neglects the effects of any consequential changes in the other independent variables although, at the cost of increased complexity, a means of including such effects (in particular, compressibility effects on drag) is provided. Several worked examples show how well the simple method compares with actual operations data. This document is an Addendum to ESDU 80032, and illustrates how the equations of motion given there combined with a parabolic drag law yield valuable results. ESDU

N87-12557*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NASA ROTOR SYSTEMS RESEARCH AIRCRAFT: FIXED-WING CONFIGURATION FLIGHT-TEST RESULTS
R. E. ERICKSON, J. L. CROSS, R. M. KUFELD, C. W. ACREE, D. NGUYEN, and R. W. HODGE (Sikorsky Aircraft, Stratford, Conn.) Feb. 1986 124 p
(NASA-TM-86789; A-85363; NAS 1.15:86789) Avail: NTIS HC A06/MF A01 CSCL 01C

The fixed-wing, airplane configuration flight-test results of the Rotor System Research Aircraft (RSRA), NASA 740, at Ames/Dryden Flight Research Center are documented. Fourteen taxi and flight tests were performed from December 1983 to October 1984. This was the first time the RSRA was flown with the main rotor removed; the tail rotor was installed. These tests confirmed that the RSRA is operable as a fixed-wing aircraft. Data were obtained for various takeoff and landing distances, control sensitivity, trim and dynamics stability characteristics, performance rotor-hub drag, and acoustics signature. Stability data were obtained with the rotor hub both installed and removed. The speed envelope was developed to 261 knots true airspeed (KTAS), 226 knots calibrated airspeed (KCAS) at 10,000 ft density altitude. The airplane was configured at 5 deg. wing incidence with 5 deg. wing flaps as a normal configuration. Level-flight data were acquired at 167 KCAS for wing incidence from 0 to 10 deg. Step inputs and doublet inputs of various magnitudes were utilized to acquire dynamic stability and control sensitivity data. Sine-wave inputs of constantly increasing frequency were used to generate parameter identification data. The maximum load factor attained was 2.34 g at 206 KCAS. Author

N87-12558*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE HANDLING QUALITIES AND FLIGHT CHARACTERISTICS OF THE GRUMMAN DESIGN 698 SIMULATED TWIN-ENGINE TILT NACELLE V/STOL AIRCRAFT
M. A. ESKEY and S. B. WILSON, III Jun. 1986 112 p
(NASA-TM-86785; A-85361; NAS 1.15:86785) Avail: NTIS HC A06/MF A01 CSCL 01C

This paper describes three government-conducted, piloted flight simulations of the Grumman Design 698 vertical and short takeoff and landing (V/STOL) aircraft. Emphasis is placed on the aircraft's handling qualities as rated by various NASA, Navy, and Grumman Aerospace Corporating pilots with flight experience ranging from conventional takeoff and landing (CTOL) to V/STOL aircraft. Each successive simulation incorporated modifications to the aircraft in order to resolve the flight problems which were of most concern to the pilots in the previous simulation. The objective of the first simulation was to assess the basic handling qualities of the aircraft with the noncross-shafted propulsion system. The objective of the second simulation was to examine the effects of incorporating the cross-shafted propulsion system. The objective of the third simulation was to examine inoperative single-engine characteristics with and without cross-shafted engines. Author

N87-12559*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A HEATER MADE FROM GRAPHITE COMPOSITE MATERIAL FOR POTENTIAL DEICING APPLICATION
C. C. HUNG, M. E. DILLEHAY (Cleveland State Univ., Ohio), and M. STAHL 1986 22 p Proposed for presentation at the 25th Aerospace Sciences Meeting, Reno, Nev., 12-15 Jan. 1987; sponsored by AIAA
(NASA-TM-88888; E-3298; NAS 1.15:88888) Avail: NTIS HC A02/MF A01 CSCL 01C
A surface heater was developed using a graphite fiber-epoxy composite as the heating element. This heater can be thin, highly electrically and thermally conductive, and can conform to an irregular surface. Therefore it may be used in an aircraft's thermal deicing system to quickly and uniformly heat the aircraft surface. One-ply of unidirectional graphite fiber-epoxy composite was laminated between two plies of fiber glass-epoxy composite, with nickel foil contacting the end portions of the composite and partly exposed beyond the composites for electrical contact. The model heater used brominated P-100 fibers from Amoco. The fiber's electrical resistivity, thermal conductivity and density were 50 micro ohms per centimeter, 270 W/m-K and 2.30 gm/cubic cm, respectively. The electricity was found to penetrate through the composite in the transverse direction to make an acceptably low foil-composite contact resistance. When conducting current, the heater temperature increase reached 50 percent of the steady state value within 20 sec. There was no overheating at the ends of the heater provided there was no water corrosion. If the foil-composite bonding failed during storage, liquid water exposure was found to oxidize the foil. Such bonding failure may be avoided if perforated nickel foil is used, so that the composite plies can bond to each other through the perforated holes and therefore lock the foil in place. Author

N87-12716# Joint Publications Research Service, Arlington, Va.
POSSIBLE MILITARY APPLICATIONS OF STRATOSPHERIC AIRSHIP DISCUSSED
J. KIMURA, R. TAKEDA, Y. FUJIMATSU, and T. KATO *In its* Japan Report: Science and Technology (JPRS-JST-86-023) p 49-62 29 Aug. 1986 Transl. into ENGLISH from Boei Gijutsu (Tokyo, Japan), Nov. 1985 p 48-58
Avail: NTIS HC A04/MF A01
The possibilities of a stratospheric airship of the LB (lifting body) types are studied from the aspect of operation. The meteorological conditions that most severely restrict its operation are considered. The advantages that the stratospheric airship has over other aircraft and artificial satellites are discussed. B.G.

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A87-13469
MICROELECTRONICS IN AIRCRAFT SYSTEMS
E. H. J. PALLETT (Civil Aviation Authority, Airworthiness Div., Redhill, England) London, Pitman, 1985, 285 p.
The design, operating principles, and performance of aircraft electronic systems based on microelectronic devices are surveyed and illustrated with photographs, diagrams, and graphs. The developmental history of aircraft electronics is traced, and individual chapters are devoted to number systems and coding, logic gates and circuits, logic devices, displays, CRT displays, logic diagrams and interpretation, computers, aircraft systems, and handling procedures to avoid electrostatic damage to microelectronic circuits. T.K.

A87-13545#
PRECISION POINT TARGET TRACKING
C. L. RICHARDS, JR. (Technology Concepts Associates, Inc., Irvine, CA) IN: ION, National Technical Meeting, Long Beach, CA, January 21-23, 1986, Proceedings . Washington, DC, Institute of Navigation, 1986, p. 105-110.
Subresolution tracking may be achieved through a combination of proper imaging sensor design and algorithm selection. The requirement on the sensor for optimum performance is that images must be sampled by a stable grid which meets the Nyquist sampling criterion. For staring array sensors this requirement leads to a detector size and sample spacing which is quite different from the classical design choice. Once the focal plane has been properly designed, there is a selection of tracking algorithms which give approximately the same tracking performance. All of these algorithms show a residual single measurement error which is inversely proportional to the signal to noise ratio. The choice of a particular algorithm comes primarily from a trade between processing burden and clutter rejection. A system which is optimized for point target tracking will also be optimized, and will show improved performance, for extended target tracking and for pattern recognition. Author

A87-13912
COMBINED RADAR, ECM FUNCTIONS WILL ENHANCE LAVI SURVIVABILITY
D. A. BROWN Aviation Week and Space Technology (ISSN 0005-2175), vol. 125, Aug. 25, 1986, p. 111, 113.
The Israeli Lavi attack fighter will incorporate an avionics system that links radar warning and active electronics countermeasures functions, as one way of enhancing aircraft survivability and freeing wing and fuselage stations for additional ordnance. The internal location of the system created problems with respect to shape, volume and weight constraints, as well as antenna position optimization. A power management concept is used which allows the system to employ its available power advantageously under any circumstances. The Lavi's ECM capability will be enhanced by an operationally redundant active subsystem which provides for dynamic location of multiple resources and will allow graceful degradation in the event of subsystem unit failures. O.C.

A87-14005#
AVIONICS SYSTEMS FOR FUTURE COMMERCIAL HELICOPTERS
BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 23 p. In German.
The state of the art and future developments in avionics for commercial helicopters are discussed. Present systems of cockpit instrumentation with color displays, systems for testing these displays, and central control systems are described. Future sensors, cockpit instrumentation, and central controls are described, stressing the greater levels of control and information about the entire aircraft that will be concentrated in the cockpit. The use of simulators to test these future technologies before their installation in helicopters is discussed, and signal standrdization, bus systems, and software that will be used in future commercial helicopters are considered. C.D.

A87-14030#
STALL MARGIN INDICATION
A. W. HOADLEY (Western Michigan University, Kalamazoo) and R. S. VANDERBOK (Electronic Systems Development Co., Canton, MI) AIAA, General Aviation Technology Conference, Anaheim, CA, Sept. 29-Oct. 1, 1986. 6 p. Research supported by the Western Michigan University.
(AIAA PAPER 86-2595)
The landing and takeoff phases of flight require control of the aircraft at airspeeds and angles of attack close to stall. This is particularly true when a wind shear condition has been encountered. During the recovery from a wind shear, the aircraft must use all available energy, the most immediately available being kinetic energy in the form of airspeed. This paper covers the concept

and hardware of a microprocessor based stall margin display system. The LCD heads up display provides accurate real time data to the provides accurate real time data to the pilot allowing the precise use of the available airspeed. The precise use of this immediately available, but limited, energy source will increase the chance that ground contact can be avoided until the engines can provide the necessary additional energy for full recovery. Author

A87-14352* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ALL-DIGITAL JETS ARE TAKING OFF
C. R. SPITZER (NASA, Langley Research Center, Hampton, VA) IEEE Spectrum (ISSN 0018-9235), vol. 23, Sept. 1986, p. 51-56. refs

The functions and advantages of second-generation digital avionics systems are described. These digital systems have increased integration, increased reliability and flexibility, and improved man-machine interface, and they provide increases in the mean time between removal of line-replacable units and fuel savings. Different redundant processors and software are utilized to achieve fault-tolerance performance of flight control systems. The improved landing capabilities, front-panel instruments, sidestick controllers, back-lighted liquid-crystal displays, and fly-by-wire system possible with digital avionics are examined. The applications of digital avionics to military and commercial aircraft are discussed and examples are provided. I.F.

A87-15028#
EXPERIMENTAL CALIBRATION OF AN AIRCRAFT VECTOR ELECTRIC FIELD METER SYSTEM
R. V. ANDERSON and J. C. BAILEY (U.S. Navy, Naval Research Laboratory, Washington, DC) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 33-1 to 33-13. refs

Although numerous aircraft have been instrumented for the measurement of electrostatic field, and there have been a few instances of calibration on an absolute basis, the absolute calibration of an airborne system for the measurement of a full three-dimensional vector field has not been reported. This report outlines the problems inherent in such a calibration. The design of field meters which are simultaneously suitable for lightning measurements and for calibration is summarized. A description of the calibration accomplished is provided, and the inherent errors are estimated. It is concluded that the process described is viable, and possible improvements are suggested. Author

A87-15415
LAMPS MK III - A 'NEW LOOK' SUCCESS STORY
T. M. GOOD (IBM Corp., Federal Systems Div., Owego, NY) IN: 1986 Annual Reliability and Maintainability Symposium, Las Vegas, NV, January 28-30, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 151-155.

The reliability enhancement elements incorporated into the LAMPS MK III development program are described. New elements included conservative derating criteria to ensure that a 20-yr service life would be available from 99 percent of the 30,000 components of the integrated system. Other program elements are parts selection and a test, analyze, and fix program. A reliability estimate for the SH-60B helicopter exceeded the reliabilities of other current systems by a factor of 2.5. M.S.K.

A87-15430#
TAILORING A MAJOR WEAPON ENVIRONMENTAL PROGRAM
J. H. WAFFORD (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: 1986 Annual Reliability and Maintainability Symposium, Las Vegas, NV, January 28-30, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 383-388.

The impact of engineering data and consequent design changes on the vibration requirements for environment tests of LANTIRN is described. LANTIRN was devised to provide tactical aircraft with low altitude, all-weather, day/night operational capability by means of an FLIR sensor, supporting electronics, and an environmental control system. Military specifications for realistic environment testing led to emulation of the vibration conditions experienced by similar stores on F-16 aircraft. Validation data were obtained for the vibration test stand with flight tests of mock-ups of the LANTIRN pod. M.S.K.

N87-11783# Science Applications, Inc., Orlando, Fla.
EVALUATION OF A VISUAL SYSTEM IN ITS SUPPORT OF SIMULATED HELICOPTER FLIGHT Final Report, Sep. 1985 - Feb. 1986
W. D. SPEARS and W. E. CORLEY Feb. 1986 113 p Prepared in cooperation with Seville Training Systems Corp.
(Contract N61339-82-D-0006)
(AD-A168829; TR-86-06) Avail: NTIS HC A06/MF A01 CSCL 05H

The Visual System Component Development Program (VSCDP) was developed by GE under contract with PM TRADE and installed at Williams AFB in spring 1985. Its purpose was to expand the state-of-the-art in visual systems by providing the capability to support nap-of-the-earth (NOE) flight simulation, which requires a high density of visual cues to allow pilots to accurately judge vertical and horizontal distances. The GE system was tested with the computer generated imagery projected in the dome with a radius of 12 feet. The Field of View (FOV) was 140 degrees horizontal by 60 degrees vertical with an enhanced Area of Interest (AOI) of 26 degrees horizontal by 20 degrees vertical inserted in the middle. The imagery centered in pilot's attention regardless of where he was looking in the dome; however, the eye tracker was not functioning for these tests. Nine experienced helicopter pilots participated as subjects. Two kinds of flight mission plans were used: a familiarization flight and a tactical maneuvers flight. The results of the experiment showed that the GE system can support all aspects of helicopter flight simulation. However, problems were found that indicate further work is needed. These included trouble with perceived sizes and distances in the visual scene, and a high incidence of simulator sickness, probably due to processing of motion cues. GRA

N87-11784# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Abteilung Traegheitsortung und Navigation.
INVESTIGATION OF MAGNETOMETER ERRORS AND THEIR COMPENSATION IN THE BO-105 HELICOPTER
H. J. HOTOP and N. NAWA Mar. 1986 62 p In GERMAN; ENGLISH summary
(DFVLR-FB-86-21; ISSN-0171-1342; ETN-86-98187) Avail: NTIS HC A04/MF A01; DFVLR, Cologne, West Germany DM 23.50

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

N87-11785# National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
SYSTEMS, AVIONICS AND INSTRUMENTATION OF TRANSPORT CATEGORY HELICOPTERS
F. J. ABBINK Aug. 1985 37 p Submitted for publication
(NLR-MP-85066-U; B8667703; ETN-86-98495) Avail: NTIS HC A03/MF A01

The development of helicopters for passenger transport is reviewed. The systems, avionics, and instrumentation of an S-76 transport helicopter used for offshore services are described. Developments in helicopter avionics are discussed. ESA

N87-11786# National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
A SMALL, FLEXIBLE AND POWERFUL DATA ACQUISITION SYSTEM FOR THE F16 AIRCRAFT
S. S. VANLEEUWEN 20 Sep. 1985 18 p
(NLR-MP-85074-U; B8667704; ETN-86-98496) Avail: NTIS HC A02/MF A01

Electrical layout, mechanical properties, performance parameters, and growth facilities of a data acquisition system for the F-16 aircraft are described. The system can be used for flight tests requiring less than 500 parameters. A selection of avionics Muxbus parameters was made, but with modifications the whole Muxbus contents can be recorded. Flight test data is written on tape during the whole flight, and telemetry to a ground-based station is possible. ESA

N87-11787 Kansas Univ., Lawrence.
DESIGN OF A TAKEOFF PERFORMANCE MONITORING SYSTEM Ph.D. Thesis
R. SRIVATSAN 1985 218 p
Avail: Univ. Microfilms Order No. DA8608473

An algorithm was developed to monitor the performance of the aircraft during the takeoff phase to improve safety in that flight phase. The algorithm is made up of two segments: a pretakeoff segment and a real time segment. One-time inputs of ambient temperature, pressure, runway wind, aircraft gross weight, and selected flap and stabilizer setting are utilized by the pretakeoff segment in generating a set of standard acceleration performance data in an off-line condition. The real-time segment, in addition to the above one-time inputs, requires the runway length available for rotation, the runway length available for stopping, and an estimated runway rolling friction coefficient. The algorithm was evaluated using a six degree-of-freedom nonlinear aircraft simulation as the plant for several design point test cases and two types of engine malfunctions. Dissert. Abstr.

07

AIRCRAFT PROPULSION AND POWER

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

A87-13318* 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 (NASA, Lewis Research Center, Cleveland, OH) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 162-169. Previously announced in STAR as N86-24697. refs

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

A87-13323
CLOSED LOOP CONTROL OF AN AFTERBURNING F100 GAS TURBINE ENGINE
S. A. EISA and H. P. TYLER (Allied Corp., Bendix Aerospace Sector, South Bend, IN) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 266-272. refs

The paper describes the development of a nonlinear multivariable closed loop control for the F100 augmented (afterburning) engine using transfer function synthesis theory and a multivariable approach. The study addresses the following issues: (1) development of a control for the augmented F100 engine which controls the complete engine in a closed loop manner, (2) extension of controller authority to the entire thrust range, and (3) demonstration of the controller's ability to minimize fan stall problems. A 15th order nonlinear F100 afterburning engine simulation is used as the plant for which a full range nonlinear transfer function controller is generated. Linear feedforward elements generated by the synthesis procedure assist the basic nonlinear closed loop controller to provide desired system response while maintaining engine input and output variables within physical position and rate constraints. Author

A87-13343
VARIABLE STRUCTURE CONTROL OF A TURBOJET ENGINE
C.-Y. CHAO (Industrial Technology Research Institute, Hsinchu, Republic of China), C.-W. CHEN (National Chiao-Tung University, Hsinchu, Republic of China), and B.-C. WANG (Chung-Shan Institute of Science and Technology, Lungtan, Republic of China) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 482-487. refs

The fuel control problem of a single-spool turbojet engine is studied. A transfer function approximation method is utilized to identify linear models for operating points. Then, a sliding mode control is developed to regulate the fuel flow so that the engine speed and temperature are within their physical constraints, based on the identified linear models. The resultant variable structure control is evaluated to determine its effectiveness in engine nonlinear simulations. Author

A87-13418* General Electric Co., Lynn, Mass.
MULTI-VARIABLE CONTROL OF THE GE T700 ENGINE USING THE LQG/LTR DESIGN METHODOLOGY
W. H. PFEIL (General Electric Co., Aircraft Engine Business Group, Lynn, MA), M. ATHANS (MIT, Cambridge, MA), and H. A. SPANG, III (GE Corporate Research and Development Center, Schenectady, NY; MIT, Cambridge, MA) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 1297-1312. Research supported by the General Electric Co. Previously announced in STAR as N86-29819. refs
(Contract NAG2-297)

The design of scalar and multi-variable feedback control systems for the GE T700 turboshaft engine coupled to a helicopter rotor system is examined. A series of linearized models are presented and analyzed. Robustness and performance specifications are posed in the frequency domain. The linear-quadratic-Gaussian with loop-transfer-recovery (LQG/LTR) methodology is used to obtain a sequence of three feedback designs. Even in the single-input/single-output case, comparison of the current control system with that derived from the LQG/LTR approach shows significant performance improvement. The multi-variable designs, evaluated using linear and nonlinear simulations, show even more potential for performance improvement. Author

A87-13647#

ON THE IMPROVEMENT OF AN EXPENDABLE TURBOJET ENGINE FLIGHT ENVELOPE

G. LEVIN, S. ARAD, and A. LEVY (Bet Shemesh Engines, Ltd., Israel) IN: Israel Annual Conference on Aviation and Astronautics, 27th, Haifa, Israel, February 27, 28, 1985, Collection of Papers . Haifa, Israel, Technion - Israel Institute of Technology, 1986, p. 118-124.

The paper describes how it was found possible to change the maximum allowed flight speed (M = 0.9) of the SOREK 4 expendable turbojet to a higher value (M = 1.1) at sea level, after an analysis of burst test results of the first compressor stage, its detailed stress calculation, and data about its material. The decision to augment the maximum allowed flight seed has been made possible by a relatively inexpensive procedure as compared with the conventional method of altitude bench testing. Author

A87-13658#

EXPERIMENTAL INVESTIGATION OF A SOLID FUEL RAMJET COMBUSTOR

R. ZUVLONI, Y. LEVY, and A. GANY (Technion - Israel Institute of Technology, Haifa) IN: Israel Annual Conference on Aviation and Astronautics, 27th, Haifa, Israel, February 27, 28, 1985, Collection of Papers . Haifa, Israel, Technion - Israel Institute of Technology, 1986, p. 205-209. refs

An experimental investigation on a small solid fuel ramjet combustor employing PMMA (Plexiglas) as a fuel has been conducted. A static test system, which includes a 20 kW electrical air heater, simulates the air temperature and pressure encountered in at a flight Mach number of 3, and enables the measurements of pressure, air temperature, and motor thrust. Fuel regression rate is studied by means of video photographs. The results reveal high combustion efficiency and indicate that average fuel regression rate correlation may be different in different motor geometries. Author

A87-13989#

TECHNICAL/ECONOMIC EVALUATION OF NEW PROPFAN CONCEPTS IN COMPARISON WITH THE TURBOFAN OF THE 1990S [TECHNISCH/WIRTSCHAFTLICHE BEWERTUNG NEUER PROPFAN-KONZEPTE IM VERGLEICH ZUM TURBOFAN DER 90ER JAHRE]

D. ECKARDT (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 25 p. In German. refs

The results of a comparative study of advanced propfan and turbofan engines, as applied to a 150-passenger short-distance aircraft (Eckardt et al., 1984) are summarized, and the development of a counter-rotating integrated shrouded propfan (CRISP) is reported. It is shown that the additional noise-reduction structures required for proposed single-rotation and counter-rotation propfans would negate most of their fuel-economy advantages vis a vis advanced turbofans. The CRISP concept combines the standard mounting position, noise damping, and blade containment of the turbofan with the higher propulsive efficiency, propeller sweep, and thrust-reversal capability of the counter-rotating propfan. The development of CRISP engines is described and illustrated with drawings and graphs. It is predicted that CRISP will save about 20 percent (relative to a 1986 turbofan) in the total propulsion weight (the sum of weights of the engine, the sound insulation, and fuel) for a typical 2300-n mi mission. T.K.

A87-13990#

IMPROVING THE ENERGY EFFICIENCY OF COOLED HIGH-TEMPERATURE TURBINES [STEIGERUNG DER ENERGIEAUSNUTZUNG IN GEKUEHLTEN HOCHTEMPERATURTURBINEN]

H.-J. DIETRICHS (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 28 p. In German.

The interaction of supersonic fields, cooling-air flows, and aperture effects in high-pressure one-stage turbines is examined, summarizing the results of analytical and experimental investigations performed during phase II of a BMFT-sponsored project to improve the efficiency of cooled high-temperature turbine engines for aircraft. The predictions of two-dimensional and three-dimensional time-dependent simulations of inviscid turbine flow are compared with data obtained in a cold-air rig, the DFVLR grid-flow wind tunnel, and under engine conditions in the new-technology gas generator GNT1. The results are presented in graphs, photographs, and drawings, and it is shown that high efficiency can be achieved at high pressures in single-stage transonic turbines. The need for improved simulations which take viscous effects and compression-shock/boundary-layer interactions into account and identify the causes of secondary flows and radial aperture effects is indicated. T.K.

A87-13998#

FURTHER DEVELOPMENT OF THE AXIAL-RADIAL COMPRESSOR [WEITERENTWICKLUNG DES AXIAL-RADIALVERDICHTERS]

U. SCHMIDT-EISENLOHR (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 17 p. In German. refs

Progress made recently in the development of an experimental axial-radial compressor for medium-performance aircraft engines is discussed. The oeprational behavior of the compressor and its insertion in the GNT 1 new technology gas generator are examined. The way the compressor's adjustable geometry works is described, and the testing of the device is reviewed. It is shown that the compressor requires an improvement in efficiency, and efforts made in that direction are discussed. Author

A87-14000#

IMPETUS OF NEW TECHNOLOGIES FOR UTILITY, EXECUTIVE, AND COMMUTER AIRCRAFT [ANTRIEB NEUER TECHNOLOGIE (ANT) FUER UTILITY-, EXECUTIVE- UND COMMUTER-FLUGZEUGE]

H. KROJER (Dornier GmbH, Friedrichshafen, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 53 p. In German.

The calculative and experimental studies undertaken in the project Impetus of New Technologies, which proposes an entirely new design concept for two-engine turboprop aircraft in general aviation, are reviewed. The calculative studies were aimed at guaranteeing a flow separation-free tail flow and at causing uniform flow conditions toward the propellers. Experimental findings concerning the installation efficiency, flow conditions toward the propellers, resistance balance and polar curves, and acoustics are discussed. Data on the flight efficiency and flight characteristics that resulted when the project concept was applied in actual engines are reported and discussed, and the propeller and engine configurations that resulted from the findings are summarized. The results using the project concept are compared with those from conventional designs concepts. C.D.

A87-14123*# Flow Research, Inc., Kent, Wash.
PROPELLER DESIGN BY OPTIMIZATION
M. H. RIZK and W.-H. JOU (Flow Research Co., Kent, WA) AIAA Journal (ISSN 0001-1452), vol. 24, Sept. 1986, p. 1554-1556. Previously cited in issue 07, p. 848, Accession no. A86-19678. refs
(Contract NAS3-24533)

A87-14139#
MATHEMATICAL MODEL AND DIGITAL SIMULATION FOR SPEED CONTROL SYSTEM OF TWO-SPOOL TURBOJET ENGINE
S. FAN (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, June 1986, p. 287-290. In Chinese, with abstract in English.

A mathematical model for the speed-control system of a two-spool turbojet engine is derived from component characteristics of the engine and construction parameters of the controller. The discretization-similitude method is adopted in the digital simulation of the nonlinear control system. The computer program written gives the steady-state and dynamic characteristics of the control system at H = 0, V = 0 under standard atmospheric conditions. Author

A87-14364*# General Dynamics Corp., Fort Worth, Tex.
TURBINE BYPASS REMOTE AUGMENTOR LIFT SYSTEM FOR V/STOL AIRCRAFT
A. E. SHERIDAN (General Dynamics Corp., Fort Worth, TX) Journal of Aircraft (ISSN 0021-8669), vol. 23, Sept. 1986, p. 703-710. NASA-supported research. Previously cited in issue 01, p. 11, Accession no. A86-10941. refs

A87-14366#
NOISE AND PERFORMANCE OF A COUNTER-ROTATION PROPELLER
S. FUJII, H. NISHIWAKI, and K. TAKEDA (National Aerospace Laboratory, Chofu, Japan) Journal of Aircraft (ISSN 0021-8669), vol. 23, Sept. 1986, p. 719-724. Research supported by the Environment Protection Agency of Japan. refs

The noise and aerodynamic performance of a 3 x 3 counter-rotating propeller scale model were quantified experimentally in anechoic environments with a velocity of 68 m/s incoming flow on. The model diameter was 400 mm and the aft blade rotational speeds and the rotational Mach numbers were varied up to 9000 rpm and 0.55, respectively, while the front blades were kept at 9000 rpm. The reinforcement of counter-rotating harmonics was observed even at high blade passage frequencies. The axial separation between two rotors had a favorable effect on the noise levels, whereas an adverse effect on the performance was found for the large spacing with axial velocity acceleration attendant. The spike due to the overturning of tangential velocity was found near the tip section. A difference of the rotational speeds yielded the spinning sound waves with a beat frequency of three times the rps difference. The split frequencies could be identified on the measured spectrum when the two rotors had such nonsynchronous rotational speeds. Author

A87-14984#
DEVELOPMENT OF AN ADVANCED VANELESS INLET PARTICLE SEPARATOR FOR HELICOPTER ENGINES
B. V. R. VITTAL, D. L. TIPTON, and W. A. BENNETT (General Motors Corp., Indianapolis, IN) Journal of Propulsion and Power (ISSN 0748-4658), vol. 2, Sept.-Oct. 1986, p. 438-444. Previously cited in issue 18, p. 2622, Accession no. A85-39694. refs

A87-15010#
AIRWORTHINESS CONSIDERATIONS OF LIGHTNING STRIKE PROTECTION FOR HELICOPTER DIGITAL ENGINE CONTROLS
R. L. VAUGHN (FAA, Fort Worth, TX) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 12-1 to 12-5. refs

The use of full-authority digital engine control (FADEC) systems in Category A transport rotorcraft, especially during IFR operations, may lead to catastrophic system failure in the absence of lightning strike protection. FAA Advisory Circular 29-2 characterizes the lightning environment and recommends test and analysis methods with which manufacturers can demonstrate adequate protection of FADECs against lightning strikes. O.C.

A87-15179
FOR SMALL AIRLINERS AND EXECUTIVE JETS
I. KINNEAR (Rolls-Royce, Ltd., Civil Engine Group, Derby, England) Exxon Air World, vol. 38, no. 2, 1986, p. 8-11.

The design of the Tay engine, which has a take-off thrust in the 12,000-15,000 range, is described. The use of a wide-chord fan and a large by-pass ratio to reduce the noise generated by the engine is examined. A three-stage intermediate-pressure compressor was incorporated into the engine design in order to increase engine efficiency and reduce noise generation. Mechanical changes such as increased fan diameter, improvements in the combustion chamber, and a new HP-turbine are considered. I.F.

A87-15204
DETERMINATION OF THE THRUST AND NET EFFICIENCY OF A PROPELLER AND FLOW PARAMETERS BEHIND THE PROPELLER [K VOPROSU OPREDELENIIA TIAGI, EFFEKTIVNOGO KPD VOZDUSHNOGO VINTA I PARAMETROV POTOKA ZA NIM]
A. A. BULAVKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1986, p. 19-23. In Russian.

The uncertainty of the estimates of the thrust of a propeller under start conditions is demonstrated. A method is proposed for determining the thrust equivalent of power from the aerodynamic characteristic of a propeller for start and flight conditions. Expressions are obtained for calculating the propeller airflow rate, the flow velocity behind the propeller, and the net efficiency of the propeller under various operating conditions of a turboprop engine. V.L.

A87-15208
THE EFFECT OF TURBINE ELEMENTS ON THE GASDYNAMIC STABILITY MARGIN [VLIIANIE ELEMENTOV TURBINY NA ZAPAS GAZODINAMICHESKOI USTOICHIVOSTI]
A. M. IDELSON Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1986, p. 38-42. In Russian.

The variance of the geometrical dimensions of turbine components during their manufacture can noticeably affect the stability margin of multishaft gas turbine engines. It is shown here that, during the large-volume production of multishaft gas turbines, the effect of the dimensional variance of turbine components on the gasdynamic stability margin of the gas-turbine engine can be determined by processing statistically the shaft rotation frequency ratios, which are commonly measured during bench testing. V.L.

A87-15210
USING VIBRATION SPECTRUM CHARACTERISTICS FOR THE FLOW-PATH DIAGNOSTICS OF AIRCRAFT GAS TURBINE ENGINES [ISPOL'ZOVANIE KHARAKTERISTIK VIBRATSIONNOGO SPEKTRA DLIA DIAGNOSTIKI PROTOCHNOI CHASTI AVIATSIONNYKH GTD]
A. G. MIRONOV and S. M. DOROSHKO Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1986, p. 45-49. In Russian.

An improved vibration spectrum model is presented which allows for the presence of combination components. Methods are then examined for evaluating the aerodynamic inhomogeneity of a rotor of a dual-shaft gas turbine engine from the vibration parameters based on the combination components. The accuracy of the results obtained is confirmed experimentally. V.L.

A87-15211
TURBINES WITH COUNTER-ROTATING ROTORS FOR AIRCRAFT POWER PLANTS [TURBINY S PROTIVOPOLOZHNYM NAPRAVLENIEM VRASHCHENIIA ROTOROV DLIA AVIATSIONNYKH SILOVYKH USTANOVOK]
B. A. PONOMAREV and IU. V. SOTSENKO Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1986, p. 50-53. In Russian.

A classification of turbines with counter-rotating rotors is presented, and their applications in aircraft power plants of various types are examined. The principal gasdynamic characteristics of the traditional (fixed-stator) and nontraditional (birotational) turbine designs are discussed. For birotational turbines, characteristic kinematic relationships are obtained, and an expression is proposed for determining the gasdynamic loading parameter. V.L.

N87-11731*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STAEBL: STRUCTURAL TAILORING OF ENGINE BLADES, PHASE 2
M. S. HIRSCHBEIN and K. W. BROWN (Pratt and Whitney Aircraft, East Hartford, Conn.) *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 13 p 1984
Avail: NTIS HC A22/MF A01 CSCL 21E

The Structural Tailoring of Engine Blades (STAEBL) program was initiated at NASA Lewis Research Center in 1980 to introduce optimal structural tailoring into the design process for aircraft gas turbine engine blades. The standard procedure for blade design is highly iterative with the engineer directly providing most of the decisions that control the design process. The goal of the STAEBL program has been to develop an automated approach to generate structurally optimal blade designs. The program has evolved as a three-phase effort with the developmental work being performed contractually by Pratt & Whitney Aircraft. Phase 1 was intended as a proof of concept in which two fan blades were structurally tailored to meet a full set of structural design constraints while minimizing DOC+I (direct operating cost plus interest) for a representative aircraft. This phase was successfully completed and was reported in reference 1 and 2. Phase 2 has recently been completed and is the basis for this discussion. During this phase, three tasks were accomplished: (1) a nonproprietary structural tailoring computer code was developed; (2) a dedicated approximate finite-element analysis was developed; and (3) an approximate large-deflection analysis was developed to assess local foreign object damage. Phase 3 is just beginning and is designed to incorporated aerodynamic analyses directly into the structural tailoring system in order to relax current geometric constraints. Author

N87-11732*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Aerospace and Ocean Engineering.
OPTIMIZATION OF CASCADE BLADE MISTUNING UNDER FLUTTER AND FORCED RESPONSE CONSTRAINTS
D. V. MURTHY and R. T. HAFTKA *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 15 p 1984
(Contract NAG3-347)
Avail: NTIS HC A22/MF A01 CSCL 21E

In the development of modern turbomachinery, problems of flutter instabilities and excessive forced response of a cascade of blades that were encountered have often turned out to be extremely difficult to eliminate. The study of these instabilities and the forced response is complicated by the presence of mistuning; that is, small differences among the individual blades. The theory of mistuned cascade behavior shows that mistuning can have a beneficial effect on the stability of the rotor. This beneficial effect is produced by the coupling between the more stable and less stable flutter modes introduced by mistuning. The effect of mistuning on the forced response can be either beneficial or adverse. Kaza and Kielb have studied the effects of two types of mistuning on the flutter and forced response: alternate mistuning where alternte blades are identical and random mistuning. The objective is to investigate other patterns of mistuning which maximize the beneficial effects on the flutter and forced response of the cascade. Numerical optimization techniques are employed to obtain optimal mistuning patterns. The optimization program seeks to minimize the amount of mistuning required to satisfy constraints on flutter speed and forced response. Author

N87-11768*# Pratt and Whitney Aircraft, East Hartford, Conn.
OPTIMIZATION APPLICATIONS IN AIRCRAFT ENGINE DESIGN AND TEST
T. K. PRATT *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 2 18 p 1984
Avail: NTIS HC A22/MF A01 CSCL 21E

Starting with the NASA-sponsored STAEBL program, optimization methods based primarily upon the versatile program COPES/CONMIN were introduced over the past few years to a broad spectrum of engineering problems in structural optimization, engine design, engine test, and more recently, manufacturing processes. By automating design and testing processes, many repetitive and costly trade-off studies have been replaced by optimization procedures. Rather than taking engineers and designers out of the loop, optimization has, in fact, put them more in control by providing sophisticated search techniques. The ultimate decision whether to accept or reject an optimal feasible design still rests with the analyst. Feedback obtained from this decision process has been invaluable since it can be incorporated into the optimization procedure to make it more intelligent. On several occasions, optimization procedures have produced novel designs, such as the nonsymmetric placement of rotor case stiffener rings, not anticipated by engineering designers. In another case, a particularly difficult resonance contraint could not be satisfied using hand iterations for a compressor blade, when the STAEBL program was applied to the problem, a feasible solution was obtained in just two iterations. Author

N87-11769*# Michigan Univ., Ann Arbor.
ON OPTIMAL DESIGN FOR THE BLADE-ROOT/HUB INTERFACE IN JET ENGINES
N. KIKUCHI and J. E. TAYLOR *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 2 14 p 1984
(Contract NAG3-388)
Avail: NTIS HC A22/MF A01 CSCL 21E

Two major problems identified with the design of the blade-root/hub interface are discussed. The first is the so-called friction contact problem which has two special features: unilateral contact and Coulomb's friction. One of the difficulties in this problem is that the portions of contact and sticking/sliding surfaces are not known a priori. The second is the shape optimization problem which is characterized either by the minimization of the maximum contact pressure or by the minimization of the equivalent stress on the boundary. Design variables are the shapes of the blade-root and the hub. It is noted that friction contact and shape optimization problems are strongly coupled in the present design problem. Author

N87-11788*# Transmission Research, Inc., Cleveland, Ohio.
THE 3600 HP SPLIT-TORQUE HELICOPTER TRANSMISSION
G. WHITE 18 Dec. 1985 95 p
(Contract NAS3-23931)
(NASA-CR-174932; NAS 1.26:174932) Avail: NTIS HC A05/MF A01 CSCL 21E

Final design details of a helicopter transmission that is powered by GE twin T 700 engines each rated at 1800 hp are presented. It is demonstrated that in comparison with conventional helicopter transmission arrangements the split torque design offers: weight reduction of 15%; reduction in drive train losses of 9%; and improved reliability resulting from redundant drive paths between the two engines and the main shaft. The transmission fits within the NASA LeRC 3000 hp Test Stand and accepts the existing positions for engine inputs, main shaft, connecting drive shafts, and the cradle attachment points. One necessary change to the test stand involved gear trains of different ratio in the tail drive gearbox. Progressive uprating of engine input power from 3600 to 4500 hp twin engine rating is allowed for in the design. In this way the test transmission will provide a base for several years of analytical, research, and component development effort targeted at improving the performance and reliability of helicopter transmission. Author

N87-11789*# Solar Turbines International, San Diego, Calif.
FABRICATION OF COOLED RADIAL TURBINE ROTOR Final Report
A. N. HAMMER, G. G. AIGRET, T. P. PSICHOGIOS, and C. RODGERS Jun. 1986 258 p
(Contract NAS3-22513; DA PROJ. 1L1-612209-AH-76)
(NASA-CR-179503; NAS 1.26:179503; SR86-R-4938-39) Avail: NTIS HC A12/MF A01 CSCL 21E

A design and fabrication program was conducted to evaluate a unique concept for constructing a cooled, high temperature radial turbine rotor. This concept, called split blade fabrication was developed as an alternative to internal ceramic coring. In this technique, the internal cooling cavity is created without flow dividers or any other detail by a solid (and therefore stronger) ceramic plate which can be more firmly anchored within the casting shell mold than can conventional detailed ceramic cores. Casting is conducted in the conventional manner, except that the finished product, instead of having finished internal cooling passages, is now a split blade. The internal details of the blade are created separately together with a carrier sheet. The inserts are superalloy. Both are produced by essentially the same software such that they are a net fit. The carrier assemblies are loaded into the split blade and the edges sealed by welding. The entire wheel is Hot Isostatic Pressed (HIPed), braze bonding the internal details to the inside of the blades. During this program, two wheels were successfully produced by the split blade fabrication technique. Author

N87-11790*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPOUND CYCLE ENGINE PROGRAM
G. A. BOBULA, W. T. WINTUCKY, and J. G. CASTOR (Garrett Turbine Engine Co., Phoenix, Ariz.) 1986 23 p Presented at the Rotary Wing Propulsion System Specialist Meeting, Williamsburg, Va., 12-14 Nov. 1986; sponsored by the American Helicopter Society
(Contract DA PROJ. 1L1-62209-AH-76)
(NASA-TM-88879; E-3286; NAS 1.26:88879; USAAVSCOM-TR-86-C-37) Avail: NTIS HC A02/MF A01 CSCL 21E

The Compound Cycle Engine (CCE) is a highly turbocharged, power compounded power plant which combines the lightweight pressure rise capability of a gas turbine with the high efficiency of a diesel. When optimized for a rotorcraft, the CCE will reduce fuel burned for a typical 2 hr (plus 30 min reserve) mission by 30 to 40 percent when compared to a conventional advanced technology gas turbine. The CCE can provide a 50 percent increase in range-payload product on this mission. A program to establish the technology base for a Compound Cycle Engine is presented. The goal of this program is to research and develop those technologies which are barriers to demonstrating a multicylinder diesel core in the early 1990's. The major activity underway is a three-phased contract with the Garrett Turbine Engine Company to perform: (1) a light helicopter feasibility study, (2) component technology development, and (3) lubricant and material research and development. Other related activities are also presented. Author

N87-11792# Materials Research Labs., Ascot Vale (Australia).
INVESTIGATION OF COATING PERFORMANCE AND CORROSION OF COMPRESSOR COMPONENTS IN THE TF30-P-3 ENGINE OF F111C AIRCRAFT
L. V. WAKE and B. S. SMITH Jan. 1986 32 p
(AD-A168802; MRL-R-984) Avail: NTIS HC A03/MF A01 CSCL 11C

This report examines factors involved in the degradation of the protective coating, Chromalloy S-A12, employed on the low pressure compressor stators in the Pratt and Whitney TF30-P-3 engine of an RAAF F111 aircraft. The study is confined to the 7th stage of the engine (4th stage; low pressure compressor). The stator examined had experienced considerable corrosion after only 427 hours operation. Stators on other engines are failing for similar reasons. Small corrosion nodules were present on specific areas of each stator vane coating. Sections on the outer ring or shroud were found to be corroded along a geometric arc around the 6 o'clock position of the stage. These included: (1) both surfaces of the outer shroud or ring (2) the air seal around the shroud and (3) the area underneath the air path seal or rub strip. The corrosion nodules on the vanes were associated with discontinuities in the coating. These discontinuities resulted in breakdown of the diffusion coating in surrounding areas forming aluminium, chromium and iron oxides. The elements sulphur and chlorine and to a lesser extent calcium and potassium were also found in the corrosion deposits. These elements are present in the local water supply and a detergent used for aircraft washing. Examination of the compressor washing and drying procedures are recommended. GRA

N87-11793# Rolls-Royce Ltd., Derby (England).
CONTROL OF GAS TURBINES. THE FUTURE: IS A RADICAL APPROACH NEEDED?
P. H. RILEY 12 Feb. 1986 26 p
(PNR-90295; ETN-86-98014) Avail: NTIS HC A03/MF A01

An engine control system which considers systems as well as individual component changes is supported. It is argued that by moving devices which dissipate a large amount of power away from the electronic engine control (EEC) box, inflight shutdown rate due to overheating can be reduced. The EEC reliability per actuator can be improved by changing to an on/off rather than a variable current transducer. ESA

N87-12560# Cambridge Univ. (England). Dept. of Engineering.
VISUALISATION OF AXIAL TURBINE TIP CLEARANCE FLOW USING A LINEAR CASCADE
J. P. BINDON 1986 66 p
(CUED/A-TURBO/TR-122; ISSN-0309-6521) Avail: NTIS HC A04/MF A01

Gas tracer techniques were not successful in revealing anything except the very generalized movement of fluid from the mainstream into the tip clearance gap. Smoke flow visualization at low Reynolds numbers revealed much of the intricate detail of the flow structure in and around the tip clearance region. Smoke traces were injected both into the mainstream fluid via a rake and also through holes in the blade surface. At low values of clearance, there was no evidence of any separation bubble in the clearance gap and the flow was attached and well behaved as it moved from pressure to suction side. Traces injected on the pressure surface moved radially to enter the clearance gap. In passing round the pressure corner, the traces became transparent indicating an acceleration around the corner. This confirms the measurements elsewhere of extremely low values of pressure on the pressure surface corner. This local high velocity would cause a high heat transfer coefficient on the corner. A test was done to investigate the possibility of cooling the pressure corner by radially exhausting cooling air from the pressure surface near the tip. Qualitative heat transfer studies using a radiantly heated optical film appeared not to be able to resolve the small scale effects near the pressure corner but did clearly show the area of low heat transfer where the separation bubble flow stagnates and separates. Author

N87-12561# Department of the Air Force, Washington, D.C.
THRUST REVERSER-EXHAUST NOZZLE ASSEMBLY FOR A GAS TURBINE ENGINE Patent
E. B. THAYER, inventor (to Air Force) 27 May 1986 8 p
Supersedes AD-D011101
(AD-D012390; US-PATENT-4,591,097; US-PATENT-APPL-SN-611041; US-PATENT-CLASS-239-265.29)
Avail: US Patent and Trademark Office CSCL 21E

This patent discloses an improved thrust reverser/exhaust nozzle assembly which has a plurality of blocker devices located in the divergent section of the exhaust nozzle and a plurality of deflector devices located in the convergent section of the nozzle. The blocker and deflector devices are linked together such that they move simultaneously and maintain a substantially constant engine between forward and reverse thrust conditions. GRA

N87-12562# Allied Bendix Aerospace, Utica, N.Y. Fluid Power Div.
COMPONENT IMPROVEMENT PROGRAM TASK 83-01, 36E133 AIR TURBINE STARTER
L. WILLIAMS Feb. 1986 36 p
(Contract N00019-80-G-0607)
(AD-A169483; REPT-8720-3173U) Avail: NTIS HC A03/MF A01 CSCL 09C

The objective of this task was to replace the mechanical cutout switch with a solid-state electronic cutout switch to improve accuracy and reliability of the automatic start cycle termination in the S-3A and F-14A aircraft. The function of the cutout switch is to terminate the start cycle at a predetermined speed. It was determined that the existing electronic circuit can be used for the 36E133/123 with only a minor resistor change to accommodate the subject unit's cutout speed. Breadboard testing was successfully completed and satisfactorily demonstrated feasibility. GRA

N87-12563# Dayton Univ., Ohio. Research Inst.
RESEARCH ON MECHANICAL PROPERTIES FOR ENGINE LIFE PREDICTION Interim Report, 1 Aug. 1984 - 31 Jul. 1985
N. E. ASHBAUGH, M. KHOBAIB, G. A. HARTMAN, T. WEERASOORIYA, and A. M. RAJENDRAN May 1986 74 p
(Contract F33615-84-C-5051)
(AD-A169570; UDR-TR-85-132; AFWAL-TR-85-4154) Avail: NTIS HC A04/MF A01 CSCL 20K

Analytical and experimental investigations have been performed to determine crack growth behavior of metals under conditions typical of the service environments of aircraft gas turbine engines. To evaluate baseline crack growth behavior, investigations have also been conducted at elevated temperature in vacuum. The work performed can be divided into three general categories -- development of experimental and automation techniques, material characterization testing, and analytic studies. An automated laser interferometric displacement-measurement system using linear array cards has been developed. Enhancements of existing system for the measurement of crack lengths and displacements are described. A number of computer automation applications are also described. Fatigue and creep crack growth tests and creep rupture and hot corrosion tests were performed. Description of the experimental techniques and the results for these tests are included. Results of analytical investigations in both material modeling and methodology development are presented, including discussions of applications within the laboratory. GRA

N87-12564# Department of the Air Force, Washington, D.C.
TURBINE AIR SEAL WITH FULL BACKSIDE COOLING Patent Application
G. LIANG, inventor (to Air Force) 12 May 1986 21 p
(AD-D012405; US-PATENT-APPL-SN-861909) Avail: NTIS HC A02/MF A01 CSCL 11A

This patent application relates to air seals for use in turbo-machinery and, more particularly relates to an air seal assembly with increased cooling that is adapted to withstand elevated engine operating temperatures. The air seal comprises a full 360 degree seal ring that assemblies to the turbine by means of interlocking flanges. A two piece impingement plate which is positioned adjacent to the air seal controls and meters cooling air flow that cools ceramic seal. The backside of air seal is thereby fully cooled before heated cooling air is exhausted from the seal through holes at expansion slots and edge holes at the axial edges of the air seal. GRA

N87-12565# Sverdrup Technology, Inc., Arnold Air Force Station, Tenn.
EFFECTS OF TEST CELL RECIRCULATION ON HIGH-BYPASS TURBOFAN ENGINES DURING SIMULATED ALTITUDE TESTS Final Report, Oct. 1984 - May 1985
R. M. DUGAS Aug. 1986 89 p Prepared in cooperation with AEDC, Arnold AFS, Tenn.
(AD-A171418; AEDC-TR-85-55) Avail: NTIS HC A05/MF A01 CSCL 21E

An experimental and analytical program was conducted to determine the nature of the flow field around a subscale model of a high bypass turbofan engine installed in a representatively scaled altitude test cell. The engine model employed variable geometry and flow conditions in order to determine their effects on test cell recirculating flows, which can affect engine performance during altitude testing. Flow field data were obtained from both two axis laser Doppler velocimeters, as well as from pressure and temperature instrumentation installed on the model and test cell. Review of full and 1/10 scale test data and the results of the subscale tests indicate that test cell recirculation effects are a function of cell geometry. Measurement of test cell effects is dependent on a baseline test configuration, such as an outdoor test, where the effects are not present. GRA

08

AIRCRAFT STABILITY AND CONTROL

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

A87-13341*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
AEROELASTIC CONTROL OF OBLIQUE-WING AIRCRAFT
J. J. BURKEN, G. B. GILYARD (NASA, Flight Research Center, Edwards, CA), and G. S. ALAG (Western Michigan University, Kalamazoo, MI) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 463-471. Previously announced in STAR as N86-26340. refs

The U.S. Navy and NASA are currently involved in the design and development of an unsymmetric-skew-wing aircraft capable of 65 deg wing sweep and flight at Mach 1.6. A generic skew-wing aircraft model was developed for 45 deg wing skew at a flight condition of Mach 0.70 and 3048 m altitude. At this flight condition the aircraft has a wing flutter mode. An active implementable control law was developed using the linear quadratic Gaussian design technique. A method of modal residualization was used to reduce the order of the controller used for flutter suppression. Author

A87-13342* University of Western Michigan, Kalamazoo.
DECOUPLING CONTROL SYNTHESIS FOR AN OBLIQUE-WING AIRCRAFT
G. S. ALAG (Western Michigan University, Kalamazoo, MI), R. W. KEMPEL, and J. W. PAHLE (NASA, Flight Research Center, Edwards, CA) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 472-480. Previously announced in STAR as N86-26339. refs

Interest in oblique-wing aircraft has surfaced periodically since the 1940's. This concept offers some substantial aerodynamic performance advantages but also has significant aerodynamic and inertial cross-coupling between the aircraft longitudinal and lateral-directional axes. This paper presents a technique for synthesizing a decoupling controller while providing the desired stability augmentation. The proposed synthesis procedure uses the concept of a real model-following control system. Feedforward gains are selected on the assumption that perfect model-following conditions are satisfied. The feedback gains are obtained by using eigensystem assignment, and the aircraft is stabilized by using partial state feedback. The effectiveness of the control laws developed in achieving the desired decoupling is illustrated by application to linearized equations of motion of an oblique-wing aircraft for a given flight condition. Author

A87-13344

AIRCRAFT FLUTTER SUPPRESSION VIA ADAPTIVE LQG CONTROL

A. CHAKRAVARTY (Boeing Commercial Airplane Co., Seattle, WA) and J. B. MOORE (Australian National University, Canberra, Australia) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 488-493.

An adaptive linear quadratic Gaussian based constant gain controller was implemented for an aircraft with one flutter mode (at 3.25 hz). The controller scheme was applied in a simulated aircraft experiencing Dryden turbulence. The discrete-time LQG regulator was defined with time-varying recursive Riccati equations and employs a flutter mode estimate to generate the required control to attain stability. The controller has a low sensitivity to the large amounts of spillover dynamics in the flutter estimate because the aileron responses to the estimate is a second-order system with the estimate as the primary mode. The controller bandwidth is thereby single-input, single-output functioning in the region of the flutter mode frequency and providing a 180 deg phase margin. M.S.K.

A87-13346

BANK-TO-TURN UTILIZING SAMPLED DATA NON-LINEAR CONTROL

D. CAUGHLIN (USAF, Edwards AFB, CA) and T. BULLOCK (Florida, University, Gainesville) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 507, 508.

Features of a nonlinear control algorithm developed for bank-to-turn homing missiles are outlined. The algorithm was constrained to 5 g acceleration in the z-axis and roling maneuvers of up to 500 deg/sec. The problem was decomposed into two models: a body-oriented control law to decouple the pitch and yaw axes and an inertial point-mass model to control inertial accelerations. Methods used to compensate for a 100 g turn capability while only 5 deg was allowed are discussed. The system estimates a closing velocity with an optimal attitude through a series of rotations and projections. M.S.K.

A87-13347* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

TIME SCALE ANALYSIS OF A DIGITAL FLIGHT CONTROL SYSTEM

D. S. NAIDU and D. B. PRICE (NASA, Langley Research Center, Hampton, VA) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 509, 510. refs

In this paper, consideration is given to the fifth order discrete model of an aircraft (longitudinal) control system which possesses three slow (velocity, pitch angle and altitude) and two fast (angle of attack and pitch angular velocity) modes and exhibits a two-time scale property. Using the recent results of the time scale analysis of discrete control systems, the high-order discrete model is decoupled into low-order slow and fast subsystems. The results of the decoupled system are found to be in excellent agreement with those of the original system. Author

A87-13352

FLIGHT CONTROL DESIGN USING NONLINEAR INVERSE DYNAMICS

R. F. STENGEL (Princeton University, NJ) and S. H. LANE IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 587-596. Research sponsored by the Schultz Foundation. refs

Aircraft in extreme flight conditions such as stalls and spins experience nonlinear forces and moments generated from high angles of attack and high angular rates. Flight control systems based upon nonlinear inverse dynamics offer the potential for providing improved levels of safety and performance in these flight conditions over the competing designs developed using linearizing assumptions. Inverse dynamics are generated for specific command variable sets of a 12-state nonlinear aircraft model to develop a control system that provides satisfactory response over the entire flight envelope. Detailed descriptions of the inertial dynamic and aerodynamic models are given, and it is shown how the command variable sets are altered as functions of the system state to add stall prevention features to the system. Simulation results are presented for various mission objectives over a range of flight conditions to confirm the effectiveness of the design. Author

A87-13355

DYNAMIC OUTPUT FEEDBACK FLIGHT CONTROL LAWS USING EIGENSTRUCTURE ASSIGNMENT

K. M. SOBEL (Lockheed-California Co., Burbank) and E. Y. SHAPIRO (HR Textron, Inc., Valencia, CA) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 605-610. refs

The eigenstructure assignment flight control design methodology is extended to include dynamic compensator synthesis. Dynamic compensators may be designed via eigenstructure assignment by utilizing a composite system structure. The success of this design methodology depends upon proper choice of the desired eigenvectors. An example of the lateral dynamics of an L-1011 aircraft is presented to illustrate the design method. Author

A87-13379

MULTIVARIABLE FLIGHT CONTROL FOR AN ATTACK HELICOPTER

D. ENNS (Honeywell Systems and Research Center, Minneapolis, MN) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 858-863.

This paper discusses advanced flight control laws for the Apache YAH-64 helicopter. The control laws have been successfully flight tested and were extensively evaluated with fixed base piloted simulation as part of the Advanced Rotorcraft Technology Integration Flight Experiment. The control laws employ three body rate gyros, and normal and lateral accelerometers as sensors and collective, tail rotor, anad lateral and longitudinal cyclic controls. The control laws were developed to provide decoupling, gust attenuation, desensitization, and stability augmentation in the face of aircraft modelling uncertainty. A multivariable proportional plus integral element is the basic ingredient of the control laws. Various analyses including frequency and time responses are presented. Stability robustness properties of the control laws are presented using singular value and structured singular value techniques. Responses of the controlled helicopter to pilot and gust inputs are presented using time histories. Author

A87-13419* Massachusetts Inst. of Tech., Cambridge.
MULTIVARIABLE CONTROL OF A TWIN LIFT HELICOPTER SYSTEM USING THE LQG/LTR DESIGN METHODOLOGY
A. A. RODRIGUEZ and M. ATHANS (MIT, Cambridge, MA) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 1325-1332. Previously announced in STAR as N86-28956. refs
(Contract NAG2-297)
Guidelines for developing a multivariable centralized automatic flight control system (AFCS) for a twin lift helicopter system (TLHS) are presented. Singular value ideas are used to formulate performance and stability robustness specifications. A linear Quadratic Gaussian with Loop Transfer Recovery (LQG/LTR) design is obtained and evaluated. Author

A87-13426
RENEWED INTEREST IN HINGE MOMENT MODELS FOR FAILURE DETECTION AND ISOLATION
H. N. GROSS, P. R. CHANDLER, and R. A. ESLINGER (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 1497-1502. refs
A hinge moment model (HMM) was developed for the direct lift flap of the Total In Flight Simulator from data obtained during a recent flight test. A typical linear trim point hinge HMM did not account for the significant oscillations in differential pressure due to nonlinear effects. An algorithm for the synthesis of polynomial networks was used to construct a nonlinear model of differential pressure. Using readily measurable flight variables, the new model residuals are shown to have a smaller mean square error. The estimate of the hinge moment is thus more accurate, leading to better detection, isolation, and estimation capability. It is concluded that this will help reduce the false alarm rate which has been a chronic problem with HMMs. B.J.

A87-13435* Alphatech, Inc., Burlington, Mass.
EVALUATION OF DETECTABILITY AND DISTINGUISHABILITY OF AIRCRAFT CONTROL ELEMENT FAILURES USING FLIGHT TEST DATA
J. L. WEISS, J. S. ETERNO, and J. Y. HSU (Alphatech, Inc., Burlington, MA) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 1551-1557. refs
(Contract NAS1-18004)
This paper examines the detectability and distinguishability of control element failures on the B-737 aircraft. The results of Weiss (1985) are used to define decentralized residuals from analytic redundancy relationships, and the results of Weiss et al. (1984) are used to define the probabilistic distance measures which provide bounds on the minimum achievable probabilities or error. The residual signals are then generated using data which were recorded during a landing approach of the NASA-Langley Advanced Transport Operations (ATOPS) transportation systems research vehicle (TSRV). The distance measures are computed using estimates of the statistics of these residual signals. Author

A87-13536#
MTFCS (MULTIPLE TARGET FORMATION FLIGHT CONTROL SYSTEM) FORMATION POSITION SENSOR TRADE-OFF ANALYSIS
L. NEWMAN (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: ION, National Technical Meeting, Long Beach, CA, January 21-23, 1986, Proceedings . Washington, DC, Institute of Navigation, 1986, p. 23-32. refs
An analysis is performed to identify a navigation/position sensor that best meets the requirements for a multiple target formation control system (MTFCS). A set of basic alternatives was chosen from among all classes of systems. GPS (Global Positioning System) derivative systems were selected from the basic alternatives through an examination of distinguishing trade-offs (the ability to meet minimum separation distance requirementes, ability to support large numbers of aircraft, communications requirements, retention of accuracy at horizontal and vertical separation maxima, coverage capabilities, range systems compatibility, minimum complexity and minimum payload). A system architecture is identified with three platform options for accuracy enhancement and range interoperability. Author

A87-13648#
DIRECT SOLUTION OF FLUTTER EQUATIONS WITH INTERACTIVE GRAPHICS PROCEDURE
I. HERSZBERG (Royal Melbourne Institute of Technology, Australia) IN: Israel Annual Conference on Aviation and Astronautics, 27th, Haifa, Israel, February 27, 28, 1985, Collection of Papers . Haifa, Israel, Technion - Israel Institute of Technology, 1986, p. 135-143. refs
A direct method for the solution of flutter equations is presented. This method enables the designer to determine the relationship between any two parameters which satisfy the flutter equations. The solution procedure is described and some of the computational considerations are briefly discussed. An example is presented of the use of this method in the investigation and solution of a flutter problem on the Jindivik MK III B (an RPV). A comparison is made of the direct and classical methods and a list of some of the advantages an disadvantages of the direct method is presented. Some of the advantages of the direct method are: it is several orders of magnitude faster for the preparation of plots other than the standard V-g-omega plots; it does not relay on any particular formulation of the flutter equations; and it may be used for determining subcritical response. Author

A87-13654#
COMBINED GUIDANCE - FLIGHT CONTROL OF ATMOSPHERIC VEHICLES
M. SHEFER (Rafael Armament Development Authority, Haifa, Israel) IN: Israel Annual Conference on Aviation and Astronautics, 27th, Haifa, Israel, February 27, 28, 1985, Collection of Papers . Haifa, Israel, Technion - Israel Institute of Technology, 1986, p. 180-184.
Guidance and flight control, traditionally two distinct problems, are combined here together in a minimal state model. Based on classical optimal control, a computerized design procedure is applied to the overall problem. This yields a fast design cycle as well as a simply implemented solution. Author

A87-13991#
DESIGN CONSIDERATIONS FOR FLY-BY-WIRE CONTROL OF NEW AIRBUS AIRCRAFT [KONZEPTIONELLE UEBERLEGUNGEN ZUR FLY-BY-WIRE-STEUERUNG FUER NEUE AIRBUS-FLUGZEUGE]
U. CARL (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 60 p. In German. refs
(Contract BMFT-LFL-8360-7)
(MBB-UT-222-86)
The development of an experimental triaxial fly-by-wire (FBW) primary flight-control system for future Airbus transport aircraft is discussed in a status report. The biaxial FBW system used in the A320 is briefly characterized; and a triaxial system with integrated active control functions, fiber-optic communications buses, and quad-redundant fault-tolerant computers and actuators controllers is described in detail and illustrated with block diagrams. Consideration is given to the definition and validation of the control laws, tests of the FBW system using the A300 simulator, and planned tests using an integrated simulation system. T.K.

A87-14013
REDUNDANT COMPUTER SYSTEM FOR FLY-BY-WIRE CONTROLS [REDUNDANTES RECHNERSYSTEM FUER FLY-BY-WIRE STEUERUNGEN]
R. REICHEL and F. BOOS (Bodenseewerk Geraetetechnik GmbH, Ueberlingen, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 29 p. In German.

A redundant computer system for active flight control in fly-by-wire (FBW) systems is discussed. The integration of the FBW control system into the general system is summarized, and different redundant computer systems are intercompared. The management of computer redundancy is addressed, and the coupling of sensors to the FBW control system is considered. C.D.

A87-14021#
POSSIBILITIES FOR OPTIMIZATION AND HIGHER-HARMONIC CONTROL OF HELICOPTER MAIN ROTORS BY BLADE FEATHERING [MOEGLICHKEITEN ZUR OPTIMIERUNG UND HOEHERHARMONISCHEN STEUERUNG VON HUBSCHRAUBER-HAUPTROTOREN DURCH BLATTVERSTELLSYSTEME] BLATTVERSTELLSYSTEME]
P. RICHTER and M. PLATZER (Henschel-Flugzeug-Werke GmbH, Kassel, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 23 p. In German. refs

The current status of the development of a helicopter-rotor vibration-control system is reported. The system is based on hydraulic actuators mounted between the swash plate and the blade-pitch control arms. Consideration is given to the operating principle of the electrical control circuits, the actuator loads, the time sequence of operations, feedback loops, safety features, and the possible extension of the system principles to single-blade control. Drawings, graphs, diagrams, and photographs are provided. T.K.

A87-14031*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXPLORATORY WIND-TUNNEL INVESTIGATION OF THE STABILITY AND CONTROL CHARACTERISTICS OF ADVANCED GENERAL AVIATION CONFIGURATIONS
L. P. YIP, P. M. KING, C. B. MUCHMORE, and P. DAVIS (NASA, Langley Research Center, Hampton, VA) AIAA, General Aviation Technology Conference, Anaheim, CA, Sept. 29-Oct. 1, 1986. 20 p. refs
(AIAA PAPER 86-2596)

Results of low-speed wind-tunnel investigations are presented for two general aviation configurations: the AVTEK canard configuration and the DeVore conventional configuration. Cooperative research programs were undertaken by industry and NASA to jointly conduct tests in the NASA Langley 12-Foot Low-Speed Wind Tunnel to explore stability and control characteristics of each configuration. A 1/5-scale AVTEK model and a 1/6-scale DeVore model were tested over an angle-of-attack range of up to 45 deg and an angle-of-sideslip range of up to 20 deg. Results from the AVTEK test are presented with an emphasis on the effects of configuration on the stall and poststall characteristics. Results from the DeVore test are presented with emphasis on the effects of wing leading-edge droop design on spin resistance characteristics. Author

A87-14032*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SUMMARY OF NASA STALL/SPIN RESEARCH FOR GENERAL AVIATION CONFIGURATIONS
J. R. CHAMBERS and H. P. STOUGH, III (NASA, Langley Research Center, Hampton, VA) AIAA, General Aviation Technology Conference, Anaheim, CA, Sept. 29-Oct. 1, 1986. 13 p. refs
(AIAA PAPER 86-2597)

The major milestones of stall/spin research conducted in the past under NACA/NASA programs are reviewed, and recent results offering promise for further improvements in design methodology and concepts for stall/spin technology are identified. Specific results discussed include: (1) development and validation of test techniques and analysis methods; (2) studies of airplane spinning and spin recovery characteristics; and (3) concepts designed to increase the spin resistance of general aviation-type vehicles. V.L.

A87-14135#
MODELING OF THE AIRCRAFT MECHANICAL CONTROL SYSTEM
X. XU, T. YAO, Y. FENG, and S. MUO (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, June 1986, p. 256-265. In Chinese, with abstract in English. refs

The mode analysis method for multipole-degree-of-freedom systems, model-uncoupling and order-reduction method, digital simulation methods for nonlinear systems, system-identification and parameter-estimation techniques, and various available calculating methods are combined in this paper to obtain an engineering calculating method for the fundamental frequency. This method is used to establish the nonlinear-approach model of the mechanical system, analyze the system dynamic characteristics, and give the equivalent linear model of the mechanical system. The relation between various major parameters and handling quality is discussed. In reference to the model-uncoupling part, it has been proved by flight test. Author

A87-14136#
THE METHOD OF CALCULATING THE DESIRED FLIGHT PATH OF TERRAIN FOLLOWING TECHNIQUE WITH CIRCULAR ARC SPLINE
Y. ZHENG and C. CHEN (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, June 1986, p. 266-272. In Chinese, with abstract in English. refs

In the algorithm-optimal control algorithm for a terrain-following (TF) system presented by Funk and Kelly (1975) the desired flight path (DFP) is designed using cubic splines from the sampled data of terrain contour; then the aircraft is forced to fly along this path by a corresponding optimal controller. This paper presents a method of designing DFP with circular-arc splines. Under forty terrain conditions, this method is compared with the DFP of cubic-spline and proved to be feasible. Author

A87-14142#
OPTIMAL DISCRETE DESIGN OF DIGITAL FLIGHT CONTROL SYSTEM
L. LI (Institute of Automatic Flight Control System, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 7, June 1986, p. 305-312. In Chinese, with abstract in English.

An engineering method of optimal discrete regulator design for digital flight control system is described. By using the engineering method proposed here, the continuous quadratic performance criterion can be simply transformed to a discrete version. The C-asterisk and D-asterisk criteria and some additional flying quality requirements are used for constituting the quadratic cost function and to precisely determine the value of the elements of the weighting matrix without repeated adjustment. An example using this method to synthesize the stability augmentation system and autopilot is given. Author

A87-14367#
COORDINATED TURN RELATIONS - A GRAPHICAL REPRESENTATION
C. LIBOVE (Syracuse University, NY) Journal of Aircraft (ISSN 0021-8669), vol. 23, Sept. 1986, p. 725, 726.

Relationships between the flight parameters involved in a controlled turn are analyzed and used to generate graphic representations which are suitable for identifying performance windows. Governing equations are defined for lift at the bank angle, the aircraft weight, the load factor, the turn rate and the lift. Subsidiary relations are developed among the governing parameters. Drag and thrust are absent from the basic parameters, but can be evaluated separately. The graphs obtained from the relationships provided are useful for delineating sets of operating conditions for attaining a specified turning performance. M.S.K.

A87-15212
THE PRINCIPLE OF OPTIMALITY IN THE MEAN FOR FAULT-TOLERANT SYSTEMS [PRINTSIP OPTIMAL'NOSTI V SREDNEM TOLERANTNYKH SISTEM]
N. E. RODNISHCHEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1986, p. 54-58. In Russian. refs

The problem of the optimization of nonlinear fault-tolerant systems in the presence of stochastic perturbations, such as white Gaussian noise, and independent failures of k out of n elements operating in parallel, that are described by stochastic differential equations, is examined with particular reference to the terminal guidance systems of flight vehicles. The problem is reduced, after certain assumptions are made, to a deterministic optimization problem with constraints. The principle of optimality in the mean is then formulated. V.L.

A87-15476
ADVANCED ACTUATION, CONTROLS AND INTEGRATION FOR AEROSPACE VEHICLES; PROCEEDINGS OF THE SYMPOSIUM, SAN DIEGO, CA, OCTOBER 9, 1985
Symposium sponsored by SAE. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE P-170), 1986, 72 p. For individual items see A87-15477 to A87-15482.
(SAE P-170)

The present conference gives attention to the reduction of system complexity in fly-by-wire aircraft flight control actuators, a systems design approach to the various actuation concept alternatives emerging in primary flight control technologies, and the features of advanced flight control actuation systems with emphasis on their interface with digital commands. Also considered are advanced digital optical control actuation, energy-efficient actuation employing variable displacement hydraulic control, and the preliminary design of electromechanical servosystems. O.C.

A87-15477
REDUCING COMPLEXITY IN FLY-BY-WIRE FLIGHT CONTROL ACTUATORS
B. S. LYLE (General Dynamics Corp., Fort Worth, TX) IN: Advanced actuation, controls and integration for aerospace vehicles; Proceedings of the Symposium, San Diego, CA, October 9, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 1-7.
(SAE PAPER 851752)

Since the inception of fly-by-wire flight control systems on high-performance aircraft, the need for highly reliable flight control actuators has been evident. Actuators capable of handling multiple failures in electronics and hydraulics have been specified as necessary to obtain high mission reliability and safety. With the recent advances in several technology areas (namely, magnetic materials, electronics, and software capability), it seems to be time to reassess these stringent actuator requirements for future aircraft. Concepts such as control law reconfiguration, new techniques of actuation, aerodynamic redundancy, and systems integration offer the control system designer new ways of obtaining mission reliability with simpler actuators. Author

A87-15478
A SYSTEM LOOK AT ACTUATION CONCEPTS AND ALTERNATIVES FOR PRIMARY FLIGHT CONTROL
J. B. LEONARD (JBL Associates, Inc., Northport, NY) IN: Advanced actuation, controls and integration for aerospace vehicles; Proceedings of the Symposium, San Diego, CA, October 9, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 9-22. refs
(SAE PAPER 851753)

Flight control engineers and managers are facing a dilemma in selection of actuation systems and concepts for new high performance aircraft. The dilemma is created by: (1) a demand for simpler, more reliable actuators; (2) a need for higher performance required by statically unstable aircraft; (3) an increasing awareness of and demand for survivability; (4) new hydraulic valve concepts; (5) all electric airplane and electromechanical actuator programs; (6) a new look at energy efficient hydraulics; and (7) innovative combinations of several of the above. This paper addresses these issues, the current state of the art of actuation system concepts, their benefits and shortcomings and the factors that influence the selection of a concept or design. Author

A87-15479
ADVANCED FLIGHT CONTROL ACTUATION SYSTEMS AND THEIR INTERFACE WITH DIGITAL COMMANDS
M. J. ANTHONY and F. MATTOS (Fairey Hydraulics, Ltd., Hounslow, England) IN: Advanced actuation, controls and integration for aerospace vehicles; Proceedings of the Symposium, San Diego, CA, October 9, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 23-35.
(SAE PAPER 851754)

Advanced flight control actuation systems require that the actuator be capable of interfacing with centralized digital computing systems. The actuation specialists must consider the electro hydraulic system as a whole, including the closed loop servo electronics, from the command distribution databus to the final output member. This paper discusses the overall approach of a primary flight control specialist company, with the lateral implications of direct drive and multi redundanat valve configurations, higher system pressures and direct rotary actuation. Author

A87-15480
ADVANCED DIGITAL OPTICAL CONTROL ACTUATION FOR THE ADOCS
F. E. SHERIF (Allied Corp., Bendix Aerospace Electrodynamics Div., North Hollywood, CA) IN: Advanced actuation, controls and integration for aerospace vehicles; Proceedings of the Symposium, San Diego, CA, October 9, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 37-50. Army-sponsored research.
(SAE PAPER 851755)

The digital fly-by-wire control systems currently being developed for next generation aircraft are not immune to lightning, electromagnetic interference (EMI), and electromagnetic pulse (EMP). Optical commands signals transmitted via fiber optic links, and optical digital transducers to generate feedback signals, provide the means to overcome this hostile environment. This paper describes the major elements of a Driver Actuation System compatible with an Advanced Digital Optical Control System (ADOCS), and demonstrates the feasibility of the design concept through presentation of bench and aircraft integration test results. Author

A87-15481
ENERGY EFFICIENT ACTUATION USING VARIABLE DISPLACEMENT HYDRAULIC CONTROL
D. J. LINTON (Sundstrand Corp., Rockford, IL) IN: Advanced actuation, controls and integration for aerospace vehicles; Proceedings of the Symposium, San Diego, CA, October 9, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 51-55.
(SAE PAPER 851757)

The features and performance characteristics of a prospective variable displacement hydraulic control system for advanced aircraft, which promises to yield a 50-80 percent savings in average power consumption over conventional fixed displacement devices, are contrasted with those of alternative advanced control systems and pressure-profiled hydraulic systems. The pressure profiling and 8000-psi methods discussed improve weight and flow consumption, but are noted to have very low efficiencies when operated below peak loads. By contrast, variable-displacement hydraulics furnish great power savings by keeping losses nearly constant at all load levels. O.C.

A87-16182
ADAPTIVE FLUTTER SUPPRESSION
J. B. MOORE, D. GANGSAAS (Australian National University, Canberra, Australia), and A. CHAKRAVARTY (Boeing Co., Seattle, WA) IN: Identification and system parameter estimation 1985; Proceedings of the Seventh Symposium, York, England, July 3-7, 1985. Volume 1 . Oxford and New York, Pergamon Press, 1985, p. 345-349.

This paper presents the application of adaptive control to flutter suppression on a flexible aircraft. 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 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 levels of spillover dynamics. Author

A87-16183
AIRCRAFT CONTROL INPUT OPTIMIZATION FOR AERODYNAMIC DERIVATIVE ESTIMATION IN DYNAMIC MANOEUVRES
J. A. MULDER (Delft, Technische Hogeschool, Netherlands) IN: Identification and system parameter estimation 1985; Proceedings of the Seventh Symposium, York, England, July 3-7, 1985. Volume 1 . Oxford and New York, Pergamon Press, 1985, p. 481-486. refs

Future prototype aircraft will be able to execute automatic flight test maneuvers for the estimation of aerodynamic derivatives. This means that methods for the optimization of input signals will be of considerable practical importance since optimized input signals can accurately be implemented in flight. The present paper gives a brief overview of existing methods for input signal optimization. A new method is proposed which avoids some of the disadvantages of earlier methods. The method is illustrated with an optimization of a two-dimensional input signal for a lateral flight test maneuver. Author

A87-16184
AIRCRAFT FLIGHT DATA COMPATIBILITY CHECKING USING MAXIMUM LIKELIHOOD AND EXTENDED KALMAN FILTER ESTIMATION
R. J. EVANS, G. C. GOODWIN (Newcastle, University, Australia), R. A. FEIK, C. MARTIN (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia), and R. LOZANO-LEAL (Instituto Politecnico Nacional, Mexico City, Mexico) IN: Identification and system parameter estimation 1985; Proceedings of the Seventh Symposium, York, England, July 3-7, 1985. Volume 1 . Oxford and New York, Pergamon Press, 1985, p. 487-492. refs

The considerable potential benefits of compatibility checking of aircraft dynamic flight data has, in the past, not been fully realized when applied to real data. It is suggested in this paper that this is partly due to the presence of errors in the real data which are not usually accounted for in computer simulation studies. When factors such as instrument offset from center of gravity, measurement time delays, sinusoidal disturbances and non-linearities are accounted for, good results can be achieved with moderate quality instrumentation. The effect of these factors on the identified instrument errors are studied in this paper using the extended Kalman filter approach and the Maximum Likelihood method. The relative merits of each approach are also studied. Author

A87-16185
APPLICATION OF REGRESSION ANALYSIS TO COUPLED RESPONSES AT HIGH ANGLES OF ATTACK
A. J. ROSS (Royal Aircraft Establishment, Farnborough, England) and B. J. HOLOHAN (Kingston Polytechic, England) IN: Identification and system parameter estimation 1985; Proceedings of the Seventh Symposium, York, England, July 3-7, 1985. Volume 1 . Oxford and New York, Pergamon Press, 1985, p. 493-497. refs

Some of the responses obtained at high angles of attack with large-scale, free-flight models of aircraft exhibit coupled longitudinal and lateral oscillations which are not predicted using mathematical models of the aerodynamic forces and moments based on wind-tunnel and other free-flight data. Several possible causes have been postulated but not confirmed, so stepwise regression analysis techniques have been applied, to see if additional terms in the mathematical model can be identified. The use of data from angular accelerometers has also been investigated to compare the information obtained with that from the usual linear accelerometers, angular and attitude gyros, incidence and sideslip vanes and control position transducers. Author

A87-16186
PARAMETER ESTIMATION OF AIRCRAFT WITH FLY-BY-WIRE CONTROL SYSTEMS
P. MEREAU and S. ABU EL ATA-DOSS (ADERSA, Palaiseau, France) IN: Identification and system parameter estimation 1985; Proceedings of the Seventh Symposium, York, England, July 3-7, 1985. Volume 1 . Oxford and New York, Pergamon Press, 1985, p. 505-510. Sponsorship: Service Technique des Programmes Aeronautiques. refs
(Contract STPA-83,95,009)

Fly-by-wire control systems (FBWCS) introduce particular correlations between the aircraft inputs (deflection angles) and outputs which lead to biased parameter estimates in the absence of decorrelating actions such as extra signals. This problem has been investigated with the aim of finding quickly nonbiased parameter values from flight data on aircraft inputs, outputs, and pilot inputs in order to provide an iterative optimization scheme with good initial values. A methodology including input design, instrumental variable estimation, and automatic estimation strategy was developed, analyzed on simulated cases, and tested with real flight data. Author

A87-16192
MAXIMUM LIKELIHOOD ESTIMATION OF PARAMETERS IN NONLINEAR FLIGHT MECHANICS SYSTEMS
R. V. JATEGAONKAR (National Aeronautical Laboratory, Bangalore, India) and E. PLAETSCHKE (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) IN: Identification and system parameter estimation 1985; Proceedings of the Seventh Symposium, York, England, July 3-7, 1985. Volume 1 . Oxford and New York, Pergamon Press, 1985, p. 663-668. refs

Two methods for maximum-likelihood estimation of flight mechanics parameters have been developed. They are applicable to system models which may be nonlinear in the state and control variables as well as in the parameters to be estimated. The optimization problem has been solved by using both minimum-search methods and the quasi-linearization method. Advantages and disadvantages of both methods are discussed. In the latter case the need for deriving explicit sensitivity equations has been avoided by approximating the sensitivity coefficients by numerical differences. This results in a computationally attractive implementation of the estimation method for routine applications to general nonlinear systems. These techniques have been applied to the problems of kinematic consistency checking of flight test data as well as estimation of aerodynamic derivatives. Author

A87-16193
FREQUENCY DOMAIN PARAMETER ESTIMATION OF AERONAUTICAL SYSTEMS WITHOUT AND WITH TIME DELAY
M. MARCHAND and K.-H. FU (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) IN: Identification and system parameter estimation 1985; Proceedings of the Seventh Symposium, York, England, July 3-7, 1985. Volume 1 . Oxford and New York, Pergamon Press, 1985, p. 669-674. refs

The paper considers the application of frequency domain methods to flight test data from rotorcraft and fixed wing aircraft. In particular, a modified frequency domain output error method is presented which can be applied to linear systems with time delays. In contrast to existing methods, the new approach enables the combination of data from several maneuvers for one evaluation, the use of test records with arbitrary initial state conditions x(t = 0), and the direct identification of time delays (instead of using Pade-approximation). Results are presented from the identication of a six-degrees-of-freedom helicopter model (Bo-105 Research Helicopter of the DFVLR) as well as from the identifiation of an equivalent low order system with time delay (HFB 320-In-Flight-Simulator of the DFVLR). Author

A87-16195
SENSOR FAILURE DETECTION IN FLIGHT CONTROL SYSTEMS USING DETERMINISTIC OBSERVERS
N. STUCKENBERG (DFVLR, Institut fuer Flugfuehrung, Brunswick, West Germany) IN: Identification and system parameter estimation 1985; Proceedings of the Seventh Symposium, York, England, July 3-7, 1985. Volume 1 . Oxford and New York, Pergamon Press, 1985, p. 705-710. refs

A sensor failure-detection concept is presented providing a duplex sensor configuration with the fail-operational properties of a conventional triplex sensor configuration. The detection of a sensor failure is supported by the internal analytic plant redundancy made available by deterministic observers. For the analysis of the failure detection problem realistic constraints such as external plant disturbances and plant parameter variations are taken into account. The failure detection performance ultimately achievable by an optimal observer is determined. The concept is applied to a flight control system of a transport aircraft. The operational feasibility is demonstrated by flight test results. Author

A87-16196
COMPARISON OF TWO TECHNIQUES OF I.F.D. BASED ON A NON-LINEAR STOCHASTIC MODEL OF AN AIRCRAFT
R. J. PATTON and S. W. WILLCOX (York, University, England) IN: Identification and system parameter estimation 1985; Proceedings of the Seventh Symposium, York, England, July 3-7, 1985. Volume 1 . Oxford and New York, Pergamon Press, 1985, p. 711-717. Research supported by the Ministry of Defence. refs

An analysis of two analytical redundancy methods for sensor fault diagnosis is given. Both methods use observers associated with k measurements. The first employs k observers, each driven by a single measurement of the process, with failure signaling developed from the state estimates of observers with dissimilar input measurements. This method is found to be sensitive to process parameter variations, and hence unsuited to the general application of fault analysis. An alternative approach, based on matching the estimation errors in the observation space on R-squared, is described. A number of two-input observers are designed forcing one mode of the estimation error system to be unobservable. The design gives low sensitivity to plant parameter variations and high sensitivity to instrument faults defined in an appropriate frequency band, and does not require explicit use of the state-space. Author

A87-16197
ANALYTICAL REDUNDANCY THROUGH NONLINEAR OBSERVERS
R. BROCKHAUS (Braunschweig, Technische Universitaet, Brunswick, West Germany) IN: Identification and system parameter estimation 1985; Proceedings of the Seventh Symposium, York, England, July 3-7, 1985. Volume 1 . Oxford and New York, Pergamon Press, 1985, p. 719-724. DFG-supported research.

By using analytical redundancy the safety of flight systems can be improved without the use of additional measuring equipment, provided the observer precision is sufficiently high. Nonlinear reduced observers have proven to be a good compromise between accuracy and real time computation problems. The aerodynamic variables, angle of sidelsip and angle of attack, are essential for aircraft control as well as for the supervision of a safe flight regime, but they can only be measured by external sensors with low reliability. Therefore they are good example to be used in an investigation of the applicability of nonlinear observers for analytical redundancy. The analysis of the observability structure of the process led to a stepwise syystem decomposition and to subsystem local observers of different complexity. These observers have been optimized in a nonlinear simulation and tested using original flight test data. The resulting accuracy is sufficient for control purposes, even in heavy flight maneuvers (such as the turn initiation or steady sideslip). One type of observer has been implemented into the on-board computer of a DO 28 test aircraft, and the good flight test results showed that this concept is well suited for on-line operation. Author

A87-16202
DETERMINATION OF NONLINEAR AERODYNAMIC COEFFICIENTS USING THE ESTIMATION-BEFORE-MODELING METHODS
M. SRI-JAYANTHA (IBM Thomas J. Watson Research Center, Yorktown Heights, NY) and R. F. STENGEL (Princeton University, NJ) IN: Identification and system parameter estimation 1985; Proceedings of the Seventh Symposium, York, England, July 3-7, 1985. Volume 1 . Oxford and New York, Pergamon Press, 1985, p. 837-844. refs

Aerodynamic coefficients of a Schweizer 2-32 sailplane have been estimated from flight test data for angles of attack (alpha) up to 30 deg and sideslip angles (beta) to + or - 17 deg. The nonlinear aerodynamic model has been identified by applying the Estimation-Before-Modeling (EBM) technique to flight data derived from fifteen maneuvers including seven stalls and 'post-stall gyrations'. An Extended Kalman-Bucy Filter and a Modified Bryson-Frazier smoother were used to estimate the time histories of the forces and moments from a fourteen-element discrete measurement vector. The optimal estimates and the measured control variables were sorted into 50 'subspaces', and the aerodynamic modeling was performed using a multiple regression scheme in each subspace. Author

A87-16209
STATE ESTIMATION OF FLYING VEHICLE
W.-C. WU, Y.-F. XIONG, and Z.-Y. LUO (Harbin Institute of Technology, People's Republic of China) IN: Identification and system parameter estimation 1985; Proceedings of the Seventh Symposium, York, England, July 3-7, 1985. Volume 1 . Oxford and New York, Pergamon Press, 1985, p. 1061-1065. refs

This paper discusses the effects of the random noises on the flight path of the flying vehicle and the application of the state estimator to the vehicle control system. According to the given spectra density of the sea-wave colored noise, a lower order model is chosen for approximating the sea-wave random process. Such an approximation simplifies greatly the design of the state estimator. On the basis of the optimal filtering theory, two state estimators are designed for the vehicle system in different noise conditions. The simulation results show that the presence of the random noises affects the normal operation of the vehicle and its control, and the flight path of the vehicle can be maintained at lower altitude relative to the sea level by using the state estimator. Author

N87-11730*# Kentron International, Inc., Hampton, Va.
TRADEOFF METHODS IN MULTIOBJECTIVE INSENSITIVE DESIGN OF AIRPLANE CONTROL SYSTEMS
A. A. SCHY and D. P. GIESY (Kentron International, Inc., Hampton, Va.) *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 15 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

The latest results of an ongoing study of computer-aided design of airplane control systems are given. Constrained minimization algorithms are used, with the design objectives in the constraint vector. The concept of Pareto optimiality is briefly reviewed. It is shown how an experienced designer can use it to find designs which are well-balanced in all objectives. Then the problem of finding designs which are insensitive to uncertainty in system parameters are discussed, introducing a probabilistic vector definition of sensitivity which is consistent with the deterministic Pareto optimal problem. Insensitivity is important in any practical design, but it is particularly important in the design of feedback control systems, since it is considered to be the most important distinctive property of feedback control. Methods of tradeoff between deterministic and stochastic-insensitive (SI) design are described, and tradeoff design results are presented for the example of the a Shuttle lateral stability augmentation system. This example is used because careful studies have been made of the uncertainty in Shuttle aerodynamics. Finally, since accurate statistics of uncertain parameters are usually not available, the effects of crude statistical models on SI designs are examined.

N87-11736*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
APPLICATION OF OPTIMIZATION TECHNIQUES TO THE DESIGN OF A FLUTTER SUPPRESSION CONTROL LAW FOR THE DAST ARW-2
W. M. ADAMS, JR. and S. H. TIFFANY *In its* Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 17 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

The design of a candidate flutter suppression (FS) control law for the symmetric degrees of freedom for the DAST ARW-2 aircraft is discussed. The results illustrate the application of several currently employed control law design techniques. Subsequent designs, obtained as the mathematical model of the ARW-2 is updated, are expected to employ similar methods and to provide a control law whose performance will be flight tested. This study represents one of the steps necessary to provide an assessment of the validity of applying current control law synthesis and analysis techniques in the design of actively controlled aircraft. Mathematical models employed in the control law design and evaluation phases are described. The control problem is specified by presenting the flutter boundary predicted for the uncontrolled aircraft and by defining objectives and constraints that the controller should satisfy. A full-order controller is obtained by using Linear Quadratic Gaussian (LQG) techniques. The process of obtaining an implementable reduced-order controller is described. One example is also shown in which constrained optimization techniques are utilized to explicitly include robustness criteria within the design algorithm.

N87-11752*# California Univ., Los Angeles.
APPLICATION OF MODERN STRUCTURAL OPTIMIZATION TO VIBRATION REDUCTION IN ROTORCRAFT
P. P. FRIEDMANN *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 2 14 p 1984
(Contract NSG-1578; NAG2-226)
Avail: NTIS HC A22/MF A01 CSCL 01C

The helicopter rotor model consists of a four bladed hingeless rotor attached to a fuselage. The helicopter is assumed to be in trimmed forward flight. Each blade is assumed to have flap, lag, and torsional degrees of freedom. The fuselage degrees of freedom are not included in the analysis. Thus the aeroelastic stability and response analysis upon which this study is based is an isolated blade analysis. The helicopter rotor vibration reduction problem expressed as a general class of structural synthesis problems is given. Author

N87-11774*# Florida Univ., Gainesville. Dept. of Engineering Sciences.
COMMENTS ON GUST RESPONSE CONSTRAINED OPTIMIZATION
P. HAJELA *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 2 14 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01C

Recent research pertaining to optimum structural design with probabilistic constraints is reviewed. The limitations and complexities introduced in the design as a result of the transition from deterministic to probabilistic constraints are underscored. A concise development of the theoretical aspects of optimum design of aircraft structures subjected to random wind loads is presented and suggestions for future research are offered. An emphasis is placed on the incorporation of recent developments in fracture mechanics in the design constraints. Author

N87-11794 Stanford Univ., Calif.
THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF SENSOR LOCATION FOR OPTIMAL AEROELASTIC SYSTEM STATE ESTIMATION Ph.D. Thesis
G. LIU 1986 184 p
Avail: Univ. Microfilms Order No. DA8608180

One of the major concerns in the design of an active control system is obtaining the information needed for effective feedback. This involves the combination of sensing and estimation. A sensor location index is defined as the weighted sum of the mean square estimation error in which the sensor locations can be regarded as estimator design parameters. The design goal is to choose these locations to minimize the sensor location index. The gradient of the sensor location index with respect to each individual sensor location is formulated and a program using this gradient for systematic optimal sensor location search is developed. The choice of the number of sensors is a tradeoff between the estimation quality based on the same performance index and the total costs of installing and maintaining extra sensors. An experimental study for choosing the sensor location is conducted on an aeroelastic system. It is the physical realization of a two degree of freedom typical section wing. It consists of a NACA 0015 typical section wing with six accelerometers installed inside along the wing chord as the estimator measuring instruments, an existing wind tunnel section, and some other accompanying experimental devices. The system modeling which includes the unsteady aerodynamics model developed by Stephen Rock has been improved. The center of percussion of the rigid two degree of freedom typical section wing has been verified as a sensor location for which the system is unobservable. Experimental results verify the trend of the theoretical predictions of the sensor location index for different sensor locations at various wind speeds. Dissert. Abstr.

N87-11795*# Northrop Corp., Hawthorne, Calif.
VORTEX FLAP TECHNOLOGY: A STABILITY AND CONTROL ASSESSMENT Final Report
K. M. CAREY and G. E. ERICKSON Nov. 1984 361 p
(Contract NAS1-17533)
(NASA-CR-172439; NAS 1.26:172439; NOR-84-158) Avail: NTIS HC A16/MF A01 CSCL 01C

A comprehensive low-speed wind tunnel investigation was performed of leading edge vortex flaps applied to representative aircraft configurations. A determination was made of the effects of analytically- and empirically-designed vortex flaps on the static longitudinal and lateral-directional aerodynamics, stability, and control characteristics of fighter wings having leading-edge sweep angles of 45 to 76.5 degrees. The sensitivity to several configuration modifications was assessed, which included the effects of flap planform, leading- and trailing-edge flap deflection angles, wing location on the fuselage, forebody strakes, canards, and centerline and outboard vertical tails. Six-component forces and moments, wing surface static pressure distributions, and surface flow patterns were obtained using the Northrop 21- by 30-inch low-speed wind tunnel. Author

N87-11796*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

AIRCRAFT AUTOMATIC-FLIGHT-CONTROL SYSTEM WITH INVERSION OF THE MODEL IN THE FEED-FORWARD PATH USING A NEWTON-RAPHSON TECHNIQUE FOR THE INVERSION

G. A. SMITH, G. MEYER, and M. NORDSTROM (Sterling Software, Palo Alto, Calif.) Jul. 1986 96 p
(NASA-TM-88209; A-2-86092; NAS 1.15:88209) Avail: NTIS HC A05/MF A01 CSCL 01C

A new automatic flight control system concept suitable for aircraft with highly nonlinear aerodynamic and propulsion characteristics and which must operate over a wide flight envelope was investigated. This exact model follower inverts a complete nonlinear model of the aircraft as part of the feed-forward path. The inversion is accomplished by a Newton-Raphson trim of the model at each digital computer cycle time of 0.05 seconds. The combination of the inverse model and the actual aircraft in the feed-forward path alloys the translational and rotational regulators in the feedback path to be easily designed by linear methods. An explanation of the model inversion procedure is presented. An extensive set of simulation data for essentially the full flight envelope for a vertical attitude takeoff and landing aircraft (VATOL) is presented. These data demonstrate the successful, smooth, and precise control that can be achieved with this concept. The trajectory includes conventional flight from 200 to 900 ft/sec with path accelerations and decelerations, altitude changes of over 6000 ft and 2g and 3g turns. Vertical attitude maneuvering as a tail sitter along all axes is demonstrated. A transition trajectory from 200 ft/sec in conventional flight to stationary hover in the vertical attitude includes satisfactory operation through lift-cure slope reversal as attitude goes from horizontal to vertical at constant altitude. A vertical attitude takeoff from stationary hover to conventional flight is also demonstrated. Author

N87-11797*# Kohlman Systems Research, Inc., Lawrence, Kans.

FLIGHT TEST REPORT OF THE NASA ICING RESEARCH AIRPLANE: PERFORMANCE, STABILITY, AND CONTROL AFTER FLIGHT THROUGH NATURAL ICING CONDITIONS Final Report

J. L. JORDAN, S. J. PLATZ, and W. C. SCHINSTOCK Oct. 1986 159 p
(Contract NAS3-24547)
(NASA-CR-179515; NAS 1.26:179515; KSR-86-01) Avail: NTIS HC A08/MF A01 CSCL 01C

Flight test results are presented documenting the effect of airframe icing on performance and stability and control of a NASA DHC-6 icing research aircraft. Kohlman System Research, Inc., provided the data acquisition system and data analysis under contract to NASA. Performance modeling methods and MMLE techniques were used to determine the effects of natural ice on the aircraft. Results showed that ice had a significant effect on the drag coefficient of the aircraft and a modest effect on the MMLE derived longitudinal stability coefficients (code version MMLE). Data is also presented on asymmetric power sign slip maneuvers showing rudder floating characteristics with and without ice on the vertical stabilizer. Author

N87-12566*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

EVALUATION OF A NONLINEAR PARAMETER EXTRACTION MATHEMATICAL MODEL INCLUDING THE TERM C(SUBM(SUB DELTA E SQUARED))

W. T. SUIT Oct. 1986 18 p
(NASA-TM-87731; NAS 1.15:87731) Avail: NTIS HC A02/MF A01 CSCL 01C

Shuttle flight test data were used to determine values for the short-period parameters. The best identified, as judged by its estimated standard deviation, was the elevon effectiveness parameter C (sub m (sub sigma e squared)). However, the scatter about the preflight prediction of C (sub m (sub sigma e squared)) was large. Other investigators have suggested that adding nonlinear terms to the mathematical model used to identify C (sub m (sub sigma e)) could reduce the scatter. The results of this investigation show that C (sub m (sub sigma e squared)) is the only identifiable nonlinear parameter applicable and that the changes in C (sub m (sub sigma e)) values when C (sub m (sub sigma e squared)) is included are in the order of ten percent for the data estimated. Author

N87-12568# Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.

A PROTOTYPE MAINTENANCE EXPERT SYSTEM FOR THE CH-47 FLIGHT CONTROL HYDRAULIC SYSTEM

C. J. LOH 28 Apr. 1986 182 p
(Contract DAAG29-84-K-0048)
(AD-A169019; MAE-1751; ARO-20155.8-MA) Avail: NTIS HC A09/MF A01 CSCL 14B

An investigation of the hydraulic flight control system of a Boeing CH-47 Chinook helicopter using artificial intelligence techniques will be undertaken. Specifically, a knowledge based expert system will employ situation-action rules (production rules) to diagnose a failure and subsequently identify specific device(s) which caused that failure. Moreover, because the behavior of the system is directly responsive to the goals the system is directly attempting to achieve, the expert system's inference engine performs a backward-chaining process via a goal-driven control strategy. This strategy involves finding rules that demonstrate the hypothesis and then verifying the facts that enable the rule to work. The List Processing Language (LIPS) is used to facilitate data processing and symbolic logic expression manipulation. GRA

N87-12569# New Mexico Univ., Albuquerque.

APPLICATION OF THE AIPA (APPROXIMATE ITERATIVE PREPROCESSING ALGORITHM) TO F-106 DATA Final Report, Jul. 1984 - Jul. 1985

S. W. PARK and J. T. CORDARO Jun. 1986 12 p
(Contract F29601-84-K-0045)
(AD-A169084; AFWL-TN-85-52) Avail: NTIS HC A02/MF A01 CSCL 20N

This report covers the application of the AIPA numerical algorithm to measured data from the F-106 fly-by electromagnetic pulse test conducted at the AFWL in 1984. The algorithm was partially successful at reducing the data. The amplitudes of the normalized coupling coefficients for the first three poles were determined. GRA

N87-12570# Ballistic Research Labs., Aberdeen Proving Ground, Md.

BLAST GUST LOADING ON A 35 DEGREE SWEPT-BACK WING Final Report

C. L. FISHER May 1986 141 p
(AD-A169415; BRL-MR-3519) Avail: NTIS HC A07/MF A01 CSCL 01C

The Ballistic Research Lab (BRL) performed shock loading tests on a generic wing in the 2.44 meter shock tube. This model was previously tested on the rocked sled facility at Holloman AFB, New Mexico, and is documented in report number DNA 5211F. The purpose of the BRL test was to determine if the data gathered at Holloman AFB on gust loading of the wing could be duplicated in the shock tube. On Feb 20 and 25, 1985, tests were conducted in the BRL shock tube to obtain pressure data on a 35 degree sweptback generic wing model. These data are subsequently compared with equivalent data taken on the same model at the Holloman sled track. GRA

N87-12571# Hughes Research Labs., Malibu, Calif.
FLIGHT MODEL DISCHARGE SYSTEM Report, Nov. 1984 - Dec. 1985
R. R. ROBSON, W. S. WILLIAMSON, and J. SANTORU Feb. 1986 170 p
(Contract F19628-83-C-0143)
(AD-A169423; AFGL-TR-86-0036; SR-2) Avail: NTIS HC A08/MF A01 CSCL 22A

The viability of the Flight Model Discharge System (FMDS) concept has been demonstrated by the successful fabrication and testing of a breadboard system. The FMDS is a spacecraft charge-control system designed to overcome the problem of charge buildup on a space vehicle which occurs during periods of adverse space-environmental conditions. Operational characteristics of the entire system are presented, including the electrostatic analyzers, surface potential monitors, transient pulse monitor, plasma source, and microprocessor-based controller, including its software. Results of the breadbhoard demonstration testing and the preliminary flight hardware design are also included. Author (GRA)

09

RESEARCH AND SUPPORT FACILITIES (AIR)

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

A87-13122
REPAIR OF COMPOSITE COMPONENTS - A NAVY APPROACH
R. E. CARSON (U.S. Navy, Naval Air Rework Facility, San Diego, CA) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 1012-1016.

The Naval Air Rework Facility at North Island Naval Air Station in San Diego, CA has recently opened a new facility for the repair and overhaul of composite and honeycomb/metal bonded aircraft components. The facility, its equipment and its uses will be discussed. The development of training programs for Depot level and intermediate/organizational level repairs will be discussed. Topics will include X-ray, 'C' scan, honeycomb core carvers, automated storage and retreival systems (ASRS), Gerber knife, autoclaves, heat blank bonding and a vertical process center. Author

A87-13988#
DESIGN AND CONSTRUCTION OF A CRYOGENIC-WIND-TUNNEL MODEL [KONSTRUKTION UND BAU EINES KRYO-WINDKANALMODELLS]
P. ESCH (Dornier GmbH, Friedrichshafen, West Germany) and U. GROSS (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 19 p. In German. refs

The status of efforts to design and fabricate a 1:10-scale model of the TST, an experimental Alpha-Jet aircraft with a transonic wing, for use in both conventional and cryogenic wind tunnels is reviewed. Consideration is given to the choice of scale, the simulation of the TST flight envelope, the model load and its implications for the balance measurement range, the strength properties of the martensitically hardenable 18 Ni 1700 steel selected for the model, and the model instrumentation. T.K.

A87-14007#
THE DEVELOPMENT OF DMS-SCALES FOR CRYOGENIC WIND TUNNELS [UEBER DIE ENTWICKLUNG VON DMS-WAAGEN FUER KRYO-WINDKANAELE]
B. EWALD (Darmstadt, Technische Hochschule, West Germany) and E. GRAEWE (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 18 p. In German. refs

The development of a DMS scale for use in a cryogenic wind tunnel is discussed. The accuracy of power measurements in wind tunnels is reviewed, and attainable accuracies for DMS scales are compared with those required for cryogenic wind tunnels. The main sources of inaccuracy in DMS scales are described, and methods to overcome them are indicated. C.D.

A87-14009#
MEASUREMENTS IN THE HIGH SUBSONIC REGION IN THE TU-BERLIN WIND TUNNEL WITH ADAPTIVE WALLS [UEBER MESSUNGEN IM HOHEN UNTERSCHALL IN DEM WINDKANAL DER TU-BERLIN MIT ADAPTIVEN WAENDEN]
U. GANZER (Berlin, Technische Universitaet, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 20 p. In German.

The construction and electronic wall regulation, as well as the measurement procedures for wall adaptation, in the flexible-wall 'Octagon' section of the wind tunnel at the University of Berlin are discussed. Numerical procedures for three-dimensional wall adaptation are addressed along with test results from the Octagon section. Wind tunnels with flexible walls for supersonic flows are briefly discussed. C.D.

A87-14023#
STATUS REPORT ON THE EUROPEAN TRANSONIC WIND TUNNEL (ETW) [STATUSBERICHT ZUM EUROPAEISCHEN TRANSSCHALL-WINDKANAL /ETW/]
F. MAURER (European Transonic Wind Tunnel, Cologne, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 42 p. In German. refs

The development of ETW during phases 2.2 (the functional-design phase begun in Fall 1985) and 3 (the construction phase, still dependent on approval by the participating governments) is discussed in a status report. The emphasis are on the new ETW organizational structure and on changes adopted in the ETW specifications. Topics examined include the duties of the industry architect in phases 2.2 and 3, the overall advantages and disadvantages of external insulation (EI) and internal insulation (II), two proposed II systems, EI/II cost comparisons, breathable atmospheres and breathing devices, the adjustable diffuser, and the temperature conditioning of models. T.K.

A87-14024#
DFVLR CRYOGENIC-WIND-TUNNEL AND MODEL TECHNOLOGY [KRYO-WINDKANAL- UND MODELLTECHNIK IN DER DFVLR]
O. LAWACZECK BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 49 p. In German. refs

Projects underway in the framework of DFVLR programs on cryogenic-wind-tunnel technology, new methods in applied fluid mechanics, and separated flows are surveyed, with a focus on the status of facilities and results applicable to the planned European Transonic Wind Tunnel (ETW). Topics examined include high-Reynolds-number profile measurements at ambient and cryogenic temperatures, the DFVLR cryogenic facilities at Goettingen and Cologne, measurements on the ETW test rig, and experiments on droplet evaporation and condensation. Photographs, graphs, diagrams, drawings, and tables are provided. T.K.

A87-15463
A WIND-TUNNEL METHOD FOR V/STOL TESTING
W. R. SEARS (Arizona, University, Tucson) IN: Recent advances in aerodynamics . New York, Springer-Verlag, 1986, p. 525-545. refs
(Contract N00014-79-C-0010; AF-AFOSR-82-0185)
Attention is given to the results of a numerical study in which the adaptive wall wind tunnel concept was modeled with a powered lift aircraft installed in the tunnel test section, and in which the process of iterative tunnel modification was simulated in detail. Since the adaptive wall scheme allows the operator to choose the simulated undisturbed stream vector in a wind tunnel, it becomes possible to eliminate the problem of the wake in high lift testing. The numerical simulations presently conducted for the case of tests of a jet-flap wing aircraft appear to confirm this claim. A panel method for jet-flap wing and wake modeling are developed, and convergence and iteration method details are explored. O.C.

A87-15464* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE EVOLUTION OF ADAPTIVE-WALL WIND TUNNELS
S. S. DAVIS (NASA, Ames Research Center, Moffett Field, CA) IN: Recent advances in aerodynamics . New York, Springer-Verlag, 1986, p. 547-566. refs
Since its inception, adaptive wall wind tunnel design has developed three major configurational possibilities: streamlined walls, variable porosity walls, and segmented plenum arrangements. All of these methods have demonstrated their feasibility for transonic flow research; development programs are noted to be underway for three-dimensional adaptive wall tunnels. With the availability of advanced computational procedures, routine angle-of-incidence or Mach sweeps may be treated numerically, while adaptive wall wind tunnels are employed for complementary point-design and for testing at flow conditions that are beyond the capabilities of current numerical modeling. O.C.

A87-15465
ADVANCES IN ADAPTIVE WALL WIND TUNNEL TECHNIQUE
U. GANZER (Berlin, Technische Universitaet, West Germany) IN: Recent advances in aerodynamics . New York, Springer-Verlag, 1986, p. 567-601. BMFT-DFG-supported research. refs
The adaptive wind tunnel wall technique requires: (1) a device that locally adjusts the flow condition near the test section wall; (2) the means with which to check how far the wall is free of interference; and (3) a strategy by means of which to arrive at wall interference-free flow conditions. Various adaptive wall wind tunnel projects are presently discussed. Attention is given to two different kinds of adaptive wall test section: the type employing perforated or slotted walls with local control of flow through the wall, and that using flexible imprermeable walls with the shape adjusted to the individual flow condition. Design features are explored for the NASA Ames, University of Southampton, AEDC, DFVLR, and Technical University of Berlin three-dimensional adaptive wall wind tunnel projects. O.C.

N87-11798# Federal Aviation Administration, Washington, D.C. Program Engineering and Maintenance Service.
FAA HELICOPTER/HELIPORT RESEARCH, ENGINEERING, AND DEVELOPMENT BIBLIOGRAPHY, 1964-1986
R. D. SMITH Nov. 1986 170 p
(FAA/PM-86/47) Avail: NTIS HC A08/MF A01
This report is a bibliography of FAA heliport related documents published in the 1964 to 1986 time period. The list is limited to documents in which the research, engineering, and development elements of the FAA were involved as sponsors, participants, or authors. Author

N87-11799# Army Engineer Waterways Experiment Station, Vicksburg, Miss. Geotechnical Lab.
ADVANCED CONSTRUCTION PROCEDURES: CONFINED BASES FOR AIRPORT PAVEMENTS Final Report, Sep. 1983 - Mar. 1986
J. C. POTTER and P. C. LAMBE Sep. 1986 96 p
(Contract DTFA01-83-Y-30606)
(FAA/PM-86/9) Avail: NTIS HC A05/MF A01
Airports for light aircraft must often be built in areas where base course material is inadequate or economically unavailable. Sand grids may provide an economical solution in these cases. Previous work with sand grids has identified optimum grid-cell geometry based on ultimate bearing capacity. Past observations also suggest the nature of sand-grid behavior for small stresses and strains. From these a model was formulated for analyzing the performance of sand grids in pavement systems and spot-checked using field data from a full-scale, accelerated-traffic sand-grid test section. Author

N87-11800*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
METHODS FOR ASSESSING WALL INTERFERENCE IN THE 2- BY 2-FOOT ADAPTIVE-WALL WIND TUNNEL
E. T. SHAIRER Jun. 1986 61 p
(NASA-TM-88252; A-86249; NAS 1.15:88252) Avail: NTIS HC A04/MF A01 CSCL 14B
Discussed are two methods for assessing two-dimensional wall interference in the adaptive-wall test section of the NASA Ames 2 x 2-Foot Transonic Wind Tunnel: (1) a method for predicting free-air conditions near the walls of the test section (adaptive-wall methods); and (2) a method for estimating wall-induced velocities near the model (correction methods), both of which methods are based on measurements of either one or two components of flow velocity near the walls of the test section. Each method is demonstrated using simulated wind tunnel data and is compared with other methods of the same type. The two-component adaptive-wall and correction methods were found to be preferable to the corresponding one-component methods because: (1) they are more sensitive to, and give a more complete description of, wall interference; (2) they require measurements at fewer locations; (3) they can be used to establish free-stream conditions; and (4) they are independent of a description of the model and constants of integration. Author

N87-11801*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A DESCRIPTION OF THE ACTIVE AND PASSIVE SIDEWALL-BOUNDARY-LAYER REMOVAL SYSTEMS OF THE 0.3-METER TRANSONIC CRYOGENIC TUNNEL
C. B. JOHNSON, A. V. MURTHY, and E. J. RAY Nov. 1986 21 p
(NASA-TM-87764; L-16178; NAS 1.15:87764) Avail: NTIS HC A02/MF A01 CSCL 14B
Results are presented for an operational checkout and shakedown of the active sidewall-boundary-layer removal system newly installed in the Langley 0.3-meter Transonic Cryogenic Tunnel (0.3-m TCT). Prior to the installation of this active removal system, the sidewall-boundary layer was removed passively by exhausting directly to the atmosphere (i.e., no reinjection). With the active removal system using the reinjection compressor, the removal capability is greatly expanded to cover the entire operating envelope of the 0.3-m TCT. Details of the active removal system are presented including the compressor reinjection circuit, the compressor pressure ratio/surge control, and the compressor recirculation loop. The control logic and features of the compressor surge control are explained. Initial tests covering critical operating conditions show mass flow removal rates of about 5 percent at lower Mach numbers can be obtained with the active system. Measured performance characteristics of the compressor are presented. As part of the validation of the active system, limited airfoil tests were made using the new system. Author

N87-11802# Toronto Univ. (Ontario). Inst. for Aerospace Studies.
MOTION CHARACTERISTICS OF THE UTIAS FLIGHT RESEARCH SIMULATOR MOTION-BASE
P. R. GRANT Jul. 1986 144 p Sponsored in part by Natural Sciences and Engineering Research Council, and by University of Toronto
(UTIAS-TN-261; ISSN-0082-5263) Avail: NTIS HC A07/MF A01
The motion characteristics of the UTIAS Flight Research Simulator Motion-Base were experimentally determined. More specifically describing function tests (under various operating conditions), 1/2 Hz noise level tests, signal-to-noise tests, and hysteresis tests were performed for all six degrees-of-freedom. Dynamic threshold tests were performed for the heave degree-of-freedom. The motion-base was found to have a reasonably flat amplitude response up to 10 Hz in all degrees-of-freedom. Motion in the non-dirven degrees-of-freedom was small compared to the driven channel. The noise of the motion-base was found to be the sum of braodband background noise and harmonics of the driven frequency, with the amplitude of the noise varying with both the amplitude and frequency of the driving signal. Hysteresis was determined to be neglible. The dynamic threshold was found to be small and quite acceptable for most projected applications involving the motion-base.
Author

N87-11803# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
THE 8 M X 6 M LOW SPEED WIND TUNNEL AT THE CHINESE AERODYNAMIC RESEARCH AND DEVELOPMENT CENTER
M. WANG and R. PAN 30 May 1986 14 p Transl. into ENGLISH from Guoji Hangkong (China), no. 10(260), Oct. 1984 p 2-4
(AD-A168448; FTD-ID(RS)T-0257-86) Avail: NTIS HC A02/MF A01 CSCL 14B
The low speed wind tunnel at CARDC is a large scale, double experimental section wind tunnel solely designed and built in China. It is primarily used for experiments in the aerodynamic characteristics of aerospace vehicles, i.e., ground wind load of guided missiles and space vehicles; large attack angle of airplanes and guided missiles; large prototypes; aerodynamics of helicopters and vertical short takeoff aircraft; and industrial aerodynamics (e.g., architecture, bridges, fans and automobiles). It passed national certification at the end of 1983 and was officially released for use. This wind tunnel is an open-circuit, closed double experimental section in series, large scale low speed wind tunnel. Its length is 237 m with a maximum width of 40 m and a maximum height of 20.5 m. It consists of air intake assembly, stabilization section, first convergence section, first experimental section, second experimental section, fan section, second divergence section, and air exhaust assembly.
GRA

N87-11805# Royal Netherlands Meteorological Inst., De Bilt. Afdeling Fysische Meteorologie.
NUMBER AND DURATION OF RUNWAY VISUAL RANGE (RVR) RUNS FOR RVR-VALUES LOWER THAN 225 M
A. H. C. STALENHOEF 1986 25 p In DUTCH; ENGLISH summary
(KNMI-TR-85(FM); ISSN-0169-1708; ETN-86-98500) Avail: NTIS HC A02/MF A01
The number and length of runway visual range (RVR) runs for values of the RVR leass than 225 m were studied in order to obtain a better insight into the appearance of dense fog at Amsterdam airport Schiphol. The study was based on 1 m data of transmissometers and matching background luminance meters at several locations in the airport for the period June 1979 till May 1985. The percentage of time during each month that the transmissometer data were not available on magnetic tape, the number of runs of specified lengths for each location, the local number of runs in the period, the relative frequencies of runs with several lengths for each location, and information about the total duration that the RVR does not exceed a certain level are tabulated. An expression for the probability distribution of the duration that dense fog may persist was derived.
ESA

N87-12572# Essex Corp., Orlando, Fla.
SIMULATOR DESIGN FEATURES FOR HELICOPTER LANDING ON SMALL SHIPS. 1: A PERFORMANCE STUDY Final Report, 1 Sep. 1981 - 26 Apr. 1985
D. P. WESTRA and G. LINTERN 27 Sep. 1985 63 p
(Contract N61339-81-C-0105)
(AD-A169514; NAVTRASYSCEN-81-C-0105-13) Avail: NTIS HC A04/MF A01 CSCL 05I
The Visual Technology Research Simulator (VTRS) at the Naval Training Systems Center was used to study the effects of six simulator features on performance for helicopter landings on small ships. The purpose of the experiment was to obtain information relevant to the design of simulators for skill maintenance and transition training, and to obtain information for decisions about future transfer-of-training studies. The six simulator factors were scene detail (high detail ship deck and hangar markings versus no deck and hangar markings), field of view (VTRS-wide versus reduced SH-60B operational flight trainer field of view), system visual lab (217 msec versus 117 msec), g-seat acceleration cuing (off versus on), and collective sound cuing (off versus on). These factors were tested across two levels of seastate and pilot experience. Pilots who participated in the experiment were experienced Navy H-3 rotary wing pilots. Results indicated large effects of scene detail, small to moderate effects for visual lag, small effects for field of view, and no meaningful effects for the g-seat factors and collective sound. Performance was better with the high-detail ship, the shorter visual lag, and the VTRS-wide field of view. Transfer-of-training research is recommended as the next step to further explore these findings and to obtain information directly relevant to the design of simulators for use by student pilots.
GRA

N87-12573# Essex Corp., Orlando, Fla.
SIMULATOR DESIGN AND INSTRUCTIONAL FEATURES FOR CARRIER LANDING: A FIELD TRANSFER STUDY Final Report
D. P. WESTRA, G. LINTERN, D. J. SHEPPARD, K. E. THOMLEY, and R. MAUK 18 Jun. 1986 91 p
(Contract N61339-85-C-0044)
(AD-A169962; NAVTRASYSCEN-85-C-0044-2) Avail: NTIS HC A05/MF A01 CSCL 01B
A transfer-of-training experiment was conducted as part of the carrier landing behavioral research program at the Visual Technology Research Simulator (VTRS). Experimental results provide information on the design and use of simulators for training the aircraft carrier landing task and also provide input on design issues for the Navy's new T-45 training system. Two visual display variables and two simulator training variables were selected for inclusion in this experiment: scene detail (day contrasted with night); field of view (wide versus narrow); approach type (circling, modified straight-in or segmented); and number of simulator trials (20, 40, or 60). 72 student pilots were trained on the VTRS prior to going through the Field Carrier Landing Practice (FCLP) phase of their pilot training program. Performance of these students at FCLP was contrasted with that of a group of 54 students who did not receive simulator training. Results show that students trained in the simulator performed better at FCLP than the control students. There was no transfer advantage for those trained with a daytime high-detail scene compared to those trained with a lower cost nighttime low-detail scene. There was also no transfer advantage for those trained with a wide FOV compared to those trained with the wide field of view compared to those trained with the lower cost narrow FOV scene.
GRA

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ASTRONAUTICS

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

A87-15920#
RAMJET APPLICATION IN ATMOSPHERES OF DIFFERENT CELESTIAL BODIES
D. M. WOLF (DFVLR, Institut fuer Chemische Antriebe und Verfahrenstechnik, Hardthausen am Kocher, West Germany) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 8 p. refs
(IAF PAPER 86-181)

Primarily, this study shall answer the question of ramjet application in the atmospheres of Venus, Mars, Jupiter, Saturn, and Titan. Atmospheric models of the specified celestial bodies are presented, describing the chemical composition as well as the temperature and pressure distribution. After selecting suitable propellants and committing to an engine configuration, the load limits of the engine model are fixed. The engine calculations are pointing out the impact of a few parameters, e.g., Mach number or mixture ratio, on the specific impulse and the thrust density. The results of the study are showing the ramjet application in all atmospheres mentioned above as being theoretically possible. Author

N87-12577# Texas Univ., Austin.
OPTIMAL DESCENDING, HYPERSONIC TURN TO HEADING
G. R. EISLER and D. G. HULL 1986 15 p Presented at the Atmospheric Flight Mechanics Conference, Williamsburg, Va., 18 Aug. 1986
(Contract DE-AC04-76DP-00789)
(DE86-010989; SAND-86-2061C; CONF-860882-2) Avail: NTIS HC A02/MF A01

Approximations are made to the point-mass equations of motion for flight within the atmosphere. Optimal controls are formulated for a reentry vehicle to execute a maximum-terminal-velocity turn to a specified heading while executing steep, descent trajectories. A Newton scheme is used repetitively to solve a nonlinear algebraic system for two parameters in the control equations to provide the on-line guidance. Trajectory comparisons from the repetitive solution of the optimal control problem, pure numerical optimization, and simulation of sample-data guidance show good agreement, if the atmospheric model is accurate. DOE

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CHEMISTRY AND MATERIALS

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

A87-13092
DEVELOPMENT OF HIGH-ALUMINA CERAMIC MATERIALS SUITABLE FOR MAKING JET ENGINE FIXTURES
M. WOOD and S. C. KUO (CEMCOM Corp., Lanham, MD) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 600-608. refs

A calcium-aluminate bonded ceramic material was developed for fabricating low cost vacuum furnace fixtures suitable for the high temperature repair of jet engine components. The material was formulated based on results obtained from a series of statistically designed experiments. The material was refined and the prototype was scaled up to practical sizes. The materials's thermophysical properties and mechanical strength characteristics were determined. Preliminary results demonstrate that the furnace time necessary for heat treating jet engine components can be reduced from the 13 hours required by graphite fixturing (due to outgassing) to six hours of less for ceramic fixtures. Author

A87-13093
RESIN-HARDENER SYSTEMS FOR RESIN TRANSFER MOLDING
W. D. WHITE (Dow Chemical Co., Coatings and Resins Technical Service and Development Dept., Freeport, TX) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 622-634.

Three resin-hardener systems developed for resin transfer molding, braiding, and filament winding are evaluated as matrix resins for glass, Kevlar, and graphite fiber reinforcements. It is shown that the three systems are suitable for fabricating composite panels with mechanical properties comparable with those of panels made of state-of-the-art 350 F dry/250 F wet epoxy systems. V.L.

A87-13121
COMPOSITE CURING WITH SEMI-PERMEABLE MEMBRANES
R. S. KIWAK and J. L. TOUCHETTE (Martin Marietta Corp., Baltimore Aerospace Div., MD) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 999-1011. refs

Absorbed moisture has been identified as the major cause of internal porosity during high temperature, low pressure curing of epoxy matrix composites needed for composite aircraft repair. Semi-permeable membranes, thin sheets of polymer that allow gases including water vapor to pass through unimpeded while stopping resin, offer a higher level of gas management processing than conventional methods. This has allowed the development of a simple concept for an improved nonautoclave cure process. The composite layup, including a predetermined amount of bleeder ply, is completely surrounded with the gas permeable membrane and hydrostatically sealed to contain the liquid resin. The layup is pressurized through the membrane, while the surrounding effluent cavity is under vacuum. Having the liquid phase under pressure at all times increases gas solubility and prevents bubble formation, thereby allowing volatiles to diffuse to the membrane interface and dissipate. Results of experiments conducted on various membranes and resulting void fraction gradients through the laminates are discussed. Author

A87-13171
DIFFUSION BONDING OF CERTAIN REFRACTORY METALS
T. G. NIEH (Lockheed Metallurgy Laboratory, Palo Alto, CA) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 1595-1603. Research supported by the Lockheed Independent Research and Development Program. refs

Fusion welding or brazing of refractory metals is, in general, not desirable due to the recrystallized, brittle microstructure produced in the joint. In view of this, it is preferable to reduce the bonding temperature by conducting solid-state diffusion bonding at a low temperature to prevent recrystallization. It will be demonstrated that a number of refractory metals systems, e.g., TZM-Mo (Mo- Ti-Zr) to TZM-Mo, TZM-Mo to C103 (89Nb-10Hf-1Ti) and W-25Re to W-25Re, can be jointed together by solid-state diffusion bonding solid-state diffusion bonding at temperatures below that for the recrystallization of the parent metals by using either Nb, Ta, Ti, or Ni as interleaf materials. In addition, it will also be demonstrated that W-25Re can be self diffusion bonded without causing a brittle joint. Parameters affecting the quality of the joint, particularly the surface preparation prior to bonding, will be discussed. This particular type of joint has immediate applications in many aerospace structures. Author

A87-13613
FIBRE REINFORCED COMPOSITES 1986; PROCEEDINGS OF THE SECOND INTERNATIONAL CONFERENCE, UNIVERSITY OF LIVERPOOL, ENGLAND, APRIL 8-10, 1986
Conference sponsored by the Institution of Mechanical Engineers, Plastics and Rubber Institute, Institution of Production Engineers, and Royal Aeronautical Society. London, Mechanical Engineering Publications, Ltd., 1986, 269 p. For individual items see A87-13614 to A87-13634.

The papers presented include thermoplastic composites in woven fabric form, the preparation of ultrahigh modulus polyethylene composites, compact disk fracture mechanics testing of injection-molded short-fiber-reinforced thermoplastics, and injection molding of thick-section-fiber-reinforced thermoplastics. Consideration is given to the flexible manufacturing of composite aerospace structures, the mechanized manufacture of composite rotor-blade spars, and AV-8B/GR Mk 5 airframe composite applications. Additional papers include the prediction of the energy absorption of composite structural materials, hovercraft skirt design and manufacture, and low-cost carbon fibers for high-performance applications. I.S.

A87-13659#
THERMOCHEMICAL EVALUATION OF FUEL CANDIDATES FOR RAMJET PROPULSION
A. GANY (Technion - Israel Institute of Technology, Haifa) and D. W. NETZER (U.S. Naval Postgraduate School, Monterey, CA) IN: Israel Annual Conference on Aviation and Astronautics, 27th, Haifa, Israel, February 27, 28, 1985, Collection of Papers . Haifa, Israel, Technion - Israel Institute of Technology, 1986, p. 210-219. refs

Thermochemical evaluation of fuel candidates for ramjet propulsion is made in terms of the theoretical heat of combustion per unit mass and per unit volume of the fuel. Combustion phenomena and combustion efficiency are not accounted for in this study. Compared with the commonly used hydrocarbons, the main advantage of using metals or metal compounds is their much higher energy density, which is of great significance in volume limited systems. For practical use, boron has the highest energy density of all elements (almost three times higher than that of hydrocarbons). However, several boron compounds exhibit similar theoretical performance, and it is highly recommended to examine them; especially boron carbide and the high borides of aluminum, magnesium and silicon. Author

A87-13985#
CLARIFICATION OF ADHESIVE BINDING MECHANISMS OF ALUMINUM STRUCTURAL BONDS IN AIRCRAFT FABRICATION [KLAERUNG DER ADHAESIVEN BINDUNGSMECHANISMEN VON STRUKTURELLEN ALUMINIUMKLEBUNGEN IM FLUGZEUGBAU]
C. MATZ (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 22 p. In German. refs
(Contract BMFT-LFF-8350)
(MBB-UT-226-86)

The material characteristics and processing parameters which determine the service life of bonded Al aircraft structures are investigated experimentally. Three primary damage mechanisms are identified: the growth of weak zones near boundary layers, the alkaline destruction of the oxide layer, and joint corrosion. For optimum bonding, it is recommended that the substrate surface be physicochemically active vis a vis the adhesive, that the adhesive-substrate interaction be resistant to hydrolysis, and that the adhesive be designed to keep the chemical environment in the joint within the stability limits of the substrate surface. T.K.

A87-14001#
STRUCTURE-COMPONENT TESTS FOR A CFK FUSELAGE [STRUKTUR-KOMPONENTENVERSUCHE FUER EINEN CFK-RUMPF]
M. KOLAX (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 19 p. In German.
(Contract BMFT-LFK-8350)
(MBB-UT-223-86)

Critical structural components for a future CFK fuselage of a large-capacity aircraft have been studied, and the results are discussed. Methods of building such a composite fuselage are addressed along with the characteristics of individual components. The development and testing of the first critical structural components are reviewed, and the selection of materials and the techniques utilized are described. C.D.

A87-14982#
COMBUSTION STUDIES OF METALLIZED FUELS FOR SOLID-FUEL RAMJETS
A. GANY (Technion - Israel Institute of Technology, Haifa) and D. W. NETZER (U.S. Naval Postgraduate School, Monterey, CA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 2, Sept.-Oct. 1986, p. 423-427. Research supported by the U.S. National Research Council. Previously cited in issue 18, p. 2653, Accession no. A85-39640. refs
(Contract N60530-85-WR-30011)

A87-14986*# United Technologies Research Center, East Hartford, Conn.
LONG-TERM DEPOSIT FORMATION IN AVIATION TURBINE FUEL AT ELEVATED TEMPERATURE
A. J. GIOVANETTI and E. J. SZETELA (United Technologies Research Center, East Hartford, CT) Journal of Propulsion and Power (ISSN 0748-4658), vol. 2, Sept.-Oct. 1986, p. 450-456. Previously cited in issue 07, p. 876, Accession no. A86-19929. refs
(Contract NAS3-24091)

A87-15187* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
POLYMER, METAL, AND CERAMIC MATRIX COMPOSITES FOR ADVANCED AIRCRAFT ENGINE APPLICATIONS
D. L. MCDANELS, T. T. SERAFINI, and J. A. DICARLO (NASA, Lewis Research Center, Cleveland, OH) Journal of Materials for Energy Systems (ISSN 0162-9719), vol. 8, June 1986, p. 80-91. Previously announced in STAR as N86-13407. refs

Advanced aircraft engine research within NASA Lewis is being focused on propulsion systems for subsonic, supersonic, and hypersonic aircraft. Each of these flight regimes requires different types of engines, but all require advanced materials to meet their goals of performance, thrust-to-weight ratio, and fuel efficiency. The high strength/weight and stiffness/weight properties of resin, metal, and ceramic matrix composites will play an increasingly key role in meeting these performance requirements. At NASA Lewis, research is ongoing to apply graphite/polyimide composites to engine components and to develop polymer matrices with higher operating temperature capabilities. Metal matrix composites, using magnesium, aluminum, titanium, and superalloy matrices, are being developed for application to static and rotating engine components, as well as for space applications, over a broad temperature range. Ceramic matrix composites are also being examined to increase the toughness and reliability of ceramics for application to high-temperature engine structures and components. Author

A87-15924#
PROSPECTIVE, CHARACTERISTICS AND PROBLEMS OF THE USE OF BORON IN DIFFERENT AIR AUGMENTED PROPULSION MODES
A. GANY and Y. M. TIMNAT (Technion - Israel Institute of Technology, Haifa) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 11 p. refs
(IAF PAPER 86-191)

The theoretical energetic advantages and the practical problems and characteristics associated with three modes of ramjet-type propulsion engines are discussed. It is shown that the use of boron results in a remarkable theoretical energy gain compared with hydrocarbon fuels, especially in volume-limited systems. However, the poor combustion characteristics of boron and the high ignition temperature required (1900 K) impose special constraints on the combustor system if high efficiencies are to be obtained. Solid fuels and propellants containing high percentage of boron tend to exhibit irregular combustion (which may cause thrust modulations), while agglomeration of boron particles may result in incomplete combustion due to the insufficient residence time in the combustor. Author

N87-11877# Amax Materials Research Center, Ann Arbor, Mich.
CARBURIZING STEEL FOR HIGH TEMPERATURE SERVICE Final Report, 1982 - Dec. 1984
T. B. CAMERON and D. E. DIESBURG Aug. 1985 53 p
(Contract DAAG46-82-C-0066)
(AD-A168327; REPT-82-C-66; AMMRC-TR-85-25) Avail: NTIS HC A04/MF A01 CSCL 13H

A prime concern in airborne equipment is to avoid a brittle fracture in gearing or bearings which could lead to catastrophic engine or propulsion system failure. Projected requirements for advanced aircraft and helicopters suggest that currently employed through-hardened materials will no longer be adequate for these applications due to their low fracture toughness. Hence there is an interest in carburized materials which have somewhat similar surface characteristics to the through-hardened materials but inherently higher core toughness due to the lower core carbon levels. Five steels similar in composition to CBS1000 and a low carbon M50 composition were evaluated with respect to carburizing characteristics, temper resistance, hot hardness and carburized fracture toughness. Si, Mo and Ni levels were varied in an effort to identify a composition that would maintain a surface hardness of 58 HRC minimum at 315 C (600 F) without a deterioration in fracture toughness properties. Si and Ni were both shown to retard carburization but have little influence on hardness retention or fracture toughness. A composition with 2.3% Ni was shown to have optimum carburizing, hardness and fracture toughness properties. The modified steel showed an improvement over CBS1000 in case fracture toughness but the core fracture toughness was lower than that of CBS1000. This steel was tested in rolling contact fatigue and found to be similar in performance to through-hardened M50. GRA

N87-11902# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ANTIMISTING KEROSENE: EVALUATION OF LOW TEMPERATURE PERFORMANCE Final Report, Mar. 1983 - Dec. 1984
P. PARIKH, A. YAVROUIAN, R. PETERSEN, and V. SAROHIA Aug. 1986 49 p
(Contract DTFA3-80-A-00215)
(DOT/FAA/CT-85/31) Avail: NTIS HC A03/MF A01

The low temperature and freezing behavior of Jet A and AMK fuels was investigated in a 50-gallon capacity wing tank simulator. The fuel in the rectangular simulator was chilled from the top and bottom surfaces while the sides were thermally insulated. The evolution of a vertical temperature profile in the simulator was studied for Jet A and AMK fuels under nearly identical bottom wall temperature histories. A small but noticeable difference between the bulk fuel thermal response of Jet A and AMK was observed with a slower response for AMK. Holdup measurements for AMK were slightly lower than those for Jet A. Rocking of the simulated wing tank did not significantly alter the cool down and freezing behavior. The performance of two boost pumps: one for the DC-10 and the other for the Cessna 441 aircraft, was evaluated with AMK fuel. For both pumps the performance deteriorated when switching from Jet A to AMK. This performance deterioration was far more dramatic for the Cessna 441 boost pump than for the DC-10 boost pump. At low temperature (-30 C) the performance of the DC-10 pump actually improved compared to ambient temperature (20 C) performance. It deteriorated, however, for the Cessna 441 pump. Author

N87-11904# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
F100 FUEL SAMPLING ANALYSIS: FOREIGN SAMPLES Final Report, Apr. 1984 - Apr. 1985
L. O. MAURICE Mar. 1986 115 p
(AD-A168573; AFWAL-TR-85-2087) Avail: NTIS HC A06/MF A01 CSCL 21D

Fuel pump cavitator problems experienced with the F100 engine used in the F-15/F-16 aircraft have led to an extensive fuel analysis program to identify properties that might be contributing to fuel pump falure. This report analyzes the chemical and physical properties of 12 JP-4 and 4 JP-8 fuel samples obtained from Foreign National Air Bases. The fuels analyzed met specifications in all but a few isolated cases, and had no unusual properties. If the fuel is causing fuel pump failure, it must be the result of a property not being measured. The fuels are as good or better than their specifications prescribed. It is concluded that the F100 fuel pump cavitation problems are most likely associated with the mechanical complexity built into the design, rather than the results of the fuel used. GRA

N87-11908# IIT Research Inst., Bartlesville, Okla.
AVIATION TURBINE FUELS, 1985
C. L. DICKSON and P. W. WOODWARD May 1986 15 p
(Contract DE-FC22-83FE-60149)
(DE86-012140; NIPER-144-PPS-86/2) Avail: NTIS HC A02/MF A01

Samples of this report are typical 1985 production and were analyzed in the laboratories of 17 manufacturers of aviation turbine (jet) fuels. The data were submitted for study, calculation, and compilation under a cooperative agreement between the National Institute for Petroleum and Energy Research (NIPER), Bartlesville, Oklahoma, the American Petroleum Institute (API), and the United States Department of Energy (DOE), Bartlesville Project Office. Results for certain properties of 88 samples of aviation turbine fuels are included in the report for military grades JP-4 and JP-5, and commercial type Jet A. Previous aviation fuel survey reports are listed. DOE

N87-12622# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
CARBON FIBERS
A. A. KONKIN and N. F. KONNOVA 22 Aug. 1986 35 p Transl. into ENGLISH from Zhurnal Vsesoyuznogo Khimicheskogo Obshchestva (USSR), v. 17, no. 6, 1972 p 632-639
(AD-A171370; AD-F250645; FTD-ID(RS)T-0761-86) Avail: NTIS HC A03/MF A01 CSCL 11B

In connection with development of missile construction, aircraft construction, mastery of space, and also other branches of technology arose acute need for high temperature (oxidation resistant) fibrous materials, reinforced plastics on basis of which were intended for exploitation at high temperatures. Common natural and synthetic fibers, including thermoresistant, could not satisfy these requirements. As a result of intensive investigations, carried out for latter by decade are developed methods of obtaining large number of high temperature (oxidation resistant) fibers different in properties, predominantly on basis of inorganic compounds. To the important of them relate carbon, boric, carbide, metallic, on the basis of oxides of the elements and some other compounds. Filamentary crystals (whisker) occupy special position in view of unique mechanical properties. This group of fibers is located on different levels of technical development. GRA

N87-12685# State Univ. of New York, Stony Brook. Dept. of Chemistry.
CHARACTERIZATION AND DYNAMICAL STUDIES OF POLYMERS IN DIPOLAR (APROTIC) LIQUIDS Final Report, 5 Jul. 1982 - 4 Jan. 1986
B. CHU 14 Apr. 1986 7 p
(Contract DAAG29-82-K-0143)
(AD-A169243; REPT-6340A; ARO-19251.5-CH) Avail: NTIS HC A02/MF A01 CSCL 20D

The aerodynamic breakup of liquids is an essential mechanism in many processes, e.g., fuel atomization in liquid rocket engine, turbojet afterburners and ramjets, paint spraying, aerial dissemination of insecticides, and explosive dissemination of fuels. Only limited studies have been conducted on the aerodynamic breakup of viscoelastic fluids where molecular parameters must necessarily play an important role in the control of both the magnitude of the mean mass diameter of the droplets and the droplet size distribution. The viscoelastic properties of bulk liquid can be altered by using polymer additives whose molecular weight, concentration an dcomposition control the conversion of bulk liquid into specific droplet sizes for a fixed stress and geometry. In this report, we want to summarize the experimental preparations we have made to characterize both static and dynamic properties of polymer additives in dipolar (aprotic) liquids. We have developed a generalized technique to determine the molecular weight, the molecular weight distribution, the polymer composition, the interaction parameters expressed in terms of the second virial coefficients, including both thermodynamic and hydrodynamic interactions for copolymers by means of laser light scattering. As a specific example, we characterized acryloid k-125, a quasiterpolymer used in aerodynamic breakup tests. GRA

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ENGINEERING

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

A87-13074
ADVANCED MANUFACTURING TECHNOLOGY FOR STRUCTURAL AIRCRAFT/AEROSPACE COMPONENTS
N. C. OLSEN (XERKON Co., Minneapolis, MN) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 387-395.

An integrated semiautomated multiple manufacturing process has been developed to produce composite primary structural parts uniquely shaped to match typical airframe taper and curvature. The initial process employs modified textile equipment to process knitted fabric broadgoods using carbon, aramid, and fiberglass fibers. The knitted fabric broadgoods are then assembled into a fiber form; dry fiber forms are impregnated using the resin film infusion process. The pressure molding process uses matched surface tooling, and the curing process uses temperature, pressure, and vacuum. The process generates fully cured or staged parts allowing the components to be co-cured to other assemblies. V.L.

A87-13123
NOVEL COMPOSITE REPAIR METHODS
R. L. COLOGNA (Boeing Aerospace Co., Seattle, WA) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 1017-1022.

Novel composite blind-side repair methods for aircraft are being developed which are particularly suitable for use in the field or at an operating base under adverse conditions and stringent time constraints. The repairs can be accomplished easily with simple hand tools and require minimum training and skill to perform. The repairs can be used to provide support to the blind side, provide a vacuum seal, and permit near-side repair by conventional methods such as scarf or doubler. Two such methods are considered: flexible-washer and turn-in disk blind-side repair. A blind-side repair validation test on a graphite-epoxy honeycomb sandwich panel was carried out. B.J.

A87-13164
USE OF FILAMENT WINDING IN MANUFACTURING HIGH QUALITY AEROSPACE COMPOSITE COMPONENTS
A. K. MUNJAL (Aerojet Strategic Propulsion Co., Sacramento, CA) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 1504-1518. refs

The use of filament winding in aircraft manufacture has been limited due to concerns regarding high void content, resin matrix selection, aerospace resign processing requirements, fiber placement accuracy, resin fiber control, composite quality, in-process inspection method applicability, aerodynamic surface finish requirements, and structural design analysis suitability. These concerns are presently addressed with a view to the improvement of quality and structural integrity in filament-wound composites. Attention is given to the optimum selection of materials, tooling and design, as well as the quality control of materials, their processing, and their handling during manufacture. The minimization of void content is noted to be the single most important factor in the determination of composites' resin-dominated properties. O.C.

A87-13173
7050 ALUMINUM RIVETS FOR MILITARY AIRCRAFT
E. R. WOOD (Lockheed-California Co., Burbank) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings. Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 1619-1630.

The use of 7075 alloy aluminum rivets leads to a sharp decline in the number of rivets that must be removed due to cracking during aircraft structure assembly, by comparison to experience with the 2024 alloy rivets previously employed. While the 2024 alloy rivets require treatment at subzero temperatures prior to installation, the 7075 rivets are driven in place in their final temper condition. Attention is given to the results of tension, lap shear and fatigue testing for 7075 rivets, in light of which a major commercial and military aircraft manufacturer is planning complete conversion to rivets of this type. O.C.

A87-13625
MECHANIZED MANUFACTURE OF COMPOSITE MAIN ROTOR BLADE SPARS
D. HOLT (Westland, PLC, Yeovil, England) IN: Fibre reinforced composites 1986; Proceedings of the Second International Conference, Liverpool, England, April 8-10, 1986 . London, Mechanical Engineering Publications, Ltd., 1986, p. 125-131.

This paper describes the latest developments in a long-term program directed at the integrated design and manufacture of composite main rotor blades. The availability of high performance composite materials made it possible to design rotor blades with considerably enhanced performance relative to standard metal blades. The use of prepreg materials called for entirely new methods of manufacture, and mechanization of the process was essential if performance and quality standards were to be guaranteed. A close liaison between design and manufacturing engineers has resulted in a series of mechanization projects culminating in an FMS cell for the manufacture of main-rotor blade spars. Author

A87-13642#
THE EFFECT OF MATERIAL COMPRESSIBILITY (POISSON RATIO) ON THE ELASTO-PLASTIC SOLUTION TO THE PROBLEM OF A CYLINDER UNDER INTERNAL PRESSURE (COLDWORKING SITUATION)
Y. BORTMAN and D. SCHUR (Tel Aviv University, Israel) IN: Israel Annual Conference on Aviation and Astronautics, 27th, Haifa, Israel, February 27, 28, 1985, Collection of Papers . Haifa, Israel, Technion - Israel Institute of Technology, 1986, p. 61-64. refs

The effect of material compressibility (Poisson ratio) on the residual elastoplastic stress distribution around a fastener hole was investigated. The aim of this study is to estimate the error which could arise in using a close form solution of the stress distribution instead of the exact solution which cannot be determined by analytical means. The finite element approach was used to show that the residual hoop stress is not significantly dependent on the Poisson ratio. Author

A87-13660#
SPRAY CHARACTERISTICS OF TWO COMBINED JET ATOMIZERS
Y. TAMBOUR and D. PORTNOY (Technion - Israel Institute of Technology, Haifa) IN: Israel Annual Conference on Aviation and Astronautics, 27th, Haifa, Israel, February 27, 28, 1985, Collection of Papers . Haifa, Israel, Technion - Israel Institute of Technology, 1986, p. 220-228. refs

The downstream changes in droplet volume concentration of a vaporizing fuel spray produced by two jet atomizers which form an overlapping zone of influence is analyzed. One of the atomizers is located below the other at a certain distance downstream. Such an injection geometry can be found in afterburners of modern jet engines. The influence of various vertical and horizontal distances between the two atomizers on the downstream spray characteristics is investigated for a vaporizing kerosene spray in a 'cold' (293 K) and a 'hot' (450 K) environment. The present analysis shows how one can control the downstream spray characteristics via the geometry of injection. Such geometrical considerations may be of great importance in the design of afterburner wall geometry and in the reduction of wall thermal damage. The injection geometry may also affect the intensity of the spray distribution which determines the mode of droplet group combustion. The latter plays an important role in improving afterburner combustion efficiency. Author

A87-13680
WHOLEFIELD DISPLACEMENT MEASUREMENTS USING SPECKLE IMAGE PROCESSING TECHNIQUES FOR CRASH TESTS
P. SRIRAM, S. HANAGUD (Georgia Institute of Technology, Atlanta), and W. F. RANSON (South Carolina, University, Columbia) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 6 p. refs
(Contract DAAG29-82-K-0094)

The digital correlation scheme of Peters et al. (1983) was extended to measure out-of-plane deformations, using a white light projection speckle technique. A simple ray optic theory and the digital correlation scheme are outlined. The technique was applied successfully to measure out-of-plane displacements of initially flat rotorcraft structures (an acrylic circular plate and a steel cantilever beam), using a low cost video camera and a desktop computer. The technique can be extended to measurements of three-dimensional deformations and dynamic deformations. I.S.

A87-13682
MECHANISM OF ENERGY ABSORPTION VIA BUCKLING - AN ANALYTICAL STUDY
S. V. HANAGUD, A. CHATTOPADHYAY, J. ZHANG, and Y. WANG (Georgia Institute of Technology, Atlanta) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 10 p. refs
(Contract DAAG29-82-K-0094)

The static postbuckling behavior of energy absorbing structures has been analyzed in this paper for the purpose of developing a procedure for optimum design of energy absorbing structures which are essential parts of a crashworthy design of rotorcraft. Finite deformations have been considered and an adapted Lagrangian approach has been used. The numerical analysis consists of discrete penalty function based finite element technique. The iteration procedure uses a constant arc-length method. Results have been presented for specific energy absorbing structure. Author

A87-13683
CORRELATION OF EXPERIMENTAL STATIC AND DYNAMIC RESPONSE OF SIMPLE STRUCTURAL COMPONENTS
J. I. CRAIG, S. V. HANAGUD, W. ZHOU, and P. SRIRAM (Georgia Institute of Technology, Atlanta) IN: National Specialist's Meeting on Crashworthy Design of Rotorcraft, Atlanta, GA, April 7-9, 1986, Proceedings . Alexandria, VA, American Helicopter Society, 1986, 5 p. refs
(Contract DAAG29-82-K-0094)

Crashworthy design of rotorcraft involves not only a systems-oriented approach but also requires that the design and performance simulation of each system be based on accurate component models. To date, much of the structural simulation work has focused on analytical models, although several programs are capable of including force-deformation characteristics derived from experimental tests. However, the formulations are based on static or quasi-static characteristics and are not capable of handling time-dependent properties. The reported work is an initial attempt to develop dynamic response characteristics for simple composite structural components that have potential for use in crashworthy design. Preliminary results from static and dynamic buckling/post-buckling tests of Kevlar corrugated-web sandwich panels are reported. Author

A87-13719
AUTOMATED INFRARED INSPECTION OF JET ENGINE TURBINE BLADES
T. BANTEL, D. BOWMAN, J. HALASE, S. KENUE, R. KRISHER (General Electric Co., Aircraft Engine Business Group, Evendale, OH) et al. IN: International Conference on Thermal Infrared Sensing for Diagnostics and Control (Thermosense VIII), Cambridge, MA, September 12-20, 1985, Proceedings . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 18-23.
(Contract F33615-80-C-5106)
The detection of blocked surface cooling holes in hollow jet engine turbine blades and vanes during either manufacture or overhaul can be crucial to the integrity and longevity of the parts when in service. A fully automated infrared inspection system is being established to inspect these surface cooling holes for blockages. The method consists of viewing the surface holes of the blade with a scanning infrared radiometer when heated air is flushed through the blade. As the airfoil heats up, the resultant infrared images are written directly into computer memory where image analysis is performed. The computer then makes a determination of whether or not the holes are open from the inner plenum to the exterior surface, and ultimately makes an accept/reject decision based on previously programmed criteria. A semiautomatic version has already been implemented and is more cost effective and more reliable than the previous manual inspection methods. Author

A87-13828
PERFORMANCE AND OPTIMISATION OF AN AIRBLAST NOZZLE - DROP SIZE DISTRIBUTION AND VOLUMETRIC AIR FLOW
M. AIGNER and S. WITTIG (Karlsruhe, Universitaet, West Germany) IN: ICLASS-85; Proceedings of the Third International Conference on Liquid Atomisation and Spray Systems, London, England, July 8-10, 1985. Volume 1 . London, Institute of Energy, 1986, p. IIC/3/1-IIC/3/8. Research supported by the Forschungsvereinigung fuer Verbrennungskraftmaschinen. refs
Detailed experimental studies of airblast atomization with its governing processes were conducted by utilizing various atomizers. In considering practical design principles, it is shown, that air consumption and drop size distribution depend on various parameters such as geometry, air swirl and acceleration. The film's inlet position and the diameter of the atomization edge are of secondary importance. In contrast to other studies it is found, that the film thickness has only an indirect effect on the quality of atomization, due to its roughness effects. Author

A87-13830
PREDICTION OF VELOCITY COEFFICIENT AND SPRAY CONE ANGLE FOR SIMPLEX SWIRL ATOMIZERS
N. K. RIZK and A. H. LEFEBVRE (Purdue University, West Lafayette, IN) IN: ICLASS-85; Proceedings of the Third International Conference on Liquid Atomisation and Spray Systems, London, England, July 8-10, 1985. Volume 1 . London, Institute of Energy, 1986, p. IIIC/2/1-IIIC/2/16. refs
The effects of atomizer dimensions and operating conditions on spray cone angle and velocity coefficient are examined. A theoretical approach is adopted to determine the liquid film thickness in the final discharge orifice and to relate this thickness to cone angle and velocity coefficient. The calculated results are shown to compare satisfactorily with the experimental data reported in the literature. Equations are presented for predicting cone angle and velocity coefficient in terms of the nozzle pressure differential and the nozzle constant K, which is defined as the ratio of inlet ports area to the product of discharge orifice diameter and swirl chamber diameter. Author

A87-13848* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
LARGE VOLUME WATER SPRAYS FOR DISPERSING WARM FOGS
V. W. KELLER, B. J. ANDERSON, R. A. BURNS (NASA, Marshall Space Flight Center, Huntsville, AL), G. G. LALA, and M. B. MEYER (New York, State University, Albany) IN: ICLASS-85; Proceedings of the Third International Conference on Liquid Atomisation and Spray Systems, London, England, July 8-10, 1985. Volume 2 . London, Institute of Energy, 1986, p. LP/VIIC/4/1-LP/VIIC/4/10. NASA-supported research. refs
A new method for dispersing of warm fogs which impede visibility and alter schedules is described. The method uses large volume recycled water sprays to create curtains of falling drops through which the fog is processed by the ambient wind and spray-induced air flow; the fog droplets are removed by coalescence/rainout. The efficiency of this fog droplet removal process depends on the size spectra of the spray drops and optimum spray drop size is calculated as between 0.3-1.0 mm in diameter. Water spray tests were conducted in order to determine the drop size spectra and temperature response of sprays produced by commercially available fire-fighting nozzles, and nozzle array tests were utilized to study air flow patterns and the thermal properties of the overall system. The initial test data reveal that the fog-dispersal procedure is effective. I.F.

A87-13872* Boeing Computer Services Co., Tukwila, Wash.
AN EXTERIOR POISSON SOLVER USING FAST DIRECT METHODS AND BOUNDARY INTEGRAL EQUATIONS WITH APPLICATIONS TO NONLINEAR POTENTIAL FLOW
D. P. YOUNG (Boeing Computer Services Co., Tukwila, WA), A. C. WOO (NASA, Ames Researh Center, Moffett Field, CA), J. E. BUSSOLETTI, and F. T. JOHNSON (Boeing Military Airplane Co., Seattle, WA) SIAM Journal on Scientific and Statistical Computing (ISSN 0196-5204), vol. 7, July 1986, p. 1009-1021. refs
(Contract NSF MCS-80-12220; NAS2-9830)
A general method is developed combining fast direct methods and boundary integral equation methods to solve Poisson's equation on irregular exterior regions. The method requires O(N log N) operations where N is the number of grid points. Error estimates are given that hold for regions with corners and other boundary irregularities. Computational results are given in the context of computational aerodynamics for a two-dimensional lifting airfoil. Solutions of boundary integral equations for lifting and nonlifting aerodynamic configurations using preconditioned conjugate gradient are examined for varying degrees of thinness. Author

A87-13986#
INCREASING THE ECONOMY OF DESIGN AND PREPARATION FOR MANUFACTURING BY INTEGRATED AND GRAPHIC DATA PROCESSING: CAD/CAM - PHASE III [ERHOEHUNG DER WIRTSCHAFTLICHKEIT VON KONSTRUKTION UND FERTIGUNGSVORBEREITUNG DURCH INTEGRIERTE UND GRAPHISCHE DATENVERARBEITUNG: CAD/CAM - PHASE III]
U. GRUPE (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 39 p. In German.
(Contract BMFT-LVS-8305)
(MBB-UT-225-86)
The development of CAD/CAM techniques and equipment for aircraft production at Dornier and MBB during the period 1983-1986 is reviewed. The topics discussed include geometry processing, structural mechanics, design of fabrication equipment, NC techniques, production planning, and processing of production orders. Consideration is given to the increased use of color graphics, the change from vector to scanning screens, and software-related problems encountered in shifting functions from the mainframe computer to terminals. T.K.

A87-13999#

TECHNOLOGIES FOR A MECHANIZED CARBON FIBER CONSTRUCTION ELEMENT FOR COMMERCIAL AIRCRAFT PRODUCTION [TECHNOLOGIEN FUER EINE MECHANISIERTE KOHLEFASERBAUTEILFERTIGUNG IM ZIVILFLUGZEUGBAU]

R. OBERFRANZ (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 24 p. In German.
(Contract BMFT-LFK-8351-4)
(MBB-UT-005-86)

Technological steps taken to improve the economicality and reproducibility of carbon fiber-reinforced elements for commercial aircraft construction are reviewed. The characterization and handling of blanks are discussed, and alloying techniques for cubic bodies are reviewed. Processing and binding techniques for thicker laminates and shaping and boring techniques for CFK structures and laminates are described. Quality control and the preparation of production materials are addressed. C.D.

A87-14006#

NEW-TECHNOLOGY GAS GENERATOR (GNT 1) - THE ACTUAL STATE OF DEVELOPMENT [GASGENERATOR NEUER TECHNOLOGIE /GNT 1/ - AKTUELLER ENTWICKLUNGSSTAND]

W. WEILER (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 46 p. In German. refs

An advanced gas generator for aircraft gas turbines of the 1000-kW class, called the new-technology generator (GNT 1), is discussed. The main components of the generator are described, and test results giving its present state of development are reviewed. C.D.

A87-14423

APPLICATION OF A MIXED VARIATIONAL APPROACH TO AEROELASTIC STABILITY ANALYSIS OF A NONUNIFORM BLADE

M. NATORI and S. NEMAT-NASSER (Northwestern University, Evanston, IL) Journal of Structural Mechanics (ISSN 0360-1218), vol. 14, no. 1, 1986, p. 5-31. refs
(Contract DAAG29-79-C-0168)

A mixed variational approach is used to investigate the coupled flap-lagtorsional aeroelastic stability of a nonuniform helicopter blade. This approach is particularly suited to treating rotating blades with sharp variations or discontinuous changes in their properties or cross-sectional dimensions. Numerical results by this approach are presented in hovering conditions, for both uniform and nonuniform blades with low torsional stiffness, and compared with the results by the usual Rayleigh-Ritz method. It is shown that the present approach has good convergence properties for both static equilibrium position and critical collective pitch angles. Author

A87-14683

METHODS FOR THE ASSEMBLY AND TESTING OF THE BEARING SUPPORTS OF GAS TURBINE ENGINES [TEKHNOLOGIIA SBORKI I KONTROLIA PODSHIPNIKOVYKH OPOR GTD]

V. A. ZAKHAROV Moscow, Izdatel'stvo Mashinostroenie, 1985, 128 p. In Russian. refs

The general design and the principal geometrical and force characteristics of the rolling bearings and bearing supports of gas turbine engines are summarized with reference to the results of recent studies in this field. Particular attention is given to the organization and optimization of the bearing assembly process. Theoretical relationships are presented for calculating the initial data required for the assembly process design; the nature and sequence of individiual assembly operations are examined, and ways of improving the assembly precision are discussed. V.L.

A87-15006#

STATE-OF-THE-ART TECHNIQUES FOR LIGHTNING SUSCEPTIBILITY/VULNERABILITY ASSESSMENTS

J. G. SCHNEIDER, M. D. RISLEY, M. J. REAZER, A. V. SERRANO (Technology/Scientific Services, Inc., Dayton, OH), and J. L. HEBERT (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 8-1 to 8-8. refs

The vulnerability of current and future aircraft to lightning-induced EMP and electrostatic discharges can be assessed by the techniques developed at Wright Aeronautical Laboratories. The methods are presently noted to possess cost-effective data acquisition, processing and storage systems, and software of exceptionally high productivity. The microcomputer-controlled minicomputers used are capable of transient as well as CW measurements, and analog fiber data links that are pneumatically controlled for use in the high EM noise environment of high voltage/current simulators are incorporated. O.C.

A87-15007#

COMPARISON OF LOW LEVEL FREQUENCY DOMAIN LIGHTNING SIMULATION TEST TO PULSE MEASUREMENTS

D. B. WALEN (Boeing Military Airplane Co., Seattle, WA) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 9-1 to 9-8.
(Contract F33615-82-C-3406)

Three lightning test techniques were used to measure induced transients on a modified F-14A airplane. The F-14A was modified by adding graphite/epoxy skin panels and by installing special avionics equipment. Test techniques demonstrated on the F-14A included low current (less than 20A) swept frequency transfer function measurements, moderate current (28 kA) pulse tests and high current (200 kA) pulse tests. The results of the measurements were compared using Fourier transformations and linear extrapolation. Responses measured at lower current levels and extrapolated to higher current levels were 23 percent lower to 32 percent higher than the responses measured at high levels. Author

A87-15023#

EXPERIMENTAL STUDY OF THE INTERACTION BETWEEN AN ARC AND AN ELECTRICALLY FLOATING STRUCTURE

G. LABAUNE, J. P. MOREAU, J. C. ALLIOT, V. GOBIN (ONERA, Chatillon-sous-Bagneux, France), B. HUTZLER (Electricite de France, Moret-sur-Loing) et al. IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 27-1 to 27-9. DRET-supported research. refs

The relationship between an arc and an electrically floating structure is investigated with a high-voltage apparatus. An analysis is conducted of the phase of the arc-structure connection when the plasma on each side of the structure is of high resistivity; it is shown that the structure is in electric equilibrium between impulsive positive and negative streamers that induce fast and strong variations of the electric field at its surface. O.C.

A87-15029#

LIGHTNING RETURN STROKE CURRENT COMPUTATION

P. R. P. HOOLE and J. E. ALLEN (Oxford University, England) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 34-1 to 34-10. Research supported by the Culham Lightning Club and ORS Committee of British Universities. refs

The paper briefly reviews the lightning return stroke models, currently in use and highlights some weaknesses of these models in relation to basic principles of physics and observed characteristics of the return stroke. The solution of diffusion equation for a distributed line is given. Then a simple distributed LCR model of the return stroke, with all the elements calculated from known data is given. The return stroke currents along the channel are calculated and its implications to current measurements and applications of the model are discussed. Author

A87-15039#
IMPROVED ELECTROSTATIC DISCHARGE WICKS FOR AIRCRAFT
R. V. ANDERSON and J. C. BAILEY (U.S. Navy, Naval Research Laboratory, Washington, DC) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 49-1 to 49-5. refs

After presenting a development history for the static discharge wicks used in reducing the static potential of aircraft employed in measurements of small, fair weather electric fields, attention is given to the results of the 1985 tests in which the dependencies of aircraft potential were observed for the number of wicks used, their length, and their diameters. Theoretical studies of corona discharge are reviewed, and their applicability to the aircraft discharge problem is discussed. It is concluded that a significant reduction in aircraft potential is obtainable through the use of metallic wicks. O.C.

A87-15193#
FINITE ELEMENT CONTACT ANALYSIS OF RING GEAR AND SUPPORT
S. SUNDARARAJAN and R. BLANCHETTE (Pratt and Whitney Canada, Inc., Longueuil, Canada) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 32, June 1986, p. 148-154. refs

In the PT6 turboprop engines of Pratt and Whitney, Canada, the turbine-to-propeller speed reduction is obtained using a two-stage planetary gearbox. This paper describes a method of analyzing the ring gear torque reacted by six steel pins. In-house finite element contact analysis computer program was developed and used to analyse in detail and optimize the geometry of the ring gear. The development of the computer program and the interplay of the different geometric parameters of the ring gear are discussed. The need for analysing gears as structures rather than as pairs of teeth in mesh is emphasized. Author

A87-15203
THE EFFECT OF LUBRICANT CAVITATION ON THE CHARACTERISTICS OF A SHORT HYDRODYNAMIC DAMPER [VLIIANIE KAVITATSII SMAZKI NA KHARAKTERISTIKI 'KOROTKOGO' GIDRODINAMICHESKOGO DEMPFERA]
A. I. BELOUSOV and V. B. BALIAKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1986, p. 15-19. In Russian.

Analytical relationships are presented for calculating the components of a hydrodynamic reaction with allowance for the true discontinuity region of a lubricant film. It is shown that the rupture of a lubricant film reduces the tangential component and gives rise to a radial component of the hydrodynamic force. Therefore, in a short hydrodynamic damper, the true size of the cavitation region of the working fluid must be taken into account to improve the accuracy of the calculated dynamic characteristics of the damper. V.L.

A87-15215
A STUDY OF LOCAL HEAT TRANSFER ON THE FACE SURFACE OF A NOZZLE RING MODEL [ISSLEDOVANIE LOKAL'NOGO TEPLOOBMENA NA TORTSEVOI POVERKHNOSTI MODELI SOPLAVOGO APPARATA]
A. A. KHALATOV, K. I. KAPITANCHUK, A. S. KOVALENKO, and A. N. TRUFANOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1986, p. 68-72. In Russian. refs

Results of an experimental study of local heat transfer on the face surface of a model of the nozzle ring of a gas turbine are reported. A method for generalizing experimental data is proposed which makes it possible to obtain a unified similarity equation allowing for the effect of the curvature of flow lines, for the three-dimensional nature of the flow, for flow acceleration along the channel, and for the laminar transition of the flow. The equation can be used for calculating local heat transfer coefficients at arbitrary points of the face surface. V.L.

A87-15218
A STUDY OF THE EFFECT OF THE TEMPERATURE FACTOR ON PRESSURE LOSSES IN THE COOLING SYSTEM OF THE LEADING EDGE OF A DEFLECTOR VANE [ISSLEDOVANIE VLIIANIIA TEMPERATURNOGO FAKTORA NA POTERI DAVLENIIA V SISTEME OKHLAZHDENIIA VKHODNOI KROMKI DEFLEKTORNOI LOPATKI]
A. I. ARKHIPOV, A. S. LIMANSKII, V. V. RUMIANTSEV, and M. M. KHASBIULLIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1986, p. 81-83. In Russian. refs

Reference is made to several earlier studies in which pressure losses associated with the use of single-row and multiple-row jet cooling of the leading edge of nozzle vanes of gas turbine engines have been estimated using independent models of the leading edge. Here, experiments are carried out on a specially designed high-temperature gasdynamic test bench in order to verify the validity of the earlier results and also to determine the effect of process nonisothermality on pressure losses. V.L.

A87-15226
ANALYSIS OF A COMPOSITE THIN-WALLED AIRCRAFT STRUCTURE [K RASCHETU SOSTAVNOI TONKOSTENNOI AVIAKONSTRUKTSII]
V. A. PAVLOV and A. S. SAFONOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 2, 1986, p. 102-104. In Russian.

A numerical method is proposed for analyzing the stress-strain state of composite thin-walled lifting surfaces, such as tail surfaces and the wing together with the lift-increasing devices. The approach used here is based on a refined discrete-continuous model and makes it possible to determine the stress-strain state of irregular structures under any conditions of external loading, including large concentrated force factors and a temperature field. As an example, a stress-strain analysis is carried out for tail surfaces of various types. V.L.

A87-15403
ENVIRONMENTAL STRESS SCREENING (ESS) DEMONSTRATES ITS VALUE IN THE FIELD
J. L. CAPITANO (Gould, Inc., Arlington, VA) and J. H. FEINSTEIN (Gould, Inc., Defense Electronics Div., Glen Burnie, MD) IN: 1986 Annual Reliability and Maintainability Symposium, Las Vegas, NV, January 28-30, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 31-35.

The failure rate of systems in the field is often much higher than planned; thereby negatively impacting support cost and availability. This paper explores the cause and presents a demonstrated solution for this unacceptably high field failure rate. A concept (ESS) is presented as not only a significant contributor to the solution of this problem but as a demonstrated cost effective one. Author

A87-15412#
RELIABILITY GROWTH DURING FLIGHT TEST
J. N. BOWER (USAF, Edwards AFB, CA) IN: 1986 Annual Reliability and Maintainability Symposium, Las Vegas, NV, January 28-30, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 101-106.

B-52 Offensive Avionics System (OAS), F-16 XL avionics system, and F-16 Multinational Staged Improvement Program (MSIP) avionics flight-test data are discussed in terms of reliability. The Duane model was used to predict reliability growth by plotting weighted linear regression values for the cumulative failure rate (MTBF) in log-log form. The method avoids the controversial aspects of MIL-STD-1635(EC), Reliability Growth Testing, which assumes independence between data points, an inaccurate technique for cumulative statistics. M.S.K.

A87-15417
RADC AUTOMATED R&M PACKAGE (RAMP)
F. WINTER and G. W. LYNE (USAF, Rome Air Development Center, Griffiss AFB, NY) IN: 1986 Annual Reliability and Maintainability Symposium, Las Vegas, NV, January 28-30, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 177-182. refs

As electronic systems become increasingly complex, more efficient and cost effective means of predicting reliability and maintainability to fulfill DOD procurement requirements are needed. Because of the increased demand for automated R&M prediction, RADC RAMP has been developed as an interface between various RADC R&M computer programs. RAMP provides a structured approach to R&M analysis, eliminating the need for certain subjective judgments and hand calculations. The computer programs made available through RAMP are discussed: the RADC Optimized Reliability and component Life Estimator (ORACLE), the ORACLE Stress Analysis Program (OSAP), the ORACLE Thermal Analysis Program (OTAP), the computer-Aided Maintainability Predictor (CAMP), and the Derivative Truncated Sequential Test Plan (DTSTP) Program. Author

A87-15423
VLSI IMPACT ON RAMS STRATEGIES IN AVIONICS DESIGN
L. R. WEBSTER and J. M. MADER (Harris Corp., Melbourne, FL) IN: 1986 Annual Reliability and Maintainability Symposium, Las Vegas, NV, January 28-30, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 303-306.

Although VLSI will improve the reliability of electronics-dominated avionics, off-chip interconnections will still limit reliability. The reliability of a VLSI chip is expected to be nearly 20 times that of LSI chips. The control over the system MTBF by the MTBF of the interconnections can be lessened by increasing the complexity of the VLSI devices, thus decreasing the number of interconnections on a board. M.S.K.

A87-15425
DEVELOPMENT OF A MAINTENANCE AUTOMATION SYSTEM
R. LOH (Mitre Corp., McLean, VA) and J. NAGER (FAA, Washington, DC) IN: 1986 Annual Reliability and Maintainability Symposium, Las Vegas, NV, January 28-30, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 332-337. refs

Given the ever increasing costs for personnel, the advent of stable and reliable albeit more complex modern equipment, the lowering of costs for computers, and the improvements in communications multiplexing technology, it is now cost-effective to implement maintenance automation systems (MAS). The objective of this paper is to define a generic MAS for a large and dispersed maintenance organization, to propose a management model for the development and implementation of such a MAS, and to cite examples from the Federal Aviation Administration's (FAA) Remote Maintenance Monitoring System (RMMS) and Maintenance Control Center (MCC) programs (hereafter referred to as the FAA's MAS in this paper) that are being implemented as part of the FAA's modernization of its maintenance operations. Author

A87-15428
BUILT-IN-TEST FOR FAIL-SAFE DESIGN
D. E. HARRIS (Westinghouse Electric Corp., Baltimore, MD) IN: 1986 Annual Reliability and Maintainability Symposium, Las Vegas, NV, January 28-30, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 361-366.

Several analytical design approaches are examined for their effectiveness in producing components with mean-time-between-hazards (catastrophic failure) of 100,000 hr or more. Attention is given to systems (such as aircraft) with identical control circuits and a cross-compare capability, and to equipment with all available control configurations and redundancies. BIT capabilities are identified as the most effective for fail-safe system operation. M.S.K.

A87-15432
REVERSE TAILORING FOR REALISTIC RELIABILITY TESTS
H. CARUSO (Westinghouse Product Qualification Laboratory, Baltimore, MD) IN: 1986 Annual Reliability and Maintainability Symposium, Las Vegas, NV, January 28-30, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 397-402. refs

Reverse tailoring is proposed as an analytical process whereby the environmental engineering specialist can evaluate the validity of specified environmental design and test criteria. Detailed examples are presented for traditionally specified high- and low-temperature values for airborne electronics. Mission-use considerations and basic physics, combined with published literature and interviews with the equipment operators, can be used to establish realistic environmental criteria in the absence of specific measured data. Author

A87-15433
SIZING HYBRID PACKAGES FOR OPTIMUM RELIABILITY
H. S. GOEDEKE (Westinghouse Electric Corp., Baltimore, MD) IN: 1986 Annual Reliability and Maintainability Symposium, Las Vegas, NV, January 28-30, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 403-407. refs

An analytical technique is defined for quantifying the package size at which a minimum hybrid failure rate will occur in microelectronics avionics packages for aircraft. The method was devised specifically to satisfy the requirements of MIL-HDBK-217D and the failure rate equation it contains. The FORTRAN code HYBRID was written to identify a minimum failure rate package size. The results of sample calculations are provided for a hybrid electronics package, showing the failure rate as a function of temperature and package size. The code is considered valuable whenever an electronics package must have a minimal size and operate over a specified temperature range. M.S.K.

A87-15435
APPLICATION OF MARKOV MODELS FOR RMA ASSESSMENT
J. V. JOSSELYN, R. E. FLEMING, J. A. FRENSTER, and R. L. DE HOFF (Systems Control Technology, Inc., Palo Alto, CA) IN: 1986 Annual Reliability and Maintainability Symposium, Las Vegas, NV, January 28-30, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 427-432. refs

Low cost methodologies for accurately evaluating designs, predicting reliability, and comparing maintenance strategies are critical to the optimization of cost-effective design, production, and support policy decisions. Both the government and contractor require effective prediction tools to monitor and compare performance at the beginning phases of a program. This ensures maximum RMA growth during later design, test, and production phases. The ideal tool needs to accurately represent the system, incorporating the necessary resolution to the component level, thus allowing sensitivity analysis and low-cost run repetitions to evaluate design trade-offs. This paper presents a procedure for the general development and solution of complex problems using Markov models. Practical application of these techniques is made with three case studies. These studies demonstrate the application to complex architectures common in today's highly reliable operational configurations. Author

A87-15482
PRELIMINARY DESIGN OF ELECTROMECHANICAL SERVOSYSTEMS
S. A. ROWE (AiResearch Manufacturing Co., Torrance, CA) IN: Advanced actuation, controls and integration for aerospace vehicles; Proceedings of the Symposium, San Diego, CA, October 9, 1985 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 57-68. refs
(SAE PAPER 851759)

The preliminary design of electromechanical (EM) servosystems is a complex engineering problem due to the numerous parameters, constraints, and performance requirements which must be satisfied. When this is coupled with optimization, the task becomes even more difficult. This paper discusses: (1) the variables that must be considered in the design phase of an EM servosystem, (2) the main constraints that must be addressed during preliminary design, and (3) a reasonable strategy for designing and optimizing an EM servosystem. Also, a computer program developed by AiResearch for the preliminary design of EM servosystems (EMSYS) and methods used by EMSYS to address the above are briefly described. Author

A87-16160
SOME EFFECTS OF MOISTURE ON ADHESIVE-BONDED CFRP-CFRP JOINTS
B. M. PARKER (Royal Aircraft Establishment, Materials and Structures Dept., Farnborough, England) (Imperial College of Science and Technology and Ciba-Geigy Plastics, International Symposium on Joining and Repair of Fibre-Reinforced Plastics, London, England, Sept. 10, 11, 1986) Composite Structures (ISSN 0263-8223), vol. 6, no. 1-3, 1986, p. 123-139. refs

Investigations have been carried out into the effect of long-term exposure to a hot, humid environment on the strength and mode of failure of CFRP-CFRP joints bonded with structural epoxy adhesives. Strengths of joints have been shown to be reduced both by absorption of moisture and by increased test temperature. There is some evidence that, with certain adhesives, the composite-adhesive interface may be weakened at long exposure times. Investigations have also been made into the effect of moisture in the composite on subsequent bonding with epoxy adhesives, with reference to the repair of composite components. It has been shown that considerable drying may be required to obtain good bonds with some 120 C-cured adhesives. The 175 C-cured adhesive tested was less susceptible. Author

N87-11733*# Lockheed-Georgia Co., Marietta.
SIZING-STIFFENED COMPOSITE PANELS LOADED IN THE POSTBUCKLING RANGE
S. B. BIGGERS and J. N. DICKSON *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 15 p 1984
Avail: NTIS HC A22/MF A01 CSCL 20K

Stiffened panels are widely used in aircraft structures such as wing covers, fuselages, control surfaces, spar webs, bulkheads, and floors. The detailed sizing of minimum-weight stiffened panels involves many considerations. Use of composite materials introduces additional complexities. Many potential modes of failure exist. Analyses for these modes are often not trivial, especially for those involving large out-of-plane displacements. Accurate analyses of all potential failure modes are essential. Numerous practical constraints arise from manufacturing/cost considerations and from damage tolerance, durability, and stiffness requirements. The number of design variables can be large when lamina thicknesses and stacking sequence are being optimized. A significant burden is placed on the sizing code due to the complex analyses, practical constraints, and number of design variables. On the other hand, sizing weight-efficient panels without the aid of an automated procedure is almost out of the question. The sizing code postbuckled Open-Stiffener Optimum Panels (POSTOP) has been developed to aid in the design of minimum-weight panels subject to the considerations mentioned above. Developed for postbuckled composite panels, POSTOP may be used for buckling resistant panels and metallic panels as well. The COPES/CONMIN optimizer is used in POSTOP although other options such as those in the ADS system could be substituted with relative ease. The basic elements of POSTOP are shown. Some of these elements and usage of the program are described. Author

N87-11910# Texas A&M Univ., College Station. Texas Transportation Inst.
CRITERIA FOR ASPHALT-RUBBER CONCRETE IN CIVIL AIRPORT PAVEMENTS: MIXTURE DESIGN Final Report, Sep. 1983 - Aug. 1986
F. L. ROBERTS, R. L. LYTTON, and D. HOYT Jul. 1986 74 p
(Contract DTFA01-83-C-30076)
(DOT/FAA/PM-86/39) Avail: NTIS HC A04/MF A01

A mixture design procedure is developed to allow the use of asphalt-rubber binders in concrete for flexible airport pavement. The asphalt-rubber is produced by reacting asphalt with ground, scrap tire rubber to produce the binder for the asphalt-rubber concrete. Procedures for laboratory preparation of alsphalt-rubber binders using an equipment setup that was found by researchers to produce laboratory binders with similar properties to field processes are included. The rubber-asphalt concrete mixture design procedure includes adjustments to the aggregate gradation to permit space for the rubber particles in the asphalt-rubber binder as well as suggested mixing and compaction temperatures, and compaction efforts. While the procedure was used in the laboratory to successfully produce asphalt-rubber concrete mixtures, it should be evaluated in the field to ensure that consistent results can be achieved in a production environment. Author

N87-11992# ESDU International Ltd., London (England).
VERTICAL DEFLECTION CHARACTERISTICS OF AIRCRAFT TYRES
May 1986 6 p
(ESDU-86005; ISBN-0-85679-557-7; ISSN-0141-4054) Avail: ESDU

This Data Item ESDU 86005 is an addition to the Aircraft Performance Sub-series. The characteristics are given for aircraft-type cross-ply tires under load normal to the runway surfaces. Equations for tire deflection are primarily for establishing aircraft pitch attitude on the ground. Equations for footprint dimensions and areas are required in calculations related to tire behavior on wet or flooded runways. The equations are found to represent load-deflection characteristics and contact area length well and some data were verified for speeds up to 100 knots. ESDU

N87-11993*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SELECTION OF ROLLING-ELEMENT BEARING STEELS FOR LONG-LIFE APPLICATION
E. V. ZARETSKY 1986 76 p Presented at International Symposium on the Effect of Steel Manufacturing Processes on the Quality of Bearing Steels, Phoenix, Ariz., 4-6 Nov. 1986; sponsored by American Society for Testing and Materials
(NASA-TM-88881; E-3288; NAS 1.15:88881) Avail: NTIS HC A05/MF A01 CSCL 13I

Nearly four decades of research in bearing steel metallurgy and processing have resulted in improvements in bearing life by a factor of 100 over that obtained in the early 1940's. For critical applications such as aircraft, these improvements have resulted in longer lived, more reliable commercial aircraft engines. Material factors such as hardness, retained austenite, grain size and carbide size, number, and area can influence rolling-element fatigue life. Bearing steel processing such as double vacuum melting can have a greater efect on bearing life than material chemistry. The selection and specification of a bearing steel is dependent on the integration of all these considerations into the bearing design and application. The paper reviews rolling-element fatigue data and analysis which can enable the engineer or metallurgist to select a rolling-element bearing steel for critical applications where long life is required. Author

N87-11995*# General Motors Corp., Indianapolis, Ind. Gas Trubine Div.
ADVANCED GAS TURBINE (AGT) TECHNOLOGY PROJECT Final Annual Report, 1985
1 Sep. 1986 160 p
(Contract DEN3-168)
(NASA-CR-179484; DOE/NASA/0168-10; NAS 1.26:179484; EDR-12344) Avail: NTIS HC A08/MF A01 CSCL 21A

Engine testing, ceramic component fabrication and evaluation, component performance rig testing, and analytical studies comprised AGT 100 activities during the 1985 year. Ten experimental assemblies (builds) were evaluated using two engines. Accrued operating time was 120 hr of burning and 170 hr total, bringing cumulative total operating time to 395 hr, all devoid of major failures. Tests identified the generator seals as the primary working fluid leakage sources. Power transfer clutch operation was demonstrated. An alpha SiC gasifier rotor engine test resulted in blade tip failures. Recurring case vibration and shaft whip have limited gasifier shaft speeds to 84%. Ceramic components successfully engine tested now include the SiC scroll assembly, Si3N3 turbine rotor, combustor assembly, regenerator disk bulkhead, turbine vanes, piston rings, and couplings. A compressor shroud design change to reduce heat recirculation back to the inlet was executed. Ceramic components activity continues to focus on the development of state-of-the-art material strength characteristics in full-scale engine hardware. Fiber reinforced glass-ceramic composite turbine (inner) backplates were fabricated by Corning Glass Works. The BMAS/III material performed well in engine testing. Backplates of MAS material have not been engine tested. Author

N87-12017*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CONCENTRATED MASS EFFECTS ON THE FLUTTER OF A COMPOSITE ADVANCED TURBOPROP MODEL
J. K. RAMSEY and K. R. V. KAZA Oct. 1986 22 p
(NASA-TM-88854; E-3247; NAS 1.15:88854) Avail: NTIS HC A02/MF A01 CSCL 20K

The effects on bending-torsion flutter due to the addition of a concentrated mass to an advanced turboprop model blade with rigid hub are studied. Specifically the effects of the magnitude and location of added mass on the natural frequencies, mode shapes, critical interblade phase angle, and flutter Mach number are analytically investigated. The flutter of a propfan model is shown to be sensitive to the change in mass distribution. Static unbalance effects, like those for fixed wings, were shown to occur as the concentrated mass was moved from the leading edge to the trailing edge with the exception of one mass location. Mass balancing is also inferred to be a feasible method for increasing the flutter speed. Author

N87-12711# Rockwell International Corp., Columbus, Ohio. North American Aircraft Operations.
FABRICATION AND TESTING OF LIGHTWEIGHT HYDRAULIC SYSTEM SIMULATOR HARDWARE Final Report, 15 May 1980 - 15 Nov. 1985
W. N. BICKEL and R. K. HANING Jan. 1986 279 p
(Contract N62269-80-C-0261)
(AD-A169884; NA-85-0134; NADC-79024-60) Avail: NTIS HC A13/MF A01 CSCL 13G

The Lightweight Hydraulic System (LHS) Advanced Development Program is a multi-phase investigation of the concept of using an 8000 psi operating pressure level to achieve smaller and lighter weight hydraulic components than those used in aircraft with conventional 3000 psi systems. This report presents the results of Phase II in which a full scale A-7E 8000 psi dual system hydraulic simulator was fabricated and tested. Tests conducted were proof pressure, system integration, baseline, dynamic performance, and 600 hours of endurance cycling. No major technological problems were encountered. Four flight control actuators accumulated over 3,000,000 cycles; one pump accumulated over 1000 hours of operation (Phase I and Phase II). Hydraulic system math models were corroborated by test data. A weight and space analysis update projected 33.1% and 36.3% savings, respectively, over an equivalent 3000 psi system. A study of simulator operating experience indicated a 23% improvement in reliability over a comparable 3000 psi system. An additional 600 hours of simulator endurance cycling are scheduled for completion in FY '86. GRA

N87-12729# Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.
A TEST ON THE RELIABILITY AND PERFORMANCE OF THE VERBEX SERIES 4000 VOICE RECOGNIZER
P. SUNTHARALINGAM Sep. 1985 21 p
(Contract DAAG29-84-K-0048)
(AD-A169066; MAE-1748; ARO-20155.6-MA) Avail: NTIS HC A02/MF A01 CSCL 17B

Voice recognition systems are becoming increasingly widespread as forms of data entry. One such use of speech input would be as an aid to pilot communication in the cockpit. The Verbex Series 4000 Voice Recognizer (VVR) was chosen as the input channel for a forthcoming flight simulation system. The VVR is a speaker dependent unit with the ability to recognize continuous speech. An additional feature of the VVR is its use of structured grammars in defining the speech format. Tests were run to determine the VVR's reliability, and also to investigate the variations in performance for different grammar structures. Author (GRA)

N87-12766# Energy Research Corp., Danbury, Conn.
AIRCRAFT BATTERY STATE OF CHARGE AND CHARGE CONTROL SYSTEM Interim Report, 1 Jul. 1984 - 30 Jun. 1985
S. VISWANATHAN and A. CHARKEY Feb. 1986 60 p
(Contract F33615-83-C-2435)
(AD-A169411; AFWAL-TR-85-2104) Avail: NTIS HC A04/MF A01 CSCL 10B

This Interim Report describes work done in developing an aircraft battery state of charge and charge control system. The basis for this system developed by ERC is a nickel-oxygen (NiO2) Pilot cell (0.374 Ah). This pilot cell is cycled in tandem with a nickel-cadmium battery. The oxygen pressure of the pilot cell is utilized to determine and control the state of charge of the nickel-cadmium battery. The NiO2 pilot cell baseline performance was determined during this period. The effect of using different nickel electrodes (ERC, SAFT, MARATHON) was also performed. GRA

N87-12768# Department of the Air Force, Washington, D.C.
CRYOGENIC WOUND ROTOR FOR LIGHTWEIGHT, HIGH VOLTAGE GENERATORS Patent Application
C. E. OBERLY, inventor (to Air Force) 23 Apr. 1986 28 p
(AD-D012370; US-PATENT-APPL-SN-855047) Avail: NTIS HC A03/MF A01 CSCL 10B

Liquid hydrogen is used to completely cool all elements of the generator including bearings, stator conductor, rotor conductor, magnetic flux shield, and excitation mechanisms. By essentially immersing the generator in liquid hydrogen, cryogenic interface problems are minimized. The conductor windings will utilize pure metals such as aluminum to minimize the weight and the ohmic heat loss in the machine. Complication of liquid helium cooling for superconducting windings and quench phenomena due to thermal instabilities in the superconductors are eliminated. The use of extremely low resistance of liquid hydrogen cooled aluminum permits heat removal in the confined space of the rotor field winding at magnetic field and current density that can exceed that of superconductors. Because iron is not required in the generator, very high voltages can be generated. GRA

N87-12816# Dayton Univ., Ohio. Research Inst.
COMPUTATIONAL FLUID DYNAMIC STUDIES OF CERTAIN DUCTED BLUFF-BODY FLOWFIELDS RELEVANT TO TURBOJET COMBUSTORS. VOLUME 1: TIME-DEPENDENT CALCULATIONS WITH THE K-EPSILON TURBULENCE MODEL FOR AN EXISTING CENTERBODY COMBUSTOR Final Report, 16 Aug. 1984 - 30 Sep. 1985
M. S. RAJU and L. KRISHNAMURTHY Jul. 1986 53 p
(Contract F22615-84-C-2411)
(AD-A171434; UDR-TR-85-82-VOL-1; AFWAL-TR-86-2004-VOL-1)
Avail: NTIS HC A04/MF A01 CSCL 21B

A numerical investigation of the near-wake region in a ducted bluff-body combustor by finite-difference computations is reported. The numerical predictions are based upon the time-dependent, compressible Navier-Stokes equations and the k-epsilon turbulence model. The standard k-epsilon turbulence model was modified to account for the nonstationary terms. The time-dependent calculations predictions addressed the nonreacting near-wake flow field of the centerbody combustor with only the annular air stream present. Flowfield predictions for a combustor inlet mass flow of 2 kg/s with the time-dependent formulation incorporating the k-epsilon turbulence model show the attainment of a steady-state recirculating flow in the near wake. The slow axial migration of the recirculation vortex towards the exit boundary which was noticed in the earlier time-dependent calculations without a turbulence model is not longer present. Present results have thus eliminated the appearance of reverse flow at the exit boundary with the consequent incompatibility of the boundary conditions, and thereby the spu rious shedding-like behavior observed previously. The steady-state results in the present study demonstrate internal consistency with the time-averaged measurements and predictions for the locations of the vortex center and the centerline rear stagnation point. GRA

N87-12830*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SUPPLEMENTARY CALIBRATION TEST OF THE TIP-AERODYNAMICS- AND ACOUSTICS-TEST PRESSURE TRANSDUCERS
M. E. WATTS Jul. 1986 44 p
(NASA-TM-88312; A-86273; NAS 1.15:88312) Avail: NTIS HC A03/MF A01 CSCL 14B

A calibration test is described that was performed to supplement the normal calibration of the 188 pressure transducers used in the Tip Aerodynamics and Acoustics Test. This calibration led to the identification of 15 transducers which had a slope change of greater than 7% from the initial calibration. The calibration procedure is described and the results presented. The effect of the slope changes on the pressure distributions are described, followed by a method to compensate for these changes. Author

N87-12868 ESDU International Ltd., London (England).
FRICTIONAL AND RETARDING FORCES ON AIRCRAFT TYRES. PART 4: ESTIMATION OF EFFECTS OF YAW
Sep. 1986 29 p
(ESDU-86016-PT-4; ISBN-0-85679-568-2; ISSN-0141-4054)
Avail: ESDU

Available as part of the ESDU Sub-series on Aircraft Performance, this ESDU gives expressions and data for calculating the forces and moments acting on the tire-ground contact area during unbraked and braked yawed rolling. The methods have been verified against experimental data drawn from a wide range of sources in the literature for speeds up to 100 knots, for a wide range of tire sizes, inflation pressures, vertical loads and runway surface conditions. Applications include estimation of minimum control speed on the ground and investigation of stopping performance with asymmetric reverse thrust and/or asymmetric braking and/or cross winds and/or low friction surface. ESDU

N87-12869*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE EVALUATION OF A NUMBER OF PROTOTYPES FOR THE FREE-TIP ROTOR CONSTANT-MOMENT CONTROLLER
L. A. YOUNG Feb. 1986 76 p
(NASA-TM-86664; A-85059; NAS 1.15:86664) Avail: NTIS HC A05/MF A01 CSCL 01C

The development of several prototypes of a constant moment controller, a critical component of the free-tip rotor (FTR) concept, is described. Also presented are the experimental results of a whirl test designed to select a final controller configuration to be included in a future wind-tunnel test of this innovative rotor system. A brief explanation of the FTR concept and its history are included. The paper documents the controller design constraints, each prototype's operating principle, the evaluation test, and the individual prototype test results. A recommended design is identified, along with the selection rationale. Author

N87-12881# Department of the Air Force, Washington, D.C.
IMPROVED VANE PLATFORM SEALING AND RETENTION MEANS Patent Application
G. A. BONNER, inventor (to Air Force) 12 May 1986 16 p
(AD-D012407; US-PATENT-APPL-SN-861905) Avail: NTIS HC A02/MF A01 CSCL 11A

This patent application describes improved vane platform feather seal is disclosed for use in turbine engines. This feather seal contains a flat, thin feather seal, which is attached by adhesive to ease assembly to an L-shaped retainer plate to result in a combined thickness of 0.032 inches. This new seal may be used to replace the inner vane platform seals which are currently used in F-100 turbine engines, which have a history of not bending easily to conform to seal slots. The new seal provides improved platform sealing without loss of platform retention in the event of vane burn through. GRA

N87-12915*# Case Western Reserve Univ., Cleveland, Ohio. Dept. of Civil Engineering.
ANALYSIS OF MIXED-MODE CRACK PROPAGATION USING THE BOUNDARY INTEGRAL METHOD Final Report
A. MENDELSON and L. J. GHOSN Sep. 1986 194 p
(Contract NAG3-396)
(NASA-CR-179518; NAS 1.26:179518) Avail: NTIS HC A09/MF A01 CSCL 20K

Crack propagation in a rotating inner raceway of a high speed roller bearing is analyzed using the boundary integral equation method. The method consists of an edge crack in a plate under tension, upon which varying Hertzian stress fields are superimposed. A computer program for the boundary integral equation method was written using quadratic elements to determine the stress and displacement fields for discrete roller positions. Mode I and Mode II stress intensity factors and crack extension forces G sub 00 (energy release rate due to tensile opening mode) and G sub r0 (energy release rate due to shear displacement mode) were computed. These calculations permit determination of that crack growth angle for which the change in the crack extension forces is maximum. The crack driving force was found to be the alternating mixed-mode loading that occurs with each passage of the most heavily loaded roller. The crack is predicted to propagate in a step-like fashion alternating between radial and inclined segments, and this pattern was observed experimentally. The maximum changes DeltaG sub 00 and DeltaG sub r0 of the crack extension forces are found to be good measures of the crack propagation rate and direction. Author

N87-12924*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A CONSTITUTIVE LAW FOR FINITE ELEMENT CONTACT PROBLEMS WITH UNCLASSICAL FRICTION
M. E. PLESHA and B. M. STEINETZ Nov. 1986 19 p
(NASA-TM-88838; E-3181; NAS 1.15:88838; ICOMP-86-1) Avail: NTIS HC A02/MF A01 CSCL 20K

Techniques for modeling complex, unclassical contact-friction problems arising in solid and structural mechanics are discussed.

A constitutive modeling concept is employed whereby analytic relations between increments of contact surface stress (i.e., traction) and contact surface deformation (i.e., relative displacement) are developed. Because of the incremental form of these relations, they are valid for arbitrary load-deformation histories. The motivation for the development of such a constitutive law is that more realistic friction idealizations can be implemented in finite element analysis software in a consistent, straightforward manner. Of particular interest is modeling of two-body (i.e., unlubricated) metal-metal, ceramic-ceramic, and metal-ceramic contact. Interfaces involving ceramics are of engineering importance and are being considered for advanced turbine engines in which higher temperature materials offer potential for higher engine fuel efficiency. Author

N87-12939# Fairchild Republic Co., Farmingdale, N.Y.
ASSESSMENT OF DAMAGE TOLERANCE REQUIREMENTS AND ANALYSES: A USER'S MANUAL FOR CRACK GROWTH AND CRACK INITIATION ANALYSIS: DAMGRO Final Report, Sep. 1982 - May 1986
M. LEVY and A. KUO 31 May 1986 142 p
(Contract F33615-82-C-3215)
(AD-A171209; AFWAL-TR-86-3028) Avail: NTIS HC A07/MF A01 CSCL 01C

A structural test program of typical aircraft structural configurations was conducted to assess the current Air Force damage tolerance design requirements defined in MIL-A-83444. The specimens, made of 2024-T3XX and 7075-T6XX, were subjected to randomized flight-by-flight spectra, representative of fighter/trainer and bomber/cargo type loading spectra, respectively, and to a constant amplitude loading spectrum. A total of two-hundred fifty-six specimens were tested. The test results were correlated with analytical predictions using crack growth and crack initiation methods. As a result of this study, recommendation is provided to the validity of MIL-A-83444, to develop guidelines for selection of critical crack locations, and to assess the state-of-the art analytical capabilities in predicting crack growth and crack initiation time. This report presents the user's manual of the computer program DAMGRO. This program has been developed in conjunction with this contract, and used to predict the crack growth and crack initiation of the structural test specimens. Author (GRA)

N87-13149# AEG-Telefunken, Ulm (West Germany). Abteilung H14E27.
OBSTACLE-WARNING RADAR FOR HELICOPTERS [DAS HINDERNISWARN-RADAR FUER HUBSCHRAUBER - EINE ANTHROPOTECHNISCHE PROBLEMSTELLUNG]
G. M. OCH *In* DGLR Proceedings of a Symposium on the Evaluation of Man-Machine Systems: Methods and Problems p 25-33 1985 In GERMAN
Avail: NTIS HC A13/MF A01

An obstacle warning radar concept for helicopters is described in both the test and operational phases. A radar sonde is mounted on the front of the helicopter under a radome and senses the atmosphere forward over a range of 180 deg azimuth and 32 deg elevation. The ray is directed by a fast-rotating mirror, resulting in an image-renewal rate of two per second. Obstacles can be detected to a distance of 800 m. depending on atmospheric conditions and obstacle size. ESA

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GEOSCIENCES

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

A87-13584
IMPACT OF AVIATION ON THE ENVIRONMENT
S. NEEL (Texas, University, San Antonio) IN: Fundamentals of aerospace medicine . Philadelphia, PA, Lea and Febiger, 1985, p. 941-957. refs

The ways in which the aviation industry has a negative impact on the environment are summarized, along with possible ameliorative action. Attention is given to potential and proven adverse effects of aircraft and airport noise, RF emissions, atmospheric contaminations, contrails, ozone depletion, and Shuttle launches. Noise is identified as the major pollutant, and several joint industry-airport-community efforts to lessen the effects of noise pollution are described. M.S.K.

A87-15002#
A REVIEW OF AEROSPACE AND GROUND LIGHTNING THREAT CHARACTERISTICS AND APPLICATIONS
P. L. RUSTAN, JR. (USAF, Wright Aeronautical Laboratory, Wright-Patterson AFB, OH) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 11th, Dayton, OH, June 24-26, 1986, Technical Papers . Fairborn, OH, National Interagency Coordination Group, 1986, p. 1-1 to 1-8. refs

A development history and a comprehensive evaluation are presented for research in the fields of ground and aerospace lightning strike protection and lightning strike threat characterization. Attention is given to the results obtained to date by research programs conducted with the NASA F-106 and FAA CV-580 aircraft. It is noted that successful simulations of aircraft strike data have been demonstrated for the cases of crowbarred switching, peaking capacitor, and UV laser methods, all of which yield currents with high rates-of-rise. O.C.

N87-12082*# South Dakota School of Mines and Technology, Rapid City. Inst. of Atmospheric Sciences.
ATMOSPHERIC ELECTRICAL MODELING IN SUPPORT OF THE NASA F106 STORM HAZARDS PROJECT Annual Report, 15 Mar. 1984 - 14 Mar. 1986
J. H. HELSDON Sep. 1986 40 p
(Contract NAG1-463)
(NASA-CR-179801; NAS 1.26:179801; SDSMT/IAS/R-86/07)
Avail: NTIS HC A03/MF A01 CSCL 04B

With the use of composite (non-metallic) and microelectronics becoming more prevalent in the construction of both military and commercial aircraft, the control systems have become more susceptible to damage or failure from electromagnetic transients. One source of such transients is the lightning discharge. In order to study the effects of the lightning discharge on the vital components of an aircraft, NASA Langley Research Center has undertaken a Storm Hazards Program in which a specially instrumented F106B jet aircraft is flown into active thunderstorms with the intention of being struck by lightning. One of the specific purposes of the program is to quantify the environmental conditions which are conductive to aircraft lightning strikes. Author

N87-13064*# Mississippi Univ., University.
MOBILE INTERCEPT OF STORMS
R. T. ARNOLD *In* NASA. Marshall Space Flight Center NASA/MSFC FY-85 Atmospheric Processes Research Review 2 p Oct. 1985
Avail: NTIS HC A07/MF A01 CSCL 04B

The primary goal was to acquire lightning data to serve as ground truth for U2 overflights. Researchers were successful in instrumenting the Univ. of Mississippi/National Severe Storms Lab.

(UM/NSSL) mobile laboratory and in coordinating storm intercept through communication to the U2 provided by airplane guidance at NSSL and through direct communication with the U2 pilot from a portable transceiver in the mobile lab. A demonstration showed that a mobile laboratory can be directed within a large geographical area and used to collect ground truth data for comparison with airborne data on a routine basis with proper utilization of forecasts, nowcasts, and communication among all participants. After the U2 flights, researchers turned their attention solely to intercepting severe storms within the area of Oklahoma with good Doppler radar coverage. They incorporated a second vehicle, which followed the mobile lab and from which they released instrumented balloons. This project utilized a standard meteorological rawinsonde and a balloon-borne electric field meter. They were successful in flying, tracking, and receiving data from mobily launched balloons on several days. Researchers believe that they have demonstrated the ability to obtain meteorological and electrical data in severe storms using instrumented balloons. This also includes the capability to launch into the mesocyclone region and for multiple launches in the same storm. Author

N87-13099# Federal Aviation Administration, Atlantic City, N.J. Technical Center.
THE SITING, INSTALLATION AND OPERATIONAL SUITABILITY OF THE AUTOMATED WEATHER OBSERVING SYSTEM (AWOS) AT HELIPORTS Final Report, Feb. 1985- Apr. 1986
R. A. MATOS, J. R. SACKETT, P. M. SHUSTER, and R. M. WEISS Aug. 1986 70 p
(DOT/FAA/PM-86/30; DOT/FAA/CT-85/9) Avail: NTIS HC A04/MF A01

The Federal Aviation Administration (FAA) Technical Center was tasked to site, install, and evaluate an Automated Weather Observing System (AWOS) at a heliport. The conclusions of the evaluation of the AWOS at the Technical Center's Interim Concept Development Heliport are given. By using the AWOS equipment installed at the Interim Concept Development Heliport, in conjunction with literature research, the following test objectives were addressed: (1) locations in the vicinity of the heliport in which helicopter operations could influence the environment causing transient AWOS sensor performance were identified; (2) areas for sensor location near the heliport that provided the most beneficial information to the pilot were identified; (3) optimal sensor location in relationship to predominant approach and departure paths was determined; (4) siting criteria and recommendations for AWOS equipment installation at heliports were developed; (5) the operational suitability of the AWOS equipment for heliport installations was determined; and (6) additional maintenance requirements for the AWOS as the result of heliport installation were identified.

N87-13105# Air Force Environmental Technical Applications Center, Scott AFB, Ill.
REVISED UNIFORM SUMMARY OF SURFACE WEATHER OBSERVATIONS (RUSSWO). PARTS A-F ELLINGTON ANGB, TEXAS Data Summary Report, Jul. 1941 - Feb. 1986
21 May 1986 298 p
(AD-A169389; USAFETAC/DS-86/024) Avail: NTIS HC A13/MF A01 CSCL 04B

A six-part statistical data summary of surface weather observations for: Ellington ANGB FL. Summary consists of: PART A, Weather Conditions and Atmospheric Phenomena; PART B, Precipitation; PART C, Surface Winds; PART D, Ceiling and Visibility; PART E, Psychrometric Summaries; PART F, Pressure Summaries. See USAFETAC/TN-83/001 (AD-A132186), An Aid for Using the Revised Uniform Summary of Surface Weather Observations (RUSSWOs) for complete descriptions of contents and instructions for use. Author (GRA)

N87-13110# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
A REVIEW OF MICROBURSTS AND THEIR ANALYSIS AND DETECTION WITH DOPPLER RADAR M.S. Thesis
G. L. FREEMAN 1986 75 p
(AD-A170458; AFIT/CI/NR-86-98T) Avail: NTIS HC A04/MF A01 CSCL 04B

Microbursts are small downbursts, less than 4km in outflow size, with peak winds lasting only 2 to 5 minutes. They can be classified as either midair or surface microbursts and also either wet or dry microbursts. All microbursts are characterized by a vertical downrush of air with a divergent outflow at its base. The parent clouds associated with microbursts are: Cumulonimbus; Towering Cumulus; and Anvil Cirrus. Most origin theories credit thermodynamic factors with microburst creation. Wolfson (1983) contends that microbursts result from dynamically induced vertical pressure gradients that are intrinsic characteristics of strong mesocyclone circulation. Doppler radar is the primary tool for detecting and observing microbursts. Wind field mapping is accomplished by either a single, dual or triple radar configuration. Single radar analysis methods require the most external assumptions but are the least expensive. Multiple radar techniques provide more accuracy but are more costly. Wilson and Roberts (1983) propose a number of alternatives for realtime operational detection of microbursts in an airport environment. Of these alternatives they chose a single radar, on airport configuration as the optimum choice when considering economic feasibility as well as technical performance. Author (GRA)

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MATHEMATICAL AND COMPUTER SCIENCES

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

A87-13200
BEYOND FTMP AND SIFT - ADVANCED FAULT-TOLERANT COMPUTERS AS SUCCESSORS TO FTMP AND SIFT
K. N. LEVITT, P. M. MELLIAR-SMITH, and R. L. SCHWARTZ (SRI International, Menlo Park, CA) IN: The fault-tolerant multiprocessor computer . Park Ridge, NJ, Noyes Publications, 1986, p. 733-782. Previously announced in STAR as N84-10769. refs

Work into possible architectures for future flight control computer systems is described. Ada for Fault-Tolerant Systems, the NETS Network Error-Tolerant System architecture, and voting in asynchronous systems are covered. Author

A87-13301
1986 AMERICAN CONTROL CONFERENCE, 5TH, SEATTLE, WA, JUNE 18-20, 1986, PROCEEDINGS. VOLUMES 1, 2, & 3
Conference sponsored by the American Automatic Control Council. New York, Institute of Electrical and Electronics Engineers, 1986. Vol. 1, 678 p.; vol. 2, 757 p.; vol. 3, 807 p. For individual items see A87-13302 to A87-13460.

Papers are presented on robustness and modeling issued in process control, stochastic control, stability theory for adaptive control, robotics, artificial intelligence in process control, direct-drive robot arms, and estimation and tracking. Also considered are performance/robustness tradeoffs inc ontroller design, linear and nonlinear systems, advances in model predictive control, simulation tools for control systems, control of flexible spacecraft, missile navigation, guidance and control, and aerospace and aircraft control applications. Other topics include real-time applications of parallel processing technology, identification, control in mechanical and optical systems, web handling, and reconfiguration strategies for flight control systems. R.R.

A87-13319
METHODS FOR OBTAINING ROBUST TRACKING CONTROL LAWS
W. E. SCHMITENDORF (Northwestern University, Evanston, IL) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 212-216. refs
(Contract NSF ECS-84-15591; AF-AFOSR-ISSA-85-00051)

This paper treats the problem of determining a tracking control law for linear systems with uncertain parameters. The tracking control is robust in the sense that it achieves asymptotic tracking of the command reference input for all admissible parameter values. Based on the available theoretical results for determining tracking controllers, numerical methods for obtaining the feedback gains for a robust control law are presented. The efficacy of these methods is demonstrated by applying them to two aircraft examples. Author

A87-13326
REACHABLE OUTPUTS IN SYSTEMS WITH BOUNDED PARAMETER UNCERTAINTIES - APPLICATION TO FAILURE DETECTION
D. T. HORAK and D. M. GOBLIRSCH (Bendix Aerospace Technology Center, Columbia, MD) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 301-308. refs

A method for computing the intervals in which the outputs of a linear multivariable dynamic system with bounded parameter uncertainties and noise must lie has been developed. It utilizes Pontryagin's Maximum Principle and is recursive. Because of its computational efficiency it can be executed in real time and used for system and sensor failure detection in systems with parameter uncertainties. Failures are detected by testing if the measured outputs lie outside the computed intervals, indicating that the system cannot be described by the given model and the specified parameter uncertainty bounds. The method is illustrated by application to the longitudinal dynamics of the AFT1 F-16 aircraft. Author

A87-13353
A DIRECT METHOD FOR ENFORCING EQUALITY CONSTRAINTS IN OPTIMAL OUTPUT FEEDBACK
K. V. RAMAN (RCA, Astro-Electronics Div., Princeton, NJ) and A. J. CALISE (Georgia Institute of Technology, Atlanta) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 597-601. refs

This paper presents an algorithm that can be used to calculate optimal output feedback gains subject to a linear constraint on the gain matrix. This method is direct in that it does not rely on a penalty function approach. The algorithm is proven to converge to a local minimum. As an application, the lateral dynamics of an L-1011 aircraft are considered both for static gain output feedback and dynamic compensator design. Author

A87-13359
COMPUTATIONAL ENHANCEMENTS TO A 4D ALGORITHM
C. A. BUCKHAM (Boeing Commercial Airplane Co., Seattle, WA) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 676-680.

An implementation of a cost-optimal four-dimensional aircraft trajectory computation algorithm was enhanced. The enhancements were aimed at providing onboard capability, and included minimizing execution time, and providing robustness and portability. The techniques discussed include creating a favorable programming environment, structuring code based on a data flow analysis, saving intermediate results for reuse, and sticking to a standard programming language. These techniques resulted in portable code which executes six times faster than the original. Some ideas for further time reduction are presented. Author

A87-13365
MULTIVARIABLE HIGH-GAIN CONTROL WITH FEEDFORWARD COMPENSATION - A DESIGN TECHNIQUE
A. HEMAMI (Concordia University, Montreal, Canada) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 751-758. refs

State space analysis of linear time-invariant multivariable systems has been the subject of many researches in the past 2-3 decades. Trying to find an analogy between single-input, single-output and multiinput and multioutput systems, so that the successful classical methods can be applied to multivariable systems, is more recent. Each individual research contributes in part to find a better solution to the main, still not completely solved, problem of designing a good controller for this class of systems. In this paper, results of several works on multivariable systems are combined to give an easy to use design technique for robust high-gain controllers by output feedback, inner-loop feedback and feedforward. An illustrative example is included. Author

A87-13385
EIGENSTRUCTURE ASSIGNMENT BY DYNAMIC OUTPUT FEEDBACK
F. L. LEWIS (Georgia Institute of Technology, Atlanta), B. L. STEVENS, R. S. KEMP, and R. D. MARSHALL (Lockheed-Georgia Co., Marietta) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 963-969. refs

A design method is proposed for low order regulators which assign desired closed-loop eigenvalues and eigenvectors. It is shown that, even if all poles are to be assigned, the regulator may have degree less than that of a minimal order state observer. Connections with the generalized dynamic cover problem are pointed out, and a simple algorithm is given to solve that problem for the special case. An example of eigenstructure assignment with dynamic output feedback for a relaxed static stability (RSS) fighter aircraft completes this paper. Author

A87-13399
EXTENSIONS OF A SIMPLIFIED CONTINUOUS-TIME MULTIVARIABLE ADAPTIVE CONTROL ALGORITHM
I. BAR-KANA (Rafael Armament Development Authority, Haifa, Israel) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 1081-1086. refs

A simplified adaptive control algorithm was recently shown to guarantee robustness with parasitic dynamics and disturbances. The algorithm uses parallel feedforward in order to satisfy necessary positive realness conditions. On the other hand, the order of the plant and the pole excess may be very large and unknown, while the model reference may be of a very low order. This paper presents an attempt to reduce the prior knowledge needed for implementation of the adaptive algorithm. It is only assumed that a necessary feedforward of a known order exists and the eigenvalues of this configuration are calculated adaptively. Although the stability analysis still presents some difficulties, the proposed algorithm seems to perform very well in difficult environments, including nonminimum-phase plants with rapidly changing parameters. Author

A87-13436
SELECTION OF MEDIA ACCESS PROTOCOL FOR DISTRIBUTED DIGITAL AVIONICS
A. RAY (Pennsylvania State University, University Park) and J. MCGOUGH (Bendix Corp., Flight Systems Div., Teterboro, NJ) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 1558-1562. refs

The paper presents the results of an ongoing research project where the objectives are to evaluate avionic network topologies and media access protocols in view of the distributed digital flight control systems (DDFCS) of high performance aircraft and to recommend a specific protocol for its prototype development. The selection of an appropriate protocol is critical for the stability of an aircraft because the DDFCS, in addition to the sampling time delay, is subject to the transport delay due to media access and message transmission in the network. The MIL-STD-1553B and SAE token ring protocols were analyzed and the analytical results have been verified by use of discrete event simulation techniques. Author

A87-13689

PARAMETER ESTIMATION AND IN-PLANE DISTORTION INVARIANT CHORD PROCESSING

D. CASASENT (Carnegie-Mellon University, Pittsburgh, PA) and W.-T. CHANG (Eastman Kodak Research Laboratory, Rochester, NY) IN: Intelligent robots and computer vision; Proceedings of the Fourth Meeting, Cambridge, MA, September 16-20, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 2-10. refs
(Contract AF-AFOSR-84-0293)

An attractive feature space (chord distributions) for pattern recognition is discussed. New advancements presented are: extensions to 3-D in-plane and out-of-plane distortion-invariant object recognition; new techniques to allow estimation of in-plane distortion parameters; and a new technique to achieve class estimation in the presence of multiple distortions. Quantitative results are provided for a ship data base (for out-of-plane distortions) and for an aircraft data base (for in-plane distortions). Author

A87-13703* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

GRUNDY - PARALLEL PROCESSOR ARCHITECTURE MAKES PROGRAMMING EASY

R. J. MEIER, JR. (NASA, Ames Research Center, Moffett Field, CA) IN: Intelligent robots and computer vision; Proceedings of the Fourth Meeting, Cambridge, MA, September 16-20, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 284-288. NASA-supported research.

The hardware, software, and firmware of the parallel processor, Grundy, are examined. The Grundy processor uses a simple processor that has a totally orthogonal three-address instruction set. The system contains a relative and indirect processing mode to support the high-level language, and uses pseudoprocessors and read-only memory. The system supports high-level language in which arbitrary degrees of algorithmic parallelism is expressed. The functions of the compiler and invocation frame are described. Grundy uses an operating system that can be accessed by an arbitrary number of processes simultaneously, and the access time grows only as the logarithm of the number of active processes. Applications for the parallel processor are discussed. I.F.

A87-14019#

CAD AS A PREREQUISITE FOR COMPUTER-INTEGRATED MANUFACTURING [CAD ALS VORAUSSETZUNG FUER DIE COMPUTER-INTEGRIERTE FERTIGUNG]

J. NAGEL (Dornier GmbH, Friedrichshafen, West Germany) BMFT, Statusseminar ueber Luftfahrtforschung und Luftfahrttechnologie, Munich, West Germany, Apr. 28-30, 1986, Paper. 17 p. In German.

Techniques for coordinating the CAD of aircraft components with their fabrication by conventional NC machining and measurement tools are discussed. The relatively straightforward use of CADAM programs for sheet-metal components comprising plane panels is contrasted with the difficulties of translating drawings of complex three-dimensional components into milling-machine instructions, combining parts lists with geometrical data, or specifying the layer and ply orientations of laminated composites. Diagrams, drawings, photographs, and sample printouts are included. T.K.

A87-14682

INTEGRATED ACTIVE CONTROL SYSTEMS: METHODS OF ALGORITHMIC INTEGRATION [INTEGRIROVANNYE SISTEMY AKTIVNOGO UPRAVLENIIA: METODY ALGORITMICHESKOI INTEGRATSII]

I. S. UKOLOV, V. V. BEK, and A. R. MAKHLIN Moscow, Izdatel'stvo Nauka, 1986, 184 p. In Russian. refs

Design principles and algorithmic support methods are developed in a general systems framework for integrated active control systems. Algorithms are obtained for the state estimation, parameter identification, and control of dynamic plants operating under significant nonlinear and nonstationary variations of the motion parameters. The proposed approach is applied to a number of problems involving the control of flight vehicles. B.J.

A87-14957

IMPLEMENTATION OF CDFM GENERATOR CONTROL

T. H. ORTMEYER (Clarkson University, Potsdam, NY) and J. A. WEIMER (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-22, July 1986, p. 349-355.
(Contract F33615-81-C-2011)

The control of a cascaded doubly fed machine (CDFM) to be used for aircraft power generation is investigated. The controller employs a resistance simulator in the generator exciter to provide machine damping. Excitation is provided by a six step inverter fed from a controlled rectifier. Delays due to the dc link time constant cause the resistance simulation to be nonideal. An investigation into the ability of resistance simulation to provide damping under these conditions is described. Author

A87-16176

IDENTIFICATION AND SYSTEM PARAMETER ESTIMATION 1985; PROCEEDINGS OF THE SEVENTH SYMPOSIUM, UNIVERSITY OF YORK, ENGLAND, JULY 3-7, 1985. VOLUMES 1 & 2

H. A. BARKER, ED. (Swansea, University College, Wales) and P. C. YOUNG, ED. (Lancaster, University, England) Symposium organized by IEE; Sponsored by IFAC and International Federation of Operational Research Societies. Oxford and New York, Pergamon Press (IFAC Proceedings Series, No. 7), 1985. Vol. 1, 1171 p.; vol. 2, 891 p. For individual items see A87-16177 to A87-16224.

A collection of papers is presented covering identification and system parameter estimation from many different areas of scientific investigation, including control and system engineering, environmental science and agriculture, biomedicine, aeronautics and astronautics, statistics and time-series analysis, economics, business forecasting, and education. A large number of the papers describe results of the latest research and development in applications of identifications and system parameter estimation to a wide variety of dynamic systems, including 54 papers on self-adaptive and self-tuning control. Practical implementation of the techniques is also extensively addressed. C.D.

A87-16179

PARAMETRIC IDENTIFICATION OF DISCONTINUOUS NONLINEARITIES

R. V. JATEGAONKAR (National Aeronautical Laboratory, Bangalore, India) IN: Identification and system parameter estimation 1985; Proceedings of the Seventh Symposium, York, England, July 3-7, 1985. Volume 1 . Oxford and New York, Pergamon Press, 1985, p. 167-172. refs

The present paper proposes a technique to identify systems with discontinuous nonlinearities. A well-established maximum likelihood estimation method has been suitably extended for this purpose. The technique enjoys the desired properties of consistency, efficiency, and unbiased estimates associated with the maximum likelihood estimation. The estimation method has been illustrated using a second-order dynamic system which incorporates specific nonlinear elements viz.: hysteresis and deadband plus saturation. Effects of additive noise on the parameter estimates have also been presented. Practical utility of the technique has been demonstrated in identifying from flight test data the discontinuous nonlinear effects in the control surface actuator system of an aircraft. Author

A87-16189
AN EFFICIENT DECISION-MAKING-FREE FILTER FOR PROCESSES WITH ABRUPT CHANGES
H. A. P. BLOM (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Identification and system parameter estimation 1985; Proceedings of the Seventh Symposium, York, England, July 3-7, 1985. Volume 1 . Oxford and New York, Pergamon Press, 1985, p. 631-636. refs

The well known system of linear stochastic difference equations with Markovian coefficients has been generalized to cover processes which jump simultaneously with the coefficients. Examples are given to illustrate the additional modeling potential of this generalized system for filtering partial observations of the generalized system, a new algorithm, called the Interacting Multiple Model (IMM) algorithm, is given. It consists of a bank of N interacting Kalman-like filters which cooperate with a filter for the N state Markov process and is free of any decision making mechanism. Comparisons with other advanced algorithms for processes with abrupt changes show that the IMM algorithm performs very well at the cost of a relatively low computational load. Due to the generalization the IMM algorithm is a serious competitor of the well known decision directed filters for processes with additive jumps. Author

N87-11740*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MULTIDISCIPLINARY SYSTEMS OPTIMIZATION BY LINEAR DECOMPOSITION
J. SOBIESKI *In its* Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 24 p 1984
Avail: NTIS HC A22/MF A01 CSCL 12B

In a typical design process major decisions are made sequentially. An illustrated example is given for an aircraft design in which the aerodynamic shape is usually decided first, then the airframe is sized for strength and so forth. An analogous sequence could be laid out for any other major industrial product, for instance, a ship. The loops in the discipline boxes symbolize iterative design improvements carried out within the confines of a single engineering discipline, or subsystem. The loops spanning several boxes depict multidisciplinary design improvement iterations. Omitted for graphical simplicity is parallelism of the disciplinary subtasks. The parallelism is important in order to develop a broad workfront necessary to shorten the design time. If all the intradisciplinary and interdisciplinary iterations were carried out to convergence, the process could yield a numerically optimal design. However, it usually stops short of that because of time and money limitations. This is especially true for the interdisciplinary iterations. Author

N87-11748*# MacNeal-Schwendler Corp., Los Angeles, Calif.
DESIGN ENHANCEMENT TOOLS IN MSC/NASTRAN
D. V. WALLERSTEIN *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 1 22 p 1984
Avail: NTIS HC A22/MF A01 CSCL 09B

Design sensitivity is the calculation of derivatives of constraint functions with respect to design variables. While a knowledge of these derivatives is useful in its own right, the derivatives are required in many efficient optimization methods. Constraint derivatives are also required in some reanalysis methods. It is shown where the sensitivity coefficients fit into the scheme of a basic organization of an optimization procedure. The analyzer is to be taken as MSC/NASTRAN. The terminator program monitors the termination criteria and ends the optimization procedure when the criteria are satisfied. This program can reside in several plances: in the optimizer itself, in a user written code, or as part of the MSC/EOS (Engineering Operating System) MSC/EOS currently under development. Since several excellent optimization codes exist and since they require such very specialized technical knowledge, the optimizer under the new MSC/EOS is considered to be selected and supplied by the user to meet his specific needs and preferences. The one exception to this is a fully stressed design (FSD) based on simple scaling. The gradients are currently supplied by various design sensitivity options now existing in MSC/NASTRAN's design sensitivity analysis (DSA). Author

N87-11754*# Kaman Aerospace Corp., Bloomfield, Conn.
REGRESSION ANALYSIS AS A DESIGN OPTIMIZATION TOOL
R. PERLEY *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 2 15 p 1984
Avail: NTIS HC A22/MF A01 CSCL 12A

The optimization concepts are described in relation to an overall design process as opposed to a detailed, part-design process where the requirements are firmly stated, the optimization criteria are well established, and a design is known to be feasible. The overall design process starts with the stated requirements. Some of the design criteria are derived directly from the requirements, but others are affected by the design concept. It is these design criteria that define the performance index, or objective function, that is to be minimized within some constraints. In general, there will be multiple objectives, some mutually exclusive, with no clear statement of their relative importance. The optimization loop that is given adjusts the design variables and analyzes the resulting design, in an iterative fashion, until the objective function is minimized within the constraints. This provides a solution, but it is only the beginning. In effect, the problem definition evolves as information is derived from the results. It becomes a learning process as we determine what the physics of the system can deliver in relation to the desirable system characteristics. As with any learning process, an interactive capability is a real attriubute for investigating the many alternatives that will be suggested as learning progresses. Author

N87-11755*# Kaman Aerospace Corp., Bloomfield, Conn.
A ROTOR OPTIMIZATION USING REGRESSION ANALYSIS
N. GIANSANTE *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 2 13 p 1984
Avail: NTIS HC A22/MF A01 CSCL 12A

The design and development of helicopter rotors is subject to the many design variables and their interactions that effect rotor operation. Until recently, selection of rotor design variables to achieve specified rotor operational qualities has been a costly, time consuming, repetitive task. For the past several years, Kaman Aerospace Corporation has successfully applied multiple linear regression analysis, coupled with optimization and sensitivity procedures, in the analytical design of rotor systems. It is concluded that approximating equations can be developed rapidly for a multiplicity of objective and constraint functions and optimizations can be performed in a rapid and cost effective manner; the number and/or range of design variables can be increased by expanding the data base and developing approximating functions to reflect the expanded design space; the order of the approximating equations can be expanded easily to improve correlation between analyzer results and the approximating equations; gradients of the approximating equations can be calculated easily and these gradients are smooth functions reducing the risk of numerical problems in the optimization; the use of approximating functions allows the problem to be started easily and rapidly from various initial designs to enhance the probability of finding a global optimum; and the approximating equations are independent of the analysis or optimization codes used. Author

N87-11775*# Boeing Computer Services Co., Seattle, Wash.
APPLYING OPTIMIZATION SOFTWARE LIBRARIES TO ENGINEERING PROBLEMS
M. J. HEALY *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 2 21 p 1984
Avail: NTIS HC A22/MF A01 CSCL 09B

Nonlinear programming, preliminary design problems, performance simulation problems trajectory optimization, flight computer optimization, and linear least squares problems are among the topics covered. The nonlinear programming applications encountered in a large aerospace company are a real challenge to those who provide mathematical software libraries and consultation services. Typical applications include preliminary design studies, data fitting and filtering, jet engine simulations, control system analysis, and trajectory optimization and optimal control. Problem sizes range from single-variable unconstrained minimization to constrained problems with highly nonlinear functions and hundreds of variables. Most of the applications can be posed as nonlinearly constrained minimization problems. Highly complex optimization problems with many variables were formulated in the early days of computing. At the time, many problems had to be reformulated or bypassed entirely, and solution methods often relied on problem-specific strategies. Problems with more than ten variables usually went unsolved. Author

N87-12265*# Virginia Univ., Charlottesville. Dept. of Computer Science.
THE IMPLEMENTATION AND USE OF ADA ON DISTRIBUTED SYSTEMS WITH HIGH RELIABILITY REQUIREMENTS Semiannual Progress Report, 5 Mar. 1982 - 31 Dec. 1986
J. C. KNIGHT Aug. 1986 73 p
(NASA-CR-179842; NAS 1.26:179842; UVA/528213/CS87/109)
Avail: NTIS HC A04/MF A01 CSCL 09B

The general inadequacy of Ada for programming systems that must survive processor loss was shown. A solution to the problem was proposed in which there are no syntatic changes to Ada. The approach was evaluated using a full-scale, realistic application. The application used was the Advanced Transport Operating System (ATOPS), an experimental computer control system developed for a modified Boeing 737 aircraft. The ATOPS system is a full authority, real-time avionics system providing a large variety of advanced features. Methods of building fault tolerance into concurrent systems were explored. A set of criteria by which the proposed method will be judged was examined. Extensive interaction with personnel from Computer Sciences Corporation and NASA Langley occurred to determine the requirements of the ATOPS software. Backward error recovery in concurrent systems was assessed. B.G.

N87-12273*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
RAPID PROTOTYPING FACILITY FOR FLIGHT RESEARCH IN ARTIFICIAL-INTELLIGENCE-BASED FLIGHT SYSTEMS CONCEPTS
E. L. DUKE, V. A. REGENIE, and D. A. DEETS Oct. 1986 19 p
(NASA-TM-88268; H-1367; NAS 1.15:88268) Avail: NTIS HC A02/MF A01 CSCL 09B

The Dryden Flight Research Facility of the NASA Ames Research Facility of the NASA Ames Research Center is developing a rapid prototyping facility for flight research in flight systems concepts that are based on artificial intelligence (AI). The facility will include real-time high-fidelity aircraft simulators, conventional and symbolic processors, and a high-performance research aircraft specially modified to accept commands from the ground-based AI computers. This facility is being developed as part of the NASA-DARPA automated wingman program. This document discusses the need for flight research and for a national flight research facility for the rapid prototyping of AI-based avionics systems and the NASA response to those needs. Author

N87-13179# Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil).
TOOL TO DEVELOP REAL TIME SIMULATION SYSTEMS M.S. Thesis [FERRAMENTA PARA DESENVOLVIMENTO DE SISTEMAS DE SIMULACAO EM TEMPO REAL]
C. L. RUYBALDOSSANTOS Aug. 1986 196 p In PORTUGUESE; ENGLISH summary
(INPE-3979-TDL/233) Avail: NTIS HC A09/MF A01

The development of a tool for testing and documenting the constituent subsystems of a real time simulation system, written in FORTRAN language, is described. This tool can be seen as an environment to simulate the operation of all subsystems of the simulated system, except one: the subsystem under test. The documentation of each subsystem is attached to it. Simulation results are presented by means of tables and curves. The tool was used in perfecting the flight simulator for the Empresa Brasileira de Aeronautica (EMBRAER) T-27 airplane, developed at the Centro tecnico Aeroespacial - CTA (IPD-PEA). Accompanying the report are printouts regarding the results of a simulation and documentation for the atmosphere subsystem which is part of the simulator described above. 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.

A87-13585
AERO- AND HYDRO-ACOUSTICS; PROCEEDINGS OF THE SYMPOSIUM, ECOLE CENTRALE DE LYON, ECULLY, FRANCE, JULY 3-6, 1985
G. COMTE-BELLOT, ED. (Lyon, Ecole Centrale, Ecully, France) and J. E. FFOWCS WILLIAMS, ED. (Cambridge University, England) Symposium sponsored by IUTAM, DRET, CNRS, et al. Berlin and New York, Springer-Verlag, 1986, 567 p. In English and French. For individual items see A87-13586 to A87-13612.

Topics discussed include diffraction, active noise control, source mechanisms, rotor noise, thermoacoustics, computational acoustics, flow noise, the acoustics of unstable flows, and flow-acoustic interaction. Particular attention is given to the influence of airfoil mean loading on convected gust interaction noise; an experimental study of unsteady flow over a trailing edge; acoustic pressure and intensity distributions in finite-length active noise control systems; a comparison of two propeller source models for aircraft interior noise studies; and the acoustoelasticity of a panel backed by a rectangular cavity. Also considered are a wind tunnel study of aeolian tones from rough-surface cylinders, wake-induced shear excitation in a basic annular jet, and the response of a flat-plate turbulent boundary layer to intense sound waves moving in the upstream direction. B.J.

A87-13587* Arizona Univ., Tucson.
INFLUENCE OF AIRFOIL MEAN LOADING ON CONVECTED GUST INTERACTION NOISE
E. J. KERSCHEN and M. R. MYERS (Arizona, University, Tucson) IN: Aero- and hydro-acoustics; Proceedings of the Symposium, Ecully, France, July 3-6, 1985 . Berlin and New York, Springer-Verlag, 1986, p. 13-20. refs
(Contract NAG3-357)

A theoretical model is developed for the noise generated when a convected vortical or entropic gust encounters an airfoil at nonzero angle of attack. The analysis is based on Rapid Distortion Theory. High frequency gusts, whose wavelengths are short compared to the airfoil chord, are considered. The noise generation is shown to be concentrated near the airfoil leading edge. The level of the generated noise is increased by airfoil mean loading, with the appropriate scaling parameter being the local leading edge incidence angle. The trailing edge simply scatters the leading edge sound field, and here the mean loading effects scale on the airfoil total lift. Calculations are presented which illustrate that, at high frequencies, moderate levels of airfoil steady loading can dramatically increase the noise produced by airfoil convected gust interactions. Author

A87-13593
THE ACTIVE MINIMIZATION OF HARMONIC ENCLOSED SOUND FIELDS
P. A. NELSON, A. R. D. CURTIS, and S. J. ELLIOTT (Southampton, University, England) IN: Aero- and hydro-acoustics; Proceedings of the Symposium, Ecully, France, July 3-6, 1985 . Berlin and New York, Springer-Verlag, 1986, p. 87-92. refs

The total time averaged acoustic potential energy in a steady harmonic sound field can be expressed as a positive definite quadratic function of the complex strengths of a number of 'secondary sources' of sound introduced into the enclosure. For a given number and location of secondary sources, there is a unique set of complex source strengths which minimizes this potential energy. This analysis is applied to the case of a lightly damped enclosure excited by a point primary source at a frequency well above the Schroeder large room frequency. It is demonstrated that in this case, the maximum reduction that can be achieved in the potential energy of the sound field is critically dependent on the relative locations of primary and secondary sources. Author

A87-13595
NOISE OF HIGH SPEED SURFACES
A. R. GEORGE (Cornell University, Ithaca, NY) IN: Aero- and hydro-acoustics; Proceedings of the Symposium, Ecully, France, July 3-6, 1985 . Berlin and New York, Springer-Verlag, 1986, p. 119-133. refs

Aerodynamic noise radiated by surfaces moving with respect to the fluid are discussed. Particular attention is given to sonic boom due to supersonic motion, rotor noise due to the acceleration of rotor volumes, steady forces and nonlinear effects, and noise due to various unsteady force effects on rotors. The unsteady forces include effects from harmonically varying inflow, impulsive blade-vortex interaction loading (including transonic effects), and broadband noise due to loading from inflow turbulence and self-generated turbulence. The state-of-the-art of predicting noise from practical configurations is considered. B.J.

A87-13605
EXPERIMENTAL INVESTIGATION OF NEAR AND FAR ACOUSTIC FIELD OF A SMALL TURBOJET
J. HAERTIG and C. JOHE (Saint-Louis, Institut Franco-Allemand de Recherches, France) IN: Aero- and hydro-acoustics; Proceedings of the Symposium, Ecully, France, July 3-6, 1985 . Berlin and New York, Springer-Verlag, 1986, p. 411-417.

Experimental results concerning the near and far acoustic field of a small turbojet are presented. At idle speed (subsonic jet) the acoustic field of the engine is similar to the one of a strongly excited free jet model (tone noise with high azimuthal coherence). At maximum speed (supersonic subcritical jet) tone noise is more or less covered by jet noise and the far field is similar to the one of quiet jet model. Author

A87-15458* Brown Univ., Providence, R. I.
LARGE-SCALE COHERENT STRUCTURES IN FREE TURBULENT FLOWS AND THEIR AERODYNAMIC SOUND
J. T. C. LIU (Brown University, Providence, RI) IN: Recent advances in aerodynamics . New York, Springer-Verlag, 1986, p. 297-334. refs
(Contract NSF MEA-78-22127; NAG1-379)

After interpreting the observed physical features of large-scale coherent structures in free shear flows on the basis of conservation principles, the role of such structures in sources of turbulent jet sound is discussed. It is found that the lower-frequency sound, which comes from lower-frequency coherent structures peaking further downstream, radiates preferentially nearer the jet axis; the peak radiation moves away from the jet axis as the frequency increases. O.C.

A87-15582
NONLINEAR ACOUSTICS - ACHIEVEMENTS, PROSPECTS, PROBLEMS [NELINEINAIA AKUSTIKA - DOSTIZHENIIA, PERSPEKTIVY, PROBLEMY]
O. V. RUDENKO (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR) Priroda (ISSN 0032-874X), July 1986, p. 16-26. In Russian. refs

The current state of theory and technology in nonlinear acoustics is examined with particular emphasis on the use of parametric antennas to detect nonlinear acoustic waves, techniques for controlling the interaction of acoustic waves, and analogies between nonlinear acoustics and nonlinear optics. Applications of nonlinear acoustics to nondestructive testing, noise control, aircraft noise, and hydroacoustics are mentioned. B.J.

N87-12322*# Lockheed-California Co., Burbank.
WINDOW ACOUSTIC STUDY FOR ADVANCED TURBOPROP AIRCRAFT Final Report
R. A. PRYDZ and F. J. BALENA Aug. 1984 48 p
(Contract NAS1-16441)
(NASA-CR-172391; NAS 1.26:172391; LR-30727) Avail: NTIS HC A03/MF A01 CSCL 20A

An acoustic analysis was performed to establish window designs for advanced turboprop powered aircraft. The window transmission loss requirements were based on A-weighted interior noise goals of 80 and 75 dBA. The analytical results showed that a triple pane window consisting of two glass outer panes and an inner pane of acrylic would provide the required transmission loss and meet the sidewall space limits. Two window test articles were fabricated for laboratory evaluation and verification of the predicted transmission loss. Procedures for performing laboratory tests are presented. Author

N87-12323*# Douglas Aircraft Co., Inc., Long Beach, Calif.
LIGHTWEIGHT SIDEWALLS FOR AIRCRAFT INTERIOR NOISE CONTROL Final Report
D. N. MAY, K. J. PLOTKIN, R. G. SELDEN, and B. H. SHARP Feb. 1985 154 p
(Contract NAS1-17263)
(NASA-CR-172490; NAS 1.26:172490) Avail: NTIS HC A08/MF A01 CSCL 20A

A theoretical and experimental study was performed to devise lightweight sidewalls for turboprop aircraft. Seven concepts for new sidewalls were analyzed and tested for noise reduction using flat panels of 1.2 m x 1.8 m (4 ft x 6 ft), some of which were aircraft-type constructions and some of which were simpler, easier-to-construct panels to test the functioning of an acoustic principle. Aircraft-application sidewalls were then conceived for each of the seven concepts, and were subjectively evaluated for their ability to meet aircraft nonacoustic design requirements. As a result of the above, the following sidewall concepts were recommended for further investigation: a sidewall in which the interior cavity is vented to ceiling and underfloor areas; sidewalls with wall-mounted resonators, one having a conventional trim panel and one a limp one; and a sidewall with a stiff outer wall and a limp trim panel. These sidewalls appear to promise lower weights than conventional sidewalls adjusted to meet similar acoustic requirements, and further development may prove them to be practical. Author

N87-12326# European Space Agency, Paris (France).
ON SOUND PROPAGATION IN CENTRIFUGAL FAN CASINGS
M. BARTENWERFER and T. GIKADI Dec. 1985 44 p Transl. into ENGLISH from "Zur Schallausbreitung in Gehaeusen von Radialventilatoren" (Berlin, West Germany) Original language document was announced at N86-16053
(ESA-TT-957; DFVLR-FB-85-32; ETN-86-98244) Avail: NTIS HC A03/MF A01; original German version avail. at DFVLR, Cologne, West Germany DM 11

Sound propagation in radial fan hollow casings was studied for cylindrical and spiral-shaped casings of the same volume and width. After measurement of the sound reflection through the different casings a monopole or dipole sound source of reduced expansion at the casing cut-off was introduced and the frequency responses in the intake and outflow canals determined. The influence of casing geometry and the flow in the casing on the rejection level and on the system frequency responses was determined. The applicability of the one-mode approximation for description of the frequency responses was verified. Torsional sound in the outflow canal can be reduced with a phase-variable sound source synchronous with the rotation frequency at the cut-off. ESA

N87-12327# Institut Franco-Allemand de Recherches, St. Louis (France).
INTRODUCTION TO HELICOPTER NOISE [INTRODUCTION AU BRUIT DES HELICOPTERES]
J. HAERTIG 7 Feb. 1984 25 p In FRENCH
(ISL-NB-401/84; ETN-86-98405) Avail: NTIS HC A02/MF A01

Literature on the intensity and characteristics of the external noise produced by helicopters was reviewed. Several types of noise are described and illustrated by measurements and calculations. ESA

N87-13252*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CRUISE NOISE OF COUNTERROTATION PROPELLER AT ANGLE OF ATTACK IN WIND TUNNEL
J. H. DITTMAR Oct. 1986 35 p
(NASA-TM-88869; E-3275; NAS 1.15:88869) Avail: NTIS HC A03/MF A01 CSCL 20A

The noise of a counterrotation propeller at angle of attack was measured in the NASA Lewis 8- by 6-Foot Supersonic Wind Tunnel at cruise conditions. Noise increases of as much as 4 dB were measured at positive angles of attack on the tunnel side wall, which represented an airplane fuselage. These noise increases could be minimized or eliminated by operating the counterrotation propeller with the front propeller turning up-inboard. This would require oppositely rotating propellers on opposite sides of the airplane. Noise analyses at different bandwidths enabled the separate front- and rear-propeller tones, as well as the total noise, at each harmonic to be determined. A simplified noise model was explored to show how the observed circumferential noise patterns of the separate propeller tones might have occurred. The total noise pattern, which represented the sum of the front- and rear-propeller tones at a particular harmonic, showed trends that would be hard to interpret without the separate-tone results. Therefore it is important that counterrotation angle-of-attack noise data be taken in such a manner that the front- and rear-propeller tones can be separated. Author

N87-13347# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
JOURNAL OF ENGINEERING THERMOPHYSICS (SELECTED ARTICLES)
L. DUAN, B. DONG, Z. WANG, Y. GAO, and K. LI 24 Jun. 1986 51 p Transl. into ENGLISH from Gongcheng Rewuli Xuebao China), v. 3, no. 2, May 1982 p 123-130, 135-137, 183-189
(AD-A169452; FTD-ID(RS)T-0312-86) Avail: NTIS HC A04/MF A01 CSCL 13G

The Journal of Engineering Thermophysics, vol.3, no.2, May 1982, contains articles on the following topics: Effect of Part Span Shroud on Performance of a Single Stage Compressor; Effect of the Rear Stage Casing Treatment on the Overall Performance of a Multistage Axial flow Compressor; Investigations on Performance of Swept Wing Aircraft; Cascade of Axial Flow Compressor; and Thermal Performance of Turbine Vane with Ceramic Coatings with Enhanced Cooling. GRA

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law, political science, and space policy; and urban technology and transportation.

A87-13636#
PARAMETRIC SIZING OF AERIAL APPLICATION AIRPLANES BASED ON VARYING LEVELS OF TECHNOLOGY
A. SIGAL (Technion - Israel Institute of Technology, Haifa) and R. YOELI IN: Israel Annual Conference on Aviation and Astronautics, 27th, Haifa, Israel, February 27, 28, 1985, Collection of Papers . Haifa, Israel, Technion - Israel Institute of Technology, 1986, p. 1-6. refs

A computer program was used to size current advanced technology configurations to given payload and performance constraints. The configurations were compared mainly from a cost point of view based on a simulation mission run by the program. The most dominant design parameter for agricultural aircraft is the wing aspect ratio. The incorporation of advanced technologies tended to reduce the size and weight of the aircraft and to improve the ratio of the payload/gross wt. Mission cost was only modestly influenced, especially due to the reduction in aircraft size, which tended to increase the number of spray passes and thus have an adverse effect on total mission time. It is concluded that, as long as the basis for comparison is mission cost only, there seems little justification for the incorporation of advanced technologies in agricultural-aircraft design. B.J.

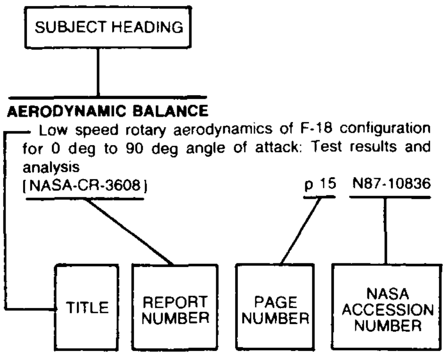
A87-14037#
GENERAL AVIATION COST EFFECTIVENESS
R. E. ETHERINGTON (Gates Learjet Corp., Wichita, KS) AIAA, General Aviation Technology Conference, Anaheim, CA, Sept. 29-Oct. 1, 1986. 8 p.
(AIAA PAPER 86-2607)

The General Aviation Industry has not recovered from the last economic recession. This paper is an update of AIAA Paper 86-4029, 'General Aviation Cost Effectiveness', presented in Colorado Springs on October 15, 1985. This paper re-examines the areas of cost effectiveness and model changes. Both cost effectiveness and model changes play an important part in the past history of general aviation growth. This paper examines these areas in greater depth and makes some recommendations for future recovery of aircraft sales. Author

N87-13352# Orlando Technology, Inc., Shalimar, Fla.
TSAR (THEATER SIMULATION OF AIRBASE RESOURCES) DATABASE DICTIONARY F-4E Final Report, 1 Aug. 1985 - 31 Jul. 1986
D. ROBINSON and C. GORNTO 28 Mar. 1986 257 p
(AD-A169575) Avail: NTIS HC A12/MF A01 CSCL 05B

A significant problem for analysts and simulation model users is the availability of complete documentation of input databases. The Theater Simulation of Airbase Resources (TSAR) model is no exception. This TSAR dictionary documents the F-4E database by translating the database codes to their English equivalents, presents graphic network models for the decision logic networks for aircraft repair tasks, and a cross-reference index to facilitate its use by modelers and analysts. GRA

Typical Subject Index Listing



The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of the document content, the title extension is added, separated from the title by three hyphens. The (NASA or AIAA) accession number and the page number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document. Under any one subject heading, the accession numbers are arranged in sequence with the AIAA accession numbers appearing first.

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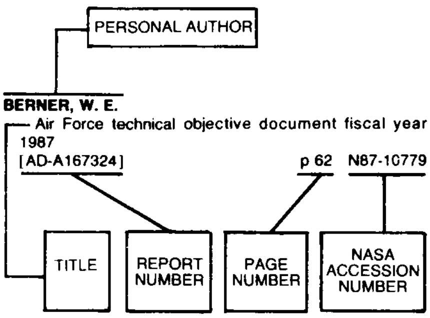
Typical Personal Author Index Listing



Listings in this index are arranged alphabetically by personal author. The title of the document provides the user with a brief description of the subject matter. The report number helps to indicate the type of document listed (e.g., NASA report, translation, NASA contractor report). The page and accession numbers are located beneath and to the right of the title. Under any one author's name the accession numbers are arranged in sequence with the AIAA accession numbers appearing first.

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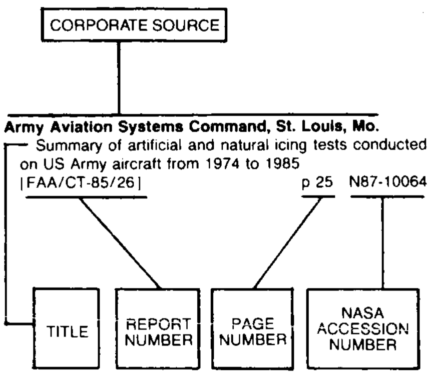
Typical Corporate Source Index Listing



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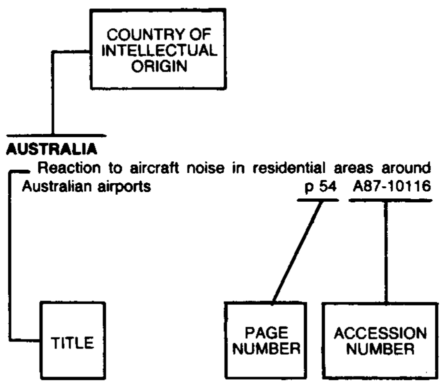
Typical Foreign Technology Index Listing



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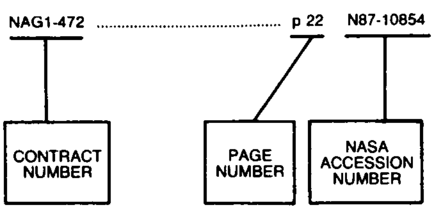

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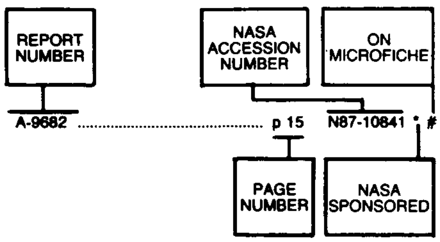

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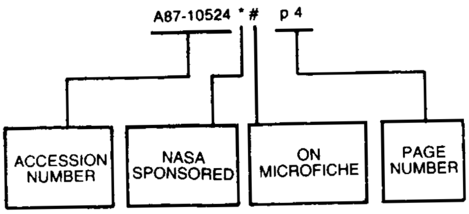

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