NASA SP-7037 (267)
July 1991

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

NASA STI PROGRAM
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NASA SP-7037 (267)
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AERONAUTICAL ENGINEERING

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NASA
National Aeronautics and Space Administration
Office of Management
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INTRODUCTION

This issue of *Aeronautical Engineering—A Continuing Bibliography* (NASA SP-7037) lists 661 reports, journal articles, and other documents originally announced in May 1991 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

Accession numbers cited in this issue are:

STAR (N-10000 Series)	N91-19024 — N91-21058
IAA (A-10000 Series)	A91-28401 — A91-32448

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 publication 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.

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

A cumulative index for 1991 will be published in early 1992.

Information on availability of documents listed, addresses of organizations, and NTIS price schedules are located at the back of this issue.

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TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

ACCESSION NUMBER → **N91-10010*#** Institute for Computer Applications in Science and Engineering, Hampton, VA. ← CORPORATE SOURCE

TITLE → **TURBULENT FLOW CALCULATIONS USING UNSTRUCTURED AND ADAPTIVE MESHES Final Report**

PUBLICATION DATE

AUTHOR → DIMITRI J. MAVRIPLIS Sep. 1990 32 p Submitted for publication

CONTRACT NUMBER → (Contract NAS1-18605)

REPORT NUMBERS → (NASA-CR-182102; NAS 1.26:182102; ICASE-90-61) Avail: NTIS ← AVAILABILITY SOURCE

HC/MF A03 CSCL 01A ← COSATI CODE

PRICE CODE

A method of efficiently computing turbulent compressible flow over complex two dimensional configurations is presented. The method makes use of fully unstructured meshes throughout the entire flow-field, thus enabling the treatment of arbitrarily complex geometries and the use of adaptive meshing techniques throughout both viscous and inviscid regions of flow-field. Mesh generation is based on a locally mapped Delaunay technique in order to generate unstructured meshes with highly-stretched elements in the viscous regions. The flow equations are discretized using a finite element Navier-Stokes solver, and rapid convergence to steady-state is achieved using an unstructured multigrid algorithm. Turbulence modeling is performed using an inexpensive algebraic model, implemented for use on unstructured and adaptive meshes. Compressible turbulent flow solutions about multiple-element airfoil geometries are computed and compared with experimental data. Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

ACCESSION NUMBER → **A91-11198*#** Oklahoma State Univ., Stillwater. ← CORPORATE SOURCE

TITLE → **FLOW AND ACOUSTIC PROPERTIES OF LOW REYNOLDS NUMBER UNDEREXPANDED SUPERSONIC JETS**

AUTHORS → TIEH-FENG HU and D. K. MCLAUGHLIN (Oklahoma State University, Stillwater) ← AUTHORS' AFFILIATION Journal of Sound and Vibration (ISSN 0022-460X), vol. 141, Sept. 22, 1990, p. 485-505. refs ← JOURNAL TITLE

CONTRACT NUMBERS → (Contract NAG1-10; NAG1-159)

Copyright

An experimental program to investigate the flow and acoustic properties of model underexpanded supersonic jets was conducted. In particular, the role played by large-scale organized fluctuations in the flow evolution and acoustic production processes was examined in detail. The experimental conditions were chosen as low-Reynolds-number (Re = 8000) Mach 1.4 and 2.1 underexpanded jets exhausting from convergent nozzles. A consequence of performing the experiments at low Reynolds number is that the broad and shock-associated noise is suppressed. The focus of the present study is on the generation of noise by large-scale instabilities in the presence of strong shock cell structures. It is demonstrated that the production of screech is related to the modulation and decay of large-scale turbulence structures. Author

ABSTRACTS

01

AERONAUTICS (GENERAL)

A91-28516#

RELEVANCE OF EMERGING TECHNOLOGIES TO AVIATION IN INDIA

C. V. GOLE Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 42, Nov. 1990, p. 317-326.

An overview is presented of the technological activities that have been associated with the development of military and civil aviation in India. It is observed that aeronautics draws upon most of the technologies and acts as a force multiplier in the technoeconomic scenario of the nation. It is suggested that three major areas of technology should be adhered to; update programs, derivative developments and some selected new designs directly related to design and development of the type of aircraft required and the related power plants, avionics, and associated systems. Also, the existing and planned facilities and infrastructure must be examined and their efforts coordinated to determine the specific areas where further inputs are required. R.E.P.

A91-29027#

EUROPEAN TRANSPORTER CONCEPTS TODAY FOR TOMORROW'S TWENTY-FIRST-CENTURY MISSIONS - HIGH TECHNOLOGY SERVES AS A PACESETTER IN THE AMBITIOUS AIRCRAFT DESIGN

New-Tech News (ISSN 0935-2694), no. 4, 1990, p. 26-29.

Copyright

The current tactical concepts call for a simple rugged aircraft with new but tried and true technology. While the aircraft should not be considerably larger than its predecessors, its transportational capacity is to be greater than that of C-130 or C-160. Emphasis is placed on the European Future Large Aircraft Group consortium created with the goal of the development, production, product support, and marketing of the program, and the contribution of Deutsche Airbus to the program. The development of digital technology, cockpit displays, and cargo doors for the aircraft is outlined, along with requirements for short takeoff and landing distances, the use of composites, the reduction of radar cross section, and mission-specific aspects such as night and poor-weather visual capabilities, terrain/threat avoidance, and high-precision navigation for load discharges. V.T.

A91-29045#

TILT ROTORS DON CIVVIES

RICHARD PIELLISCH Aerospace America (ISSN 0740-722X), vol. 29, March 1991, p. 26-30.

Copyright

The aircraft industry faces a formidable challenge in developing a civil tilt rotor, in great part because the proposed elimination of the V-22 Osprey by DOD threatens the loss of data from operating hundreds of aircraft required for certification purposes. A civil version would differ substantially from the V-22, e.g., operators would not need to fold wings and rotors for stowage, and conversely, passengers will desire pressurization and amenities like lavatories, necessitating a different fuselage. Advanced composites, which comprise more than half the weight of the Osprey, would probably be changed in favor of aluminum. In addition, a typical helicopter time between overhaul of 1,500-3,000 flight hours compared to a standard 6000 hours for fixed-wing aircraft would be prohibitively costly. The airlines may demand development of vertiports and necessary air traffic control and other system modifications with the understanding that they will operate the tilt rotor only after the infrastructure is in place. R.E.P.

A91-29053

RE-ENGINING APPEARS TO OFFER BEST PAYBACK FOR YOUNG CHAPTER 2 COMPLIANT AIRCRAFT

M. J. T. SMITH (Rolls-Royce, PLC, London, England) ICAO Journal (ISSN 0018-8778), vol. 45, Nov. 1990, p. 12-14.

Copyright

A review is presented of the huskit versus reengining options available for reducing the noise impact of Chapter 2 aircraft. Although hushkits help reduce the noise effect of the high velocity jet, often with a severe performance penalty, a much more effective method for reducing noise and achieving improvements in propulsive efficiency is to convert the engine to a higher bypass ratio and thereby reduce its jet velocity. Also reengining offers other benefits, e.g., substantial reduction in time to climb to cruise altitude, better fuel consumption allowing significant enhancements in field performance and payload/range, and the advantages of the lower maintenance costs of a modern engine. Hushkits offer very little in terms of expected pay-off as the aerodynamic drag losses and extra powerplant mass increase fuel consumption, increase pollution and degrade payload/range. R.E.P.

A91-29054

CO-OPERATION IS CRUCIAL TO SUCCESS OF AGING AIRCRAFT REVIEW PROGRAMMES

COLIN TORKINGTON (Australia's Civil Aviation Authority, Canberra) ICAO Journal (ISSN 0018-8778), vol. 45, Nov. 1990, p. 15-20.

Copyright

An outline is presented of structural design concepts involved in the continuing programs associated with aging commercial aircraft inspections. The safe life concept requires that those parts of the structure whose failure could result in loss of the aircraft must be able to remain safely in use up to a predetermined retirement life. Although safe life components are now rarely utilized in the primary flight structure of commercial aircraft, many older safe life designs are still operating. Other design concepts described include the fail-safe concept, damage tolerance evaluation, the supplemental inspection document (SID) that was introduced to bring the aircraft up to a safety level equivalent to the new damage tolerance rules, and the Boeing approach to the SID audit approach. Additional concepts and recommendations are discussed, including research work, tear-down inspections of old aircraft, fatigue testing, nondestrutive testing techniques, communication, human factors, and maintenance. R.E.P.

A91-29436

U.S. ARMY ROTORCRAFT COMPOSITE TECHNOLOGY - PAST, PRESENT, AND FUTURE

DANNY E. GOOD (U.S. Army, Aviation Applied Technology

Directorate, Fort Eustis, VA) Vertiflite (ISSN 0042-4455), vol. 37, Mar.-Apr. 1991, p. 7-10.
Copyright
The present development-history analysis of military helicopter structural design attempts to project future developments in view of discernible trends, and gives attention to the continuing debates *concerning the role which composite materials should be* encouraged to play in such developments. The U.S. Army's Advanced Composite Airframe Program (ACAP) established cost- and weight-saving goals of the order of 17 and 22 percent, respectively, relative to an all-metal baseline helicopter airframe; ACAP materials were kevlar- and graphite-reinforced epoxy resins, fabricated with a variety of tooling concepts. Composite materials are noted to significantly add to structural design and analysis complexity; nevertheless, thermoplastics appear to be the materials of choice for future airframes. O.C.

A91-29437
SUBSTANTIATION OF FIBER COMPOSITE VS. CONVENTIONAL ROTORCRAFT STRUCTURE
MIKE MATHIAS and JAMES MAJOR (FAA, Southwest Region Rotorcraft Directorate, Fort Worth, TX) Vertiflite (ISSN 0042-4455), vol. 37, Mar.-Apr. 1991, p. 11-15.
Copyright
Rotorcraft structures are unique in their routine subjection to severe cyclic stresses, and require special consideration in the matter of composite materials substantiation; such considerations are rendered more complex relative to the metallic-structures case by the 'batch-by-batch' variability of composite materials' various constituents. An account is presently given of FAR requirements concerning basic constituent, prepreg, and laminate property-determination and acceptance, structural protection, lightning protection, fatigue evaluation, dynamic loading and response, special repairs, and continued airworthiness. A phased-approval, 'building block' certification process is recommended for these structures. O.C.

A91-29439
MCDONNELL DOUGLAS HELICOPTER CO. COMPOSITE MATERIALS TECHNOLOGY
J. K. SEN and A. D. STEMPLE (McDonnell Douglas Helicopter Co., Mesa, AZ) Vertiflite (ISSN 0042-4455), vol. 37, Mar.-Apr. 1991, p. 26-31. refs
Copyright
An evaluation is made of the results obtained to date by a major U.S. rotorcraft manufacturer's advanced composite structures development efforts; these extend not only over the range of helicopter structural components, but also to secondary structures for the C-17 military airlifter. Intensive researches are being conducted into the use of thermoplastic composite matrices in primary structures, as well as such structures' analytical and certification methodologies. Probabilistic methods are being used in order to deepen understanding of material composition and geometric parameter sensitivities associated with failure, and energy-absorbing structural design practices are being applied to enhance crashworthiness. O.C.

A91-30110
GOSSAMER ODYSSEY - THE TRIUMPH OF HUMAN-POWERED FLIGHT
MORTON GROSSER New York, Dover Publications, Inc., 1991, 366 p. refs
Copyright
The histories of the Gossamer Condor and Gossamer Albatross human-powered aircraft are recounted in detail by a member of the Albatross team. The emphasis is on the successful work of the team members in winning the Kremer Cross-Channel Prize with the Albatross in 1979. Diagrams, drawings, and extensive photographs are provided. T.K.

A91-30558
AEROSPACE CORROSION CONTROL; PROCEEDINGS OF THE SYMPOSIUM, AUCHTERARDER, SCOTLAND, FEB. 28-MAR. 2, 1989
London, Sawell Publications, Ltd., 1989, 363 p. For individual items see A91-30559 to A91-30574.
Copyright
The papers contained in this volume provide an overview of the problem of corrosion in aerospace equipment and recent developments in corrosion control. Topics discussed include corrosion evaluation of alloys for flexural hosing in the Space Shuttle launch environment; prevention of galvanic corrosion in complex metal/CFRP satructures; and high-temperature corrosion control in aircraft turbines. Papers are also presented on inspection of corrosion and corrosion cracking on airframes; avoiding stress corrosion by surface prestressing; and engineering for corrosion control in manufacture and service operation. V.L.

A91-30559
CORROSION EXPERIENCE ON IN-SERVICE AIRPLANES - AN OPERATOR'S VIEWPOINT
LOONG KWAN CHEW, M. SIRISENA, and KONG CHAN CHEW (Singapore Airlines, Singapore) IN: Aerospace corrosion control; Proceedings of the Symposium, Auchterarder, Scotland, Feb. 28-Mar. 2, 1989. London, Sawell Publications, Ltd., 1989, 30 p.
Copyright
The problem of the corrosion damage of in-service aircraft structures is reviewed with reference to data based on actual operation experience with Boeing (747, 707, 737, 727, and 757) and Airbus (A300 and A310) aircraft. The mechanisms of corrosion are briefly reviewed, and the aircraft structural components that are particularly susceptible to corrosion are identified. The typical corrosion damage, immediate causes of corrosion, detectability, methods of prevention, and repair techniques are then summarized for each of the most vulnerable areas, including fuselage and skin joints, bilge area, wing spars, primary structures under galleys and toilet, structures under fairings, and cargo hold. Finally, some design improvements aimed at reducing corrosion and corrosion control measures are discussed. V.L.

A91-30560
CORROSION CONTROL - A SCEPTICAL VIEWPOINT
B. F. LAVERS (Civil Aviation Authority, London, England) IN: Aerospace corrosion control; Proceedings of the Symposium, Auchterarder, Scotland, Feb. 28-Mar. 2, 1989. London, Sawell Publications, Ltd., 1989, 10 p.
Copyright
The problem of corrosion is reviewed with particular reference to the air transport industry and its approach to corrosion control. Attention is given to the principal causes of corrosion, the corrosion-prone areas, the principal methods of corrosion protection, and corrosion control strategies. It is noted that successful corrosion control requires large investments in the form of experienced inspection staff, better maintenance access, and aircraft kept clean, dry, and better protected. The most important factor, however, is the need to allow for adequate maintenance downtime. V.L.

A91-30570
ENGINEERING FOR CORROSION CONTROL IN MANUFACTURE AND SERVICE OPERATION
P. J. BASHFORD (British Aerospace, PLC, Civil Aircraft Div., London, England) IN: Aerospace corrosion control; Proceedings of the Symposium, Auchterarder, Scotland, Feb. 28-Mar. 2, 1989. London, Sawell Publications, Ltd., 1989, 40 p.
Copyright
Design considerations relevant to corrosion and its control over the life of aircraft are reviewed, as are the corresponding design requirements in both military and civil aviation fields. The choice of materials and corrosion protection are then discussed with reference to different types of corrosion, including surface and intergranular corrosion, exfoliation, filiform corrosion, stress

corrosion, fretting corrosion, and galvanic corrosion. The discussion also covers maintenance practices and documentation, and hazardous cargoes. V.L.

A91-30572
FUNDAMENTAL PROPERTIES AND SPECIFIC USES OF HIGH PERFORMANCE CORROSION PROTECTIVES IN THE AEROSPACE INDUSTRY
PIERRE CHEMIN (Ardrox, S.A., Paris, France) and CHRISTOPHER G. B. RICH (Brent Chemicals International, PLC, Surface Technology Div., Iver, England) IN: Aerospace corrosion control; Proceedings of the Symposium, Auchterarder, Scotland, Feb. 28-Mar. 2, 1989. London, Sawell Publications, Ltd., 1989, 11 p.
Copyright
The corrosive effects of solid contaminants and sea water on the painted and unpainted surfaces of the airframe and engines of helicopters and fixed-wing aircraft are examined, and some cost-effective products for protection against corrosive contaminants are characterized. In particular, attention is given to two types of protectives: (1) temporary protectives and water-displacing fluids and (2) long-term but easily removable heavy-duty protectives with self-healing properties. The specific uses of these protectives are reviewed. V.L.

A91-30573
NEW TECHNOLOGY AIRCRAFT PAINTING - FIGHTING CORROSION AT SOURCE
MIKE COWLEY (Graco UK, Ltd., England) IN: Aerospace corrosion control; Proceedings of the Symposium, Auchterarder, Scotland, Feb. 28-Mar. 2, 1989. London, Sawell Publications, Ltd., 1989, 19 p.
Copyright
The principal functions and properties of aircraft paints and paint application techniques are examined with emphasis on environmental considerations. The protective, camouflage, and aesthetic apects of paint coatings and the cost effectiveness issues are addressed. Among the innovative painting technologies, the advantages of a new self-generating electrostatic air-assisted spraying process are pointed out. Examples of applications of the new painting process are presented. V.L.

A91-30574
ADVANCES IN THE ANTICORROSION PROPERTIES OF AIRCRAFT CLEANING AND DE-ICING FORMULATIONS
C. G. SMALL, K. R. WINTER (Airworthy, Ltd., Midhurst, England), R. D. DAVIES, and P. J. STAINER IN: Aerospace corrosion control; Proceedings of the Symposium, Auchterarder, Scotland, Feb. 28-Mar. 2, 1989. London, Sawell Publications, Ltd., 1989, 21 p.
Copyright
The development of new compressor washing fluids and deicing/antiicing formulations characterized by improved anticorrosion properties is reported. The discussion covers the reasons for compressor cleaning, cleaning methods, the pros and cons of cold and hot washing, and types of compressor cleaning fluids. Attention is also given to some alternatives to weight loss experiments that allow quicker evaluation of candidate formulations at the development stage in more severe corrosive environments. Test results for new cleaning fluids and deicing/antiicing compounds are presented. V.L.

A91-30726
PLASTIC TIGER
GEORGE MARSH Aerospace Composites and Materials (ISSN 0954-5832), vol. 3, Mar.-Apr. 1991, p. 4-7.
Copyright
This paper reviews the advanced composite structure of the combat helicopter, Tiger, designed to meet the anti-tank mission requirements of the French and German armies, which will have a composite content by weight of almost 80 percent. Designers have selected T300 carbon and Kevlar 49 fibers, utilized in epoxy resins having curing temperatures of 120 C or 180 C, depending on the service temperature expected in the particular airframe zone. Kevlar and carbon skins over Nomex honeycomb core make up most fuselage panels. Frames plus longitudinal and transverse beams are of carbon/Kevlar or carbon-epoxy laminate. Elastomeric bearings allow for the necessary blade articulation of the 13 m diameter, four-blade hingeless-type main rotor. Tail rotor blades comprise a carbon composite envelope with glass composite trailing edge, over a profiled rigid foam inner, stiffened by carbon ribs and a glassfiber roving stiffener. R.E.P.

A91-30727
NOT BLACK ALUMINIUM
FRANK COLUCCI Aerospace Composites and Materials (ISSN 0954-5832), vol. 3, Mar.-Apr. 1991, p. 8-11.
Copyright
This paper describes Boeing's Model 360 high-speed research helicopter, built as a technology demonstrator largely to evaluate composite materials and fabrication techniques. The Model 360 has a design gross weight of 30,500 lb, making extensive utilization of Kevlar-skinned Nomex core sandwich, and main rotor driveshafts and other dynamic components made of glass-graphite hybrids. The fuselage is calculated to be 22 percent lighter than a comparable metal airframe and has 85 percent fewer parts and 90 percent fewer fasteners. Designers have avoided employing principles developed for metal aircraft on carbon fiber composite types (black aluminum). Mixed-modulus hybrid composites containing up to 50 percent graphite have combined the tailored stiffness of carbon with the slow, detectable failure modes of glass utilized throughout the vehicle dynamics. Landing gear beams are composed of unidirectional prepreg in a quasi-isotropic lay-up, half the plies at + or - 45 deg orientation and half at 0 to 90 deg. It is estimated that each graphite beam weighs at least 45 lb less than comparable metal parts; and the entire landing gear bellcrank mechanism is composed of graphite. R.E.P.

A91-30729
BUILDING AIR SUPERIORITY
FRANK COLUCCI Aerospace Composites and Materials (ISSN 0954-5832), vol. 3, Mar.-Apr. 1991, p. 16-19.
Copyright
A review is presented of the new materials and fabrication techniques incorporated in the YF-23 ATF whose reduced radar and IR signatures to avoid detection rely on subtle shaping to deflect and special materials to absorb radar signals. It is estimated that production versions would be 45 to 50 percent composite as compared to the present F-18 comprising just 9.9 percent composites. The thermal requirements of the aircraft resulted in turning to bismaleimide resins that cure at 350 F, with higher temperature polyamide also utilized in composite parts around the engines. The seven large graphite-bismaleimide skin panels on the aft fuselage are combined in a single 10 x 15 demonstration piece that is 20 percent lighter than a comparable aluminum structure. This single-piece aft fuselage skin eliminates 8,000 individual fasteners and incorporates cocured hat stiffeners rather than honeycomb for greater durability and easier repair. Frames, longeron webs and other interior structures will be cobonded with wet fiber tows to eliminate shimming. R.E.P.

A91-30731
THE CAUTIOUS APPROACH
BARRY D. SMITH Aerospace Composites and Materials (ISSN 0954-5832), vol. 3, Mar.-Apr. 1991, p. 24, 25, 27, 28, 30.
Copyright
A review is presented of Boeing's cost effective approach to commercial and military composites and the evolution of composite material applications. Composite applications are described for the 767 that include the use of carbon, Kevlar and carbon/Kevlar throughout the aircraft structure, which is about three percent composite by weight. The development of processes and materials that do not utilize toxic material or reduce their use is seen as a prime thrust in this decade. While composites may always cost more pound for pound, the environmental concerns of processing aluminum show composites to be more competitive. Composites are expected to play an important role in the development of a

supersonic transport, as studies indicate that the only way to meet the required speed, weight, range and payload criteria is to use composites. Attention is also given to advanced composite manufacturing techniques and equipment including a variety of tape-laying machines, large autoclaves, and computer software to operate the equipment, permitting complex curves and shapes to be managed by machine instead of by hand. R.E.P.

A91-30851
NAECON 90; PROCEEDINGS OF THE IEEE NATIONAL AEROSPACE AND ELECTRONICS CONFERENCE, DAYTON, OH, MAY 21-25, 1990. VOLS. 1-3
FRANK L. PALAZZO, ED. (Questech, Inc., Dayton, OH)
Conference sponsored by IEEE. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. Vol. 1, 466 p.; vol. 2, 456 p.; vol. 3, 424 p. For individual items see A91-30852 to A91-31031.
Copyright
The present conference discusses advancements in VLSI components/packaging, signal processing, airborne computers, data transmission, advanced avionics architectures. optical applications, data control and display, airborne image processing, target acquisition and recognition, airborne radar and fire control, navigation, weapons guidance and interfaces, Kalman filtering, power generation and control, and command control and communications. Also discussed are flight control reconfiguration, multivariable control theory, flight management, Ada language applications, object-oriented Ada simulations, software management and quality assurance, visual system software, voice-interaction applications, human/machine interfaces, pilot acceleration protection, electronic combat analysis, modular avionics, expert systems, machine vision/optical image processing, adaptive networks, logistics readiness, automated testing, and total quality management. O.C.

A91-30977
MILITARY AVIONICS RETROFIT PROGRAMS - ENGINEERING AND MANAGEMENT CONSIDERATIONS
ALFRED TERRIS IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1012-1017.
Copyright
Some of the factors that should be considered by the avionic systems retrofit buyer in generating his specifications and request for proposal, as well as some of the factors that should be considered by the retrofit supplier and equipment manufacturer in preparing their proposals, are discussed. When replacing obsolescent equipment with new equipment, there is an effect on aircraft cooling and electrical systems which must be considered. The new equipment will require new ground support equipment at all echelons of maintenance. This can be an expensive item in the total retrofit program budget, and several different approaches to the logistic support part of the program are described. Several avionics retrofit programs that have been executed in the past ten years are described, and several aircraft that will probably undergo avionics retrofit programs in the next five years are discussed. I.E.

A91-31073*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SOFTWARE SAFETY - A USER'S PRACTICAL PERSPECTIVE
WILLIAM R. DUNN and LLOYD D. CORLISS (NASA, Ames Research Center, Moffett Field, CA) IN: 1990 Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 23-25, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 430-435. refs
(Contract NCC2-276; NCC2-609)
Software safety assurance philosophy and practices at the NASA Ames are discussed. It is shown that, to be safe, software must be error-free. Software developments on two digital flight control systems and two ground facility systems are examined, including the overall system and software organization and function, the software-safety issues, and their resolution. The effectiveness of safety assurance methods is discussed, including conventional life-cycle practices, verification and validation testing, software safety analysis, and formal design methods. It is concluded (1) that a practical software safety technology does not yet exist, (2) that it is unlikely that a set of general-purpose analytical techniques can be developed for proving that software is safe, and (3) that successful software safety-assurance practices will have to take into account the detailed design processes employed and show that the software will execute correctly under all possible conditions. I.E.

A91-31284
INNOVATIONS IN ROTORCRAFT TEST TECHNOLOGY FOR THE 90'S; PROCEEDINGS OF THE AHS NATIONAL TECHNICAL SPECIALISTS' MEETING, SCOTTSDALE, AZ, OCT. 8-12, 1990
Alexandria, VA, American Helicopter Society, Inc., 1990, 258 p. For individual items see A91-31285 to A91-31298.
Copyright
Topics presented include optimizing wire crimps using Taguchi designed experiments, the use of a reliability model in the fatigue substantiation of helicopter dynamic components, composite structures designed for impulsive pressure loads, and modal analysis of UH-60A instrumented rotor blades. Also presented are resonance and control response tests using a control stimulation device, a facility for helicopter control systems development, the NASA/Army rotor systems flight research leading to the UH-60 airloads program, and the challenges, problems and resolution in the V-22 flight test program. R.E.P.

A91-31501
HELICOPTER AIRWORTHINESS IN THE 1990S: HEALTH AND USAGE MONITORING SYSTEMS - EXPERIENCE AND APPLICATIONS; PROCEEDINGS OF THE CONFERENCE, LONDON, ENGLAND, NOV. 29, 1990
London, Royal Aeronautical Society, 1990, 78 p. For individual items see A91-31502 to A91-31506.
Copyright
Topics discussed include the regulatory viewpoint, development to production of an integrated HUM system, an operator's viewpoint, and the UK military experience and viewpoint. Also discussed are the development of HUMS for new generation helicopters, the certification and validation process for HUMs in new generation helicopters, and recent developments in airworthiness assurance using unsupervised diagnostic systems for helicopter maintenance. R.E.P.

A91-31504
UK MILITARY EXPERIENCE AND VIEWPOINT
W. J. H. WESTERN (Royal Navy, Directorate of Helicopter Projects, England) and N. J. BOULDING (RAF, London, England) IN: Helicopter airworthiness in the 1990s: Health and usage monitoring systems - Experience and applications; Proceedings of the Conference, London, England, Nov. 29, 1990. London, Royal Aeronautical Society, 1990, p. 4.1-4.15. Ministry of Defence Procurement Executive-supported research.
Copyright
A review is presented of the differences between civil and military health and usage monitoring techniques and discusses the objectives and requirements for any HUMS to be retrofitted to a current military helicopter. Some key areas of military experience and lessons gained from research and development are described. Consideration is given to the military objectives for HUMS, health and usage monitoring requirements, gearbox vibration analysis, rotor track and balance, structural usage monitoring, engine usage monitoring, and fault confirmation. It is suggested that a comprehensive integrated HUMS appears more easily justifiable for the military when included within the design integration of a new helicopter type rather than an existing model. R.E.P.

A91-31505
CERTIFICATION AND VALIDATION PROCESS FOR HUMS IN NEW GENERATION HELICOPTERS
D. FRANCOIS and J. P. DEDIEU (Aerospatiale, Marignane, France) IN: Helicopter airworthiness in the 1990s: Health and usage monitoring systems - Experience and applications; Proceedings of the Conference, London, England, Nov. 29, 1990. London, Royal Aeronautical Society, 1990, p. 6.1-6.4.
Copyright
This paper discusses various problems raised by the HUMS program and describes current work in progress to certify an 'with maintenance credit' HUMS in the future that will improve safety while providing on-condition maintenance. Although extensive tests have been conducted, HUMS introduction in service in the near future will probably raise some problems, i.e., reliability of system components, high purchase cost due to system complexity, unjustified transmission removal costs due to HUMS warnings issued for sensitive criteria, and the management of numerous results and interpretation of trend monitoring for several parameters by the operator. Several techniques are described for monitoring usage and health that will be incorporated in an advanced helicopter design. R.E.P.

A91-31506
RECENT DEVELOPMENTS IN AIRWORTHINESS ASSURANCE USING UNSUPERVISED DIAGNOSTIC SYSTEMS FOR HELICOPTER MAINTENANCE
M. J. ANDREW (M.J.A. Dynamics, Ltd., Southampton, England) IN: Helicopter airworthiness in the 1990s: Health and usage monitoring systems - Experience and applications; Proceedings of the Conference, London, England, Nov. 29, 1990. London, Royal Aeronautical Society, 1990, p. 7.1-7.11. Research supported by Bristow Helicopters, Ltd., Ministry of Defence, and Civil Aviation Authority. refs
Copyright
A number of recent developments in unsupervised diagnostics are presented, ranging from troubleshooting main rotor irregularities, to airframe and component anomalies, to faults which might result in catastrophic failure. The diagnostics, once established, are software coded and implemented on a ground station computer that directly supports the avionic based Integrated Health and Usage Monitoring System (IHUMS) operations. Consideration is given to the computer math model, checking maintenance/data integrity, airframe/component diagnostics, transfer function analysis, and potentially catastrophic faults. R.E.P.

A91-31726
AIAA LIGHTER-THAN-AIR SYSTEMS TECHNOLOGY CONFERENCE, 9TH, SAN DIEGO, CA, APR. 9-11, 1991, TECHNICAL PAPERS
Washington, DC, American Institute of Aeronautics and Astronautics, 1991, 110 p. For individual items see A91-31727 to A91-31739.
Copyright
The present conference discusses airship defensive weaponry, the DOD's recent policy toward airship development in view of prospective defense missions, TCOM LTA technology and operations, analytical results for airship lateral maneuverability, a desktop-computer nonlinear-aerodynamics airship simulator, and flight-dynamics simulations of airship responses to turbulence. Also discussed are an empirical method for nonrigid airship drag estimation, U.S. Navy airship testing practices, LTA developments in the UK, the Varicar airship, the use of airships as research platforms, FAA-type certification of the US/LTA 138S, and applications of a cycloidal propeller. O.C.

A91-31735#
LIGHTER-THAN-AIR DEVELOPMENTS IN THE UNITED KINGDOM
A. W. L. NAYLER (Royal Aeronautical Society, London, England) IN: AIAA Lighter-Than-Air Systems Technology Conference, 9th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 70-80. refs
(AIAA PAPER 91-1280) Copyright
An account is given of the design features and performance characteristics of some of the 26 helium-lift and over 100 thermal airship designs which British companies have designed, built, and in many cases successfully commercialized over the last 20 years; nearly all have been sold in export markets. While most of these small nonrigid airships have been used in advertising and promotion activities, two of the larger Skyship designs have been sold to Japan and South Korea for manned police and surveillance duties. Attention is given to the specifications of the Sentinel 1000 and YEZ-2A helium airships, which are representative of state-of-the-art design in components, avionics, structures, and propulsion. O.C.

A91-31737#
AIRSHIPS AS AIRBORNE RESEARCH PLATFORMS
RON HOCHSTETLER (Veda, Inc., Arlington, VA) IN: AIAA Lighter-Than-Air Systems Technology Conference, 9th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 90-93.
(AIAA PAPER 91-1287) Copyright
The airship intrinsically incorporates some features typical of airborne and others of seaborne research platforms; they are presently evaluated as lower cost/longer mission duration alternatives to aircraft. A particular virtue of the airship in research applications is its low-speed stability, which allows sensors to conduct higher-resolution observations. Airships also provide the low-vibration environment required for motion-sensitive instruments, and allow sensor arrays to be towed or dragged. The large dimensions of even the smallest airship facilitate the incorporation of large wind profilers, radar arrays, etc. A tabulation is presented of commercially available airships' endurance and maximum disposable load performance figures. O.C.

A91-32001*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN OVERVIEW OF NASA RESEARCH RELATED TO THE AGING COMMERCIAL TRANSPORT FLEET
CHARLES E. HARRIS and JOSEPH S. HEYMAN (NASA, Langley Research Center, Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1661-1666. refs
(AIAA PAPER 91-0952) Copyright
This paper describes the research activities of the NASA Airframe Structural Integrity Program for the aging commercial transport fleet. Advanced analysis methods are under development to predict the fatigue crack growth in complex built-up shell structures. Innovative nondestructive examination technologies are under development to provide large area inspection capability to detect corrosion, disbonds, and fatigue cracks. The ultimate goal of this interdisciplinary program is to develop and transfer advanced technology to the airline operators and airframe manufacturers. The program is being conducted cooperatively with the FAA and the U.S. industry. Author

A91-32176#
PERFORMANCE DATA ACQUISITION FROM FLEXIBLE AERODYNAMIC DECELERATORS
J. K. TYAGI, P. C. KHANDELWAL, and R. K. KALE (Aerial Delivery Research and Development Establishment, Agra, India) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 223-229. refs
(AIAA PAPER 91-0861) Copyright
Instrumentation and techniques utilized to acquire flight performance data from a flexible aerodynamic decelerator are discussed. These techniques are used for obtaining useful parameters from snatch load, opening shock load, fabric stress, suspension line tension, oscillations, and pressure distribution

during tests in a wind tunnel, free flight or rocket sled. Different types of transducers utilized with parachutes for data acquisition are described, and details and specifications are given of signal conditioners, charge amplifier and related hardware for collecting the measurements and converting them into a form suitable for simultaneous transmission on a single carrier (radio) frequency to a receiving (ground) station. R.E.P.

N91-19024*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
JOINT UNIVERSITY PROGRAM FOR AIR TRANSPORTATION RESEARCH, 1989-1990
FREDERICK R. MORRELL, comp. Washington Dec. 1990 183 p Conference held in Athens, OH, 14-15 Jun. 1990; sponsored by NASA and FAA
(NASA-CP-3095; L-16848; NAS 1.55:3095) Avail: NTIS HC/MF A09 CSCL 01A

Research conducted during the academic year 1989-90 under the NASA/FAA sponsored Joint University Program for Air Transportation research is discussed. Completed works, status reports and annotated bibliographies are presented for research topics, which include navigation, guidance and control theory and practice, aircraft performance, human factors, and expert systems concepts applied to airport operations. An overview of the year's activities for each university is also presented.

N91-19040# Wichita State Univ., KS. National Inst. for Aviation Research.
DEDICATION OF NATIONAL INSTITUTE FOR AVIATION RESEARCH
WILLIAM H. WENTZ, JR. Jul. 1990 15 p
(NIAR-90-21) Avail: NTIS HC/MF A03

The research activities performed at the Wichita State University are reviewed. The following subject areas are covered: aerodynamics, propulsion, de-icing, human factors, flight controls, navigation, advanced composites, materials, cryogenics/superconductors, CIM (Computer-Integrated-Manufacturing), aircraft inspection robot, crash sled, and crash computations. Y.S.

N91-19041*# Army Aviation Research and Development Command, Moffett Field, CA. Aeroflightdynamics Directorate.
A FLIGHT-DYNAMIC HELICOPTER MATHEMATICAL MODEL WITH A SINGLE FLAP-LAG-TORSION MAIN ROTOR
MARC D. TAKAHASHI Feb. 1990 114 p
(NASA-TM-102267; A-90037; NAS 1.15:102267; USAAVSCOM-TM-90-A-004) Avail: NTIS HC/MF A06 CSCL 01B

A mathematical model of a helicopter system with a single main rotor that includes rigid, hinge-restrained rotor blades with flap, lag, and torsion degrees of freedom is described. The model allows several hinge sequences and two offsets in the hinges. Quasi-steady Greenberg theory is used to calculate the blade-section aerodynamic forces, and inflow effects are accounted for by using three-state nonlinear dynamic inflow model. The motion of the rigid fuselage is defined by six degrees of freedom, and an optional rotor rpm degree of freedom is available. Empennage surfaces and the tail rotor are modeled, and the effect of main-rotor downwash on these elements is included. Model trim linearization, and time-integration operations are described and can be applied to a subset of the model in the rotating or nonrotating coordinate frame. A preliminary validation of the model is made by comparing its results with those of other analytical and experimental studies. This publication presents the results of research compiled in November 1989. Author

N91-20042# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
ANALYSIS OF THE MAINTAINABILITY OF THE F-16 A/B ADVANCED MULTI-PURPOSE SUPPORT ENVIRONMENT M.S. Thesis
VAUGHN K. GRACE Dec. 1990 285 p
(AD-A230604; AFIT/GCS/ENC/90D-1) Avail: NTIS HC/MF A13 CSCL 12/5

The goal of this thesis was to develop an object oriented design methodology for use within the F-16 A/B advanced multi-purpose support environment (AMPSE). The instrument landing system (ILS) was the software simulation model chosen to be redesigned using the object oriented design guidelines developed over the course of this study. The new ILS design was then implemented in the Ada programming language. This model served as a prototype to test the feasibility of developing object oriented flight simulator environments. This thesis presents background on the F-16 A/B AMPSE system, the structure of the current system and simulation, guidelines for redesigning the current F-16 A/B AMPSE system, and guidelines for developing future object oriented AMPSE systems. GRA

N91-20710*# Aerospace Medical Research Labs., Wright-Patterson AFB, OH.
A SPATIAL DISORIENTATION PREDICTOR DEVICE TO ENHANCE PILOT SITUATIONAL AWARENESS REGARDING AIRCRAFT ATTITUDE
T. L. CHELETTE, DANIEL W. REPPERGER, and W. B. ALBERY *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 536-541 Jan. 1991
Avail: NTIS HC/MF A14 CSCL 01/4

An effort was initiated at the Armstrong Aerospace Medical Research Laboratory (AAMRL) to investigate the improvement of the situational awareness of a pilot with respect to his aircraft's spatial orientation. The end product of this study is a device to alert a pilot to potentially disorienting situations. Much like a ground collision avoidance system (GCAS) is used in fighter aircraft to alert the pilot to 'pull up' when dangerous flight paths are predicted, this device warns the pilot to put a higher priority on attention to the orientation instrument. A Kalman filter was developed which estimates the pilot's perceived position and orientation. The input to the Kalman filter consists of two classes of data. The first class of data consists of noise parameters (indicating parameter uncertainty), conflict signals (e.g. vestibular and kinesthetic signal disagreement), and some nonlinear effects. The Kalman filter's perceived estimates are now the sum of both Class 1 data (good information) and Class 2 data (distorted information). When the estimated perceived position or orientation is significantly different from the actual position or orientation, the pilot is alerted. Author

02

AERODYNAMICS

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

A91-28473
INFLUENCE OF FUSELAGE ON ROTOR INFLOW PERFORMANCE AND TRIM
ARNAUD DEHONDT (Ecole Nationale Superieure de Mecanique et d'Aerotechnique, Poitiers, France) and FRANCOIS TOULMAY (Aerospatiale, Division Helicopteres, Marignane, France) Vertica (ISSN 0360-5450), vol. 14, no. 4, 1990, p. 573-585. refs
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The correlation between a new rotor code and extensive velocity measurements performed at NASA Langley Research Center is showing that the interference from the fuselage significantly modifies the inflow in the front part of the rotor disk; in the rear part, the inviscid flow prediction of the fuselage effect fails presumably due to the wake of the rotor hub and upper cowlings. A crude but satisfactory approximation of the actual inflow is obtained, in this case, by computing with the fuselage perturbation velocity on the front half disk and without it on the rear half disk.

Under the unfluence of the fuselage and for constant rotor forces, the induced power is sharply reduced and this explaines a similar but lower reduction in total power. The cyclic pitch required to trim the rotor laterally is augmented under the influence of the fuselage. The magnitude of these effects is highly dependent on the actual downwash in the rear half disk. Author

A91-28474

PARAMETRIC STUDY OF A PRESCRIBED WAKE MODEL OF A ROTOR IN FORWARD FLIGHT

O. RAND and A. ROSEN (Technion - Israel Institute of Technology, Haifa) Vertica (ISSN 0360-5450), vol. 14, no. 4, 1990, p. 587-598.

Copyright

A study of the influence of different parameters on the results of an unsteady prescribed wake model of a rotor in forward flight, is presented. The investigation includes the relative importance of different elements of the wake and the influence of the number of segments along the blade, number of azimuthal control stations, Mach and lift curve slope corrections, number of bound circulation harmonics, the wake length, rollup location, and other parameters. The parametric study is performed for a four bladed rotor in forward flight and compared with flight test results. The results of the study may serve as guidelines for constructing an aerodynamic model of a rotor in forward flight. Author

A91-28513#

AN EXPERIMENTAL DATA BASED COMPUTER CODE FOR THE NORMAL FORCE CHARACTERISTICS OF WINGS UP TO HIGH ANGLES OF ATTACK

S. VENUGOPAL (Defence Research and Development Laboratory, Hyderabad, India) and M. KRISHNAMURTHY (National Aeronautical Laboratory, Bangalore, India) (National Conference on Aerodynamics, 5th, Poona, India, May 1990) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 42, Nov. 1990, p. 293-298. Research sponsored by Defence Research and Development Laboratory. refs

A computer code is presented to compute the normal force characteristics of thin wings with zero trailing-edge sweep up to very high angles of attack. The methodology utilizes linear/quadratic interpolation/extrapolation from a data base constructed utilizing the experimental data available in the literature. This data base has been constructed for a range of aspect ratios from 0.5 to 3.53, for taper ratios from 0 to 1.0, for Mach numbers from 0.8 to 3.0, and for angles of attack up to 60 deg. It is shown that the DATCOM predictions agree well with the results based on the constructed data base up to alpha = 30 deg. R.E.P.

A91-28514#

PITCH AND ROLL DERIVATIVES OF A DELTA WING WITH CURVED LEADING EDGE IN HIGH SPEED FLOW

K. GHOSH (Indian Institute of Technology, Kanpur, India), M. MURTHY, S. A. KHAN, and P. K. PANDE (National Conference on Aerodynamics, 5th, Poona, India, May 1990) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 42, Nov. 1990, p. 299-303. refs

A theory is presented that provides a simple method of predicting the damping derivative with respect to pitch rate and the damping derivative with respect to incidence rate separately. The damping derivative with respect to pitch rate curve for the combined effect of windward and lee surfaces can be constructed from the damping derivative with respect to incidence rate. This theory, which utilizes unified similitude and includes the effect of leeward surface, is compared with the results obtained by Ghosh (1984) for a hypersonic delta wing. It is shown that the contribution of the lee side is significant at lower Mach numbers. R.E.P.

A91-28590* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

NUMERICAL SIMULATIONS OF SUPERSONIC FLOW THROUGH OSCILLATING CASCADE SECTIONS

DENNIS L. HUFF (NASA, Lewis Research Center, Cleveland, OH) and T. S. R. REDDY (Toledo, University, OH) IN: Developments in theoretical and applied mechanics. Vol. 15 - Proceedings of the 15th Southeastern Conference on Theoretical and Applied Mechanics, Atlanta, GA, Mar. 22, 23, 1990. Atlanta, GA, Georgia Institute of Technology, 1990, p. 187-194. refs

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A finite difference code has been developed for modeling inviscid, unsteady supersonic flow by solution of the compressible Euler equations. The code uses a deforming grid technique to capture the motion of the airfoils and can model oscillating cascades with any arbitrary interblade phase angle. A flat plate cascade is analyzed, and results are compared with results from a small-perturbation theory. The results show very good agreement for both the unsteady pressure distributions and the integrated force predictions. The reason for using the numerical Euler code over a small-perturbation theory is the ability to model 'real' airfoils that have thickness and camber. Sample predictions are presented for a cascade of loaded airfoils and show appreciable differences in the unsteady surface pressure distributions when compared with the flat plate results. Author

A91-28602* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AN AIRFOIL DESIGN METHOD FOR VISCOUS FLOWS

J. B. MALONE (NASA, Langley Research Center, Hampton, VA), J. C. NARRAMORE (Bell Helicopter Textron, Inc., Fort Worth, TX), and L. N. SANKAR (Georgia Institute of Technology, Atlanta) IN: Developments in theoretical and applied mechanics. Vol. 15 - Proceedings of the 15th Southeastern Conference on Theoretical and Applied Mechanics, Atlanta, GA, Mar. 22, 23, 1990. Atlanta, GA, Georgia Institute of Technology, 1990, p. 463-470. refs

Copyright

An airfoil design procedure is described that has been incorporated into an existing two-dimensional Navier-Stokes airfoil analysis method. The resulting design method, an iterative procedure based on a residual-correction algorithm, permits the automated design of airfoil sections with prescribed surface pressure distributions. This paper describes the inverse design method and the technique used to specify target pressure distributions. An example airfoil design problem is described to demonstrate application of the inverse design procedure. It shows that this inverse design method develops useful airfoil configurations with a reasonable expenditure of computer resources. Author

A91-28604

A STUDY OF THE DYNAMIC STALL CHARACTERISTICS OF CIRCULATION CONTROL AIRFOILS

GEORGE SHREWSBURY and L. N. SANKAR (Georgia Institute of Technology, Atlanta) IN: Developments in theoretical and applied mechanics. Vol. 15 - Proceedings of the 15th Southeastern Conference on Theoretical and Applied Mechanics, Atlanta, GA, Mar. 22, 23, 1990. Atlanta, GA, Georgia Institute of Technology, 1990, p. 479-486. refs

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A two-dimensional, time accurate Navier-Stokes analysis method is employed to determine the dynamic airloads of a circulation control airfoil. The unsteady two-dimensional and quasi-three-dimensional, Reynolds averaged, compressible Navier-Stokes equations are solved in a body-fitted coordinate system utilizing an alternating direction implicit procedure. It is concluded that circulation control can effectively modulate the lift for rotorcraft applications. When dynamic stall is encountered the loss in lift is spread over a greater portion of the pitching cycle and the minimum lift is not seen until the separation vortex is convected free of the airfoil surface. The almost constant reduced values of lift noted on the downstroke of conventional airfoil encountering dynamic stall are not observed for the circulation control airfoil, and the lift starts to recover immediately following the minimum lift condition. R.E.P.

A91-28620

FLOWFIELD MEASUREMENTS NEAR THE TIP OF A ROTOR BLADE NEAR STALL

S.-G. LIOU and N. M. KOMERATH (Georgia Institute of Technology, Atlanta) IN: Developments in theoretical and applied mechanics. Vol. 15 - Proceedings of the 15th Southeastern Conference on Theoretical and Applied Mechanics, Atlanta, GA, Mar. 22, 23, 1990. Atlanta, GA, Georgia Institute of Technology, 1990, p. 703-710.

Copyright

This paper describes an experiment to visualize and measure the flowfield around the tip of a model helicopter rotor at high pitch angles. Strobed and continuous laser sheet flow visualization and laser Doppler velocimetry are used to understand the behavior of the flow over an advanced blade tip shape at high pitch angles, under incompressible flow conditions. No strong vortices are seen to emanate from the forward-swept leading edge of the blade; however, the velocity data indicate the presence of two distinct sets of vortical structures. This is in accordance with computational predictions, and at variance with fixed-wing studies of such blade shapes. The tip vortex structure is quite different at high pitch settings, where it resembles the vortex flow over a stalled delta wing. Author

A91-28621

INFLOW TO A ROTOR BLADE UNDER CONTROLLED EXCITATION

S.-G. LIOU and N. M. KOMERATH (Georgia Institute of Technology, Atlanta) IN: Developments in theoretical and applied mechanics. Vol. 15 - Proceedings of the 15th Southeastern Conference on Theoretical and Applied Mechanics, Atlanta, GA, Mar. 22, 23, 1990. Atlanta, GA, Georgia Institute of Technology, 1990, p. 711-717. U.S. Army-supported research. refs

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The inflow to a two-bladed rotor in hover has been measured using a laser velocimeter, first under steady conditions, and then under prescribed periodic pitch excitation. This experiment requires high data rates, and new data acquisition techniques, which have been demonstrated. The steady case has been compared with lifting-line-based analytical predictions, and shows that the measurements are free of facility confinement effects. Initial results of the unsteady measurements are presented. Author

A91-28622* McDonnell-Douglas Helicopter Co., Mesa, AZ.

FINITE-DIFFERENCE SOLUTIONS OF THREE-DIMENSIONAL ROTOR BLADE-VORTEX INTERACTIONS

A. A. HASSAN (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: Developments in theoretical and applied mechanics. Vol. 15 - Proceedings of the 15th Southeastern Conference on Theoretical and Applied Mechanics, Atlanta, GA, Mar. 22, 23, 1990. Atlanta, GA, Georgia Institute of Technology, 1990, p. 718-724. refs

(Contract NAS1-17145)

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A numerical finite-difference procedure has been developed for the modeling of rotor self-generated blade-vortex interactions (BVI). The interaction velocity field is obtained through a nonlinear superposition of the rotor and the vortex wake flow fields. Vortex effects are simulated using the velocity 'transpiration' approach. Potential blade-vortex encounters are identified and tracked in time at equal increments of rotor azimuth using the lifting-line helicopter/rotor trim code CAMRAD. Accuracy of the numerical results were found to rely heavily on the CAMRAD-predicted vortex orientation, vortex strength, and user specified vortex core radius. Results for the subcritical self-generated BVI for the model OLS rotor are presented. They show good agreement with the experimental wind tunnel data. Author

A91-29752

MODELLING OF TURBULENT TRANSONIC FLOW AROUND AEROFOILS AND WINGS

BERNHARD MUELLER and ARTHUR RIZZI (Aeronautical Research Institute of Sweden, Bromma) Communications in Applied Numerical Methods (ISSN 0748-8025), vol. 6, Nov. 1990, p. 603-613. refs

Copyright

Turbulent flows around aerofoils and wings are simulated by solving the two- and three-dimensional Navier-Stokes equations in quadrilaterals and hexahedrons, respectively. Turbulent flow is described by an algebraic eddy viscosity model. Boundary-conforming O- and O-O-type meshes are generated by the transfinite interpolation method. The finite-volume technique is employed for spatial discretization using two cells in each computational coordinate direction more than the conventional approach to evaluate the viscous fluxes. An explicit three-stage Runge-Kutta scheme is used for time integration. The method is applied to compute turbulent transonic flow over the NACA 0012 aerofoil and the ONERA M6 wing. The results are compared with experimental and computational data. Author

A91-29830

CHARACTERISTICS OF THE INTERACTION OF SHOCK WAVES WITH A TURBULENT BOUNDARY LAYER UNDER CONDITIONS OF TRANSONIC AND SUPERSONIC VELOCITIES [OSOBENNOSTI VZAIMODEISTVIIA SKACHKOV UPLOTNENIIA S TURBULENTNYM POGRANICHNYM SLOEM V USLOVIIAKH TRANS- I SVERKHZVUKOVYKH SKOROSTEI]

A. A. ZHELTOVODOV (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR), R. DVORAK, and P. SAFARIK (Czechoslovak Academy of Sciences, Institute of Thermomechanics, Prague, Czechoslovakia) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Dec. 1990, p. 31-42. In Russian. refs

Copyright

The conditions leading to flow separation and separated flow evolution are investigated experimentally and analytically for the case of flows with sliding direct shock waves, such as flow around a vertical fin on a plane surface. In particular, attention is given to two-dimensional interaction between a direct shock wave and a turbulent boundary layer at transonic velocities and three-dimensional interaction between sliding shock waves and a turbulent boundary layer. Criteria are proposed which determine the characteristic stages of two- and three-dimensional separation, and the possibility of applying these criteria to the general case of flow past three-dimensional corner configurations is demonstrated. V.L.

A91-29834

INTERACTION BETWEEN A SUPERSONIC UNDEREXPANDED JET AND A SCREEN WITH AN OPENING COAXIAL WITH THE JET [VZAIMODEISTVIE SVERKHZVUKOVOI NEDORASSHIRENNOI STRUI S PREGRADOI, IMEIUSHCHEI SOOSNOE SO STRUEI OTVERSTIE]

IU. R. VAKHITOV and B. P. RUDOI (Ufimskii Aviatsionnyi Institut, Ufa, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Dec. 1990, p. 64-66. In Russian.

Copyright

The interaction between a supersonic jet and a screen was investigated experimentally using jets with internal-to-external pressure ratios of 8.5 for Mach 1.2 at the nozzle exit section. Two types of screens were used: a solid screen and a screen with an opening coaxial with the jet; the opening diameter was equal to that of the jet (8.1 mm). It is found that the flow structure upstream of the screen is essentially the same in both cases. The parameters of the jet issuing from the opening are dependent on the distance between the nozzle and the screen. However, there are certain differences in the flow regimes. One of the differences is the absence of strong instability in the case of the screen with an opening. V.L.

A91-29921

AN EXPERIMENTAL STUDY OF FLOW SEPARATION OVER A SPHERE [EKSPERIMENTAL'NYE ISSLEDOVANIIA OTRYVA POTOKA PRI OBTEKANII SFERY]

V. P. KARIAGIN, A. I. LOPATKIN, A. I. SHVETS, and M. M. SHILIN Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i

Gaza (ISSN 0568-5281), Jan.-Feb. 1991, p. 152-156. In Russian. refs
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Flow past a sphere was investigated experimentally over a wide range of Mach (0.3-3) and Reynolds (3 x 10 to the 4th - 3 x 10 to the 7th) numbers. The experiments were carried out on a ballistic test stand and in a wind tunnel. Flow patterns and pressure distributions are determined. The effect of the M and Re numbers on the location of the separation point and compression shock is discussed. The separation point is found to shift nonmonotonically during the supersonic transition. V.L.

A91-30014*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THREE-DIMENSIONAL VISCOUS FLOW COMPUTATIONS OF HIGH AREA RATIO NOZZLES FOR HYPERSONIC PROPULSION
D. R. REDDY and G. J. HARLOFF (NASA, Lewis Research Center; Sverdrup Technology, Inc., Brook Park, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Jan.-Feb. 1991, p. 84-89. refs
(Contract NAS3-24105; NAS3-25266)
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The PARC3D code was selected by the authors to analyze a variety of complex and high-speed flow configurations. Geometries considered for code validation include ramps and corner flows, which are characteristic of inlets and nozzles. Flows with Mach numbers of 3-14 were studied. Both two- and three-dimensional experimental data for shock-boundary-layer interaction were considered to validate the code. A detailed comparison of various flow parameters with available experimental data is presented; agreement between the solutions and the experimental data in terms of pitot pressure profiles, yaw-angle distributions, static pressures, and skin friction is found to be very good. In addition, two- and three-dimensional flow calculations were performed for a hypersonic nozzle. Comparison of the wall pressure results with the published solutions is made for the two-dimensional case. Author

A91-30018#
ANALYSIS OF SLOT INJECTION IN HYPERSONIC FLOW
J. A. SCHETZ, F. S. BILLIG, and S. FAVIN (Johns Hopkins University, Laurel, MD) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Jan.-Feb. 1991, p. 115-122. U.S. Navy-supported research. Previously cited in issue 20, p. 3082, Accession no. A89-46844. refs
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A91-30021* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NEWTON'S METHOD APPLIED TO FINITE-DIFFERENCE APPROXIMATIONS FOR THE STEADY-STATE COMPRESSIBLE NAVIER-STOKES EQUATIONS
HARRY E. BAILEY and RICHARD M. BEAM (NASA, Ames Research Center, Moffett Field, CA) Journal of Computational Physics (ISSN 0021-9991), vol. 93, March 1991, p. 108-127. refs
Copyright

Finite-difference approximations for steady-state compressible Navier-Stokes equations, whose two spatial dimensions are written in generalized curvilinear coordinates and strong conservation-law form, are presently solved by means of Newton's method in order to obtain a lifting-airfoil flow field under subsonic and transonnic conditions. In addition to ascertaining the computational requirements of an initial guess ensuring convergence and the degree of computational efficiency obtainable via the approximate Newton method's freezing of the Jacobian matrices, attention is given to the need for auxiliary methods assessing the temporal stability of steady-state solutions. It is demonstrated that nonunique solutions of the finite-difference equations are obtainable by Newton's method in conjunction with a continuation method. O.C.

A91-30081* Georgia Inst. of Tech., Atlanta.
A PROPOSED COMPUTATIONAL TECHNIQUE FOR OBTAINING HYPERSONIC AIR DATA ON A SHARP-NOSED VEHICLE
JAMIE B. TARASIDIS (Georgia Institute of Technology, Atlanta), R. F. HELLBAUM, and H. DOUGLAS GARNER (NASA, Langley Research Center, Hampton, VA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 777-781. refs
(Contract NAS1-18000)
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A computational technique has been developed to obtain final air data quantities for a sharp-nosed hypersonic vehicle. Pressure measurements from five flush pressure ports are the only input needed. Four of the ports are installed around the forebody circumference and the fifth is on the nose. The pressure model is based on Lees-modified Newtonian method and corrected by pressure data from computational fluid dynamics analysis. Although this approach is similar to that used for the blunt-nosed space shuttle, it is designed specifically for a sharp-nosed aircraft. The potential of this method has been demonstrated, especially in obtaining values for dynamic pressure and angle of attack. I.E.

A91-30530
VELOCITY MEASUREMENTS AND STABILITY INVESTIGATIONS ON BURSTING TIP VORTICES [GESCHWINDIGKEITSMESSUNGEN UND STABILITAETSUNTERSUCHUNGEN AN AUFPLATZENDEN RANDWIRBELN]
T. VITTING, R. STAUFENBIEL, and D. COORS (Aachen, Rheinische-Westfaelische Technische Hochschule, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 15, Feb. 1991, p. 33-42. In German. refs
(Contract DFG-SFB-25)
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Experiments on disturbed and bursting tip vortices are described. A combination of flow visualization and laser velocimetry is used to obtain the velocity profiles of the disturbed vortex core in the transition to breakdown regime. Stability investigations using these data show a correlation between core instability and breakdown. Author

A91-30541
COMPUTATION OF HYPERSONIC FLOWS ROUND A BLUNT BODY
CHARLES-HENRI BRUNEAU (Paris XI, Universite, Orsay, France) Computers and Fluids (ISSN 0045-7930), vol. 19, no. 2, 1991, p. 231-242. Research supported by ESA, CNES, Dassault Aviation, and Ecole Polytechnique. refs
(Contract DRET-87-229)
Copyright

The two-dimensional Euler equations in density and velocity variables are solved by a variational method based on a Newton linearization and a least-squares embedding. Flows around a blunt body are computed for hypersonic regimes. The strong bow shock occurring in front of the nose is captured in a first step by means of an entropy corrector added to the least-squares functional. Then a mesh adaptation and displacement procedure is used to fit the mesh to the shock and to give the location of the shock. Numerical results are presented for Mach numbers at infinity of 3 and 8 round a circular cylinder and an ellipse. Author

A91-30732
AIRFOILS WITH SIMILAR BOUNDARY LAYERS [PROFILY S PODOBNYMI MEZNIMI VRSTVAMI]
PETR BERAK Zpravodaj VZLU (ISSN 0044-5355), no. 1, 1991, p. 5-15. In Czech. refs
Copyright

By applying the inverse method, it is possible to compute wing sections that have boundary layers on one side identical with or similar to those of selected aerofoils. The basic aerofoil section was computed in analogy with the Liebeck L1003 section. With an affine increase of velocity of 10 percent, maintaining at the same time the aerofoil thickness, the maximum lift coefficient increased from 2.17 to 2.89, or 33 percent. But the fineness of the aerofoil sections decreases. Further, a 50.4 percent symmetrical section designed as an aerodynamical fairing was computed. The work represents a shape study of the method of aerodynamic modifications and is aimed at laminar aerofil sections for gliders and light aircraft. Author

A91-30766
NUMERICAL SIMULATION IN HYPERSONIC AERODYNAMICS - TAKING INTO ACCOUNT THE EQUILIBRIUM CHEMICAL COMPOSITION OF AIR USING A VECTORIZED EQUATION OF STATE [SIMULATION NUMERIQUE EN AERODYNAMIQUE HYPERSONIQUE - PRISE EN COMPTE DE LA CHIMIE DE L'AIR A L'EQUILIBRE AU MOYEN D'UNE EQUATION D'ETAT 'VECTORISEE']
J. P. MORREEUW (CEA, Centre d'Etudes de Limeil-Valenton, France) Revue Scientifique et Technique de la Defense (ISSN 0994-1541), 2nd Quarter, 1990, p. 33-39. In French. refs
Copyright

The Hansen model is used to obtain a curve fitting of an air equation of state. The validity of this approximation lies in a range of air density between 100 and 10 to the -6th kg/cu m, and for a specific energy less than 7 x 10 to the 7th SI. This corresponds to hypersonic-aerodynamics applications at Mach numbers up to 30. R.E.P.

A91-31305* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SUGGESTED FUTURE DIRECTIONS IN HIGH-SPEED TRANSITION EXPERIMENTAL RESEARCH
DENNIS BUSHNELL (NASA, Langley Research Center, Hampton, VA) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 1. New York, Springer-Verlag, 1990, p. 45-48.
Copyright

Historical developments in the area of high-speed experimental transition research are outlined, and future directions in this area as determined by the panel membership are listed. The directions include measurement and modeling of initial disturbance fields, both in ground facilities and flight, for all modes; development of advanced high-speed instrumentation for disturbance field measurements, measurements of the details of receptivity in multitudinous flows; further development and use of high-speed quiet tunnels; stability and transition studies for multitudinous flows; detailed studies of the transitional region for boundary layers, free flows, vortices separated flows, corner flows, etc.; and studies of flow-chemistry effects on transition phenomena. Applied research such areas as the physics of perforated-surface suction stabilization and the resolution of anomalies in the existing high-speed database is also suggested. V.T.

A91-31307* Montana State Univ., Bozeman.
TRANSITION IN HIGH-SPEED FREE SHEAR LAYERS
A. DEMETRIADES (Montana State University, Bozeman) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 1. New York, Springer-Verlag, 1990, p. 52-67. refs
(Contract NAS1-18605)
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The laminar free-shear layers considered in the study are formed by combinations of the velocities and momentum thicknesses of two adjacent parallel flows. Transition in wakes, pure free-shear layers of the Chapman type, and separate and partition flows are discussed. A stability-transition connection is emphasized, and it is suggested that a recurring deficiency in some stability calculations is the use of overly simplified laminar profiles. It is also noted that physical principles can be used for estimating the transition location or providing the factors affecting it. One such approach, a threshold theory, is discussed by way of example. V.T.

A91-31308 Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SOME COMPARISONS OF LINEAR STABILITY THEORY WITH EXPERIMENT AT SUPERSONIC AND HYPERSONIC SPEED
JAMES M. KENDALL, JR. (JPL, Pasadena, CA) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 1. New York, Springer-Verlag, 1990, p. 68-76. refs
(Contract NAS1-18605)
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Measurements of waves initiated by wind-tunnel sounds are obtained for both supersonic and hypersonic speed. Flat-plate experiments carried out at Mach numbers of 4.5, 3.7, and 2.4 under the condition of laminar tunnel-wall boundary layers whereby a low background fluctuation level prevailed are outlined, as well as flat-plate experiments with sound-induced waves at supersonic speeds. Experimental studies of 'natural' wave growth on sharp cones at zero angle of attack and Mach numbers near 8 are discussed. Attention is focused on experimental research needed on boundary-layer receptivity to eddy Mach-wave radiation, hypersonic speed, and the stability-transition relationship in zero-pressure-gradient layers. V.T.

A91-31310* Case Western Reserve Univ., Cleveland, OH.
TRANSITION RESEARCH USING FLIGHT EXPERIMENTS
ELI RESHOTKO (Case Western Reserve University, Cleveland, OH) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 1. New York, Springer-Verlag, 1990, p. 88-90.
(Contract NAS1-18605)
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The paper deals with flight experiments as a means of obtaining proper transition information in an uncontaminated environment. Flight transition experiments performed in the early to middle 1950s using rocket-propelled vehicles are outlined. It is noted that the standards for research quality experiments on stability and transition are no different for flight studies than for wind-tunnel experiments. The guidelines formulated by the U.S. Boundary Layer Transition Study Group are listed. Attention is focused on the relationship between the model design and the measurement of disturbance environment, the maintenance and monitoring of test and model-surface conditions, and a need for high data-sampling rates. V.T.

A91-31311
HYPERSONIC TRANSITION TESTING IN WIND TUNNELS
KENNETH F. STETSON (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 1. New York, Springer-Verlag, 1990, p. 91-100.
Copyright

The correlation of a transition Reynolds number obtained in any wind tunnel, conventional or quiet, to a flight value is discussed. It is suggested that a hypersonic wind tunnel cannot duplicate the atmospheric environment of the boundary-layer profiles; therefore, there is no reason to expect the wind tunnel to duplicate the flight transition Reynolds numbers. It is pointed out that a change in the environment will most likely change the transition Reynolds number, that the temperatures in the boundary layer of a hypersonic wind-tunnel model will be less than the corresponding boundary-layer temperature of a flight vehicle, and that there is an absence of second-mode disturbances. V.T.

A91-31312* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TRANSITION RESEARCH OPPORTUNITIES AT SUBSONIC AND TRANSONIC SPEEDS
PERCY J. BOBBITT (NASA, Langley Research Center, Hampton, VA) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 1. New York, Springer-Verlag, 1990, p. 108-129. refs
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A number of opportunities available to experimentalists in the subsonic- and transonic-flow regime is discussed, including the needs for improving the quality of flow in wind tunnels and the techniques used to measure it. Attention is focused on uncertainties in transition data obtained in wind-tunnel experiments, methods of flow quality improvements, relationships between Reynolds-number effects and flow quality, spanwise pressure gradient, and active transition control. Advances in stability theory and Navier-Stokes simulations are outlined, along with measurement/instrument needs, advantages of momentum-thickness transition criteria, and the effects of laminar flow on the induced drag of a wing. V.T.

A91-31313* Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France).
SOME TRANSITION PROBLEMS IN THREE-DIMENSIONAL FLOWS
DANIEL ARNAL (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 1. New York, Springer-Verlag, 1990, p. 130-135. refs
(Contract NAS1-18605)
Copyright
This paper deals with a brief description of transition problems arising on swept wings in incompressible flow. Two transition processes are discussed: the cross-flow instability, and the leading-edge contamination. Author

A91-31319* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPUTATION OF INSTABILITY AND TRANSITION
P. R. SPALART (NASA, Ames Research Center, Moffett Field, CA) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 1. New York, Springer-Verlag, 1990, p. 192-199.
Copyright
The state of transition calculations in 1989 and desirable future trends are analyzed within the framework of aeronautical applications with emphasis on wall-bounded flows. A shift to studies of the early stages of transition, particularly to receptivity, from studies of the late stages in excessively confined periodic domains is proposed. It is pointed out that early-stage studies require a larger computational domain and more difficult boundary conditions but not a very fine grid. Intermediate strategies, more involved than the classical Orr-Sommerfeld equation but much more economical than full Navier-Stokes equations, are emphasized, along with the need for compressible calculations. V.T.

A91-31332* Arizona State Univ., Tempe.
EXPERIMENTS ON A SEPARATION BUBBLE OVER AN EPPLER 387 AIRFOIL AT LOW REYNOLDS NUMBERS USING THIN-FILM ARRAYS
MARC C. MOUSSEUX (Arizona State University, Tempe), NDAONA CHOKANI (North Carolina State University, Raleigh), JOHN P. STACK, and ROBERT J. MCGHEE (NASA, Langley Research Center, Hampton, VA) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 1. New York, Springer-Verlag, 1990, p. 387-407. refs
(Contract NAS1-18599; NAS1-18605)
Copyright
Experiments carried out at the NASA Langley Low-Turbulence Pressure Tunnel on an Eppler 387 airfoil at several angles of attack for Reynolds numbers of 100,000 to 300,000 are discussed. Cross-correlations and phase diagrams are used in calculating velocities, while spectra are used in checking for amplified frequencies, and coherence plots for causality. Hot-film measurements, oil-flow visualization, pressure measurements, and Drela code are compared for finding the leading and trailing edges of the bubble. It is observed that all methods agree in showing the beginning and end of the separation bubble, the velocity measurements agree in magnitude for the lower velocities, and wave packets appear in the cross-correlation. V.T.

A91-31333* Arizona Univ., Tucson.
BOUNDARY LAYER RECEPTIVITY DUE TO THREE-DIMENSIONAL CONVECTED GUSTS
MEELAN CHOUDHARI and EDWARD J. KERSCHEN (Arizona, University, Tucson) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 1. New York, Springer-Verlag, 1990, p. 414-425. McDonnell Douglas Corp.-supported research. refs
(Contract NSF MEA-83-51929; NAS1-18605)
Copyright
Compressible fully three-dimensional interactions involving convected free-stream disturbances are analyzed by utilizing a rapid distortion theory in conjunction with triple-deck concepts. Only one class of regions where the boundary layer is receptive is considered; these regions are downstream from the leading edge, where a local feature, such as a wall hump, forces the boundary layer to make a short-scale adjustment. The results obtained are applicable to a variety of situations such as receptivity due to shallow three-dimensional roughness elements or three-dimensional wall-suction distributions. The influence of the gust orientation, frequency, and the type of mean flow disturbance on the amplitudes of the generated instability waves is demonstrated. It is found that a three-dimensional instability wave can be generated by the interaction of an oblique gust with a two-dimensional mean flow disturbance. V.T.

A91-31336* Exeter Univ. (England).
AMPLITUDE-DEPENDENT NEUTRAL MODES IN COMPRESSIBLE BOUNDARY LAYER FLOWS
J. S. B. GAJJAR (Exeter, University, England) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 2. New York, Springer-Verlag, 1990, p. 40-66. refs
(Contract NAS1-18605)
Copyright
The ideas of Benney and Bergeron (1969) and Davies (1969) on nonlinear critical layers are extended, and some new nonlinear neutral modes are computed for compressible boundary layer flow. A special case of the work is when the generalized inflexion point criterion holds. Neutral modes are found for a range of phase-speeds, dependent on the Mach number, and the properties of these are discussed. As in the linear case when the flow is relatively supersonic, multiple neutral modes exist. The behavior of the neutral amplitude in some limiting cases is also considered, and it is found that the results are significantly different from that in incompressible flow when the flow is locally supersonic. Author

A91-31338 Ohio State Univ., Cleveland.
THE EFFECT OF APPROXIMATIONS TO THE THERMODYNAMIC PROPERTIES ON THE STABILITY OF COMPRESSIBLE BOUNDARY LAYER FLOW
FABIO BERTOLOTTI (Ohio State University, Cleveland) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 2. New York, Springer-Verlag, 1990, p. 83-98.
(Contract NGT-50259; NAS1-18605)
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A study is conducted to investigate the effect of thermodynamic properties on the stability of compressible boundary layer flows. Both variable Prandtl number and variable Cp show up to 25 percent variation in the growth rates when compared against results obtained when these parameters are held constant. This suggests that nonparallel computations should incorporate the proper temperature dependence of these quantities. Author

A91-31340* Manchester Univ. (England).
THE INVISCID STABILITY OF SUPERSONIC FLOW PAST AXISYMMETRIC BODIES
PETER W. DUCK (Manchester, Victoria University, England) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 2. New York, Springer-Verlag, 1990,

p. 110-120. refs
(Contract SERC-GR/E/25702; NAS1-18605)
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The supersonic flow past a sharp cone is studied. The associated boundary layer flow (i.e., the velocity and temperature field) is computed. The inviscid linear temporal stability of axisymmetric boundary layers in general is considered, and in particular, a so-called 'triply generalized' inflection condition for 'subsonic' nonaxisymmetric neutral modes is presented. Preliminary numerical results for the stability of the cone boundary layer are presented for a freestream Mach number of 3.8. In particular, a new inviscid mode of instability is seen to occur in certain regimes, and this is shown to be related to a viscous mode found by Duck and Hall (1988). Author

A91-31344* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
BOUNDED FREE SHEAR FLOWS - LINEAR AND NONLINEAR GROWTH
MICHELE G. MACARAEG (NASA, Langley Research Center, Hampton, VA) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 2. New York, Springer-Verlag, 1990, p. 177-186. refs
Copyright
The physics of bounded free shear flows is studied at supersonic Mach numbers. Wall locations are at 1500 momentum thicknesses away from the shear layer center line. Intrinsic to this flow are high multiplicities of supersonic modes not present in the unbounded case. It is seen that these supersonic modes are resistant to subharmonic growth, a necessary precursor for efficient mixing. Previous results (Eberhardt et al., 1988) with wall locations at less than one half momentum thickness away from the shear layer center indicate that modes resembling channel modes (maximum amplification at the walls) did not roll up in numerical simulations. The similarity between these two cases is pointed out. Author

A91-31348
EFFECT OF WALL SUCTION AND COOLING ON THE SECOND MODE INSTABILITY
MUJEEB R. MALIK and A. A. GODIL (High Technology Corp., Hampton, VA) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 2. New York, Springer-Verlag, 1990, p. 235-245. refs
Copyright
Compressible linear viscous stability theory is used to study the effect of combined wall suction and cooling on the second mode instability in a flat plate boundary layer. While wall cooling destabilizes the boundary layer, calculations at Mach 4.5 and 8 show that wall suction may be used to stabilize the boundary layer with respect to second mode (subsonic) instability. Author

A91-31349* High Technology Corp., Hampton, VA.
ON THE DESIGN OF A NEW MACH 3.5 QUIET NOZZLE
FANG-JENQ CHEN, MUJEEB R. MALIK (High Technology Corp., Hampton, VA), and IVAN E. BECKWITH (NASA, Langley Research Center, Hampton, VA) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 2. New York, Springer-Verlag, 1990, p. 246-257. refs
Copyright
To advance boundary-layer stability and transition research and to ultimately provide reliable predictions of transition for supersonic flight vehicles, a wind tunnel is required with very low stream disturbance levels comparable to free flight conditions. A new concept for nozzle design is presented which promises a large increase in the length of the quiet test core. The Advanced Mach 3.5 Axisymmetric Quiet Nozzle is the first prototype built to prove the new design concept. The Reynolds numbers based on the measured length of the quiet test core for this new nozzle are in excellent agreement with the theoretical predictions. Author

A91-31351* Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.).
THE STABILITY OF A THREE DIMENSIONAL LAMINAR BOUNDARY LAYER OVER A SWEPT FLAT PLATE
B. MUELLER, H. BIPPES (DLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany), and F. S. COLLIER, JR. (High Technology Corp., Hampton, VA) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 2. New York, Springer-Verlag, 1990, p. 268-277. refs
(Contract NAS1-18240; NAS1-18605)
Copyright
The linear stability of the laminar boundary layer on a swept flat plate with an imposed favorable pressure gradient was studied utilizing a linear stability model which accounts for streamline curvature for three-dimensional incompressible flows. Calculations were performed for a leading-edge sweep angle of 45 degrees and freestream valocity of 19 m/s. Computed disturbance amplification rates and wavelengths for stationary crossflow vortices were compared with available experimental results. Author

A91-31353* High Technology Corp., Hampton, VA.
NONLINEAR DEVELOPMENT OF CROSSFLOW VORTICES
BART A. SINGER (High Technology Corp., Hampton, VA), F. MEYER, and LEONHARD KLEISER (DLR, Institut fuer theoretische Stroemungsmechanik, Goettingen, Federal Republic of Germany) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 2. New York, Springer-Verlag, 1990, p. 300-312. refs
(Contract NAS1-18605; NAS1-18240)
Copyright
Nonlineare crossflow vortices in an incompressible three-dimensional boundary layer are computed by weakly nonlinear theory and direct numerical simulations. The parallel basic flow is defined by Falkner-Skan-Cooke similarity profiles. The temporal evolution of spanwise periodic, quasi-two-dimensional disturbances without variations along the vortex axis is considered. The nonlinear theory is based on the approach of Herbert (1980, 1983). The theory predicts the existence of the finite amplitude equilibrium states seen in earlier simulations. When the disturbance amplitudes are small, there is very good quantitative agreement in the fundamental disturbance velocity components between the theory and the simulations. Author

A91-31355* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A STUDY OF TURBULENCE MODELS FOR PREDICTION OF TRANSITIONAL BOUNDARY LAYERS
RIDHA ABID (NASA, Langley Research Center; Vigyan, Inc., Hampton, VA) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 2. New York, Springer-Verlag, 1990, p. 335-351. refs
Copyright
Calculations of two-dimensional transitional boundary layer flows in zero and favorable pressure gradients are presented. The major focus is on the evaluation of current turbulence models to predict quantities such as skin-friction and heat transfer coefficients. Three turbulence models using the mixing length concept along with a one-equation model are considered. These models are tested by comparison with the experiments of Blair and Werle, who investigated flows over a heated flat plate for various levels of free-stream turbulence. Author

A91-31359* Analytical Services and Materials, Inc., Hampton, VA.
CONTROL OF THE VORTICAL STRUCTURE IN THE EARLY STAGES OF TRANSITION IN BOUNDARY LAYERS
NABIL M. EL-HADY (Analytical Services and Materials, Inc., Hampton, VA) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 2. New York, Springer-Verlag, 1990, p. 426-442. refs

(Contract NAS1-18599)
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The effect of suction and pressure gradient on controlling the production of the three-dimensional vortical structure due to secondary instability is investigated for a boundary layer in the presence of small but finite amplitude Tollmien-Schlichting wave. The subharmonic instability is the focus of the study due to its realistic application in low disturbance flight environment. The spanwise wavelength of the most unstable secondary subharmonic disturbance increases with the increase of control indicating possible alteration of the flow structure from H-type to C-type.
Author

A91-31360* Technische Univ., Brunswick (Germany, F.R.).
ON THE NUMERICAL SIMULATION OF SPATIAL DISTURBANCES IN BLUNT-NOSE FLAT PLATE FLOW
ECKART LAURIEN (Braunshweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 2. New York, Springer-Verlag, 1990, p. 443-447.
(Contract DFG-LA-553/2; NAS1-18605)
Copyright
The feasibility of the simulation of the evolution of spatially amplified disturbances in realistic airfoil flows using a standard Navier-Stokes airfoil code is considered for a blunt-nose flat plate flow. A basic stationary flow and its linear-stability-theory characteristics are analyzed. A computational C-grid is generated using an algebraic grid-generation technique. It is concluded that further improvements to the computational grid and to the code are necessary to make the proposed simulations economical.
V.T.

A91-31361* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPARISON OF TWO TRANSITION MODELS
SURYA P. G. DINAVAHI (NASA, Langley Research Center; Analytical Services and Materials, Inc., Hampton, VA) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 2. New York, Springer-Verlag, 1990, p. 453-462. refs
(Contract NAS1-18599)
Copyright
Two transition functions, one given by Arnal, Coustols and Juillen and the other by Narasimha, are incorporated into a boundary layer program along with an otherwise conventional Baldwin-Lomax turbulence model. Calculations are performed for incompressible flow past a flat plate and compressible flow past a sharp cone at Mach 6 from the leading edge through transition to the fully turbulent state. Results from these calculations are compared with the available experimental data.
Author

A91-31402#
NUMERICAL COMPUTATION OF INTERNAL FLOWS FOR SUPERSONIC INLET
SHIN-ICHI KURODA and KOZO FUJII Ishikawajima-Harima Engineering Review (ISSN 0578-7904), vol. 30, Nov. 1990, p. 456-462. In Japanese, with abstract in English. refs
Supersonic inlet is one of the important components for realizing the supersonic/hypersonic air-breathing engines. In this paper, numerical simulations of the flow around and inside the inlet are performed by solving the two-dimensional thin-layer Navier-Stokes equations. Roe's upwind scheme with the higher-order extension by MUSCL interpolation is used on the righthand side and LU-ADI implicit time-integration algorithm on the lefthand side. The Fortified Navier-Stokes (FNS) approach is used to simulate supersonic inlet flow fields with mixed external-internal compressions in a single computational zone. The FNS has been conventionally used to enforce the proper solution in the appropriate flow region, but here it is used to introduce the wall-boundary condition into the computational domain. Computed results show good agreement with the experimental Schlieren photographs.
Author

A91-31427
DRAG AND AERO-TORQUE FOR CONVEX SHELLS OF REVOLUTION IN LOW EARTH ORBIT
WILLIAM C. STONE and CHRISTOPH WITZGALL (NIST, Gaithersburg, MD) Journal of Aerospace Engineering (ISSN 0893-1321), vol. 4, April 1991, p. 145-163. refs
Copyright
A numerical procedure is described in which the aerodynamic drag and torque are calculated for convex shells of revolution for any given angle of attack based on free molecular flow theory. Assumptions are that the center of gravity lies on the axis of revolution and that there are no significant appendages. The contours of the shells are considered to consist of strictly cancave ascending and descending portions connecting smoothly to an optional horizontal middle section. Each portion is described by a series of parametric equations. The drag profile, that is, the projection of the entire shell, is approximated by the convex envelope of finitely many ellipses. The area of the drag profile and its center of area moment are then calculated and permit determination of drag force and aerodynamic torque. For a given shell, the functional dependence of drag area and aerodynamic eccentricity on the angle of attack can be expressed to a high degree of accuracy in the least-squares sense by polynomials of low degree suitable for processing in real time.
Author

A91-31484
STABILITY OF THREE-DIMENSIONAL SUPERSONIC BOUNDARY LAYERS
PONNAMPALAM BALAKUMAR and HELEN L. REED (Arizona State University, Tempe) Physics of Fluids A (ISSN 0899-8213), vol. 3, April 1991, p. 617-632. Research supported by USAF, McDonnell Douglas Corp., General Dynamics Corp., and NSF. refs
Copyright
A rotating cone that is located in a supersonic free stream at zero angle of attack is used as a model to investigate the stability of three-dimensional supersonic boundary layers. The boundary-layer profiles on the surface are calculated using the Cebeci-Keller box scheme. The stability equations are solved to determine the eigenvalues using a two-point fourth-order finite-difference scheme. The results show that the amplification rate of the first mode is increased by a factor of 2 to 4 due to the cross-flow, compared with a two-dimensional flow with the same streammmmmwise profile. This increase decreases with increasing Mach number. The instability with cross-flow covers a wide range of unstable frequencies (including zero) and wave numbers. The results also show that the second mode in a three-dimensional boundary layer is oblique, whereas the second mode in a two-dimensional boundary layer is two-dimensional. The maximum amplification rate of the second mode decreases more slowly with increasing wave angle in a three-dimensional boundary layer than in a two-dimensional boundary layer. It is concluded that the cross-flow instability becomes important for cross-flow Reynolds number on the order of 50 for low Mach numbers and 100 for high Mach numbers, this Reynolds number range corresponds to a maximum cross-flow velocity of about 4 percent.
Author

A91-31526#
VORTEX DYNAMICS ANALYSIS OF UNSTEADY VORTEX WAKES
P. SUNDARAM (Vigyan, Inc., Hampton, VA), M. KUROSAKA, and J. M. WU (Tennessee, University, Tullahoma) AIAA Journal (ISSN 0001-1452), vol. 29, March 1991, p. 321-326. Previously cited in issue 20, p. 3387, Accession no. A88-48797. refs
Copyright

A91-31528#
PARAMETRIC STUDY OF THERMAL AND CHEMICAL NONEQUILIBRIUM NOZZLE FLOW
PHILIPPE SAGNIER and LIONEL MARRAFFA (ONERA, Chatillon, France) AIAA Journal (ISSN 0001-1452), vol. 29, March 1991,

p. 334-343. Previously cited in issue 18, p. 2757, Accession no. A89-42084. refs
Copyright

A91-31529*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NUMERICAL SIMULATION OF THE EFFECT OF SPATIAL DISTURBANCES ON VORTEX ASYMMETRY
DAVID DEGANI and LEWIS B. SCHIFF (NASA, Ames Research Center, Moffett Field, CA) . AIAA Journal (ISSN 0001-1452), vol. 29, March 1991, p. 344-352. U.S. Army-supported research. Previously cited in issue 09, p. 1279, Accession no. A89-25287. refs
Copyright

A91-31536#
MODELING OF SUBSONIC FLOW THROUGH A COMPACT OFFSET INLET DIFFUSER
RICHARD C. JENKINS and ALBERT L. LOEFFLER, JR. (Grumman Corporate Research Center, Bethpage, NY) AIAA Journal (ISSN 0001-1452), vol. 29, March 1991, p. 401-408. Research supported by Grumman Corp. Previously cited in issue 09, p. 1284, Accession no. A89-25505. refs
Copyright

A91-31547#
CALCULATION OF MERGING TURBULENT WAKES
SUNG-SOON AHN (California State University, Long Beach) AIAA Journal (ISSN 0001-1452), vol. 29, March 1991, p. 473, 474. refs
Copyright
The Cebeci et al. (1986) and Chang et al. (1986) eddy-viscosity hypothesis-based wall calculations of wall boundary layers and wakes are presently extended to the case of the merging of multiple wakes downstream of a high-lift arrangement of flaps, in order to compare the results thus obtained with those of the two-equation model of Hanjalic and Launder (1980). The results of the two approaches are virtually identical, and their agreement with experimental data is noted to improve with downstream distance. O.C.

A91-31751#
MODELLING OF SUPERSONIC FLOW FOR THE CALCULATION OF THE MAIN AERODYNAMIC CHARACTERISTICS OF AN AIRCRAFT [MODELOWANIE OPLYWU NADDZWIEKOWEGO NA POTRZEBY OBLICZEN PODSTAWOWYCH CHARAKTERYSTYK AERODYNAMICZNYCH SAMOLOTU]
TOMASZ GOETZENDORF-GRABOWSKI and JOZEF PIETRUCHA (Warszawa, Politechnika, Warsaw, Poland) Politechnika Slaska, Zeszyty Naukowe, Mechanika (ISSN 0434-0817), no. 99, 1990, p. 85-91. In Polish. refs
As a result of physical modeling the mathematical model of supersonic flow around an entire aircraft has been obtained. This model has the form of a linear partial differential equation for disturbed velocity potential. Results of calculations are compared with other numerical and theoretical results. Good agreement has been confirmed. Author

A91-31880#
A METHODOLOGY FOR DETERMINING AERODYNAMIC SENSITIVITY DERIVATIVES WITH RESPECT TO VARIATION OF GEOMETRIC SHAPE
ARTHUR C. TAYLOR, III, GENE W. HOU, and VAMSHI MOHAN KORIVI (Old Dominion University, Norfolk, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 477-489. refs
(Contract NSF DMC-86-57917)
(AIAA PAPER 91-1101) Copyright
A general procedure is developed for calculating aerodynamic sensitivity coefficients using the full equations of fluid flow, where the focus of the work is the treatment of arbitrary variations of geometric shape design variables. Using an upwind cell-centered finite volume approximation to represent the governing equations, sensitivity derivatives are determined by direct differentiation of the resulting set of coupled nonlinear algebraic equations which model the fluid flow. The technique is implemented and successfully tested in two dimensionas for inviscid flow (i.e., the Euler equations) through a subsonic nozzle and a supersonic inlet. Author

A91-31882*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
SENSITIVITY ANALYSIS OF A WING AEROELASTIC RESPONSE
RAKESH K. KAPANIA, LLOYD B. ELDRED (Virginia Polytechnic Institute and State University, Blacksburg), and JEAN-FRANCOIS M. BARTHELEMY (NASA, Langley Research Center, Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 497-505. refs
(Contract NAS1-18471)
(AIAA PAPER 91-1103)
A variation of Sobieski's Global Sensitivity Equations (GSE) approach is implemented to obtain the sensitivity of the static aeroelastic response of a three-dimensional wing model. The formulation is quite general and accepts any aerodynamics and structural analysis capability. An interface code is written to convert one analysis's output to the other's input, and visa versa. Local sensitivity derivatives are calculated by either analytic methods or finite difference techniques. A program to combine the local sensitivities, such as the sensitivity of the stiffness matrix or the aerodynamic kernel matrix, into global sensitivity derivatives is developed. The aerodynamic analysis package FAST, using a lifting surface theory, and a structural package, ELAPS, implementing Giles' equivalent plate model are used. Author

A91-31903*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
VORTICAL FLOW COMPUTATIONS ON A FLEXIBLE BLENDED WING-BODY CONFIGURATION
GURU P. GURUSWAMY (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 719-734. refs
(AIAA PAPER 91-1013) Copyright
Flows over blended wing-body configurations are often dominated by vortices. The unsteady aerodynamic forces due to such flows can couple with the elastic forces of the wing and lead to aeroelastic oscillations. Such aeroelastic oscillations can impair the performance of an aircraft; it is necessary to account for structural properties of the configuration and solve the aerodynamic and aeroelastic equations of motion simultaneously. The flow is modeled using the Navier-Stokes equations coupled with the aeroelastic equations of motion. Computations are made for a blended wing-body configuration at flow conditions dominated by vortices and separation. The computed results are validated with the available experimental data. Sustained aeroelastic oscillations observed in the wind tunnel are successfully simulated for freestream Mach = 0.975, alpha of 8.0 deg, and a frequency of about 2 Hz. Author

A91-32005*# United Technologies Research Center, East Hartford, CT.
INCIPIENT TORSIONAL STALL FLUTTER AERODYNAMIC EXPERIMENTS ON A SWEPT THREE-DIMENSIONAL WING
PETER F. LORBER and FRANKLIN O. CARTA (United Technologies Research Center, East Hartford, CT) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1692-1701.

NASA-supported research. refs
(Contract DAAL03-89-C-0013)
(AIAA PAPER 91-0935) Copyright

The aerodynamics of small amplitude pitching motions near stall have been studied experimentally in order to improve understanding of the torsional stall flutter problem for propeller blades. A model wing was oscillated in pitch at several small amplitudes over a wide and representative range of conditions. Unsteady surface pressures were measured and integrated to determine the aerodynamic damping at five spanwise stations. Strong negative damping was found for motions centered near static stall for all studied reduced frequencies, Mach numbers, and sweep angles. The 30-deg sweptback configuration was found to become negatively damped over the entire span nearly simultaneously, while the unswept model exhibited local regions of negative damping that moved toward the wing tip as the mean angle of attack was increased. Author

A91-32021*# Old Dominion Univ., Norfolk, VA.
UNSTEADY SUPERSONIC FLOW AROUND DELTA WINGS WITH SYMMETRIC AND ASYMMETRIC FLAPS OSCILLATION
OSAMA A. KANDIL and AHMED A. SALMAN (Old Dominion University, Norfolk, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1888-1903. refs
(Contract NAG1-648)
(AIAA PAPER 91-1105) Copyright

A parametric study is presented to investigate the effect of reduced frequency of the leading-edge flaps on the locally-conical, unsteady, supersonic flow around a delta wing. This study covers symmetric and antisymmetric forced oscillation of the leading-edge flaps. The effects of the freestream Mach number and angle of attack are also presented. The problem is solved using time-accurate integration of the unsteady, compressible, thin-layer Navier-Stokes equations and the unsteady, linearized, Navier-displacement equations. The delta wing is of aspect ratio of 1.5 and its leading-edge flaps are hinged at 65 percent of the local-half span length. The reduced frequency is varied between 2 pi and pi/2. Two supersonic flow conditions have been investigated; the first is for a freestream Mach number of 2.4 and an angle of attack of 19 deg and the second is for a freestream Mach number of 1.5 and an angle attack of 15 deg. Author

A91-32022# Purdue Univ., West Lafayette, IN.
SPATIAL ADAPTION PROCEDURES ON UNSTRUCTURED MESHES FOR ACCURATE UNSTEADY AERODYNAMIC FLOW COMPUTATION
RUSS D. RAUSCH, HENRY T. Y. YANG (Purdue University, West Lafayette, IN), and JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1904-1918. refs
(Contract NGT-50406)
(AIAA PAPER 91-1106) Copyright

Spatial adaption procedures for the accurate and efficient solution of steady and unsteady inviscid flow problems are described. The adaption procedures were developed and implemented within a two-dimensional unstructured-grid upwind-type Euler code. These procedures involve mesh enrichment and mesh coarsening to either add points in high gradient regions of the flow or remove points where they are not needed, respectively, to produce solutions of high spatial accuracy at minimal computational cost. The paper gives a detailed description of the enrichment and coarsening procedures and presents comparisons with alternative results and experimental data to provide an assessment of the accuracy and efficiency of the capability. Steady and unsteady transonic results, obtained using spatial adaption for the NACA 0012 airfoil, are shown to be of high spatial accuracy, primarily in that the shock waves are very sharply captured. The results were obtained with a computational savings of a factor of approximately fifty-three for a steady case and as much as twenty-five for the unsteady cases. Author

A91-32023*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TRANSONIC SHOCK-INDUCED DYNAMICS OF A FLEXIBLE WING WITH A THICK CIRCULAR-ARC AIRFOIL
ROBERT M. BENNETT, BRIAN E. DANSBERRY, MOSES G. FARMER, CLINTON V. ECKSTROM, DAVID A. SEIDEL (NASA, Langley Research Center, Hampton, VA) et al. IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1919-1928. refs
(AIAA PAPER 91-1107) Copyright

A simple flexible wing model with an 18-percent circular arc airfoil was constructed and tested in the Langley Transonic Dynamics Tunnel to investigate the dynamic characteristics that a wing might have under these conditions. In the region of shock-boundary layer oscillations, buffeting of the first bending mode was obtained. This mode was well separated in frequency from the shock boundary layer oscillations. A limit cycle oscillation was also measured in a 'third bending-like' mode, involving wing vertical bending and splitter plate motion, which was in the frequency range of the shock-boundary layer oscillations. Several model configurations were tested, and a few potential fixes were investigated. Author

A91-32024*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
UNSTEADY SHOCK-VORTEX INTERACTION ON A FLEXIBLE DELTA WING
SHIGERU OBAYASHI and GURU P. GURUSWAMY (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1929-1950. refs
(AIAA PAPER 91-1109) Copyright

Unsteady Navier-Stokes computations have been carried out for simulating transonic flows over a clipped delta wing undergoing oscillatory and ramp motions, including flexibility. The implicit upwind algorithm has been validated by comparing the solutions with experimental data for the oscillatory pitching motion cases. The numerical and experimental results agree well at moderate angles of attack, where a leading-edge vortex develops. The ramp motion cases have demonstrated the effects of unsteadiness of the flow field and structural flexibility on the wing responses. For the 10 deg ramp motion, a vortex breakdown is observed. The interaction with the shock wave plays an essential role in the process of the breakdown observed in the present calculation. Author

A91-32025*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A METHODOLOGY FOR USING NONLINEAR AERODYNAMICS IN AEROSERVOELASTIC ANALYSIS AND DESIGN
WALTER A. SILVA (NASA, Langley Research Center, Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1951-1963. refs
(AIAA PAPER 91-1110) Copyright

A methodology is presented for using the Volterra-Wiener theory of nonlinear systems in aeroservoelastic (ASE) analyses and design. The theory is applied to the development of nonlinear aerodynamic response models that can be defined in state-space form and are, therefore, appropriate for use in modern control theory. The theory relies on the identification of nonlinear kernels that can be used to predict the response of a nonlinear system due to an arbitrary input. A numerical kernel identification technique, based on unit impulse responses, is presented and applied to a simple bilinear, single-input-single-output system. The linear kernel (unit impulse response) and the nonlinear second-order kernel of the system are numerically-identified and compared with the exact, analytically-defined linear and second-order kernels. This kernel identification technique is then applied to the CAP-TSD code for identification of the linear and second-order kernels of a NACA64A010 rectangular wing undergoing pitch at M = 0.5, M = 0.85 (transonic), and M = 0.93 (transonic). Results presented demonstrate the feasibility of this approach for use with nonlinear, unsteady aerodynamic responses. Author

A91-32152#
METHODS OF ANALYSIS FOR FLOW AROUND PARACHUTE CANOPIES
TURGUT SARPKAYA (U.S. Naval Postgraduate School, Monterey, CA) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1-17. Research supported by NSF and Sandia National Laboratories. refs
(AIAA PAPER 91-0825)
The added-mass and resistance in time-dependent flows are reviewed, and focus is placed on the Morison's equation, coexisting flow fields, and governing parameters. Models of fluid-canopy interactions are discussed with emphasis on vortex-element methods, vortex-panel methods, and three-dimensional flow models. It is observed that though the two-dimensional models need further work and verification, future efforts should be directed toward their generalization into full three-dimensional models. These models may be able to make definite predictions about the results of future experiment. V.T.

A91-32154#
APPARENT MASS - ITS HISTORY AND ITS ENGINEERING LEGACY FOR PARACHUTE AERODYNAMICS
DAVID J. COCKRELL (Leicester, University, England) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 23-32. refs
(AIAA PAPER 91-0827) Copyright
The physical meaning of apparent mass, and its relevance to both parachute canopy inflation models and the equations of motion for the descent of fully-deployed steady-state parachute systems, are described. The essential differences between the unsteady motion of parachutes through ideal fluids, when potential flow solutions are possible, and through real fluids, when recourse must be made to experimental studies, are considered. Because of its complexity, its probable lack of relevance to the parachute problems to which it has been applied in the past, and the dearth of good experimental data, that the apparaent mass concept has little more to offer to contemporary parachute design. Author

A91-32166#
ON ACCOUNTING FOR PARACHUTE CANOPY POROSITY IN ESTIMATING PARACHUTE PEAK INFLATION LOAD
DEAN S. JORGENSEN (Textron Defense Systems, Wilmington, MA) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 137-144.
(AIAA PAPER 91-0848) Copyright
The study deals with the general requirement to account for canopy fabric porosity, or 'permeability' in developing an empirical expression for the opening load factor. The porosity of parachute-canopy broadcloths made of nylon and Kevlar materials is discussed, and the effect of yarn twist on porosity and the effect of porosity on maximum opening force are covered. A case study is used for developing the general argument for accounting for porosity. The effect of canopy porosity on the peak inflation load of a small cruciform parachute is analyzed. It is shown that a 63-pct underestimation of peak inflation load is possible if porosity is not accounted for. V.T.

A91-32168#
A DISCRETE FREE VORTEX METHOD OF ANALYSIS FOR INVISCID AXISYMMETRIC FLOWS AROUND PARACHUTE CANOPIES
Y. I. FRUCHT and D. J. COCKRELL (Leicester, University, England) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 153-162. refs
(AIAA PAPER 91-0850) Copyright
A discrete vortex method developed for modeling inviscid incompressible axisymmetric flows at high Reynolds numbers around parachute canopies is presented. The canopy surface is represented by a lattice of panels each one of which contains a bound vortex ring. The free shear layer carrying high-vorticity fluid from the upstream surface boundary layer is simulated by a sheet of discrete free vortex rings. The wake developed behind the canopy is found to be characterized by vortex-ring clusters shed at periodic intervals. Calculated results for differential pressure distributions and the resulting axial forces, in both steady and unsteady flows, obtained from the model are shown to be in good agreement with experimental data. V.T.

A91-32169#
WAKE BEHIND A CIRCULAR DISK IN UNSTEADY AND STEADY INCOMING STREAMS
HIROSHI HIGUCHI (Syracuse University, NY) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 163-170. Research supported by Syracuse University and Sandia National Laboratories. refs
(AIAA PAPER 91-0852) Copyright
An experimental investigation on the wake structure behind various axisymmetric bluff bodies simulating a round parachute canopy has been initiated, and the results from its initial stage are presented. The small scale water towing tank was designed and built, and the wake development during the acceleration and deceleration stages was investigated using a digital image capture system. The phenomenon was compared with the wake behind a disk placed in a steady incoming flow where the wake structure becomes fully three-dimensional. Some discussions are presented in light of the wake recontact problem during the parachute deployment. Author

A91-32170#
EXPERIMENTAL INVESTIGATION OF ADDED MASS DURING PARACHUTE DECELERATION - PRELIMINARY RESULTS
BRUCE R. WHITE (California, University, Davis), J. MICHAEL MACHA (Sandia National Laboratories, Albuquerque, NM), and BRAD C. COCHRAN IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 171-180. refs
(AIAA PAPER 91-0853) Copyright
The focus of this experimental study is to describe the effect of added mass on the retarding force produced by a decelerating parachute, as a function of canopy geometry and motion dynamics. While not ignoring the forces in the radial direction, this study is particularly interested in defining the more predominate effects which occur in the axial plane. The parametric information gathered in this study will be used as input into a state-of-the art inflation model based on a system of coupled radial and axial momentum equations. Author

A91-32171*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AERODYNAMICS OF SPHERES FOR MACH NUMBERS FROM 0.6 TO 10.5 INCLUDING SOME EFFECTS OF TEST CONDITIONS

M. LEROY SPEARMAN (NASA, Langley Research Center, Hampton, VA) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 181-188. refs
(AIAA PAPER 91-0894) Copyright

Wind tunnel tests were made for spheres of various sizes over a range of Mach numbers and Reynolds numbers. The results indicated some conditions where the drag was affected by changes in the afterbody pressure due to a shock reflection from the tunnel wall. This effect disappeared when the Mach number was increased for a given sphere size or when the sphere size was decreased for a given Mach number. Drag measurements and Schlieren photographs show the possibility of obtaining inaccurate data when tests are made with a sphere too large for the test section size and Mach number. Tests were also made of an oblate spheroid. The results indicated a region at high Mach numbers where inherent positive static stability might occur with the oblate-face forward. The drag results are compared with those for a sphere and those for various other shapes. The drag results for the oblate spheriod and the sphere are also compared with some calculated results.
Author

A91-32172#

FLOW FIELD CHARACTERISTICS AROUND CUP-LIKE BLUFF BODIES, PARACHUTE CANOPIES

C. Q. SHEN (Shanghai Aircraft Research Institute, People's Republic of China) and D. J. COCKRELL (Leicester, University, England) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 189-193. refs
(AIAA PAPER 91-0855) Copyright

The flow field around parachute canopies is highly complex. In the current investigation visualization studies using both helium bubbles and wool tufts are undertaken to determine the nature of the flow field around parachute canopies. Statistical correlation analyses made with a hot wire anemometer in their wake indicated the periodic nature of the wake formed behind these three-dimensional bluff bodies. The most probable description for the wake formed behind a parachute canopies is that chains of irregularly-shaped vortex loops move at about 0.7 times of the disturbed stream velocity. The Strouhal number of the periodic flow in the wake is obtained and found to be 0.15 approximately.
Author

A91-32174#

PARACHUTE DEPLOYMENT EXPERIMENT IN TRANSONIC AND SUPERSONIC WIND TUNNELS

MOTOKI HINADA, YOSHIFUMI INATANI, TAKASHI NAKAJIMA (Institute of Space and Astronautical Science, Sagamihara, Japan), MASAHISA HONDA (Nissan Motor Co., Ltd., Tokyo, Japan), KOJU HIRAKI et al. IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 207-215. refs
(AIAA PAPER 91-0859) Copyright

Prelminary wind tunnel tests have been made in ISAS in order to study the characteristics of the parachutes at transonic and supersonic Mach number regions. A device has been made to eject a model parachute into a wind tunnel flow and to measure the drag force acting on it. Some experimental studies on parachute deployment have been carried out by using the device set on the inside wall of transonic and supersonic wind tunnels having test sections of 60 cm square in ISAS with the flow conditions of Mach number from 0.8 to 3.0 and Reynold number from 2.2 to 2.9 x 10 to the 7th/m. Parachute models employed in this study have been made of practical parachute materials. The relations between the Mach number and the drag, parachute diameter, oscillating angle are obtained, and these comparative aerodynamic characteristics were discussed, including the effect of forebody wake. Some typical phenomena such as 'breathing' at supersonic speed are observed, and their frequencies are measured.
Author

A91-32177#

APPLICATION OF INFLATION THEORIES TO PRELIMINARY PARACHUTE FORCE AND STRESS ANALYSES

WILLIAM L. GARRARD (Minnesota, University, Minneapolis) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 230-239. refs
(AIAA PAPER 91-0862) Copyright

Simple formulas for the estimation of canopy stresses and forces during parachute inflation are presented. It is important to know the maximum force and stress in order to determine the required strength of the materials to be utilized for the various elements, e.g., the risers, canopy cloth and suspension lines. The calculation method based on the assumption that the inflation of each parachute type is characterized by a unique nondimensional drag area versus time history is developed. Equations for force and stress are derived, and simplifying assumptions which permit the calculation of maximum force and stress, and explicit formulas for these quantities are developed.
R.E.P.

A91-32179#

COMPUTATIONS OF THE FLOW CHARACTERISTICS OF AERODYNAMIC DECELERATORS USING COMPUTATIONAL FLUID DYNAMICS

KEITH STEIN (U.S. Army, Natick Research, Development, and Engineering Center, MA) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 249-257. refs
(AIAA PAPER 91-0866)

This paper reports current work at the U.S. Army Natick Research, Development, and Engineering Center on aerodynamic decelerators using computational fluid dynamics. Results from two different problems are presented. First, predicted aerodynamic characteristics of two-dimensional circular arcs of various sizes are reported and compared with known results. Secondly, the effect of the vent size on the performance of an annular decelerator was investigated and predicted results are presented.
Author

A91-32180#

TESTS OF SAMARA-WING DECELERATOR CHARACTERISTICS

PETER CRIMI and DEAN S. JORGENSEN (Textron Defense Systems, Wilmington, MA) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 265-279. DARPA-supported research. refs
(Contract DAAA21-86-C-0298)
(AIAA PAPER 91-0868) Copyright

Samara-wing decelerators on full-scale, full-weight submunition simulators were tested to determine steady-state descent characteristics and to examine factors controlling transition from carrier release conditions to steady descent on a samara wing. Attention is given to the test articles, test facilities and instrumentation, steady-state and transition test scenarios, and data acquisition. It is concluded that samara wings can develop substantially higher aerodynamic loading than predicted by utilizing flat-plate section coefficients, apparently due to the effects of fabric porosity and/or wing deformation.
R.E.P.

A91-32183*# Technion - Israel Inst. of Tech., Haifa.

MEASUREMENT OF THE STATIC AND DYNAMIC COEFFICIENTS OF A CROSS-TYPE PARACHUTE IN SUBSONIC FLOW

ZALMAN SHPUND (Technion - Israel Institute of Technology, Haifa) and DANIEL LEVIN (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 295-303. refs
(AIAA PAPER 91-0871) Copyright

An experimental parametric investigation of the aerodynamic qualities of cross-type parachutes was performed in a subsonic wind tunnel, using a new experimental technique. This investigation included the measurement of the static and dynamic aerodynamic coefficients, utilizing the measuring apparatus modified specifically for this type of testing. It is shown that the static aerodynamic coefficients of several configurations are in good agreement with available data, and assisted in validating the experimental technique employed. Two configuration parameters were varied in the static tests, the cord length and the canopy aspect ratio, with both parameters having a similar effect on the drag measurement, i.e., any increase in either of them increased the effective blocking area, and therefore the axial force. R.E.P.

A91-32184#
PARAMETRIC STUDY OF UNICROSS PARACHUTE UNDER INFINITE AND FINITE MASS CONDITIONS
J. K. TYAGI and PARAG KUMAR (Aerial Delivery Research and Development Establishment, Agra, India) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 304-309. refs
(AIAA PAPER 91-0872) Copyright

Experiments performed on small models in a low speed wind tunnel under infinite mass condition to study the effect of configurational parameters on drag coefficient and stability of a unicross parachute are presented. The parameters selected should include fabric porosity, arm ratio, suspension line length to nominal diameter ratio, and slits in the arms to attain highest drag along with good stability. Results of testing conducted on the same models as well as some larger parachutes on a rocket sled under finite mass condition are also included. It is concluded that unicross parachutes having an arm ratio of 3 to 3.7 have good lateral stability under both infinite and finite mass condition. R.E.P.

A91-32185#
PANEL STABILIZED SQUARE PARACHUTE FLIGHT TESTING
CARL T. CALLIANNO (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 310-315.
(AIAA PAPER 91-0873)

This paper describes the results of flight tests conducted at an airspeed of 250 knots indicated air speed (KIAS). These tests determined the effects of airspeed and three different stabilizing panel configurations on parachute opening performance and stability. The results showed that a panel-stabilized square parachute, configured with the smallest of the three stabilizing panels, worked properly. The other two larger size panels would not inflate and were ineffective. During previous tests at 30 KIAS, all three stabilizing panels functioned normally. Additional testing showed that a new stabilizing panel configuration, which would inflate at 250 knots airspeed, could be achieved. It was sized midway between the smallest and midsized panel configurations, which were established at 30 knots airspeed. Author

A91-32272
THE GLANCING INTERACTION OF A PRANDTL-MEYER EXPANSION FAN WITH A SUPERSONIC WAKE
M. K. SMART and R. J. STALKER (Queensland, University, Saint Lucia, Australia) Aeronautical Journal (ISSN 0001-9240), vol. 95, Feb. 1991, p. 39-47. refs
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The downstream effects of the glancing interaction of a Prandtl-Meyer expansion fan with a supersonic wake are analyzed. The combustion wake generated by a vertical-strut-injected scramjet is investigated, as well as the side-wall boundary layer of a supersonic wind tunnel. The phenomenon of wake-flow overturning in response to the expansion is examined, and it is shown that the overturning produces a high-pressure zone on the expansion-generating surface. Combustion-wake overturning is suggested to be a major thrust-producing mechanism in this form of scramjet. Pressure measurements taken on the expansion-generating surface are compared with the results of an approximate analysis for predicting the pressure. V.T.

A91-32275
PERFORMANCE OF IMPROVED THIN AEROFOIL THEORY FOR MODERN AEROFOIL SECTIONS
K. ABU-ABDOU and M. F. ZEDAN (King Saud University, Riyadh, Saudi Arabia) Aeronautical Journal (ISSN 0001-9240), vol. 95, Feb. 1991, p. 64-70. King Saud University-supported research. refs
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An improved thin airfoil method, which features extended expressions for lift and moment coefficients, is considered for further investigation and validation. The procedure to calculate the singularity coefficients is improved by using all airfoil coordinates as control points in a least squares scheme. The classical NACA 0012 and NACA 65012 sections, the modern aviation airfoil LS(1)-0417 and the extremely thick Kennedy-Marsden airfoil are validated in place of the previously cited Karman-Trefftz airfoil. This selection covers thickness ratios of up to 27.9 percent, camber ratios up to 7.69 percent and incidence up to 16.7 deg. Comparisons of velocity (or pressure) distributions and aerodynamic coefficients are made with two panel methods and with exact solution or experimental results. Results indicated that the accuracy of the extended method is much better than expected and compares well with panel methods except for the extremely thick airfoil. Author

N91-19045*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
INFLIGHT SOURCE NOISE OF AN ADVANCED FULL-SCALE SINGLE-ROTATION PROPELLER
RICHARD P. WOODWARD and IRVIN J. LOEFFLER 1991 20 p Presented at the 29th Aerospace Sciences Meeting, Reno, NV, 7-10 Jan. 1991; sponsored by AIAA
(NASA-TM-103687; E-5906; NAS 1.15:103687; AIAA-91-0594)
Avail: NTIS HC/MF A03 CSCL 01A

Flight tests to define the far field tone source at cruise conditions were completed on the full scale SR-7L advanced turboprop which was installed on the left wing of a Gulfstream II aircraft. This program, designated Propfan Test Assessment (PTA), involved aeroacoustic testing of the propeller over a range of test conditions. These measurements defined source levels for input into long distance propagation models to predict en route noise. Inflight data were taken for 7 test cases. The sideline directivities measured by the Learjet showed expected maximum levels near 105 degrees from the propeller upstream axis. However, azimuthal directivities based on the maximum observed sideline tone levels showed highest levels below the aircraft. An investigation of the effect of propeller tip speed showed that the tone level of reduction associated with reductions in propeller tip speed is more significant in the horizontal plane than below the aircraft. Author

N91-19046*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ICING CHARACTERISTICS OF A NATURAL-LAMINAR-FLOW, A MEDIUM-SPEED, AND A SWEPT, MEDIUM-SPEED AIRFOIL
COLIN S. BIDWELL 1991 32 p Presented at the 29th Aerospace Sciences Meeting, Reno, NV, 7-10 Jan. 1991; sponsored by AIAA
(NASA-TM-103693; E-5912; NAS 1.15:103693; AIAA-91-0447)
Avail: NTIS HC/MF A03 CSCL 01A

Tests were conducted at the Icing Research Tunnel at the NASA Lewis Research Center to determine the icing characteristics of three modern airfoils, a natural laminar flow, a medium speed and a swept medium speed airfoil. Tests measured the impingement characteristics and drag degradation for angles of attack typifying cruise and climb for cloud conditions typifying the range that might be encountered in flight. The maximum degradation occurred for the cruise angle of attack for the long glaze ice condition for all three airfoils with increases over baseline drag being 486 percent, 510 percent, and 465 percent for the natural laminar flow, the medium speed and the swept medium speed airfoil respectively. For the climb angle of attack, the maximum drag degradation (and extent of impingement) observed were also for the long glaze ice condition, and were 261 percent, 181 percent and 331 percent respectively. The minimum drag degradation (and extent of impingement) occurred for the cruise condition and for the short, rime spray which increases over baseline drag values of 47 percent, 28 percent and 46 percent respectively. Author

N91-19047*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PREDICTION OF ICE SHAPES AND THEIR EFFECT ON AIRFOIL PERFORMANCE
JAIWON SHIN, BRIAN BERKOWITZ, HSUN CHEN, and TUNCER CEBECI (California State Univ., Long Beach.) 1991 23 p
Presented at the 29th Aerospace Sciences Meeting, Reno, NV, 7-10 Jan. 1991; sponsored by AIAA
(NASA-TM-103701; E-5924; NAS 1.15:103701; AIAA-91-0264)
Avail: NTIS HC/MF A03 CSCL 01A

Calculations of ice shapes and the resulting drag increases are presented for experimental data on a NACA 0012 airfoil. They were made with a combination of LEWICE and interactive boundary-layer codes for a wide range of conditions which include air speed and temperature, the droplet size and liquid water content of the cloud, and the angle of attack of the airfoil. In all cases, the calculated results account for the drag increase due to ice accretion and, in general, show good agreement. Author

N91-19048*# CFD Research Corp., Huntsville, AL.
RAPID MIX CONCEPTS FOR LOW EMISSION COMBUSTORS IN GAS TURBINE ENGINES Final Report
MILIND V. TALPALLIKAR, CLIFFORD E. SMITH, and MING-CHIA LAI (Wayne State Univ., Detroit, MI.) Oct. 1990 70 p LIMITED REPRODUCIBILITY: More than 20% of this document may be affected by color photographs Original contains color illustrations
(Contract NAS3-25834)
(NASA-CR-185292; NAS 1.26:185292) Avail: NTIS HC/MF A04; 13 functional color pages CSCL 01A

NASA LeRC has identified the Rich burn/Quick mix/Lean burn (RQL) combustor as a potential gas turbine combustor concept to reduce NOx emissions in High Speed Civil Transport (HSCT) aircraft. To demonstrate reduced NOx levels, NASA LeRC soon will test a flametube version of an RQL combustor. The critical technology needed for the RQL combustor is a method of quickly mixing combustion air with rich burn gases. Two concepts were proposed to enhance jet mixing in a circular cross-section: the Asymmetric Jet Penetration (AJP) concept; and the Lobed Mixer (LM) concept. In Phase 1, two preliminary configurations of the AJP concept were compared with a conventional 12-jet radial-inflow slot design. The configurations were screened using an advanced 3-D Computational Fluid Dynamics (CFD) code named REFLEQS. Both non-reacting and reacting analyses were performed. For an objective comparison, the conventional design was optimized by parametric variation of the jet-to-mainstream momentum flux (J) ratio. The optimum J was then employed in the AJP simulations. Results showed that the three-jet AJP configuration was superior in overall mixedness compared to the conventional design. However, in regards to NOx emissions, the AJP configuration was inferior. The higher emission level for AJP was caused by a single hot spot located in the wake of the central jet as it entered the combustor. Ways of maintaining good mixedness while eliminating the hot spot were identified for Phase 2 study. Overall, Phase 1 showed the viability of using CFD analyses to evaluate quick-mix concepts. A high probability exists that advancing mixing concepts will reduce NOx emissions in RQL combustors, and should be explored in Phase 2, by parallel numerical and experimental work. Author

N91-19049*# Hamilton Standard, Windsor Locks, CT.
UNIFIED AEROACOUSTICS ANALYSIS FOR HIGH SPEED TURBOPROP AERODYNAMICS AND NOISE. VOLUME 1: DEVELOPMENT OF THEORY FOR BLADE LOADING, WAKES, AND NOISE Final Report
D. B. HANSON Mar. 1991 135 p
(Contract NAS3-23720)
(NASA-CR-4329; E-6021-VOL-1; NAS 1.26:4329) Avail: NTIS HC/MF A07 CSCL 01A

A unified theory for the aerodynamics and noise of advanced turboprops are presented. Aerodynamic topics include calculation of performance, blade load distribution, and non-uniform wake flow fields. Blade loading can be steady or unsteady due to fixed distortion, counter-rotating wakes, or blade vibration. The aerodynamic theory is based on the pressure potential method and is therefore basically linear. However, nonlinear effects associated with finite axial induction and blade vortex flow are included via approximate methods. Acoustic topics include radiation of noise caused by blade thickness, steady loading (including vortex lift), and unsteady loading. Shielding of the fuselage by its boundary layer and the wing are treated in separate analyses that are compatible but not integrated with the aeroacoustic theory for rotating blades. Author

N91-19050*# Continuum Dynamics, Inc., Princeton, NJ.
FREE WAKE ANALYSIS OF HOVER PERFORMANCE USING A NEW INFLUENCE COEFFICIENT METHOD
TODD R. QUACKENBUSH, DONALD B. BLISS, CHING CHO ONG, and CHO ONG CHING Washington, DC NASA Jul. 1990 100 p
(Contract NAS2-12148)
(NASA-CR-4309; A-90091; NAS 1.26:4309) Avail: NTIS HC/MF A05 CSCL 01A

A new approach to the prediction of helicopter rotor performance using a free wake analysis was developed. This new method uses a relaxation process that does not suffer from the convergence problems associated with previous time marching simulations. This wake relaxation procedure was coupled to a vortex-lattice, lifting surface loads analysis to produce a novel, self contained performance prediction code: EHPIC (Evaluation of Helicopter Performance using Influence Coefficients). The major technical features of the EHPIC code are described and a substantial amount of background information on the capabilities and proper operation of the code is supplied. Sample problems were undertaken to demonstrate the robustness and flexibility of the basic approach. Also, a performance correlation study was carried out to establish the breadth of applicability of the code, with very favorable results. Author

N91-19051*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
F-18 HIGH ALPHA RESEARCH VEHICLE SURFACE PRESSURES: INITIAL IN-FLIGHT RESULTS AND CORRELATION WITH FLOW VISUALIZATION AND WIND-TUNNEL DATA
DAVID F. FISHER, DANIEL W. BANKS, and DAVID M. RICHWINE (PRC Systems Services Co., Edwards, CA.) Aug. 1990 36 p
Presented at the AIAA 8th Applied Aerodynamics Conference, Portland, OR, 20-22 Aug. 1990 Previously announced in IAA as A90-45885
(NASA-TM-101724; H-1633; NAS 1.15:101724; AIAA-90-3018)
Avail: NTIS HC/MF A03 CSCL 01A

Pressure distributions measured on the forebody and the leading-edge extensions (LEX's) of the NASA F-18 high alpha research vehicle (HARV) were reported at 10 and 50 degree angles of attack and at Mach 0.20 to 0.60. The results were correlated with HARV flow visualization and 6-percent scale F-18 wind-tunnel-model test results. The general trend in the data from the forebody was for the maximum suction pressure peaks to first appear at an angle of attack (alpha) of approximately 19 degrees and increase in magnitude with angle of attack. The LEX pressure distribution general trend was the inward progression and increase in magnitude of the maximum suction peaks up to vortex core breakdown and then the decrease and general flattening of the pressure distribution beyond that. No significant effect of Mach number was noted for the forebody results. However, a substantial compressibility effect on the LEX's resulted in a significant reduction in vortex-induced suction pressure as Mach number increased. The forebody primary and the LEX secondary vortex separation lines, from surface flow visualization, correlated well with the end of pressure recovery, leeward and windward, respectively, of maximum suction pressure peaks. The flight to wind-tunnel correlations were generally good with some exceptions. Author

N91-19052*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MODAL ANALYSIS OF UH-60A INSTRUMENTED ROTOR BLADES
KAREN S. HAMADE and ROBERT M. KUFELD Washington Nov. 1990 45 p
(NASA-TM-4239; A-90252; NAS 1.15:4239) Avail: NTIS HC/MF A03 CSCL 01A

The dynamic characteristics of instrumented and production UH-60A Black Hawk main rotor blades were measured, and the results were validated with NASTRAN finite element models. The blades tested included pressure and strain-gage instrumented blades, which are part of the NASA Airloads Flight Research Phase of the Modern Technology Rotor Program. The dynamic similarity of the blades was required for accurate data collection in this program. Therefore, a nonrotating blade modal analysis was performed on the first 10 free-free modes to measure blade similarities. The results showed small differences between the modal frequencies of instrumented and production blades and a close correlation with the NASTRAN models. This type of modal testing and analysis is recommended as a standard procedure for future instrumented blade flight testing. Author

N91-19053*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ACOUSTIC RADIATION FROM LIFTING AIRFOILS IN COMPRESSIBLE SUBSONIC FLOW
HAFIZ M. ATASSI, SHANKAR SUBRAMANIAM (Notre Dame Univ., IN.), and JAMES R. SCOTT 1990 22 p Presented at the 13th Aeroacoustics Conference, Tallahassee, FL, 22-24 Oct. 1990; sponsored by AIAA Previously announced in IAA as A91-12427
(NASA-TM-103650; E-5830; NAS 1.15:103650; AIAA-90-3911) Avail: NTIS HC/MF A03 CSCL 01A

The far field acoustic radiation from a lifting airfoil in a three-dimensional gust is studied. The acoustic pressure is calculated using the Kirchhoff method, instead of using the classical acoustic analogy approach due to Lighthill. The pressure on the Kirchhoff surface is calculated using an existing numerical solution of the unsteady flow field. The far field acoustic pressure is calculated in terms of these values using Kirchhoff's formula. The method is validated against existing semi-analytical results for a flat plate. The method is then used to study the problem of an airfoil in a harmonic three-dimensional gust, for a wide range of Mach numbers. The effect of variation of the airfoil thickness and angle of attack on the acoustic far field is studied. The changes in the mechanism of sound generation and propagation due to the presence of steady loading and nonuniform mean flow are also studied. Author

N91-19055*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
SUMMARY OF IN-FLIGHT FLOW VISUALIZATION OBTAINED FROM THE NASA HIGH ALPHA RESEARCH VEHICLE
DAVID F. FISHER, JOHN H. DELFRATE, and FANNY A. ZUNIGA Jan. 1991 41 p Presented at the High Angle of Attack Technology Symposium, Hampton, VA, 30 Oct. - 1 Nov. 1990
(NASA-TM-101734; H-1686; NAS 1.15:101734) Avail: NTIS HC/MF A03 CSCL 01A

A summary of the surface and off-surface flow visualization results obtained in flight on the F-18 high alpha research vehicle (HARV) is presented, highlighting the extensive 3-D vortical flow on the aircraft at angles of attack up to 50 degs. The emitted fluid technique, as well as tufts and flow cones, were used to document the surface flow. A smoke generator system injected smoke into the vortex cores generated by the forebody and leading edge extensions (LEXs). Documentation was provided by onboard still and video, by air-to-air, and by postflight photography. The surface flow visualization techniques revealed laminar separation bubbles near the forebody apex, lines of separation on the forebody and LEX, and regions of attached and separated flow on the wings and fins. The off-surface flow visualization techniques showed the path of the vortex cores on the forebody and LEX as well as the LEX vortex core breakdown location. An interaction between the forebody and LEX vortices was noted. The flow over the surfaces of the vertical tail was categorized into regions of attached, unsteady, or separated flow using flow tufts. Author

N91-19056*# Sverdrup Technology, Inc., Brook Park, OH.
ONGOING DEVELOPMENT OF A COMPUTER JOBSTREAM TO PREDICT HELICOPTER MAIN ROTOR PERFORMANCE IN ICING CONDITIONS Final Report
RANDALL K. BRITTON Feb. 1991 16 p Proposed for presentation at the 47th Annual Forum and Technology Display, Phoenix, AZ, 6-8 May 1991; sponsored by American Helicopter Society
(Contract NAS3-25266)
(NASA-CR-187076; E-6026; NAS 1.26:187076) Avail: NTIS HC/MF A03 CSCL 01A

Work is currently underway at the NASA Lewis Research Center to develop an analytical method for predicting the performance degradation of a helicopter operating in icing conditions. A brief survey is performed of possibilities available to perform such a calculation along with the reasons for choosing the present approach. A complete description of the proposed jobstream is given as well as a discussion of the present state of the development. Author

N91-19060*# Analytical Methods, Inc., Redmond, WA.
A NOVEL POTENTIAL/VISCOUS FLOW COUPLING TECHNIQUE FOR COMPUTING HELICOPTER FLOW FIELDS
J. MICHAEL SUMMA, DANIEL J. STRASH, and SUNGYUL YOO Aug. 1990 39 p Original contains color illustrations
(Contract NAS2-12962)
(NASA-CR-177568; A-90283; NAS 1.26:177568) Avail: NTIS HC/MF A03; 3 functional color pages CSCL 01A

Because of the complexity of helicopter flow field, a zonal method of analysis of computational aerodynamics is required. Here, a new procedure for coupling potential and viscous flow is proposed. An overlapping, velocity coupling technique is to be developed with the unique feature that the potential flow surface singularity strengths are obtained directly from the Navier-Stokes at a smoother inner fluid boundary. The closed-loop iteration method proceeds until the velocity field is converged. This coupling should provide the means of more accurate viscous computations of the near-body and rotor flow fields with resultant improved analysis of such important performance parameters as helicopter fuselage drag and rotor airloads. Author

N91-19062*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AN EXPERIMENTAL STUDY OF THE TURBULENT BOUNDARY LAYER ON A TRANSPORT WING IN SUBSONIC AND TRANSONIC FLOW
FRANK W. SPAID, FREDERICK W. ROOS (McDonnell-Douglas Research Labs., Saint Louis, MO.), and RAYMOND M. HICKS Aug. 1990 78 p Contains MF as supplement
(NASA-TM-102206; A-89194; NAS 1.15:102206) Avail: NTIS HC/MF A05 CSCL 01A

The upper surface boundary layer on a transport wing model was extensively surveyed with miniature yaw probes at a subsonic and a transonic cruise condition. Additional data were obtained at a second transonic test condition, for which a separated region was present at mid-semispan, aft of mid-chord. Significant variation in flow direction with distance from the surface was observed near the trailing edge except at the wing root and tip. The data collected at the transonic cruise condition show boundary layer growth associated with shock wave/boundary layer interaction, followed by recovery of the boundary layer downstream of the shock. Measurements of fluctuating surface pressure and wingtip acceleration were also obtained. The influence of flow field unsteadiness on the boundary layer data is discussed. Comparisons among the data and predictions from a variety of computational methods are presented. The computed predictions are in reasonable agreement with the experimental data in the outboard regions where 3-D effects are moderate and adverse pressure gradients are mild. In the more highly loaded mid-span region near the trailing edge, displacement thickness growth was significantly underpredicted, except when unrealistically severe adverse pressure gradients associated with inviscid calculations were used to perform boundary layer calculations. Author

N91-19065# Sandia National Labs., Albuquerque, NM.
THE DESIGN AND FLIGHT TESTING OF A HIGH-PERFORMANCE LOW-COST PARACHUTE SYSTEM FOR A 1000 LB PAYLOAD
V. L. BEHR 1991 8 p Presented at the 11th AIAA Aerodynamic Decelerator Systems Technology Conference, San Diego, 9-11 Apr. 1991
(Contract DE-AC04-76DP-00789)
(DE91-007733; SAND-90-2113C; CONF-9104171-1) Avail: NTIS HC/MF A02

An airdrop system is being developed by Sandia National Laboratories for the U.S. Army which is to be delivered as low as 300 ft above ground level and at speeds as high as Mach 0.95. The development of the system includes both the vehicle and the parachute recovery system. The gross weight of the vehicle when dropped is approximately 950 lbs. The parachute system employs an aerodynamically deployed tailplate, a reefed and staged drogue parachute, and a cluster of three main parachutes. The three main parachutes are T-10 personnel parachutes. The use of these parachutes will help minimize the cost of the parachute system. This system has been both ground and flight tested. This paper stresses the results of the flight test program and the impact those results had on the design of the parachute system. DOE

N91-19066# National Aerospace Lab., Tokyo (Japan).
RESULT OF ONERA STANDARD MODEL TEST IN 2M X 2M TRANSONIC WIND TUNNEL
H. SAWADA, K. SUZUKI, M. NAKAMURA, M. SUZUKI, Y. KOMATSU, and A. KOIKE Mar. 1990 28 p In JAPANESE
(DE91-750115; NAL-TM-616) Avail: NTIS HC/MF A03

Wind tunnel test under the international correspondence between Japan and France are reported. In the past, when test was made in a 2 x 2 m transonic wind tunnel (TWT) in the National Aerospace Laboratory (NAL), by use of a standard model NAL-M5, reproduced from the drawing, drawn by the ONERA, France, discrepancy existed in a part of pressure distribution from the ONERA data. The heightening in pressure was sluggish by the wing surface impact wave at the same elevation angle. Discrepancy existed in lift coefficient (C sub L)-pitching moment (C sub m) curve. In C sub L-elevation angle of model alpha curve, C sub L alpha was measured to be large with an early appearance of stall phenomenon. To solve those points of problem, test was made by having borrowed models M5 and M2, similar to those of ONERA standard. The discrepancy in data was elucidated to be caused by error in measurement, difference in compared condition and difference between both the models NAL-M5 and ONERA-M5. The C sub L-alpha curve and C sub L-C sub m curve of ONERA-M2 agrees well with those, adjusted in lift interference, of test result by ONERA-M5. Discrepancy exists in C sub L-drag coefficient (C sub D) curve, which necessitates the model M5 data to be adjusted. DOE

N91-19067*# Continuum Dynamics, Inc., Princeton, NJ.
A NEW METHODOLOGY FOR FREE WAKE ANALYSIS USING CURVED VORTEX ELEMENTS Final Report
DONALD B. BLISS, MILTON E. TESKE, and TODD R. QUACKENBUSH Washington Dec. 1987 137 p
(Contract NAS2-11295)
(NASA-CR-3958; NAS 1.26:3958; CDI-84-6) Avail: NTIS HC/MF A07 CSCL 01A

A method using curved vortex elements was developed for helicopter rotor free wake calculations. The Basic Curve Vortex Element (BCVE) is derived from the approximate Biot-Savart integration for a parabolic arc filament. When used in conjunction with a scheme to fit the elements along a vortex filament contour, this method has a significant advantage in overall accuracy and efficiency when compared to the traditional straight-line element approach. A theoretical and numerical analysis shows that free wake flows involving close interactions between filaments should utilize curved vortex elements in order to guarantee a consistent level of accuracy. The curved element method was implemented into a forward flight free wake analysis, featuring an adaptive far wake model that utilizes free wake information to extend the vortex filaments beyond the free wake regions. The curved vortex element free wake, coupled with this far wake model, exhibited rapid convergence, even in regions where the free wake and far wake turns are interlaced. Sample calculations are presented for tip vortex motion at various advance ratios for single and multiple blade rotors. Cross-flow plots reveal that the overall downstream wake flow resembles a trailing vortex pair. A preliminary assessment shows that the rotor downwash field is insensitive to element size, even for relatively large curved elements. Author

N91-19068# Bristol Univ. (England). Dept. of Aerospace Engineering.
THE EFFECT OF BODY SHAPE ON THE DEVELOPMENT OF VORTEX ASYMMETRY IN THE FLOW PAST SLENDER BODIES
A. L. WILLIAMS Jun. 1990 28 p
(BU-413; ETN-91-98864) Avail: NTIS HC/MF A03

The vortex sheet model originally described by Legendre and developed by Smith is applied to the study of inviscid separated flow past slender bodies with rounded corner 'square' or 'triangular' cross sections. The effect of the cross sectional shape and orientation on asymmetry is examined. The simplified case of conical flow is considered in detail, whilst preliminary results from a non conical model are also included. The existence of symmetric and asymmetric vortices above a cone of 'square' cross section is confirmed using a laser light sheet to illuminate cross flow planes along the slender body. ESA

N91-20043*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
WALL-INTERFERENCE ASSESSMENT AND CORRECTIONS FOR TRANSONIC NACA 0012 AIRFOIL DATA FROM VARIOUS WIND TUNNELS M.S. Thesis - George Washington Univ., 1988
LAWRENCE L. GREEN and PERRY A. NEWMAN Apr. 1991 63 p Presented at AIAA Meeting, Honolulu, HI, 8-10 Jun. 1987
(NASA-TP-3070; L-16721; NAS 1.60:3070; AIAA-87-1431) Avail: NTIS HC/MF A04 CSCL 01/1

A nonlinear, four wall, post-test wall interference assessment/correction (WIAC) code was developed for transonic airfoil data from solid wall wind tunnels with flexibly adaptable top and bottom walls. The WIAC code was applied over a broad range of test conditions to four sets of NACA 0012 airfoil data, from two different adaptive wall wind tunnels. The data include many test points for fully adapted walls, as well as numerous partially adapted and unadapted test points, which together represent many different model/tunnel configurations and possible wall interference effects. Small corrections to the measured Mach numbers and angles of attack were obtained from the WIAC code even for fully adapted data; these corrections generally improve the correlation among the various sets of airfoil data and simultaneously improve the correlation of the data with calculations for a 2-D, free air, Navier-Stokes code. The WIAC corrections for airfoil data taken in fully adapted wall test sections are shown to be significantly smaller than those for comparable airfoil data from straight, slotted wall test sections. This indicates, as expected, a lesser degree of wall interference in the adapted wall tunnels relative to the slotted wall tunnels. Application of the WIAC code to this data was, however, somewhat more difficult and time consuming than initially expected from similar previous experience with WIAC applications to slotted wall data. Author

N91-20044*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NASA LOW-SPEED CENTRIFUGAL COMPRESSOR FOR 3-D VISCOUS CODE ASSESSMENT AND FUNDAMENTAL FLOW PHYSICS RESEARCH
M. D. HATHAWAY, J. R. WOOD, and C. A. WASSERBAUER (Sverdrup Technology, Inc., Brook Park, OH.) 1991 15 p Presented at the 36th International Gas Turbine and Aeroengine Congress and Exposition, Orlando, FL, 3-6 Jun. 1991; sponsored by the American Society of Mechanical Engineers
(Contract DA PROJ. 1L1-61102-AH-45)
(NASA-TM-103710; E-5938; NAS 1.15:103710; AVSCOM-TR-91-C-003) Avail: NTIS HC/MF A03 CSCL 01/1

A low speed centrifugal compressor facility recently built by the NASA Lewis Research Center is described. The purpose of this facility is to obtain detailed flow field measurements for computational fluid dynamic code assessment and flow physics modeling in support of Army and NASA efforts to advance small gas turbine engine technology. The facility is heavily instrumented with pressure and temperature probes, both in the stationary and rotating frames of reference, and has provisions for flow visualization and laser velocimetry. The facility will accommodate rotational speeds to 2400 rpm and is rated at pressures to 1.25 atm. The initial compressor stage being tested is geometrically and dynamically representative of modern high-performance centrifugal compressor stages with the exception of Mach number levels. Preliminary experimental investigations of inlet and exit flow uniformly and measurement repeatability are presented. These results demonstrate the high quality of the data which may be expected from this facility. The significance of synergism between computational fluid dynamic analysis and experimentation throughout the development of the low speed centrifugal compressor facility is demonstrated. Author

N91-20045*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TRANSONIC AERODYNAMICS OF DENSE GASES M.S. Thesis - Virginia Polytechnic Inst. and State Univ., Apr. 1990
SYBIL HUANG MORREN Jan. 1991 84 p
(NASA-TM-103722; E-5953; NAS 1.15:103722) Avail: NTIS HC/MF A05 CSCL 01/1

Transonic flow of dense gases for two-dimensional, steady-state, flow over a NACA 0012 airfoil was predicted analytically. The computer code used to model the dense gas behavior was a modified version of Jameson's FL052 airfoil code. The modifications to the code enabled modeling the dense gas behavior near the saturated vapor curve and critical pressure region where the fundamental derivative, Gamma, is negative. This negative Gamma region is of interest because the nonclassical gas behavior such as formation and propagation of expansion shocks, and the disintegration of inadmissible compression shocks may exist. The results indicated that dense gases with undisturbed thermodynamic states in the negative Gamma region show a significant reduction in the extent of the transonic regime as compared to that predicted by the perfect gas theory. The results support existing theories and predictions of the nonclassical, dense gas behavior from previous investigations. Author

N91-20046*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STRUCTURAL DYNAMICS DIVISION RESEARCH AND TECHNOLOGY ACCOMPLISHMENTS FOR FISCAL YEAR 1990 AND PLANS FOR FISCAL YEAR 1991
ELEANOR C. WYNNE Jan. 1991 225 p
(NASA-TM-102770; NAS 1.15:102770) Avail: NTIS HC/MF A10 CSCL 01/1

The research accomplishments of the Structural Dynamics Division for F.Y. 1991 are presented. The work is discussed in terms of highlights of accomplishments during the past year and plans for the current year as they relate to 5-year plans and the objectives of each technical area. Included is research on unsteady aerodynamics, helicopter rotors, computational fluid dynamics, oscillations of leading edge flaps of a delta wing, and aircraft wing loads. Author

N91-20047*# Arizona Univ., Tucson.
LEADING-EDGE RECEPTIVITY FOR BLUNT-NOSE BODIES Annual Progress Report, 1 May 1990 - 30 Apr. 1991
EDWARD J. KERSCHEN Apr. 1991 26 p
(Contract NAG1-1135)
(NASA-CR-188063; NAS 1.26:188063) Avail: NTIS HC/MF A99 CSCL 01/1

This research program investigates boundary-layer receptivity in the leading-edge region for bodies with blunt leading edges. Receptivity theory provides the link between the unsteady distrubance environment in the free stream and the initial amplitudes of the instability waves in the boundary layer. This is a critical problem which must be addressed in order to develop more accurate prediction methods for boundary-layer transition. The first phase of this project examines the effects of leading-edge bluntness and aerodynamic loading for low Mach number flows. In the second phase of the project, the investigation is extended to supersonic Mach numbers. Singular perturbation techniques are utilized to develop an asymptotic theory for high Reynolds numbers. In the first year, the asymptotic theory was developed for leading-edge receptivity in low Mach number flows. The case of a parabolic nose is considered. Substantial progress was made on the Navier-Sotkes computations. Analytical solutions for the steady and unsteady potential flow fields were incorporated into the code, greatly expanding the types of free-stream disturbances that can be considered while also significantly reducing the the computational requirements. The time-stepping algorithm was modified so that the potential flow perturbations induced by the unsteady pressure field are directly introduced throughout the computational domain, avoiding an artificial 'numerical diffusion' of these from the outer boundary. In addition, the start-up process was modified by introducing the transient Stokes wave solution into the downstream boundary conditions. Author

N91-20048*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SPATIAL ADAPTION PROCEDURES ON UNSTRUCTURED MESHES FOR ACCURATE UNSTEADY AERODYNAMIC FLOW COMPUTATION
RUSS D. RAUSCH, JOHN T. BATINA, and HENRY T. Y. YANG (Purdue Univ., West Lafayette, IN.) Mar. 1991 17 p Presented at the AIAA/ASME/ASCE/AHS/ASC 32nd Structures, Structural Dynamics and Materials Conference, Baltimore, MD, 8-10 Apr. 1991
(Contract NGT-50406)
(NASA-TM-104039; NAS 1.15:104039; AIAA-91-1106) Avail: NTIS HC/MF A03 CSCL 01/1

Spatial adaption procedures for the accurate and efficient solution of steady and unsteady inviscid flow problems are described. The adaption procedures were developed and implemented within a two-dimensional unstructured-grid upwind-type Euler code. These procedures involve mesh enrichment and mesh coarsening to either add points in a high gradient region or the flow or remove points where they are not needed, respectively, to produce solutions of high spatial accuracy at minimal computational costs. A detailed description is given of the enrichment and coarsening procedures and comparisons with alternative results and experimental data are presented to provide an assessment of the accuracy and efficiency of the capability. Steady and unsteady transonic results, obtained using spatial adaption for the NACA 0012 airfoil, are shown to be of high spatial accuracy, primarily in that the shock waves are very sharply captured. The results were obtained with a computational savings of a factor of approximately fifty-three for a steady case and as much as twenty-five for the unsteady cases. Author

N91-20050# Sverdrup Technology, Inc., Arnold AFS, TN.
DEVELOPMENT OF A FREE-JET FOREBODY SIMULATOR DESIGN OPTIMIZATION METHOD Final Report, 1 Oct. 1988 - 30 Jun. 1990
DAVID H. HUDDLESTON Dec. 1990 78 p Prepared in cooperation with Arnold Engineering Development Center, Arnold AFS, TN
(AD-A230162; AEDC-TR-90-22) Avail: NTIS HC/MF A05 CSCL 21/5

An aerodynamic design optimization technique is presented that couples direct optimization algorithms with the analysis capability provided by appropriate computational fluid dynamics (CFD) programs. This technique is intended to be an aid in designing the aerodynamic shapes and establishing test conditions required for the successful simulation of aircraft engine inlet conditions in a ground test environment. However, the method is also applicable to other aerodynamic design problems such as airfoil design, turbomachinery cascade design, and nozzle design. The approach involves minimization of a nonlinear least-squares objective function that may be defined in a region remote to the geometric surface being optimized. In this study, finite, difference Euler and Navier-Stokes codes were applied to obtain the objective function evaluation, although the applied optimization method can be coupled with any appropriate CFD analysis technique. Using CFD to compute design space gradients within an optimization algorithm has received little prior attention in the literature. It is demonstrated that CFD can be used in this manner by applying the developed design technique to a variety of aerodynamic design problems. Results are presented for several typical aerospace examples, including inviscid and viscous flow over airfoils flows in convergent/divergent nozzles in both two and three dimensions, and supersonic flow about a planar forebody simulator. GRA

N91-20053# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
INVESTIGATION OF THE HIGH ANGLE OF ATTACK DYNAMICS OF THE F-15B USING BIFURCATION ANALYSIS M.S. Thesis
ROBERT J. MCDONNELL Dec. 1990 123 p
(AD-A230462; AFIT/GAE/ENY/90D-16) Avail: NTIS HC/MF A06 CSCL 01/1

Previous studies predicted the F-15B high angle of attack and flat spin behavior using bifurcation analysis. These studies varied control surface deflections to find equilibrium and periodic solutions. The purpose of this research was to use bifurcation analysis to predict the F-15B high angle attack and flat spin behavior as a result of variable thrust, asymmetric thrust, and thrust vectoring. Using a previously developed model of the F-15, bifurcation analysis and continuation methods were used to map out the equilibrium and periodic solutions of the model as a function of the thrust parameters. A baseline bifurcation diagram,, as a function of alpha and elevator deflection angel, of the equilibrium solutions for the F-15 was developed. Thrust was varied and changes were identified. Thrust asymmetries were introduced and their effect on entering and recovering from spins was identified. Thrust vectoring was introduced to see how pitch and yaw vectoring can aid in the entry and recovery from spins. Where deemed necessary, time history simulations were presented to further explain F-15 behavior. GRA

N91-20054# Applied and Theoretical Mechanics, Inc., Oakland, CA.
HEAT TRANSFER PREDICTIONS OF HYPERSONIC TRANSITIONAL FLOWS Final Report, 1 Oct. 1989 - 31 Oct 1990
JOELLE M. CHAMPNEY Nov. 1990 45 p
(Contract F49620-90-C-0004)
(AD-A230748; ATM-TR-90-025; AFOSR-90-1188TR) Avail: NTIS HC/MF A03 CSCL 20/13

A numerical model to solve transition process observed in hypersonic flows over cones has been developed. Low Reynolds number two-equation turbulence models were employed with a production term modification (PTM) technique. The approach determined the extent of the transition zone. The onset of transition was imposed using experimental measurements when available. When not available, the onset of transition was determined by a stability criterion which is related to the Bushnell-Reshotko transition criterion. The PTM technique was incorporated into a NASA-Ames implicit Reynolds averaged Navier Stokes solver, the TURF code, and tested for transitional hypersonic flows over flat plates. The model parameters were tuned as a function of free stream Mach number. The PTM technique was also tested for transitional hypersonic flows over sharp cones and blunt cones for a variety of flow conditions. Comparisons of computed heat transfer with experimental measurements are shown to be good. GRA

N91-20055*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
IN-FLIGHT FLOW VISUALIZATION CHARACTERISTICS OF THE NASA F-18 HIGH ALPHA RESEARCH VEHICLE AT HIGH ANGLES OF ATTACK
DAVID F. FISHER, JOHN H. DELFRATE, and DAVID M. RICHWINE (PRC Systems Services Co., Edwards, CA.) Washington May 1991 34 p Previously announced in IAA as A90-45439 LIMITED REPRODUCIBILITY: More than 20% of this document may be affected by color photographs Original contains color illustrations
(NASA-TM-4193; H-1576; NAS 1.15:4193) Avail: NTIS HC/MF A03; 22 functional color pages CSCL 01/1

Surface and off-surface flow visualization techniques were used to visualize the 3-D separated flows on the NASA F-18 high alpha research vehicle at high angles of attack. Results near the alpha = 25 to 26 deg and alpha = 45 to 49 deg are presented. Both the forebody and leading edge extension (LEX) vortex cores and breakdown locations were visualized using smoke. Forebody and LEX vortex separation lines on the surface were defined using an emitted fluid technique. A laminar separation bubble was also detected on the nose cone using the emitted fluid technique and was similar to that observed in the wind tunnel test, but not as extensive. Regions of attached, separated, and vortical flow were noted on the wing and the leading edge flap using tufts and flow cones, and compared well with limited wind tunnel results. Author

N91-20056# Royal Aerospace Establishment, Farnborough (England).
TEMPERATURE ERROR COMPENSATION APPLIED TO PRESSURE MEASUREMENTS TAKEN WITH MINIATURE SEMICONDUCTOR PRESSURE TRANSDUCERS IN A HIGH-SPEED RESEARCH COMPRESSOR
M. A. CHERRETT 30 Oct. 1990 25 p Presented at the 10th International Symposium on Measuring Techniques for Transonic and Supersonic Flows in Cascades and Turbomachines, Brussels, Belgium, 17-18 Sep. 1990
(RAE-TM-P-1192; BR115684; ETN-91-99004) Copyright Avail: NTIS HC/MF A03

An easily implemented system, developed for the compensation of temperature errors for measurements taken using miniature semiconductor pressure transducers to investigate unsteady viscous flows within high speed axial compressors and fans, is discussed. Data was taken, using this compensation system, from a single sensor traverse probe in a high speed research compressor. Implementation of the system is discussed and comparisons of the tranducer measurements with conventional pneumatic data are made. An automated facility for steady state pressure and temperature calibration of tranducers is described. ESA

N91-20057# Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.
PRELIMINARY STUDIES FOR AIRCRAFT PARAMETER ESTIMATION USING MODIFIED STEPWISE RECOGNITION Annual Report, Nov. 1989
H. A. HINDS and M. V. COOK Nov. 1989 54 p
(CRANFIELD-AERO-8911; ISBN-1-871564-02-6; ETN-91-99012)
Avail: NTIS HC/MF A04; Cranfield Inst. of Technology, Coll. of Aeronautics, Cranfield, Bedford MK43 0AL, England, HC 8 sterling pounds

The application of the parameter estimation Modified Stepwise Regression (MSR) model to an aircraft model is discussed. A dynamic wind tunnel test facility in which the model is suspended with four degrees of freedom is described. Calibration and dynamic stability of the control surface angles carried out on a British Aerospace Hawk model are discussed. The computerization of the procedure for aircraft equations of motion in FORTRAN 77 is outlined. Aircraft simulation using an Advanced Continuous Simulation Language (ACSL) and a complete set of stability and control derivatives for the Hawk is described. Hawk model kinematics, attitude rate information, the MSR method, mathematical model formulation and the MSR software are discussed. Current status and future work of the facility are outlined. ESA

N91-20058# Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.
APPLICATION OF MODIFIED STEPWISE REGRESSION FOR THE ESTIMATION OF AIRCRAFT STABILITY AND CONTROL PARAMETERS Quarterly Report No. 3
H. A. HINDS and M. V. COOK Jul. 1989 36 p
(CRANFIELD-AERO-9008; ISBN-1-871564-06-9; ETN-91-99014)
Avail: NTIS HC/MF A03; Cranfield Inst. of Technology, Coll. of Aeronautics, Cranfield, Bedford MK43 0AL, England, HC 8 sterling pounds

Progress on the research program concerned with the use of a Modified Stepwise Regression Method (MSR) for estimating the stability and control derivatives of a British Aerospace Hawk aircraft from data obtained by the use of a scaled model on a dynamic wind tunnel test is discussed. The longitudinal and lateral equations of motion for the ACSL (Advanced Continuous Simulation Language) digital simulation program which will provide data to test the FORTRAN 77 MSR program are given. Estimation of full scale Hawk derivatives for ACSL program, improvements to the lateral simulation programs, modeling of control surface inputs, Hawk model and dynamic rig status, derivation of aircraft attitude rates and the MSR procedure are described. Future objectives are summarized and results reported so far lead to the conclusion that the ACSL program represents the full scale Hawk satisfactorily. ESA

N91-20059# Sandia National Labs., Albuquerque, NM.
DESIGN AND PERFORMANCE OF A PARACHUTE FOR THE RECOVERY OF A 760-LB PAYLOAD
D. E. WAYE 1991 11 p Presented at the 11th AIAA Aerodynamic Decelerator Systems Technology Conference, San Diego, CA, 9-11 Apr. 1991
(Contract DE-AC04-76DP-00789)
(DE91-007509; SAND-90-2158C; CONF-9104171-3) Avail: NTIS HC/MF A03

A 26 ft. diameter ribbon parachute deployed using a pilot parachute system has been developed at Sandia National Laboratories for the recovery of a 760 lb. payload released at subsonic and transonic speeds. The wide range of deployment dynamic pressures led to the design, utilizing wind tunnel testing and computer simulation, of a unique pilot parachute system verified in full-scale flight tests. Performance data from 20 full-scale flight tests were used to evaluate system performance and structural validity. The concical ribbon parachute design chosen for this development effort follows the practice of previous Sandia National Laboratory parachute development programs for high performance airdropped payloads. The design process for this parachute system included a tradeoff study to evaluate and compare the performance between an equivalent drag area 26 ft. diameter single parachute system and a cluster system of three 14 ft. diameter parachutes. The results showed a small advantage for the cluster system in inflation and initial deceleration characteristics. However, the higher cost, higher weight, greater packing complexity and greater risk involved in the development of the cluster system outweighed the performance advantages and led to the choice of the 26 ft. diameter parachute as the baseline design for the development. This paper describes the design and performance of the 26 ft. diameter parachute which was chosen for the recovery of a 760 lb. payload. The results of 20 full-scale flight test of this parachute system are summarized. DOE

N91-20060# Lawrence Livermore National Lab., CA.
AERODYNAMICS MODELING OF TOWED-CABLE DYNAMICS
S. W. KANG and V. R. LATORRE 17 Jan. 1991 45 p
(Contract W-7405-ENG-48)
(DE91-008426; UCRL-ID-106509) Avail: NTIS HC/MF A03

The dynamics of a cable/drogue system being towed by an orbiting aircraft has been investigated as a part of an LTWA project for the Naval Air Systems Command. We present here a status report on the tasks performed under Phase 1. The following tasks were accomplished under Phase 1: A literature survey on the towed-cable motion problem has been conducted. While both static (steady-state) and dynamic (transient) analyses exist in the literature, no single, comprehensive analysis exists that directly addresses the present problem. However, the survey also reveals that, when judiciously applied, these past analyses can serve as useful building blocks for approaching the present problem. A numerical model that addresses several aspects of the towed-cable dynamic problem has been adapted from a Canadian underwater code for the present aerodynamic situation. This modified code, called TOWDYN, analyzes the effects of gravity, tension, aerodynamic drag, and wind. Preliminary results from this code demonstrate that the wind effects alone CAN generate the drogue oscillation behavior, i.e., the yo-yo phenomenon. This code also will serve as a benchmark code for checking the accuracy of a more general and complete R and D model code. Efforts were initiated to develop a general R and D model supercomputer code that also takes into account other physical factors, such as induced oscillations and bending stiffness. This general code will be able to evaluate the relative impacts of the various physical parameters, which may become important under certain conditions. This R and D code will also enable development of a simpler operational code that can be used by the Naval Air personnel in the field. DOE

N91-20062*# Notre Dame Univ., IN. Dept. of Aerospace and Mechanical Engineering.
VISUALIZATION OF LEADING EDGE VORTICES ON A SERIES OF FLAT PLATE DELTA WINGS
FRANCIS M. PAYNE, T. TERRY NG, and ROBERT C. NELSON Washington Apr. 1991 81 p
(Contract NAG2-258)
(NASA-CR-4320; A-90094; NAS 1.26:4320) Avail: NTIS HC/MF A05 CSCL 01/1

A summary of flow visualization data obtained as part of NASA Grant NAG2-258 is presented. During the course of this study, many still and high speed motion pictures were taken of the leading edge vortices on a series of flat plate delta wings at varying angles of attack. The purpose is to present a systematic collection of photographs showing the state of vortices as a function of the angle of attack for the four models tested. Author

N91-20063*# Institute for Computer Applications in Science and Engineering, Hampton, VA.
UNSTRUCTURED AND ADAPTIVE MESH GENERATION FOR HIGH REYNOLDS NUMBER VISCOUS FLOWS Final Report
DIMITRI J. MAVRIPLIS Feb. 1991 26 p Prepared for presentation of the 3rd International Conference on Numerical Grid Generation Conference, Barcelona, Spain, 3-7 Jun. 1991
(Contract NAS1-18605)

(NASA-CR-187534; ICASE-91-25; NAS 1.26:187534) Avail: NTIS HC/MF A03 CSCL 01/1

A method for generating and adaptively refining a highly stretched unstructured mesh suitable for the computation of high-Reynolds-number viscous flows about arbitrary two-dimensional geometries was developed. The method is based on the Delaunay triangulation of a predetermined set of points and employs a local mapping in order to achieve the high stretching rates required in the boundary-layer and wake regions. The initial mesh-point distribution is determined in a geometry-adaptive manner which clusters points in regions of high curvature and sharp corners. Adaptive mesh refinement is achieved by adding new points in regions of large flow gradients, and locally retriangulating; thus, obviating the need for global mesh regeneration. Initial and adapted meshes about complex multi-element airfoil geometries are shown and compressible flow solutions are computed on these meshes. Author

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AIR TRANSPORTATION AND SAFETY

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

A91-29435
AIRWORTHINESS CERTIFICATION ASPECTS OF SOFTWARE
G. A. BURTENSHAW (Civil Aviation Authority, Safety Regulation Group, Gatwick, England) IN: Maintenance and development of software; Proceedings of the Conference, London, England, Oct. 23, 1990. London, Royal Aeronautical Society, 1990, p. 7.1-7.7. refs
Copyright

The current certification procedures applied for systems and equipment containing software are reviewed and some of the issues which have led to the major exercise to update the guidelines contained within EUROCAE/RTCA documents ED-12A/DO-178A are discussed. A summary is given of the current status of this activity. The need for continuing development of the practices and procedure as issued for certification of airborne systems and equipment containing software is highlighted. L.K.S.

A91-29476
WINDSHEAR; PROCEEDINGS OF THE CONFERENCE, LONDON, ENGLAND, NOV. 1, 1990
London, Royal Aeronautical Society, 1990, 78 p. For individual items see A91-29477 to A91-29481.
Copyright

Topics presented include an update on wind shear technical progress, airborne system perspectives for wind shear detection, the integration of ground-based sensors to produce effective aircraft avoidance of microburst wind shear, and flight test aspects of airborne wind shear system FAA certification. Also discussed are an equipment manufacturer's perspective on wind shear detection and recovery guidance, an automatic pilot recovery method, wind shear detection and recovery guidance on the BAe 146, and wind shear in airline operations. R.E.P.

A91-29477
MICROBURST WIND SHEAR - INTEGRATION OF GROUND-BASED SENSORS TO PRODUCE EFFECTIVE AIRCRAFT AVOIDANCE
WAYNE SAND and JOHN MCCARTHY (NCAR, Boulder, CO) IN: Windshear; Proceedings of the Conference, London, England, Nov. 1, 1990. London, Royal Aeronautical Society, 1990, p. 3.1-3.7. NSF-supported research. refs
(Contract DTFA01-82-Y-10513)
Copyright

The various methods for detecting microburst wind shear using ground-based sensing systems are presented, and the effectiveness of the systems is discussed along with what represents 'effective avoidance' of the microburst. Microbursts, as defined by ground-based sensing systems, represent a detected divergent wind velocity across the event of 30 kts or greater. The original six-station Low-Level Windshear Alert System has been progressively enhanced to not only detect hazardous wind shear events but also to provide wind direction and velocity information from the anemometer sites that are determined to be in a wind shear condition using logic that is more robust and more sensitive. Considerations are presented on the integration of ground-based microburst detection systems. The implications of this integration logic for ground-based sensors and airborne look-ahead sensors are also presented. R.E.P.

A91-29481
WINDSHEAR IN AIRLINE OPERATIONS
M. L. F. KNOWLES (Air Europe, Crawley, England) IN: Windshear; Proceedings of the Conference, London, England, Nov. 1, 1990. London, Royal Aeronautical Society, 1990, p. 8.1-8.5. refs
Copyright

An overview of airline operations involving wind shear incidents is presented. Particular attention is given to a case involving a low level topographical wind shear. The objectives and guidance provided by the FAA Training Aid and the studies and research conducted by the National Center for Atmospheric Research have been adopted in the airline training curriculum described. Initial training in wind shear techniques by most airlines include the suggested training sequence developed as a result of these studies beginning with classroom videos and tutorials. Various wind shear simulator techniques are described and the need for wind shear and microburst models is discussed. R.E.P.

A91-30064* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SIMULATOR EVALUATION OF THE FINAL APPROACH SPACING TOOL
THOMAS J. DAVIS, HEINZ ERZBERGER, and STEVEN M. GREEN (NASA, Ames Research Center, Moffett Field, CA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 521-528. Previously announced in STAR as N90-23374. refs
Copyright

The design and simulator evaluation of an automation tool for assisting terminal radar approach controllers in sequencing and spacing traffic onto the final approach course is described. The automation tool, referred to as the Final Approach Spacing Tool (FAST), displays speed and heading advisories for arrivals and sequencing information on the controller's radar display. The main functional elements of FAST are a scheduler that schedules and sequences the traffic, a four-dimensional trajectory synthesizer that generates the advisories, and a graphical interface that displays the information to the controller. FAST has been implemented on a high-performance workstation. It can be operated stand-alone in the terminal radar approach control (TRACON) facility or as an element of a system integrated with automation tools in the Air Route Traffic Control Center). Simulation results show that FAST significantly reduced controller workload and demonstrated a potential for an increase in landing rate. Author

A91-30769* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE AUTOMATIC HUMAN
CHARLES BILLINGS (NASA, Ames Research Center, Moffett Field, CA) Aerospace (UK) (ISSN 0305-0831), vol. 18, March 1991, p. 14-19.
Copyright

An overview is presented of the growth and role of automation in civil aircraft operations for both cockpit management and ground control. NASA has initiated a research program centered on furthering automation and developing a consistent and rational philosophy of human centered aircraft and air traffic control automation. Introduction of the NASA Aviation Safety Reporting

System (ASRS) has proved successful in bringing together pilots and ground controllers to report incidents of operational anomalies that can then be analyzed, leading to corrective action to prevent similar reoccurrences. Attention is given to the growing trend of extensive automation in the cockpit that appears to be leading to a diminution of management control of the aircraft by the decreasing number of flight crew members. A majority of reports indicate that there is a serious mismatch between new aircraft capabilities and ATC procedures, which were designed for older aircraft. ASRS has also kept research oriented toward real problems and community needs. R.E.P.

A91-31429
AIRCRAFT GROUND ATTITUDE AND STABILIZATION FOR VARIED LOADING CONDITIONS
C. S. CHU (Lockheed Aeronautical Systems Co., Marietta, GA) Journal of Aerospace Engineering (ISSN 0893-1321), vol. 4, April 1991, p. 184-193.
Copyright

It is important to be able to predict cargo aircraft ground attitude and stabilization during loading of cargo in order to prevent possible damage to the aircraft. In the present study, two simultaneous equations with two unknowns were formulated according to the equilibrium conditions of all forces and moments; a nonlinearity was introduced into the equations to account for the load-deflection characteristics of landing gears. Newton-Raphson's method, an iterative approach, was employed to solve these two nonlinear equations. The number of iterations was controlled by the mean-square error. The predictions of the vertical displacements at the supports and the angular rotation of the cargo floor would provide the information for stabilization requirements. More than 100 loading conditions were tested; no solution was divergent. The analytical approach proves very successful and efficient for this particular problem. Furthermore, the approach is adaptable to all cargo aircraft. Author

A91-32155#
A SMOKEJUMPERS' PARACHUTE MANEUVERING TRAINING SIMULATOR
JEFFREY R. HOGUE, WALTER A. JOHNSON, R. WADE ALLEN (Systems Technology, Inc., Hawthorne, CA), and DAVE PIERCE (USDA, Equipment Development Center, Fort Missoula, MT) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 33-41.
(AIAA PAPER 91-0829) Copyright

Parachute-maneuvering training requirements are outlined, along with the motivations for the development of a smokejumpers' interactive training simulator. The simulator is based on a PC with an analog interface. A monitor displays the landing scene which moves and rotates in response to inputs from two steering toggles attached to steering lines routed through pulleys to a force-feel system. Visual-display requirements are discussed and such parachute maneuvering features as the visual scene, instructor's-monitor features, and terrain model are described. Landing hazards including strong-wind conditions and maneuvering near the ground to avoid obstacles such as trees are considered. V.T.

A91-32164#
DYNAMICS OF THE PARACHUTE SLING - TESTING PROCEDURES AND EVALUATIONS
D. C. PREVORSEK, H. B. CHIN, and Y. D. KWON (Allied-Signal, Inc., Morristown, NJ) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 120-129. refs
(AIAA PAPER 91-0846) Copyright

This paper discusses material science aspects of a parachute sling. During the deployment of a parachute, the sling experiences the impact caused by rapid deceleration of the parachute. To survive this operation, the sling must have sufficient impact resistance in addition to the strength to withstand the tension due to the weight of payload. The amount of energy absorbed by the sling due to the impact was estimated from the dynamic analysis of a parachute. From the results of the dynamic analysis, the key properties required for a sling material were determined and testing procedures to evaluate those properties were established. The experimental evaluation results for two candidate materials are presented. Author

A91-32186#
AN IMPULSE APPROACH FOR DETERMINING PARACHUTE OPENING LOADS FOR CANOPIES OF VARYING STIFFNESS
EUGENE E. NIEMI, JR. (Lowell, University, MA) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 316-322. U.S. Army-supported research. refs
(AIAA PAPER 91-0874) Copyright

A method of adapting the relative stiffness index to correlate data on parachute opening shock through a parameter called the modified impulse is presented. Results of the modified impulse approach are compared to predictions from an opening dynamics theory for two parachute mass ratios and various Froude numbers. The parachute relative stiffness index is first utilized to determine parachute opening time. The modified impulse concept can then be employed to obtain fair to good correlation for parachute opening shock for flat circular canopies of various canopy materials and sizes. This method makes it possible to utilize scale model drop test data to predict prototype performance with improved confidence. R.E.P.

A91-32188#
9DOF-SIMULATION OF ROTATING PARACHUTE SYSTEMS
K.-F. DOHERR (DLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) and H. SCHILLING (Rheinmetall GmbH, Duesseldorf, Federal Republic of Germany) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 333-343. refs
(AIAA PAPER 91-0877) Copyright

A 9 degree-of-freedom computer program is developed for the simulation of trajectory and dynamic behavior of a parachute system to reduce time-consuming field tests using expensive hardware. The influence of the important system parameters, mass, dimensions, aerodynamic coefficients, moments of inertia, wind disturbances, position of the parachute connection point, and initial conditions, can now be analyzed by simulation. To better understand the complicated motion, the computed trajectory and attitude data are graphically processed in a computer movie. The mathematical model of the parachute load system is described along with typical simulation results. R.E.P.

A91-32191#
THE DESIGN AND FLIGHT TESTING OF A HIGH-PERFORMANCE, LOW-COST PARACHUTE SYSTEM FOR A 1000 LB PAYLOAD
VANCE L. BEHR (Sandia National Laboratories, Albuquerque, NM) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 366-373. U.S. Army-sponsored research.
(Contract DE-AC04-76DP-00789)
(AIAA PAPER 91-0881)

An airdrop system is being developed by Sandia National Laboratories for the U.S. Army which is to be delivered as low as 300 ft above ground level and at speeds as high as Mach 0.95. The development of the system includes both the vehicle and the parachute recovery system. The gross weight of the vehicle when dropped is approximately 950 lbs. The parachute system employs an aerodynamically deployed tailplate, a reefed and staged drogue parachute, and a cluster of three main parachutes. The three main parachutes are T-10 personnel parachutes. The use of these

parachutes will help minimize the cost of the parachute system. This system has been both ground and flight tested. This paper stresses the results of the flight test program and the impact those results had on the design of the parachute system.
Author

A91-32192#
DESIGN AND PERFORMANCE OF A PARACHUTE FOR THE RECOVERY OF A 760-LB PAYLOAD
DONALD E. WAYE (Sandia National Laboratories, Albuquerque, NM) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 374-383. refs
(Contract DE-AC04-76DP-00789)
(AIAA PAPER 91-0882)

A 26-ft-diameter ribbon parachute deployed using a pilot parachute system has been developed at Sandia National Laboratories for the recovery of a 760-lb payload released at subsonic and transonic speeds. The wide range of deployment dynamic pressures led to the design, utilizing wind tunnel testing and computer simulation, of a unique pilot parachute system verified in full-scale flight tests. Performance data from 20 full-scale flight tests were used to evaluate system performance and structural adequacy.
Author

A91-32196#
RAPID - THE DESIGN OF A LOW ALTITUDE PARACHUTE
ELSA J. HENNINGS (U.S. Navy, Naval Weapons Center, China Lake, CA) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 408-420.
(AIAA PAPER 91-0887)

The regulated area progressive inflation decelerator (RAPID) was designed to address the need for protective ejection capsules to replace open ejection seats in future high speed aircraft. Utilizing a new reefing system, the parachute was designed to open rapidly at low speeds and to open at a rate controlled by the force on the parachute at high speeds, thus optimizing the inflation process. Tests conducted compared performances of the 28 ft flat circular parachute with a RAPID prototype having an equivalent drag area. Results showed that at low speeds the RAPID parachute consistently opened quicker than the 28 ft flat chute, opening almost twice as fast during the lowest speed test. Consideration is given to the design theory, scale model basic configuration, full scale deployment testing, and comparison testing of the RAPID system.
R.E.P.

A91-32198#
LOW ALTITUDE RETROROCKET SYSTEM (LARRS) - SYSTEM OVERVIEW AND PROGRESS
BRUCE A. WILSON (AAI Corp., Hunt Valley, MD) and HENRY ANTKOWIAK (U.S. Army, Natick Research, Development, and Engineering Center, MA) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 436-447.
(AIAA PAPER 91-0890)

This paper presents the design, manufacture and test of the airdrop system, LARRS, which utilizes retrorockets as the system's main decelerating component that can be dropped as low as 300 ft above ground level. Drop tests to characterize extraction/stabilization parachute performance are described as well as static tests of the retrorockets which verify predicted performance. Horizontal dynamic tests and bench tests of the system's controlling electronics have been performed and various communications errors have been corrected. Inert, low velocity drop tests have also been conducted as the final step prior to live testing with several corrections applied to the altimeter and sequencer programming.
R.E.P.

A91-32199#
ROCKET ASSISTED AIR DROP SYSTEM
ED VICKERY, JOHN SMITH, ED FALLON (Pioneer Aerospace Corp., South Windsor, CT), and HENRY E. ANTKOWIAK (U.S. Army, Natick Research, Development, and Engineering Center, MA) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 448-454.
(AIAA PAPER 91-0891)

The Low Altitude Retrorocket System (LARRS) is being developed to enable the Army to airdrop supplies and equipment weighing 6,700 to 60,000 lbs from aircraft flying as low as 300 ft above ground level at 130 to 250 knots. This paper studies the weight range between 6,700 and 20,000 lbs, which is divided into discrete segments and using only one size parachute. A laser ground sensor used in conjunction with a microprocessor/logic system computes the height above the ground, rate of descent, and initiates retrorocket fire. The retrorockets decelerate the load to a touchdown of less than eight feet per second. Attention is given to the overall system, the parachute system, parachute dynamics and trajectory analysis, the LARRS mathematical model, the LARRS simulation parachute parameters, and correlation to flight test results.
R.E.P.

N91-19028*# Ohio Univ., Athens. Dept. of Electrical and Computer Engineering.
INVESTIGATION OF AIR TRANSPORTATION TECHNOLOGY AT OHIO UNIVERSITY, 1989-1990
ROBERT W. LILLEY *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1989-1990 p 61-66 Dec. 1990
Avail: NTIS HC/MF A09 CSCL 01A

The activities of the participants in the Joint University Program (JUP) at Ohio University are briefly surveyed. During 1989 to 1990, five topics received emphasis. A spectrum-efficient weather data uplink system was designed, constructed, and flight tested. An integrated Global Positioning System/Inertial Navigation System (GPS/INS) study continued, utilizing the Redundant strapdown Inertial Measurement Unit (IMU) on loan from NASA. The Ridge Regression theory was refined and applied to air navigation scenarios. System Identification theory was applied to GPS data to point the way to better understanding of the effects of Selective Availability on civilian users of this navigation system. An analysis of thought-related (electroencephalographic) signals for application to control of computer systems that could have significance in aiding paraplegics or for hands-off systems control in industrial or air traffic control areas was carried out.
Author

N91-19033*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
INVESTIGATION OF AIR TRANSPORTATION TECHNOLOGY AT PRINCETON UNIVERSITY, 1989-1990
ROBERT F. STENGEL *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1989-1990 p 105-118 Dec. 1990
Avail: NTIS HC/MF A09 CSCL 01A

The Air Transportation Technology Program at Princeton University proceeded along six avenues during the past year: microburst hazards to aircraft; machine-intelligent, fault tolerant flight control; computer aided heuristics for piloted flight; stochastic robustness for flight control systems; neural networks for flight control; and computer aided control system design. These topics are briefly discussed, and an annotated bibliography of publications that appeared between January 1989 and June 1990 is given.
Author

N91-19034*# Princeton Univ., NJ.
PROGRESS ON INTELLIGENT GUIDANCE AND CONTROL FOR WIND SHEAR ENCOUNTER
D. ALEXANDER STRATTON *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research,

1989-1990 p 119-131 Dec. 1990
Avail: NTIS HC/MF A09 CSCL 01A

Low altitude wind shear poses a serious threat to air safety. Avoiding severe wind shear challenges the ability of flight crews, as it involves assessing risk from uncertain evidence. A computerized intelligent cockpit aid can increase flight crew awareness of wind shear, improving avoidance decisions. The primary functions of a cockpit advisory expert system for wind shear avoidance are discussed. Also introduced are computational techniques being implemented to enable these primary functions. Author

N91-19073*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ROBUST FAULT DIAGNOSIS OF PHYSICAL SYSTEMS IN OPERATION Ph.D. Thesis - Rutgers - The State Univ.
KATHY HAMILTON ABBOTT Jan. 1991 166 p
(NASA-TM-102767; NAS 1.15:102767) Avail: NTIS HC/MF A08 CSCL 01C

Ideas are presented and demonstrated for improved robustness in diagnostic problem solving of complex physical systems in operation, or operative diagnosis. The first idea is that graceful degradation can be viewed as reasoning at higher levels of abstraction whenever the more detailed levels proved to be incomplete or inadequate. A form of abstraction is defined that applies this view to the problem of diagnosis. In this form of abstraction, named status abstraction, two levels are defined. The lower level of abstraction corresponds to the level of detail at which most current knowledge-based diagnosis systems reason. At the higher level, a graph representation is presented that describes the real-world physical system. An incremental, constructive approach to manipulating this graph representation is demonstrated that supports certain characteristics of operative diagnosis. The suitability of this constructive approach is shown for diagnosing fault propagation behavior over time, and for sometimes diagnosing systems with feedback. A way is shown to represent different semantics in the same type of graph representation to characterize different types of fault propagation behavior. An approach is demonstrated that threats these different behaviors as different fault classes, and the approach moves to other classes when previous classes fail to generate suitable hypotheses. These ideas are implemented in a computer program named Draphys (Diagnostic Reasoning About Physical Systems) and demonstrated for the domain of inflight aircraft subsystems, specifically a propulsion system (containing two turbofan systems and a fuel system) and hydraulic subsystem. Author

N91-19074*# Continuum Dynamics, Inc., Princeton, NJ.
FEASIBILITY OF AN ONBOARD WAKE VORTEX AVOIDANCE SYSTEM Final Report
ALAN J. BILANIN, MILTON E. TESKE, and HOWARD C. CURTISS, JR. Apr. 1987 80 p
(Contract NAS1-17742; DTRS-57-85-C-000123)
(NASA-CR-187521; NAS 1.26:187521; CDI-87-02) Avail: NTIS HC/MF A05 CSCL 01C

It was determined that an onboard vortex wake detection system using existing, proven instrumentation is technically feasible. This system might be incorporated into existing onboard systems such as a wind shear detection system, and might provide the pilot with the location of a vortex wake, as well as an evasive maneuver so that the landing separations may be reduced. It is suggested that this system might be introduced into our nation's commuter aircraft fleet and major air carrier fleet and permit a reduction of current landing separation standards, thereby reducing takeoff and departure delays. Author

N91-19075# MiTech, Inc., Washington, DC.
THE 1990-1991 AVIATION SYSTEM CAPACITY PLAN Report, Jul. 1989 - Jun. 1990
Sep. 1990 312 p
(Contract DTFA01-89-Y-01047)
(AD-A229863) Avail: NTIS HC/MF A14 CSCL 01/3

This is a comprehensive review of the Federal Aviation Administration's program to improve the capacity of the National Air Transportation System. The Plan identifies the causes and extent of capacity and delay problems currently associated with air travel in the U.S., and outlines various planned and ongoing FAA projects that will reduce the severity of the problem in the future. The major areas of discussion are: (1) Airport Development; (2) Airport and Airspace Capacity Improvement; (3) Technological Improvements; and (4) Marketplace Solutions. GRA

N91-20064# Federal Aviation Administration, Atlantic City, NJ.
DEVELOPMENT AND GROWTH OF INACCESSIBLE AIRCRAFT FIRES UNDER INFLIGHT AIRFLOW CONDITIONS Final Report
DAVID BLAKE Feb. 1991 33 p
(DOT/FAA/CT-91/2) Avail: NTIS HC/MF A03

An attempt was made to determine the likelihood of fire development and growth in accessible areas of an aircraft and the resulting hazards to cabin occupants from these fires. Numerous inflight fires or smoke events occur in accessible areas but are controlled by the crew or self-extinguish. Fatal inflight fires are rare events but start in inaccessible areas. Some 57 tests of hidden inflight fires in a section of a DC-10 aircraft were performed. The fires were started behind sidewall panels, below the cabin floor, above the cabin ceiling, in overhead stowage bins, in lavatory trash receptacles, and adjacent to lavatory flush motors. The conclusions are that although uncontaminated insulation blankets did not readily support combustion, contaminated insulation blankets were found to support combustion and the built in Halon 1301 trash receptacle extinguishers did not always completely extinguish trash fires. Author

N91-20066# Sandia National Labs., Albuquerque, NM.
F111 CREW ESCAPE MODULE PILOT PARACHUTE
E. L. TADIOS 1991 6 p Presented at the 11th AIAA Aerodynamic Decelerator Systems Technology Conference, San Diego, CA, 9-11 Apr. 1991
(Contract DE-AC04-76DP-00789)
(DE91-007573; SAND-90-2124C; CONF-9104171-5) Avail: NTIS HC/MF A02

A successfully deployment of a parachute system highly depends on the efficiency of the deployment device and/or method. There are several existing methods and devices that may be considered for a deployment system. For the F111 Crew Escape Module (CEM), the recovery parachute system deployment is initiated by the firing of a catapult that ejects the complete system from the CEM. At first motion of the pack, a drogue gun is fired, which deploys the pilot parachute system. The pilot parachute system then deploys the main parachute system, which consists of a cluster of three 49 ft diameter parachutes. The pilot parachute system which extracts the F111 Crew Escape Module recovery parachute system must provide reasonable bag strip velocities throughout the flight envelope (10 to 300 psf). The pilot parachute system must, therefore, have sufficient drag area at the lower dynamic pressures and a reduced drag area at the high end of the flight envelope. The final design that was developed was a dual parachute system which consists of a 5 ft diameter guide surface parachute tethered inside a 10 ft diameter flat circular parachute. The high drag area is sustained at the low dynamic pressures by keeping both parachutes intact. The drag area is reduced at the higher extreme by allowing the 10 ft parachute attachment to fail. The discussions to follow describe in detail how the system was developed. DOE

N91-20120*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NASA'S AIRCRAFT ICING TECHNOLOGY PROGRAM
JOHN J. REINMANN *In its* Aeropropulsion 1991 24 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 01/3

NASA's Aircraft Icing Technology Program is aimed at developing innovative technologies for safe and efficient flight into forecasted icing. The program addresses the needs of all aircraft classes and supports both commercial and military applications. The program is guided by three key objectives: (1) to numerically

simulate an aircraft's response to an in-flight icing encounter; (2) to provide improved capabilities and techniques for ground and flight icing testing; and (3) offer innovative approaches to ice protection. The fundamental research focuses on topics that directly support stated industry needs, and work is performed closely with industry to assure a rapid and smooth transfer of technology. The progress toward the three stated strategic objectives is reviewed.
Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A91-28826
STRAPDOWN ASTRO-INERTIAL NAVIGATION UTILIZING THE OPTICAL WIDE-ANGLE LENS STARTRACKER
S. LEVINE (Northrop Corp., Electronics Systems Div., Hawthorne, CA), R. DENNIS (USAF, Wright-Patterson AFB, OH), and K. L. BACHMAN (U.S. Navy, Naval Air Development Center, Warminster, PA) Navigation (ISSN 0028-1522), vol. 37, Winter 1990-1991, p. 347-362.
Copyright
This paper discusses the application of strapdown stellar inertial systems as autonomous navigators for manned aircraft, ships, missiles, and remote piloted vehicles. It analyzes the implications of gyroscopic performance, artificial stellar image stabilization, star density, sky visibility, and sky background irradiance considerations for system performance. It concludes that a high-precision, reliable, low-cost stellar inertial system can be achieved by eliminating gimbals and combining a strapdown INS with an optical wide-angle lens startracker (OWLS).
Author

A91-29122
SPECIAL REPORT - AIR TRAFFIC CONTROL
TEKLA S. PERRY and JOHN A. ADAM IEEE Spectrum (ISSN 0018-9235), vol. 28, Feb. 1991, p. 22-36.
Copyright
Measures being undertaken to improve the U.S. ATC system are discussed. Near-term improvements in the system are examined, and concerns over whether these changes will be comprehensive and made quickly enough to keep up with traffic growth are addressed. Longer-term solutions to air traffic management are examined. The use of global networks of satellites to replace ground radars is considered along with the development of greater capability in cockpits, better weather prediction and information transfer, and the use of artificial intelligence in the ATC system. Finally, a forum of 15 experts in ATC operations present their opinions on top priorities for safe and accessible skies.
C.D.

A91-29138
TERMINAL CONTROL MONITOR FOR ATC USING KNOWLEDGE-BASED SYSTEM
CHIN E. LIN and YI-TSER LIU (National Cheng Kung University, Tainan, Republic of China) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. 27, Jan. 1991, p. 111-117. refs
Copyright
A knowledge-based system for air traffic control (ATC) in terminal control regions is designed for improving service and operation. Domain knowledge is established following rules, regulations, and comments from controllers. An expert system is adopted for approach control and airport control in the terminal control region. The proposed system was implemented in PC-AT with Turbo Prolog. The air terminal control monitor was checked with regard to flight information input, real-time data refreshment, air traffic rescheduling, constraint violation double checking, emergency responses, and normal monitoring. Simulation results are given.
I.E.

A91-30000
RADIO COMMUNICATIONS IN AVIATION: HANDBOOK [AVIATSIONNAIA RADIOSVIAZ': SPRAVOCHNIK]
PETR V. OLIANIUK, VLADIMIR A. RUSOL, VLADIMIR N. GAN'SHIN, G. O. KRYLOV, V. F. KISELEV et al. Moscow, Izdatel'stvo Transport, 1990, 208 p. In Russian.
Copyright
The basic requirements on radio communication in aviation are given, and theoretical questions are clarified. The characteristics of onboard and ground-based radio stations and satellite communication systems are examined. Particular attention is given to aspects of the organization of communication in aviation, as well as to regulations governing radio communication pertaining to international flights.
B.J.

A91-30060
ARRIVAL PLANNING AND SEQUENCING WITH COMPAS-OP AT THE FRANKFURT ATC-CENTER
U. VOELCKERS (DLR, Institut fuer Flugfuehrung, Brunswick, Federal Republic of Germany) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 496-501. refs
Copyright
An overview of the COMPAS-OP project is given. Its objectives were to develop an operational computer-oriented metering, planning, and advisory system (COMPAS-OP) for the air traffic control (ATC) center at Frankfurt/Main and to verify the experimental investigations of COMPAS. Basically, COMPAS is a computer-controlled planning system that helps the ATC controllers to plan and control the inbound flow of air traffic into the terminal control area of an airport more efficiently. The planning algorithm suggests a landing sequence and schedule to air traffic controllers, taking into account a variety of constraints and parameters in order to exploit the available capacity of an airport in an optimal way. Unnecessary delays are avoided and unavoidable delays are reduced as early as possible.
I.E.

A91-30061
MAESTRO - A METERING AND SPACING TOOL
JEAN-LOUIS GARCIA (Centre d'Etudes de la Navigation Aerienne, Orly Aerogare, France) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 502-507.
Copyright
An arrival management tool for airports, called MAESTRO (means to aid expedition and sequencing of traffic with research and optimization), is described. The main goal of MAESTRO, which is based on estimated time computation and sequencing criteria consideration, is to provide a proposal for arrival flight sequencing and indication for actions leading to the proposed sequence. The overall philosophy of MAESTRO is to have computation and proposal done by the machine, and actions and decision made by the controllers. The objectives of the tool are: to guarantee the optimal feeding of the airport; to improve the interface between Tracon and ACC; to lead to a better use of the control system capacity; and to optimize the delay management process in all centers. The system consists in four basic functions: (1) estimated time computation; (2) sequence elaboration; (3) user assistance provision for actions to be undertaken; (4) man-machine interface. MAESTRO has been operated at Orly airport and Paris ACC since December 1989.
I.E.

A91-30062
A PROTOTYPING EFFORT TO DEVELOP A NEW ARTS-IIIA AUTOMATION AID
DAVID R. BARKER and JENNIFER LEVIN (Mitre Corp., Bedford, MA) IN: 1990 American Control Conference, 9th, San Diego,

CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 508-513. refs
Copyright

A prototyping process that has resulted in the imminent fielding of an air traffic controller display aid at Lambert-St. Louis International Airport's terminal radar approach control (TRACON) facility is presented. The automation aid will be implemented in the St. Louis automated radar terminal system (ARTS) computer for field evaluation, which, if successful, will lead to a national implementation. The aid is designed to allow two streams of aircraft to be safely controlled when approaching converging runways. I.E.

A91-30063* San Jose State Univ., CA.
THE TRAFFIC MANAGEMENT ADVISOR
WILLIAM NEDELL (San Jose State University, CA), HEINZ ERZBERGER, and FRANK NEUMAN (NASA, Ames Research Center, Moffett Field, CA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 514-520. refs
Copyright

The traffic management advisor (TMA) is comprised of algorithms, a graphical interface, and interactive tools for controlling the flow of air traffic into the terminal area. The primary algorithm incorporated in it is a real-time scheduler which generates efficient landing sequences and landing times for arrivals within about 200 n.m. from touchdown. A unique feature of the TMA is its graphical interface that allows the traffic manager to modify the computer-generated schedules for specific aircraft while allowing the automatic scheduler to continue generating schedules for all other aircraft. The graphical interface also provides convenient methods for monitoring the traffic flow and changing scheduling parameters during real-time operation. I.E.

A91-30065
A TAXI AND RAMP MANAGEMENT AND CONTROL SYSTEM (TARMAC)
D. DIPPE (DLR, Institut fuer Flugfuehrung, Brunswick, Federal Republic of Germany) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 529-534.
Copyright

A novel operational concept which necessitates not only new solutions in hardware or software functions but also a very careful new design of the ground controller's working environment is under development at DLR. The current system is examined from the viewpoints of surveillance and identification, communication, navigation and guidance, and control and planning. Guidelines for the new system are developed. Based on the guidelines, a new system, called the integrated ground movement planning system, is described. I.E.

A91-30066
ANALYSIS OF THE POTENTIAL BENEFITS OF TERMINAL AIR TRAFFIC CONTROL AUTOMATION (TATCA)
STEVEN B. BOSWELL, JOHN W. ANDREWS, and JERRY D. WELCH (MIT, Lexington, MA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 535-542. FAA-sponsored research. refs
Copyright

Terminal Air Traffic Control Automation (TATCA) is an FAA research and development program to provide computer-aided sequencing, spacing, and management of air traffic flows in terminal areas. Technical and national economic benefits that are attainable with such a terminal automation program are discussed. Overall, capacity gains obtainable with TATCA have been estimated to range between 14 percent and 24 percent in most IFR conditions, averaging approximately 16 percent. The gains arise from landing sequence planning, from final approach timing aids that increase runway delivery precision, and from the dynamic time-based plans (DTP's) role in maintaining an uninterrupted flow of traffic to the final vector area. The DTP arrival schedule, along with advisories that enable controllers to execute the schedule, permit air traffic control to offer descent profiles and delay absorption techniques to the user community that are more cost-effective than those in use today. Together, TATCA's capacity increases and improved flight efficiency represent savings to the nation that are estimated to total $3.5 billion annually. I.E.

A91-30533
THE CONTROL OF INBOUND FLIGHTS
ANDRE BENOIT and SIP SWIERSTRA (EUROCONTROL, Brussels, Belgium) Journal of Navigation (ISSN 0373-4633), vol. 44, Jan. 1991, p. 85-96. refs
Copyright

This paper describes the basic principles of a method developed to guide aircraft accurately down to the runway in a time-of-arrival constrained environment. The method is designed to be used in a 'zone of convergence' context or in any similar advanced air traffic control system characterized by the integration of control phases over an extended area on the one hand and true 'computer assistance' to the air traffic controller on the other; that is, assistance provided at the decision-making level through the automatic generation of guidance advisories. The method includes two closely-coupled basic components: (1) a 'predictor' which computes a trajectory once initial conditions and plans are known and (2) a 'profile manager' which adapts the plans to meet the time constraints and generates the guidance directions on the basis of present position, actual surveillance information, aircraft operation, and route constraints. Author

A91-30534
ESTIMATION ACCURACY OF CLOSE APPROACH PROBABILITY FOR ESTABLISHING A RADAR SEPARATION MINIMUM
SAKAE NAGAOKA and OSAMU AMAI (Electronic Navigation Research Institute, Tokyo, Japan) Journal of Navigation (ISSN 0373-4633), vol. 44, Jan. 1991, p. 110-121.
Copyright

An evaluation is conducted of the sufficiency of the safety margin obtainable through the use of a 5-n.m. radar-separation minimum with a monopulse long-range secondary surveillance radar (LSSR), in view of the estimation accuracy of the close-approach probability (CAP). The ratio of the minimum CAP for LSSR and conventional radar is estimated by means of a bootstrap based on empirical data obtained by the two radars. The results obtained confirm the Nagaoka et al. (1989) conclusions for an LSSR CAP of 5 n.m. O.C.

A91-30760
AGING ATC RADARS BEG FOR UPGRADES
RON SCHNEIDERMAN Microwaves & RF (ISSN 0745-2993), vol. 30, March 1991, p. 33, 34, 37 (4 ff.).
Copyright

The current status of FAA programs for upgrading airport ATC radar equipment is surveyed from an electronics industry perspective. A number of program delays are discussed, and it is suggested that they may lead to business opportunities for firms in the HF hardware sector. Particular attention is given to phased-array antenna systems for monitoring traffic on the ground, runway-incursion management systems, recent accidents involving ground collisions, delays in implementation due to antenna problems, proposed improvements in long-range en route radars, and continuing disagreements with respect to the transmission system for digital ATC messages. D.G.

A91-30902
INTEGRATED COMMUNICATION, RADIO NAVIGATION AND IDENTIFICATION SYSTEM (ICRNI)
JONATHAN SINAY (Elbit Computers, Ltd., Advanced Technology Center, Haifa, Israel) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May

21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 424-429.
Copyright

A description is given of the integrated communication, radio navigation, and identification (ICRNI) system been developed to resolve operational and logistical problems arising from the large quantities of communication equipment in the modern airborne platform and the heavy workload required to operate them. The ICRNI system was designed to fulfill the following objectives: centralized operation using the avionics display system; operation and control of communication, radio navigation, and identification equipment, and audio devices; equipment/channel selection; synthetic voice and tonal warning function; definition of priorities and parameters for alarms; failure tolerance, enabling communication operation during major failures of the system; and integration with avionics. I.E.

N91-19026*# Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
THE TEMPORAL LOGIC OF THE TOWER CHIEF SYSTEM
LYMAN R. HAZELTON, JR. *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1989-1990 p 15-28 Dec. 1990
(Contract NGL-22-009-640)
Avail: NTIS HC/MF A09 CSCL 17G

The purpose is to describe the logic used in the reasoning scheme employed in the Tower Chief system, a runway configuration management system. First, a review of classical logic is given. Defensible logics, truth maintenance, default logic, temporally dependent propositions, and resource allocation and planning are discussed. Author

N91-19027*# Massachusetts Inst. of Tech., Cambridge.
BUBBLES: AN AUTOMATED DECISION SUPPORT SYSTEM FOR FINAL APPROACH CONTROLLERS
ZHIZANG CHI *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1989-1990 p 29-36 Dec. 1990
Avail: NTIS HC/MF A09 CSCL 17G

With the assumptions that an explicit schedule exists for landings (and takeoffs) at each runway, that each aircraft has declared an IAS for final approach and will be obligated to fly it as accurately as possible, and that there is a continuous estimate of average windspeed on approach, the objective was to provide automated cues to assist controllers in the spacing of landing aircraft. The cues have two characteristics. First, they are adaptive to estimation errors in position and speed by the radar tracking process and piloting errors in the execution of turns and commanded speed reductions. Second, the cues are responsive to the desires of the human controller. Several diagrams are used to help explain the system. Author

N91-19032*# Ohio Univ., Athens.
INTEGRATED INERTIAL/GPS
PAUL KLINE and FRANK VANGRAAS *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1989-1990 p 97-103 Dec. 1990
Avail: NTIS HC/MF A09 CSCL 17G

The presence of failures in navigation sensors can cause the determination of an erroneous aircraft state estimate, which includes position, attitude, and their derivatives. Aircraft flight control systems rely on sensor inputs to determine the aircraft state. In the case of integrated Inertial/NAVSTAR Global Positioning System (GPS), sensor failures could occur in the on-board inertial sensors or in the GPS measurements. The synergistic use of both GPS and the Inertial Navigation System (INS) allows for highly reliable fault detection and isolation of sensor failures. Integrated Inertial/GPS is a promising technology for the High Speed Civil Transport (HSCT) and the return and landing of a manned space vehicle. Author

N91-20067# Federal Aviation Administration, Washington, DC. Aviation System.
CAPITAL INVESTMENT PLAN
Dec. 1990 345 p
Avail: NTIS HC/MF A15

This is the Federal Aviation Administrations (FAA) first annual aviation system capital investment plan (CIP). The CIP describes the policies and strategies that the FAA will pursue in addressing key concerns of the National Airspace System (NAS). The plan addresses safety, efficiency, traffic demands, aging equipment and facilities, and airspace use. It creates a foundation for evolution of the existing NAS through use of new technologies and development of new products obtained from continuing research. The following topics are covered: (1) a summary of the overall plan; (2) remaining original NAS plan projects; (3) requirements that expand, relocate, or consolidate existing facilities/equipment; (4) projects that refurbish structures, replace obsolete equipment, or relocate facilities to maintain service, improve effectiveness, or reduce cost; (5) projects that support logistics, provide for personnel training, and manage the information and human resource aspects of NAS modernization; and (6) new projects which, if implemented, are expected to add significant new capabilities to the NAS. Author

N91-20068# Computer Technology Associates, Inc., McKee City, NJ.
CODEC TEST PLAN, PHASE 3
MARK GRABLE Sep. 1990 46 p
(Contract DTFA03-89-C-00023)
(AD-A230395; DOT/FAA/CT-TN90/16-PHASE-3) Avail: NTIS HC/MF A03 CSCL 25/2

The Federal Aviation Administration (FAA) Coder/Decoder (CODEC) Test Program will determine the suitability of low data rate digitized voice via a satellite link for air traffic control (ATC) applications. A primary concern of the FAA in assessing low data rate CODECs will be to minimize satellite bandwidth and power requirements while achieving acceptable voice performance. The final results of the FAA CODEC test plan will be analyzed and a recommendation of a low data rate voice CODEC for ATC communications will be proposed for inclusion to the Aeronautical Mobile Satellite Service (AMSS). The FAA CODEC testing will support the validation of Standards and Recommended Practices (SARPS), prepared by the International Civil Aviation Organization (ICAO), as well as Minimal Operational Performance Standards (MOPS), developed by the Radio Technical Commission for Aeronautics (RTCA), for AMSS voice communications. GRA

N91-20069# Federal Aviation Administration, Washington, DC. Office of Safety Oversight.
AUTOMATIC BAROMETRIC UPDATES FROM GROUND-BASED NAVIGATIONAL AIDS Final Report
W. J. COX, CAROL SIMPSON, and W. C. CONNOR 12 Mar. 1990 46 p
(AD-A230508; DOT/FAA/AOV-90-2) Avail: NTIS HC/MF A03 CSCL 01/4

This study examined techniques for transmitting automatic barometric updates of altimeter settings to pilots from ground-based navigation aids. It also examined the human factors and operational impact of providing automatic altimeter updates to flight crewmembers. The study considered the altimeter setting procedures of general aviation aircraft pilots operating in compliance with the Visual Flight Rules. And, it considered the altimeter setting procedures of pilots operating within the Instrument Flight Rules requirements. The study concludes that there are no insurmountable human factors or operational problems associated with the implementation of ABU, if the technique is based on automatic transmission of the barometric data through synthesized or digitized voice updates from the selected navigation aids. The study also concluded there is potential for improvement of aviation safety by implementing ABU techniques. These improvements would be in the form of: (1) enhancement of the quality of altimeter setting data used by VFR flight crewmembers operating below 18,000 feet MSL, (2) a reduction of workload for flight crewmembers of operating in either VFR or IFR environments, (3) a reduction of air traffic controller workload, and, (4) a small, but positive, reduction of traffic on ATC communication channels. GRA

N91-20070# Department of the Navy, Washington, DC.
ALL-WEATHER APPROACH AND LANDING GUIDANCE SYSTEM USING PASSIVE DIHEDRAL REFLECTORS Patent Application
GERALD E. HART, inventor (to Navy) 24 Jul. 1990 52 p
(AD-D014749; US-PATENT-APPL-SN-556606) Avail: NTIS HC/MF A04 CSCL 17/7

An all-weather aircraft landing system includes a plurality of ground based passive 90 deg dihedral reflectors for producing two-bounce reflected signals without ground reflections, and an airborne radar system which may transmit and receive 'same sense' circularly polarized radiation, while completely rejecting 'opposite sense' polarization returns or else using them to indicate weather conditions. Radar clutter from objects such as rain, building and trees which produce opposite sense reflections are rejected by the 'same sense' receiver or switched to an 'opposite sense' receiver to provide weather/obstacle condition information. By properly orienting a plurality of 90 deg dihedral angle reflectors of a particular size in a predetermined array pattern and tilt-angle adjacent a runway, the reflections from airborne radar signals are processed and displayed to provide a visual means for determining glide slope deviation and approach vector of the landing aircraft. In a preferred embodiment, two (portable) reflectors are used in conjunction with a conventional linearly polarized wave airborne radar system (e.g., standard modern weather radar), requiring no modifications to the airborne equipment while still providing an inexpensive means to obtain precise visual indication of glide slope and approach vector information. GRA

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A91-28470
A THEORETICAL MODEL FOR PREDICTING THE BLADE SAILING BEHAVIOUR OF A SEMI-RIGID ROTOR HELICOPTER
S. J. NEWMAN (Southampton, University, England) Vertica (ISSN 0360-5450), vol. 14, no. 4, 1990, p. 531-544. Ministry of Defence Procurement Executive-supported research.
Copyright

A theoretical aeroelastic model has been developed for determining the blade flapwise motion of a helicopter rotor during rotor engagement and disengagement, particularly in high wind conditions during operation from the flight deck of a ship. A computer program has been written and results from it are presented for a Lynx helicopter. Details of the flow state over typical flight deck are provided by wind tunnel tests of a 1/120th scale model of a ship of the Rover class of the Royal Fleet Auxiliary. Author

A91-28471* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
APPLICATION OF HIGHER HARMONIC CONTROL TO HINGELESS ROTOR SYSTEMS
KHANH NGUYEN (NASA, Ames Research Center, Moffett Field, CA) and INDERJIT CHOPRA (Maryland, University, College Park) Vertica (ISSN 0360-5450), vol. 14, no. 4, 1990, p. 545-556. refs
Copyright

A comprehensive analytical formulation has been dveloped to predict the vibratory hub loads of a helicopter rotor system in forward flight. The analysis is used to calculate the optimal higher harmonic control inputs and associated actuator power required to minimize these hub loads. The present formulation is based on a finite element method in space and time. A nonlinear time domain, unsteady aerodynamic model is used to obtain the airloads, and the rotor induced inflow is calculated using a nonuniform inflow model. Predicted vibratory hub loads are correlated with experimental data obtained from a scaled model rotor. Results of a parametric study on a hingeless rotor show that blade flap, lag and torsion vibration characteristics, offset of blade center of mass from elastic axis, offset of elastic axis from quarter-chord axis, and blade thrust greatly affect the higher harmonic control actuator power requirement. Author

A91-29438
THE BK 117 COMPOSITE HELICOPTER FUSELAGE
MICHAEL STEPHAN (MBB GmbH, Munich, Federal Republic of Germany) Vertiflite (ISSN 0042-4455), vol. 37, Mar.-Apr. 1991, p. 21-24.
Copyright

In 1985, the FRG's Ministry of Defense initiated a research program for the development of a helicopter FRP composite fuselage and its full-scale structural and flight testing. Attention was given to quantification of the weight-reduction and parts number-reduction potential of the FRP structure, as well as to the refinement of FRP-FRP and FRP-metal component-joining techniques. The BK 117 fuselage design was chosen for this development effort, in view of its configurational affinities with currently envisioned next-generation rotorcraft. The primary composite material system used was the 120 C-curing Fibredux/Vicotex 913 epoxy-resin prepreg, with glass, carbon, aramid, and hybrid fiber reinforcements. Outstanding environmental resistance was obtained in the -55 to + 130 C range. O.C.

A91-29440
ADVANCED COMPOSITE MATERIALS ON THE V-22
JAMES H. SCHAEFER (U.S. Navy, Naval Air Systems Command, Washington, DC) Vertiflite (ISSN 0042-4455), vol. 37, Mar.-Apr. 1991, p. 32-35.
Copyright

An unprecedented proportion of approximately half (6,372 lbs) of the V-22 tilt-rotor VTOL aircraft's structural weight consists of carbon/epoxy composites. The wing, fuselage, and empennage are virtually all-composite; the proprotor is 15-percent (612 lbs) carbon/epoxy and 17 percent (961 lbs) glass/epoxy. A discussion is presented of the risk/benefit considerations associated with the application of so high a proportion of advanced composites. In addition to substantial weight savings, the advantages of greater-than-metallic fatigue damage, enhanced survivability, and superior corrosion resistance, were considered compelling by the V-22's structural designers. The fuselage underfloor structure, wing support structure, and sections of the wing, are reinforced to furnish crash protection. O.C.

A91-29449
EH101 UPDATE; PROCEEDINGS OF THE CONFERENCE, LONDON, ENGLAND, OCT. 31, 1990
London, Royal Aeronautical Society, 1990, 68 p. No individual items are abstracted in this volume.
Copyright

The current status of the UK EH101 experimental combat helicopter development program is examined in reviews and reports. Consideration is given to engineering issues, handling aspects, avionics integration, and the EH101 utility variant. Diagrams, drawings, graphs, and tables of numerical data are provided. T.K.

A91-29465
LIGHTWEIGHT MODULAR INFRARED RADIATION SUPPRESSION SYSTEMS FOR AIRCRAFT
JAMES EASTWOOD and JAMES MCBRIDE (Allied-Signal Aerospace Co., Torrance, CA) IN: Rotary Wing Propulsion Specialists' Meeting, Williamsburg, VA, Nov. 13-15, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 7 p.
Copyright

The need for a low-cost, lightweight, easily maintained, high-quality, and highly effective IR suppression system for military aircraft has led to the development of a rectangular IR suppressor that utilizes a bolted assembly construction. This paper describes current modular suppressor design, fabrication, and application versatility intended to meet engine flow ranges from 3 to 30 pps. The suppressor system generally consists of an IR suppressor assembly, an engine compartment cooling duct, and an engine exhaust nozzle. This low-cost rectangular IR suppression system approach has been successfully demonstrated in terms of low engine power penalty, reduced manufacturing costs, and the ability to meet low signature level requirements. R.E.P.

A91-29478
FLIGHT TEST ASPECTS OF AIRBORNE WINDSHEAR SYSTEM FAA CERTIFICATION
JAMES B. ASHLEY (FAA, Long Beach, CA) IN: Windshear; Proceedings of the Conference, London, England, Nov. 1, 1990. London, Royal Aeronautical Society, 1990, p. 4.1-4.14.
Copyright

An overview is presented of the simulation and flight tests necessary for FAA certification of airborne wind shear detection and guidance systems. These tests comprise evaluation of wind shear detection and annunciation in the horizontal, vertical, and combined axis, and flight director guidance which is employed as an aid for exiting the wind shears. Six-degrees-of-freedom simulators and a flight test aircraft are used to conduct these tests. Simulator runs are performed with various aircraft configurations and performance levels to show at what windshear conditions the caution (increasing updraft or headwind) and/or warning (downdraft or increasing tailwind) are made possible. The flight test goal is to determine that the system in operation is free of nuisance failures and alerts, that it does not interfere with other systems, that it performs its intended function, and that engine operating characteristics are proper at the command angles of attack. R.E.P.

A91-29722
STALL TACTICS
PRESTON LERNER Air and Space (ISSN 0886-2257), vol. 6, Apr.-May 1991, p. 29-37.
Copyright

A review is presented of the X-31 Enhanced Fighter Maneuverability demonstrator. The fundamental goal of the X-31 project is to test dynamic maneuvers at angles of attack up to 70 degrees. Poststall stability in itself is not the goal but rather the means to the more specific end of poststall maneuverability. This aircraft departs radically from conventional form by not having to depend on rudder control to maneuver in the poststall regime. Instead, a thrust vectoring system provides the pilot with extra pitch authority and becomes the only source of yaw in the poststall regime. The thrust vectoring system, which is integrated with the automated flight control system, is made up of three paddles extending from the rear of the fuselage that by maneuvering into the exhaust plume can deflect the X-31 thrust 10 degrees from the centerline. In theory this will force the aircraft into a steep 70 degree angle of attack, actually pointing the nose away from the flight path. The X-31 is scheduled to continue evaluation flights until 1992 when it will be turned over to the military for a further 120 demonstration sorties of combat effectiveness. R.E.P.

A91-29787*# Cornell Univ., Ithaca, NY.
OPTIMAL AIRCRAFT PERFORMANCE DURING MICROBURST ENCOUNTER
MARK L. PSIAKI (Cornell University, Ithaca, NY) and ROBERT F. STENGEL (Princeton University, NJ) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 440-446. FAA-supported research. Previously cited in issue 21, p. 3487, Accession no. A88-50609. refs
(Contract NGL-31-001-252)
Copyright

A91-30232
PLANES WITHOUT PILOTS - ADVANCES IN UNMANNED FLIGHT
BILL SIURU (Colorado, University, Colorado Springs) Blue Ridge Summit, PA; TAB Books, 1991, 92 p.
Copyright

The history and current status of unmanned air vehicle (UAV) technology in the U.S. are discussed in an overview for the general reader. The different types of UAVs are defined, and sections are devoted to UAVs before 1940, World War II UAVs, UAVs of 1950-1970, Israeli UAVs, UAVs for support missions, and UAVs as weapons and targets. Consideration is given to remotely piloted research vehicles, battlefield robots, and civilian applications of UAVs. Drawings, diagrams, and extensive photographs are provided. T.K.

A91-30768
OCEANIC TWINJET POWER
PETER VINALL (Civil Aviation Authority, London, England) Aerospace (UK) (ISSN 0305-0831), vol. 18, March 1991, p. 10-13.
Copyright

A review is presented of the commercial airline propulsion reliability record with particular attention given to extended range twinjet operations (ETOPS). Improvements in engine reliability are continually developing due to the constant effort and care in design, material selection, special manufacturing quality control, conservative time extension policies, diagnostic procedures, trend monitoring, and overhaul and maintenance quality control. Combinations of new design approaches and materials are being developed for high energy rotating parts that will overcome the adverse scale effect for large engines so that significantly greater containment of high energy debris can be attained without unacceptable sacrifices in cost, weight, payload and fuel consumption. The introduction of ETOPS has concentrated attention on inflight shutdown rates to ensure that the risk of total loss of thrust from independent causes is maintained at an acceptably low level. Consideration is given to bird ingestion problems, foreign object damage, and other possible causes of potential multiple power loss. R.E.P.

A91-31031#
SURFACE MOUNT SOLDER JOINT ISSUES IMPACTING AVIONIC INTEGRITY
CYNTHIA L. LINGG (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1369-1378. refs

Some issues affecting surface mount solder joint life are addressed. Solder joint life expectancy depends on the level of stress experienced and the number of cycles of stress. Service life within a surface mount solder fillet follows mechanical failure models. These models predict failure at a predetermined number of cycles for different stress levels in the solder fillet. Fatigue in surface mount devices, castellations and surface finishes, life predictions, design criteria, manufacturing processes and controls, accelerated fatigue testing, and quality assurance provisions for solder joints are discussed. Each topic is introduced with a question expressing a concern relating to avionics integrity. I.E.

A91-31057
LANDING GEAR STEER-BY-WIRE CONTROL SYSTEM - DIGITAL VS ANALOG STUDY
LESZEK M. DACKO, RALPH F. DARLINGTON, and DAVID SHINDMAN (Dowty Canada, Ltd., Ajax) IN: 1990 Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 23-25, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 215-220.
Copyright

A worthiness study in which the digital steer-by-wire control system was compared to an analog one using the life-cycle cost procedure is presented. The purpose of the study was to determine whether the higher reliability, ease of test, decrease in maintenance cost, and lower delay and cancellation rates foreseen for the digital system were worth increased recurring and nonrecurring costs. A potential drawback is the cost of the software development and certification. It is strongly influenced by proper programming techniques and good definition of requirements. The life-cycle cost analysis has shown that it is advantageous to make a large initial investment in technology that will be paid back over the life of the system. I.E.

A91-31290* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MODAL ANALYSIS OF UH 60A INSTRUMENTED ROTOR BLADES
KAREN S. HAMADE and ROBERT M. KUFELD (NASA, Ames Research Center, Moffett Field, CA) IN: Innovations in rotorcraft test technology for the 90's; Proceedings of the AHS National Technical Specialists' Meeting, Scottsdale, AZ, Oct. 8-12, 1990. Alexandria, VA, American Helicopter Society, Inc., 1990, 13 p. refs
Copyright

The dynamic characteristics of instrumented and production UH-60A Black Hawk main rotor blades were measured, and the results were validated with NASTRAN finite element models. The blades tested included pressure and strain-gage instrumented blades which are part of NASA's Airloads Flight Research Phase of the Modern Technology Rotor Program. The dynamic similarity of the blades was required for accurate data collection in this program. Therefore, a nonrotating blade modal analysis was performed on the first 10 free-free modes to measure blade similarities. The results showed small differences between the modal frequencies of instrumented and production blades and a close correlation with the NASTRAN models. This type of modal testing and analysis is recommended as a standard procedure for future instrumented blade flight testing. Author

A91-31291* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ROTOR AND CONTROL SYSTEM LOADS ANALYSIS OF THE XV-15 WITH THE ADVANCED TECHNOLOGY BLADES
JOSEPH J. TOTAH and JOHN F. MADDEN, III (NASA, Ames Research Center, Moffett Field, CA) IN: Innovations in rotorcraft test technology for the 90's; Proceedings of the AHS National Technical Specialists' Meeting, Scottsdale, AZ, Oct. 8-12, 1990. Alexandria, VA, American Helicopter Society, Inc., 1990, 20 p. refs
Copyright

An analysis of the rotor and control system loads of the XV-15 with the Advanced Technology Blades (XV-15/ATB) was conducted to investigate the effects of modifications designed to alleviate high collective actuator loads encountered during initial flight tests. Rotor loads predictions were correlated with flight data to establish accuracies of the methodology used in the analysis. Control system loads predictions were then examined and were also correlated with flight data. The results showed a significant reduction in 3/rev collective actuator loads of the XV-15/ATB when the control system stiffness was increased and the rotor blade chord balance and tip twist were modified. Author

A91-31292
RESONANCE AND CONTROL RESPONSE TESTS USING A CONTROL STIMULATION DEVICE
HUBERT MUELLER and ALFRED GRUENEWALD (MBB GmbH, Munich, Federal Republic of Germany) IN: Innovations in rotorcraft test technology for the 90's; Proceedings of the AHS National Technical Specialists' Meeting, Scottsdale, AZ, Oct. 8-12, 1990. Alexandria, VA, American Helicopter Society, Inc., 1990, 9 p.
Copyright

This paper presents the main functions of the STIMULI-system currently utilized for ground and flight testing of the BO 108. Using this system reduces the pilot's workload considerably as he only has to stabilize the initial flight condition while the automatic main rotor control input occurs. From the helicopter's instrumentation pack a list of up to 15 channels can be indicated on the screen in text mode. For each measurement signal a digital on-line information is given about minima and maxima, respectively. Further details for the STIMULI system are furnished that cover component description, computer unit, operation and program menu, ground and air resonance tests, and engine resonance testing. R.E.P.

A91-31295* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NASA/ARMY ROTOR SYSTEM FLIGHT RESEARCH LEADING TO THE UH-60 AIRLOADS PROGRAM
W. J. SNYDER, J. L. CROSS, and ROBERT KUFELD (NASA, Ames Research Center, Moffett Field, CA) IN: Innovations in rotorcraft test technology for the 90's; Proceedings of the AHS National Technical Specialists' Meeting, Scottsdale, AZ, Oct. 8-12, 1990. Alexandria, VA, American Helicopter Society, Inc., 1990, 50 p. refs
Copyright

A review is presented of some of the early rotor systems flight research leading to the present comprehensive NASA/Army rotor system airloads program with the UH-60 helicopter. The experimental and analytical plans and progress for this program are described, including the design and development of a rotor blade which incorporated 242 pressure transducers buried in the surface of the blade, and also the development of calibration hardware for regular calibration and testing of the transducers. Supporting analytical developments based on the comprehensive analytical model of rotorcraft aerodynamics and dynamics (CAMRAD) and various CFD codes are discussed. The highly instrumented UH-60 as well as companion programs of full-scale and model wind tunnel tests of the UH-60 rotor with identical instrumentation will provide the opportunity to explore a full range of rotor experiments and the data necessary to validate the advanced methodologies under development. R.E.P.

A91-31296
V-22 FLIGHT TEST PROGRAM CHALLENGES, PROBLEMS AND RESOLUTION
PHILIP DUNFORD and KEN LUNN (Boeing Helicopters, Philadelphia, PA) IN: Innovations in rotorcraft test technology for the 90's; Proceedings of the AHS National Technical Specialists' Meeting, Scottsdale, AZ, Oct. 8-12, 1990. Alexandria, VA, American Helicopter Society, Inc., 1990, 18 p. refs
Copyright

A review of tiltrotor history is presented along with a description of the test considerations, test methods and extra testing required as a result of the V-22's unique multimode characteristics. Preflight testing is summarized and some of the significant milestones and accomplishments achieved during the envelope expansion and configuration development period are discussed. Consideration is also given to aeroservoelastics/dynamics, flight loads, avionics, data processing, and simulator support of flight test. The full envelope configuration/expansion development phase of the flight test program is progressing with structural load limiting, the incorporation of conversion corridor protection and the automatic flight control system scheduled for late 1990. R.E.P.

A91-31298
AGILITY AND MANEUVERABILITY FLIGHT TESTS OF THE BOEING SIKORSKY FANTAIL DEMONSTRATOR
NICHOLAS D. LAPPOS (Sikorsky Aircraft, Stratford, CT) IN: Innovations in rotorcraft test technology for the 90's; Proceedings of the AHS National Technical Specialists' Meeting, Scottsdale, AZ, Oct. 8-12, 1990. Alexandria, VA, American Helicopter Society, Inc., 1990, 8 p. refs
Copyright

An advanced fan-in-fin antitorque system designated Fantail is described and the flight test program to explore the demonstrators agility and maneuverability in the LH specification maneuvers is defined. The demonstrator is a modified S-76B aircraft with new vertical and horizontal tails along with the fan mechanism itself. It appears that the Fantail antitorque device has a strong advantage over conventional tail rotors in its excellent structural response to extreme yaw maneuvers. Flight test results indicate that the Fantail structure does not exceed unlimited life endurance loads in any maneuver yet tested. Several LH maneuvers were performed to explore measurement methods and techniques, including 180 deg hover turns accomplished stop to stop in less than four seconds. R.E.P.

A91-31527*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
UNSTEADY EULER ALGORITHM WITH UNSTRUCTURED DYNAMIC MESH FOR COMPLEX-AIRCRAFT AERODYNAMIC ANALYSIS
JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 29, March 1991, p. 327-333. Previously cited in issue 12, p. 1780, Accession no. A89-30679. refs
Copyright

A91-31576#
TOWARDS INTEGRATED MULTIDISCIPLINARY SYNTHESIS OF ACTIVELY CONTROLLED FIBER COMPOSITE WINGS
E. LIVNE, L. A. SCHMIT, and P. P. FRIEDMANN (California, University, Los Angeles) Journal of Aircraft (ISSN 0021-8669), vol. 27, Dec. 1990, p. 979-992. Previously cited in issue 12, p. 1781, Accession no. A89-30751. refs
(Contract F49620-87-K-0003)
Copyright

A91-31577*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SENSITIVITY ANALYSIS AND MULTIDISCIPLINARY OPTIMIZATION FOR AIRCRAFT DESIGN - RECENT ADVANCES AND RESULTS
JAROSLAW SOBIESZCZANSKI-SOBIESKI (NASA, Langley Research Center, Hampton, VA) (ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2, p. 953-964) Journal of Aircraft (ISSN 0021-8669), vol. 27, Dec. 1990, p. 993-1001. Previously cited in issue 03, p. 393, Accession no. A89-13598. refs
Copyright

A91-31583*# Lockheed Engineering and Sciences Co., Hampton, VA.
AIRCRAFT DESIGN FOR MISSION PERFORMANCE USING NONLINEAR MULTIOBJECTIVE OPTIMIZATION METHODS
AUGUSTINE R. DOVI and GREGORY A. WRENN (Lockheed Engineering and Sciences Co., Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Dec. 1990, p. 1043-1049. Previously cited in issue 21, p. 3267, Accession no. A89-49442. refs
(Contract NAS1-1800)
Copyright

A91-31584*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
INTEGRATED AERODYNAMIC-STRUCTURAL DESIGN OF A TRANSPORT WING
B. GROSSMAN, R. T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg), JAROSLAW SOBIESZCZANSKI-SOBIESKI (NASA, Langley Research Center, Hampton, VA), P.-J. KAO, D. M. POLEN, and M. RAIS-ROHANI Journal of Aircraft (ISSN 0021-8669), vol. 27, Dec. 1990, p. 1050-1056. Previously cited in issue 05, p. 3268, Accession no. A89-49475. refs
(Contract NSF DMC-86-15336; NAG1-603)
Copyright

A91-31586#
AIRCRAFT DESIGN OPTIMIZATION WITH DYNAMIC PERFORMANCE CONSTRAINTS
STEPHEN J. MORRIS and ILAN KROO (Stanford University, CA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Dec. 1990, p. 1060-1067. Previously cited in issue 12, p. 1781, Accession no. A89-30749. refs
Copyright

A91-31587#
STRATEGY FOR MULTILEVEL OPTIMIZATION OF AIRCRAFT
T. R. LOGAN (Rockwell International Corp., Los Angeles, CA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Dec. 1990, p. 1068-1072. Rockwell International Corp.-sponsored research. refs
Copyright

A specific decomposition methodology of a complex system of aircraft design variables to discrete levels where the variables have relatively equal impact is proposed. Multidisciplinary optimization techniques utilizing sensitivity derivatives and a global sensitivity matrix to combine the levels are used to develop a total optimum design. An advanced fighter wing example is used to illustrate the potential of improved design optimization in this multidisciplinary environment as compared to conventional sequential design development. Author

A91-31588#
EFFICIENT OPTIMIZATION OF AIRCRAFT STRUCTURES WITH A LARGE NUMBER OF DESIGN VARIABLES
UWE L. BERKES (ESA, Toulouse, France) (ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2, p. 1487-1497) Journal of Aircraft (ISSN 0021-8669), vol. 27, Dec. 1990, p. 1073-1078. Previously cited in issue 03, p. 266, Accession no. A89-13651. refs
Copyright

A91-31589#
COMPUTER-AIDED OPTIMIZATION OF AIRCRAFT STRUCTURES
P. BARTHOLOMEW (Royal Aerospace Establishment, Farnborough, England) and H. K. WELLEN (Deutsche Airbus GmbH, Bremen, Federal Republic of Germany) (ICAS, Congress, 16th, Jerusalem, Israel, Aug. 28-Sept. 2, 1988, Proceedings. Volume 2, p. 1650-1663) Journal of Aircraft (ISSN 0021-8669), vol. 27, Dec. 1990, p. 1079-1086. Previously cited in issue 03, p. 267, Accession no. A89-13669. refs
Copyright

A91-31622#
F-14 - NEW WINE IN OLD BOTTLES
RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 29, April 1991, p. 20-22, 34.
Copyright

Some proposed derivative versions of the F-14 and attendant advanced avionics and armament are discussed. The advanced F-14 would incorporate more powerful F-110 engines providing more thrust and less fuel burned and permitting carrier launches without the use of afterburners. New digital avionics could include a GPS satellite receiver, programmable system controls and displays, inertial navigation, and stores management systems. Electronic countermeasures could be enhanced with a new airborne self protection jammer and new radar warning receiver. For improved weaponry, armaments include the Advanced Medium-Range Air-to-Air Missile which has an effective target range up to 40 miles and a new gunsight that improves the kill probability of the 20 mm Gatling gun, which is capable of firing up to 100 rounds per second. R.E.P.

A91-31728#
A FRESH LOOK AT LIGHTER THAN AIR TECHNOLOGY
CARTER J. WARD (Ward Technology, Malibu, CA) and ATILLA M. TALUY (Taluy Co., Oxnard, CA) IN: AIAA Lighter-Than-Air Systems Technology Conference, 9th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 6-12. refs
(AIAA PAPER 91-1267) Copyright

A development history is presented for the dissemination of the remotely-controlled 'Stealth Mini-Blimp' technology which originated in the Naval Civil Engineering Laboratory's 1986 efforts to create a low radar/IR observables surveillance platform for the Seabees which would allow them to obtain construction-related information for potentially mine-infested areas. Other DOD agencies have used the blimp for ship-deployed surveillance and counterinfiltration surveillance. Nondefense and commercial organizations have used the blimp for communications support, air sampling, and visual-data display. Efforts are underway to develop a solar-powered, high-altitude version of the blimp. O.C.

A91-31733#
AN EMPIRICAL METHOD FOR NON-RIGID AIRSHIP PRELIMINARY DRAG ESTIMATION
J. M. WRIGHT, JR. and R. E. ADAMS (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: AIAA Lighter-Than-Air Systems Technology Conference, 9th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 59-66. refs
(AIAA PAPER 91-1277)

A preliminary drag estimation method for nonrigid airships was developed for use in airship conceptual design. Historical drag area trends for various airship components were developed based on performance estimation reports for several past Navy nonrigid airships. Wherever possible, drag area was based on overall airship size (envelope volume), with configuration differences taken into account. The component drag area equations were determined from a linear fit of the appropriate drag area trends. Published empirical drag estimation methods were used for the envelope and tail surfaces. A comparison between the drag area values calculated using this method and the historical data base indicates that this method provides an accurate preliminary estimation of airship drag area (both on a component and a total drag area basis). Author

A91-31734#
U.S. NAVY AIRSHIP TESTING
MICHAEL L. MCDANIEL (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: AIAA Lighter-Than-Air Systems Technology Conference, 9th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 67-69.
(AIAA PAPER 91-1272)

The USN has instituted a five-phase program running through most of the 1990s for flight testing and qualification of the YEZ-2A airship, which incorporates an unprecedentedly high proportion of advanced technologies. These encompass fly-by-light flight controls, a diesel/gas turbine combined powerplant, and a composite envelope. The long mission endurance for which the YEZ-2A is designed places a premium on all-weather underway replenishment and good human-factors design; some patrols of month-duration are envisioned. O.C.

A91-31736#
THE VARICAR AIRSHIP
DONALD M. LAYTON IN: AIAA Lighter-Than-Air Systems Technology Conference, 9th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 86-89. refs
(AIAA PAPER 91-1282) Copyright

An evaluation is made of the consequences for performance and costs of the 'VariCar' interchangeable-gondola concept for large-volume pressure airships. Broadly speaking, alternative passenger and/or cargo gondola sections can be attached to a permanent airframe encompassing the control cabin, propulsion system, landing gear, and gondola/hull structural interface. Two types of removable 'cab' are considered, one of which constitutes the whole of the gondola structure aft of the control cabin, while the other constitutes only a central section; in this case, the aft of the gondola is also part of the permanent airframe. O.C.

A91-31738#
AN OVERVIEW OF FAA TYPE CERTIFICATION OF THE US/LTA 138S AIRSHIP
PETER PUPATOR (US/LTA Corp., Eugene, OR), MICHAEL BERRY (M.B. Associates, Redondo Beach, CA), and JIM LARSEN (AeroAcoustics, Inc., Bothell, WA) IN: AIAA Lighter-Than-Air Systems Technology Conference, 9th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 94-100. refs
(AIAA PAPER 91-1290) Copyright

This paper presents an overview of the engineering data obtained during FAA Type Certification of the US/LTA model 138S Airship. All tests, analyses and descriptions were conducted during the time between application for Type Certificate, February 2, 1989, and receipt of the TC on July 24, 1990. Data presented includes airship system descriptions, maneuver models and results of relevant flight tests. Author

A91-31752#
SELF-EXCITED VIBRATION OF AN AIRCRAFT TIRE [DRGANIA SAMOWZBUDNE OPONY LOTNICZEJ]
ZDOBYSLAW GORAJ and WITOLD MOLICKI (Warszawa, Politechnika, Warsaw, Poland) Politechnika Slaska, Zeszyty Naukowe, Mechanika (ISSN 0434-0817), no. 99, 1990, p. 93-100. In Polish. refs

This paper presents some models of an isolated aircraft tire useful for self-excited vibration analysis. Necessary conditions for self-excited vibration to arise are presented. The paper includes some numerical results obtained for real designs, which are discussed in detail. Author

A91-31756#
MATHEMATICAL MODEL OF A HANG GLIDER DURING FLIGHT [MATEMATYCZNY MODEL LOTNI W LOCIE]
JERZY MARYNIAK and JACEK GOSZCZYNSKI (Warszawa, Politechnika, Warsaw, Poland) Politechnika Slaska, Zeszyty Naukowe, Mechanika (ISSN 0434-0817), no. 99, 1990, p. 235-244. In Polish. refs

This paper presents the physical and mathematical modeling of man-glider system. The modeling accounts for the aerodynamic characteristics of both the hang glider and the man. Author

A91-31854#
APPLICATION OF OPTIMIZATION TECHNIQUES TO HELICOPTER STRUCTURAL DYNAMICS
MICHAEL R. SMITH, M. A. V. RANGACHARYULU (Bell Helicopter Textron, Inc., Fort Worth, TX), BO P. WANG, and Y. K. CHANG (Texas, University, Arlington) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 227-237. refs
(AIAA PAPER 91-0924) Copyright

This paper presents the salient features and applications of a structural dynamics optimization program SOAR (Structural Optimization and Reanalysis). This program uses efficient reanalysis and optimum search techniques in conjunction with the widely used NASTRAN structural analysis code. A variety of objective function options tailored to the specific needs of the rotorcraft structural dynamicist are embedded in SOAR. Objective functions may include weight, dynamic response, static displacement, and an error norm suitable for correlation of dynamic analysis with measured test data. The program allows simultaneous optimization of multiple configurations with constraints on natural frequencies, static displacement, and dynamic response. A brief description of SOAR's theoretical background is presented along with examples and case studies to illustrate the capabilities of SOAR. Author

A91-31868*# General Dynamics Corp., Fort Worth, TX.
A TAGUCHI STUDY OF THE AEROELASTIC TAILORING DESIGN PROCESS
JONATHAN D. BOHLMANN (General Dynamics Corp., Fort Worth, TX) and ROBERT C. SCOTT (NASA, Langley Research Center, Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 364-372. refs
(AIAA PAPER 91-1041) Copyright

A Taguchi study was performed to determine the important players in the aeroelastic tailoring design process and to find the best composition of the optimization's objective function. The Wing Aeroelastic Synthesis Procedure (TSO) was used to ascertain the effects that factors such as composite laminate constraints, roll effectiveness constraints, and built-in wing twist and camber have on the optimum, aeroelastically tailored wing skin design. The results show the Taguchi method to be a viable engineering tool for computational inquiries, and provide some valuable lessons about the practice of aeroelastic tailoring. Author

A91-31870#
SENSITIVITY ANALYSIS OF DISCRETE PERIODIC SYSTEMS WITH APPLICATIONS TO ROTOR DYNAMICS
YI LU and V. R. MURTHY (Syracuse University, NY) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 384-393. refs
(AIAA PAPER 91-1090) Copyright
This paper presents an analytical formulation to determine the derivatives of eigenvalues and eigenvectors of periodic systems. This formulation is validated by applying it to a coupled rotor-body problem. The present formulation and the rotor model are applied to a sample helicopter rotor problem in forward flight, to determine the stability eigenvalues, eigenvectors, and the derivatives of eigenvalues and eigenvectors. The results are compared with those obtained using the existing methods and substantial savings in computation time is observed. The greatest advantage of the present method is that the order of the Floquet transition matrix to be used to determine the derivatives does not depend upon the number of parameters to be investigated, and remains the same as in the original problem. Author

A91-31877#
STUDIES IN INTEGRATED AEROSERVOELASTIC OPTIMIZATION OF ACTIVELY CONTROLLED COMPOSITE WINGS
E. LIVNE (Washington, University, Seattle), P. P. FRIEDMANN, and L. A. SCHMIT (California, University, Los Angeles) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 447-461. refs
(Contract F49620-87-K-0003)
(AIAA PAPER 91-1098) Copyright
Structural, aerodynamic, and control system mathematical models that are suitable for the preliminary design of airplanes are used in an integrated manner to synthesize wings and their active control systems. Optimization techniques developed for structural synthesis are adapted to the integrated aeroservoelastic wing synthesis problem. The effectiveness and efficiency of the new capability are studied using mathematical models of an RPV as well as more complex F16 and X29 type airplane models. Simplified handling quality constraints are added to the set of design requirements. The performance of several complex eigenvalue approximations is examined. Effects of control law structure on the weight and robustness of the resulting aeroservoelastic designs provide new insights into the complex multidisciplinary interactions involved. Author

A91-31878#
AEROELASTIC TAILORING IN VEHICLE DESIGN SYNTHESIS
MICHAEL H. LOVE and JONATHAN D. BOHLMANN (General Dynamics Corp., Fort Worth, TX) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 462-469. refs
(AIAA PAPER 91-1099) Copyright
A parametric study of a fighter wing geometry is presented which demonstrates the use of the wing aeroelastic synthesis computer procedure known as TSO. The study also demonstrates aeroelastic tailoring concepts for acquiring design sensitivities for configuration definition. The modeling aspects are described as they apply within the TSO methodology. Data are presented which provide sensitivities of structural weight associated with aeroelastic criteria and vehicle geometry and thus provide indicators of structural and vehicle efficiency. C.D.

A91-31879#
INFLUENCE OF STATIC AND DYNAMIC AEROELASTIC CONSTRAINTS ON THE OPTIMAL STRUCTURAL DESIGN OF FLIGHT VEHICLE STRUCTURES
ALFRED G. STRIZ (Oklahoma, University, Norman), FRANKLIN E. EASTEP (Dayton, University, OH), and VIPPERLA B. VENKAYYA (USAF, Wright Aeronautical Laboratores, Wright-Patterson AFB, OH) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 470-476. refs
(AIAA PAPER 91-1100)
This investigation focused upon the structural weight optimized design of a fighter-type wing of low aspect ratio using ASTROS. The optimal redesign of a preliminary finite element model representing the wing structure is obtained with constraints imposed on strength, control reversal, and flutter using both subsonic and supersonic aerodynamic theories. It is demonstrated that the optimization capabilities of the ASTROS procedure are well suited for the preliminary structural design environment. ASTROS gives to the structural designer the capability to develop unique solutions to the design problem facing flight vehicle structures with many constraints. Recommendations are made to include a transonic aerodynamic formulation with ASTROS for the structural design of a flight vehicle over the entire Mach number regime. Author

A91-31881#
OPTIMIZATION OF AIRCRAFT ENGINE SUSPENSION SYSTEMS
DOUGLAS A. SWANSON, HENRY T. WU (Lord Corp., Erie, PA), and HASHEM ASHRAFIUON (Villanova University, PA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 490-496. refs
(AIAA PAPER 91-1102) Copyright
An interactive computer program has been developed to design aircraft engine mounting systems used for vibration isolation. Mount design is largely driven by two competing criteria. Mounts must be soft enough to provide vibration isolation, yet stiff enough to support the engine without excessive motions. The constrained variable metric optimization technique is used to determine the mount design parameters which minimize the transmitted forces in the mounts, subject to constraints on the maximum allowable deflection of the engine to static forces. The design parameters are the stiffness and orientation of each individual engine mount. The aircraft engine is modeled as a rigid body that is mounted to a rigid base representing the nacelle. An example is used to show that the optimization technique is effective in designing engine mounting system. Author

A91-31902#
DETERMINATION OF HELICOPTER FLIGHT LOADS FROM FIXED SYSTEM MEASUREMENTS
DAVID J. HAAS (U.S. Navy, David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 710-718.
(AIAA PAPER 91-1012)
Multiple regression analysis is applied to flight test data to develop equations that predict rotating component loads from fixed system parameters. The parameters of interest consists of pilot control stick inputs, aircraft angular rates, velocity, and normal load factor. A model is developed for predicting main rotor normal

bending and pushrod loads during a symmetric pull out maneuver with a 95 and 89 percent correlation, respectively. Effects of various pilot techniques are included. Author

A91-31958#
PROBABILISTIC AIRCRAFT STRUCTURAL DYNAMICS MODELS
HAYM BENAROYA and HOWARD J. FLEISHER (Rutgers University, Piscataway, NJ) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1254-1260. refs
(AIAA PAPER 91-0921) Copyright
Since its development began in 1971, the U.S. Army's airframe impact dynamics and mechanics modeling-conceptualization code KRASH has undergone numerous changes and refinements, including those due to its civil adaptation by the FAA, starting in 1975. The developmental step beyond the current, KRASH89 version will encompass uncertainty-modeling capabilities, using a Monte Carlo simulation framework, in order to allow the output variables to be bound. This probabilistic code will be tailored to PC implementation, after which it is expected to help in the improvement of design guidelines and airframe crash-damage experiment-planning. O.C.

A91-31970#
A NOVEL METHOD FOR FATIGUE LIFE MONITORING OF NON-AIRFRAME COMPONENTS
S. S. TANG (Structural Integrity Associates, San Jose, CA) and L. J. O'BRIEN (Infometrics, Inc., Silver Spring, MD) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1357-1370. U.S. Army-supported research. refs
(AIAA PAPER 91-1088) Copyright
A semi-empirical method is developed for the application of on-board fatigue life monitoring of dynamic components in rotorcraft. This method drastically reduces computation time, rendering real-time on-board monitoring possible. The method utilizes pattern recognition method to classify load cycle spectra using commonly available flight data as input. Maximum load range is also correlated using the same input. Fatigue usage calculated using this approach shows good agreement with the results obtained directly from component load histories. Author

A91-32002#
THE CORROSION OF AGING AIRCRAFT AND ITS CONSEQUENCES
J. J. DE LUCCIA (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1667-1675. refs
(AIAA PAPER 91-0953) Copyright
The time-dependent, time-related, and time-independent aspects of airframe corrosion are considered, identifying the specific types of corrosion and characterizing them with respect to severity, frequency, and cycle-dependency. Time-dependent corrosion processes occur as long as a susceptible metal, a corrosive environment, and a continuous electrical path between metal and environment are present; time-related ones, such as corrosion fatigue, involve both the presence of corrosion conditions and of cyclic stresses on the corroding parts. Cyclic stressing can have its bases in cabin pressurization/depressurization cycles, as well as the effects of maneuvers and gusts. A time-independent process such as stress corrosion cracking proceeds in the presence of such highly corrosive species as chloride ions during enduring tensile stressing of high-strength Al alloys. O.C.

A91-32004#
AEROELASTICITY OF ANISOTROPIC COMPOSITE WING STRUCTURES INCLUDING THE TRANSVERSE SHEAR FLEXIBILITY AND WARPING RESTRAINT EFFECTS
G. KARPOUZIAN (U.S. Naval Academy, Annapolis, MD) and L. LIBRESCU (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1683-1691. refs
(AIAA PAPER 91-0934) Copyright
The equations governing the static and dynamic aeroelastic equilibrium of cantilevered wing structures laminated of advanced composite materials are derived. These equations based upon the plate-beam model incorporate a number of effects which are essential for the accurate prediction of their aeroelastic behavior, namely (1) the anisotropy of the materials of constituent layers, (2) the warping restraint effect, (3) the transverse shear flexibility, and (4) the rotatory inertias. A simple case emphasizing the effect played by transverse shear flexibility coupled with the warping restraint on the aeroelastic divergence of swept wing structures is considered and pertinent conclusions are outlined. Author

A91-32033#
HELICOPTER ROTOR BLADE AEROELASTICITY IN FORWARD FLIGHT WITH AN IMPLICIT STRUCTURAL FORMULATION
ROBERTO CELI (Maryland, University, College Park) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2051-2058. University of Maryland-supported research. refs
(Contract DAAL03-88-C-0002)
(AIAA PAPER 91-1219) Copyright
This paper describes an aeroelastic stability and response analysis in which the structural operator is formulated numerically, without expanding analytically the various algebraic expressions that make up the beam model. No ordering schemes need to be invoked to simplify the algebraic manipulators, and the various components of the mathematical model of the beam can be implemented and modified independently from the other components. Two different implicit formulations are presented. The results of two illustrative examples are also presented, focusing on the importance of geometric nonlinearities, and of nonlinearities in the shear stress-strain relationship respectively. Author

A91-32034#
DYNAMICS AND AEROELASTICITY OF A COUPLED HELICOPTER ROTOR-PROPULSION SYSTEM IN HOVER
CARL J. OCKIER and ROBERTO CELI (Maryland, University, College Park) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2059-2070. refs
(AIAA PAPER 91-1220) Copyright
The dynamic interaction between a helicopter rotor, propulsion system and drive train is analyzed for a hover flight condition. The nonlinear mathematical model is formulated in state variable form. The coupled flap-lag dynamics of the hingeless rotor blades is modeled using an offset-hinge spring restrained rigid blade approximation. The propulsion system is represented using a component type engine model and a simplified second order fuel control system model with proportional-plus-integral controller. The results show that the rotor speed degree of freedom couples only with the collective lag mode. For a typical medium weight helicopter configuration, including the rotor speed degree of freedom more than doubles the natural frequency of the collective lag mode. Parametric studies show the effect of blade rotating frequencies, elastic coupling, drive train mass moment of inertia and fuel flow gain on the coupled rotor speed-collective lag dynamics. It is shown

that for certain combinations of design parameters the propulsion system has a destabilizing effect on the lag dynamics of the rotor. Author

A91-32035#
NONLINEAR LARGE AMPLITUDE VIBRATION OF COMPOSITE HELICOPTER BLADE AT LARGE STATIC DEFLECTION
TAEHYOUN KIM and JOHN DUGUNDJI (MIT, Cambridge, MA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2071-2081. refs
(Contract DAAL03-87-K-0024)
(AIAA PAPER 91-1221) Copyright

The nonlinear, large amplitude free vibration of composite helicopter blades under large static deflection is investigated analytically and experimentally. A new model capable of handling large amplitudes as well as large deflections was developed based on the use of Euler angles, and a harmonic balance, finite difference solution of the basic large deflection equations. The behavior of the first and second bending, the first fore and aft, and the first torsional modes of two lay-ups of graphite/epoxy flat beams are presented analytically as tip static deflection and tip amplitudes increase. Free vibration tests of several different lay-ups of composite blades show good agreement between theory and experiment. Author

A91-32038#
VIBRATION CHARACTERISTICS OF ANISOTROPIC COMPOSITE WING STRUCTURES
S. THANGJITHAM and L. LIBRESCU (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2115-2122. refs
(AIAA PAPER 91-1185) Copyright

The vibration characteristics of anisotropic laminated composite wing structures are analytically investigated. The exact solutions for both the free warping and warping restraint wing models are obtained by solving the systems of sixth and eighth order coupled partial differential equations of wing motion, respectively. To simplify the solution procedure, the Laplace transform method is utilized. The effects of the warping restraint on the natural frequencies and dynamic response functions are presented as a function of the wing aspect ratio. It is found that, with the proper selection of fiber orientation in each individual layer, the warping restraint can be used to enhance the dynamic performance of the composite wing structures. Author

A91-32039*# California Univ., Davis.
TAILORING OF COMPOSITE WING STRUCTURES FOR ELASTICALLY PRODUCED CAMBER DEFORMATIONS
LAWRENCE W. REHFIELD, STEPHEN CHANG, PETER J. ZISCHKA, RICHARD D. PICKINGS, and MICHAEL W. HOLL (California, University, Davis) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2123-2127. refs
(Contract NAS1-18754)
(AIAA PAPER 91-1186) Copyright

Structural concepts have been created which produce chordwise camber deformation that results in enhanced lift. A wing box can be tailored to utilize these concepts with composites. In attempting to optimize the aerodynamic benefits, it is found that there are two optimum designs that are of interest. There is a 'weight' optimum which corresponds to the maximum lift per unit structural weight. There is also a 'lift' optimum that corresponds to maximum absolute lift. Experience indicates that a large weight penalty accompanies the transition from weight to lift optimum designs. New structural models, the basic deformation mechanisms that are utilized and typical analytical results are presented. It appears that lift enhancements of sufficient magnitude can be produced to render this type of wing tailoring of practical interest. Author

A91-32098#
TIME DOMAIN APPROACH FOR NONLINEAR RESPONSE AND SONIC FATIGUE OF NASP THERMAL PROTECTION SYSTEMS
R. VAICAITIS (Columbia University, New York) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2685-2708. refs
(AIAA PAPER 91-1177) Copyright

The thermal surface protection systems of advanced high speed vehicles such as the National Aerospace Space Plane (NASP) will be constructed from high temperature resistant composite and intermetallic materials. The information that is available indicates that under severe aerodynamic, acoustic and thermal evvironment the dynamic response of these surface structures will be nonlinear. A time domain Monte Carlo type approach can be utilized to develop solutions for nonlinear response and sonic fatigue. A brief overview of the time domain method for structural dynamic applications is given. This includes simulation of multidimensional random surface pressures, formulation and solution procedure of the nonlinear equations of motion, nonsteady aerodynamic and cavity pressure effects, parametric excitations, thermal loads, static pressure and oscillating surface shocks. Numerical results are presented for several structural configurations. Author

A91-32130#
EFFECTS OF BATTLE DAMAGE REPAIR ON THE NATURAL FREQUENCIES AND MODE SHAPES OF CURVED RECTANGULAR COMPOSITE PANELS
H. D. GANS, T. HINNERICHS (USAF, Institute of Technology, Wright-Patterson AFB, OH), and W. P. GOODWIN (U.S. Army, Safety Center, Fort Rucker, AL) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 3026-3038. refs
(AIAA PAPER 91-1242)

This paper presents an investigation of the effects of battle damage repair on the free vibrational behavior of thin, curved, rectangular composite panels. Specifically, interferometric holography and a finite-element computer code are used to experimentally and analytically compare the natural frequencies and mode shapes of the panels before and after the application of mechanically fastened, aluminum patches. The aluminum patches introduce a combination of dissimilar mass and stiffness properties to the composite panels while the fasteners introduce point masses with insignificant stiffening effect. The location of patch fasteners relative to vibrational nodes and antinodes introduce the most significant effects altering the free vibrational behavior of these panels. Author

A91-32173#
LOW COST TECHNIQUES FOR GLIDING PARACHUTE TESTING
JON KEMNITZ (Alliant Techsystems, Inc., Minnetonka, MN) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 194-206. refs
(AIAA PAPER 91-0857) Copyright

A method for instrumenting and testing a payload body for a small guided ram-air parachute development is presented with emphasis on glide performance, control response, and body dynamics in response to steering input. Helicopters, larger fixed-wing aircraft, and ultralight aircraft are considered as drop aircraft, and radio control systems are discussed. Yaw rate sensors, attitude sensors, airspeed measurements, onboard video, and battery packs are covered. Ultralight aircraft were used and are considered to be most suitable as drop aircraft, while hobbyist radio control equipment was adapted, and those with PCM are recommended. Clinometers substituted for gyroscopes in measuring pitch angles, and camcorders provided a sensor-view image. V.T.

A91-32193#
F111 CREW ESCAPE MODULE PILOT PARACHUTE
EDEN L. TADIOS (Sandia National Laboratories, Albuquerque, NM) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 384-389. USAF-supported research.
(Contract DE-AC04-76DP-00789)
(AIAA PAPER 91-0883)

The pilot parachute system which extracts the F111 crew escape module recovery parachute sysem must provide reasonable bag strip velocities throughout the flight envelope (10 psf to 300 psf). The pilot parachute system must, therefore, have sufficient drag area at the lower dynamic pressures and a reduced drag area at the high end of the flight envelope. The final design developed was a dual parachute system which consists of a 5-ft-diameter guide surface parachute tethered inside a 10-ft-diameter flat circular parachute. The high drag area is sustained at the low dynamic pressures by keeping both parachutes intact. The drag area is reduced at the higher extreme by allowing the 10-ft parachute attachment to fail. Author

A91-32269
PROTECTING HYDRAULICALLY POWERED FLIGHT CONTROL SYSTEMS
Aerospace Engineering (ISSN 0736-2536), vol. 11, April 1991, p. 11-14.
Copyright

Several types of damages to aircraft, including a mid-air collision, striking the tail on the runway surface when the aircraft nose is rotated excessively during the takeoff roll, and bird strikes are outlined. Possible sources of internal damage to hydraulic systems, such as fire, turbine bursts, tire damage, or structural failure are discussed. The use of one or a combination of three basic options - redundancy, shielding, and shutoff devices is analyzed. It is shown that manual reversion as a backup for flight control systems is not a practical option for large commercial transports; separation of redundant systems offers the best protection for the hydraulic systems used to power flight control systems; and shutoff devices are the most effective means of protecting hydraulic system. V.T.

N91-19078*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
INTRODUCTION OF THE M-85 HIGH-SPEED ROTORCRAFT CONCEPT
ROBERT H. STROUB Jan. 1991 32 p
(NASA-TM-102871; A-90307; NAS 1.15:102871) Avail: NTIS HC/MF A03 CSCL 01/3

As a result of studying possible requirements for high-speed rotorcraft and studying many high-speed concepts, a new high-speed rotorcraft concept, designated as M-85, was derived. The M-85 is a helicopter that is reconfigured to a fixed-wing aircraft for high-speed cruise. The concept was derived as an approach to enable smooth, stable conversion between fixed-wing and rotary-wing while retaining hover and low-speed flight characteristics of a low disk loading helicopter. The name, M-85, reflects the high-speed goals of 0.85 Mach number at high altitude. For a high-speed rotorcraft, it is expected that a viable concept must be a cruise-efficient, fixed-wing aircraft so it may be attractive for a multiplicity of missions. It is also expected that a viable high-speed rotorcraft concept must be cruise efficient first and secondly, efficient in hover. What makes the M-85 unique is the large circular hub fairing that is large enough to support the aircraft during conversion between rotary-wind and fixed-wing modes. With the aircraft supported by this hub fairing, the rotor blades can be unloaded during the 100 percent change in rotor rpm. With the blades unloaded, the potential for vibratory loads would be lessened. In cruise, the large circular hub fairing would be part of the lifting system with additional lifting panels deployed for better cruise efficiency. In hover, the circular hub fairing would slightly reduce lift potential and/or decrease hover efficiency of the rotor system. The M-85 concept is described and estimated forward flight performance characteristics are presented in terms of thrust requirements and L/D with airspeed. The forward flight performance characteristics reflect recent completed wind tunnel tests of the wing concept. Also presented is a control system technique that is critical to achieving low oscillatory loads in rotary-wing mode. Hover characteristics, C(sub p) versus C(sub T) from test data, is discussed. Other techniques pertinent to the M-85 concept such as passively controlling inplane vibration during starting and stopping of the rotor system, aircraft control system, and rotor drive technologies are discussed. Author

N91-19079*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
A SIMPLE DYNAMIC ENGINE MODEL FOR USE IN A REAL-TIME AIRCRAFT SIMULATION WITH THRUST VECTORING
STEVEN A. JOHNSON Oct. 1990 21 p Presented at the AIAA/SAE/ASME/ASEE Joint Propulsion Conference, Orlando, FL, 16-18 Jul. 1990 Previously announced in IAA as A90-42054
(NASA-TM-4240; H-1643; NAS 1.15:4240; AIAA-90-2166) Avail: NTIS HC/MF A03 CSCL 01/3

A simple dynamic engine model was developed at the NASA Ames Research Center, Dryden Flight Research Facility, for use in thrust vectoring control law development and real-time aircraft simulation. The simple dynamic engine model of the F404-GE-400 engine (General Electric, Lynn, Massachusetts) operates within the aircraft simulator. It was developed using tabular data generated from a complete nonlinear dynamic engine model supplied by the manufacturer. Engine dynamics were simulated using a throttle rate limiter and low-pass filter. Included is a description of a method to account for axial thrust loss resulting from thrust vectoring. In addition, the development of the simple dynamic engine model and its incorporation into the F-18 high alpha research vehicle (HARV) thrust vectoring simulation. The simple dynamic engine model was evaluated at Mach 0.2, 35,000 ft altitude and at Mach 0.7, 35,000 ft altitude. The simple dynamic engine model is within 3 percent of the steady state response, and within 25 percent of the transient response of the complete nonlinear dynamic engine model. Author

N91-19080*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
TECHNIQUES FOR HOT STRUCTURES TESTING
V. MICHAEL DEANGELIS and ROGER A. FIELDS Nov. 1990 28 p Presented at the First Thermal Structures Conference, Charlottesville, VA, 13-15 Nov. 1990 Previously announced in IAA as A91-16035
(NASA-TM-101727; H-1664; NAS 1.15:101727) Avail: NTIS HC/MF A03 CSCL 01/3

Hot structures testing have been going on since the early 1960's beginning with the Mach 6, X-15 airplane. Early hot structures test programs at NASA-Ames-Dryden focused on operational testing required to support the X-15 flight test program, and early hot structures research projects focused on developing lab test techniques to simulate flight thermal profiles. More recent efforts involved numerous large and small hot structures test programs that served to develop test methods and measurement techniques to provide data that promoted the correlation of test data with results from analytical codes. In Nov. 1988 a workshop was sponsored that focused on the correlation of hot structures test data with analysis. Limited material is drawn from the workshop and a more formal documentation is provided of topics that focus on hot structures test techniques used at NASA-Ames-Dryden. Topics covered include the data acquisition and control of testing, the quartz lamp heater systems, current strain and temperature sensors, and hot structures test techniques used to simulate the flight thermal environment in the lab. Author

N91-19081*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
MONITORING TECHNIQUES FOR THE X-29A AIRCRAFT'S HIGH-SPEED ROTATING POWER TAKEOFF SHAFT
DAVID F. VORACEK Dec. 1990 25 p Presented at the 2nd International Machinery Monitoring and Diagnostic Conference, Los Angeles, CA, 22-25 Oct. 1990
(NASA-TM-101731; H-1680; NAS 1.15:101731) Avail: NTIS HC/MF A03 CSCL 01/3

The experimental X-29A forward swept-wing aircraft has many unique and critical systems that require constant monitoring during ground or flight operation. One such system is the power takeoff shaft, which is the mechanical link between the engine and the aircraft-mounted accessory drive. The X-29A power takeoff shaft opertes in a range between 0 and 16,810 rpm, is longer than most jet engine power takeoff shafts, and is made of graphite epoxy material. Since the X-29A aircraft operates on a single engine, failure of the shaft during flight could lead to loss of the aircraft. The monitoring techniques and test methods used during power takeoff shaft ground and flight operations are discussed. Test data are presented in two case studies where monitoring and testing of the shaft dynamics proved instrumental in discovering and isolating X-29A power takeoff shaft problems. The first study concerns the installation of an unbalanced shaft. The effect of the unbalance on the shaft vibration data and the procedure used to correct the problem are discussed. The second study deals with the shaft exceeding the established vibration limits during flight. This case study found that the vibration of connected rotating machinery unbalances contributed to the excessive vibration level of the shaft. The procedures used to identify the contributions of other rotating machinery unbalances to the power takeoff shaft unbalance are discussed. Author

N91-19082*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
STATE ESTIMATION APPLICATIONS IN AIRCRAFT FLIGHT-DATA ANALYSIS: A USER'S MANUAL FOR SMACK
RALPH E. BACH, JR. Mar. 1991 134 p
(NASA-RP-1252; A-88203; NAS 1.61:1252) Avail: NTIS HC/MF A07 CSCL 01/3

The evolution in the use of state estimation is traced for the analysis of aircraft flight data. A unifying mathematical framework for state estimation is reviewed, and several examples are presented that illustrate a general approach for checking instrument accuracy and data consistency, and for estimating variables that are difficult to measure. Recent applications associated with research aircraft flight tests and airline turbulence upsets are described. A computer program for aircraft state estimation is discussed in some detail. This document is intended to serve as a user's manual for the program called SMACK (SMoothing for AirCraft Kinematics). The diversity of the applications described emphasizes the potential advantages in using SMACK for flight-data analysis. Author

N91-19083*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
THERMOELASTIC VIBRATION TEST TECHNIQUES
MICHAEL W. KEHOE and H. TODD SNYDER (PRC Kentron, Inc., Edwards, CA.) Apr. 1991 21 p Presented at the 9th International Modal Analysis Conference, Florence, Italy, 14-18 Apr. 1991
(NASA-TM-101742; H-1707; NAS 1.15:101742) Avail: NTIS HC/MF A03 CSCL 01/3

The structural integrity of proposed high speed aircraft can be seriously affected by the extremely high surface temperatures and large temperature gradients throughout the vehicle's structure. Variations in the structure's elastic characteristics as a result of thermal effects can be observed by changes in vibration frequency, damping, and mode shape. Analysis codes that predict these changes must be correlated and verified with experimental data. The experimental modal test techniques and procedures used to conduct uniform, nonuniform, and transient thermoelastic vibration tests are presented. Experimental setup and elevated temperature instrumentation considerations are also discussed. Modal data for a 12 by 50 inch aluminum plate heated to a temperature of 475 F are presented. These data show the effect of heat on the plate's modal characteristics. The results indicated that frequency decreased, damping increased, and mode shape remained unchanged as the temperature of the plate was increased. Author

N91-19084# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.).
PROPULSION SYSTEM CONCEPT FOR THE EUROFAR TILT ROTOR AIRCRAFT
AXEL FISCHER and JOSEF UNTERHITZENBERGER Sep. 1990 13 p Presented at the 16th European Rotorcraft Forum, Glasgow, Scotland, 18-21 Sep. 1990
(MBB-UD-0573-90-PUB; ETN-91-98823) Avail: NTIS HC/MF A03

A three year preliminary working phase is being carried out in order to define the baseline for the European tilt rotor aircraft Eurofar. This program is commonly conducted by the following European partners: Aerospatiale (France), Augusta (Italy), Casa (Spain), Westland (U.K.) and MBB (Germany). A vital part of the tiltrotor aircraft is the propulsion system. In contrast to the American V22 tiltrotor (completely tiltable propulsion nacelles) the Eurofar team has mainly concentrated on a nacelle concept with stationary engines. A first overview about findings gained up to now is given as well as the current status of design investigations comprising: tilt concepts; propulsion nacelle arrangement; main gearbox design; cross shaft design; engine; and nacelle structure design. ESA

N91-19085# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Helicopter Div.
BO 108 DEVELOPMENT STATUS AND PROSPECTS
HELMUT HUBER and WERNER REINL Sep. 1990 12 p Presented at the 16th European Rotorcraft Forum, Glasgow, Scotland, 18-21 Sep. 1990
(MBB-UD-0574-90-PUB; ETN-91-98824) Avail: NTIS HC/MF A03

In 1983, the MBB helicopter division started design and development of a new light twin, multipurpose helicopter, now designated as the BO 108. After an intensive phase of technology investment, many technology advances were incorporated into the design, in order to meet the demanding requirements of the future market. The aircraft (prototype 1) flew for the first time in October 1988, and has accomplished about 110 flight test hours so far. The design philosophy is illustrated and the technology advances in terms of the various components involved are reviewed. An overview about the current status of bench and inflight testing are reviewed, and the progress achieved in the fields of performance, flying qualities, noise and vibrations, weight, reliability, and safety is assessed. Activities for increasing the aircraft's capabilities are described and a prospective about the future program plans is given. ESA

N91-19086# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.).
DEVELOPMENT OF BEARINGLESS TAIL ROTORS
VALENTIN KLOEPPEL, HELMUT HUBER, and BERNHARD ENENKL Sep. 1990 15 p Presented at the 16th European Rotorcraft Forum, Glasgow, Scotland, 18-21 Sep. 1990
(MBB-UD-0575-90-PUB; ETN-91-98825) Avail: NTIS HC/MF A03

Conventional helicopter Tail Rotors (CTR) represent a highly efficient but complex control concept. They provide uniquely low power requirements and outstanding controllability. On the other hand, they often imply problems with respect to maintenance efforts and lifetime. The key for overcoming such problems is the application of new composite materials which, for several reasons, is particularly attractive for tail rotors. This enables a new design solution in the form of the bearingless tail rotor (BTR). An overview of the development and tests of advanced composite tail rotors since the late 1970's and early 1980's is given. After the discussion of general design aspects, the layout structural design and testing of several bearingless prototypes are demonstrated. Emphasis is also on the assessment of relevant technological criteria, such as weight, manufacturing costs, maintenance effort, reliability, and vulnerability. A view is taken of the BTR's potential for further development and its application to future product range. ESA

N91-19087# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Henschel Flugzeug-Werke.
DESIGN AND FIRST TESTS OF INDIVIDUAL BLADE CONTROL ACTUATORS
PETER RICHTER, HANS-DIETER EISBRECHER, and VALENTIN KLOEPPEL Sep. 1990 10 p Presented at the 16th European Rotorcraft Forum, Glasg, Scotland, 18-21 Sep. 1990
(MBB-UD-0577-90-PUB; ETN-91-98827) Avail: NTIS HC/MF A02

In order to increase the helicopter's share in future air traffic, its efficiency, reliability and its public acceptance have to be improved. Using modern technologies it is possible to reduce weight, power requirement, noise, pilot's workload and maintenance efforts and to increase comfort and flight envelope. One tool to realize a relevant part of these goals is the Higher Harmonic Control (HHC) but it is only possible to superimpose some selected harmonic functions to the 1/rev input. By means of a new control system using actuators between swashplate and rotor blade, the total range of superimposition from single harmonic control up to individual blade control can be opened. Such a new control system was designed. Tests were carried out on test benches and on a whirl tower before flight tests on a BO 105 started. The results of these tests are shown and an outlook to the planned program continuation is given. ESA

N91-19088# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.).
CRASHWORTHINESS INVESTIGATIONS IN THE PRELIMINARY DESIGN PHASE OF THE NH90
DIETER NITSCHKE and JOHANNES FRESE Sep. 1990 11 p Presented at the 16th European Rotorcraft Forum, Glasgow, Scotland, 18-21 Sep. 1990
(MBB-UD-0579-90-PUB; ETN-91-98829) Avail: NTIS HC/MF A03

After the introduction of MIL STD 1290, several helicopters like the AH64 Apache and the UH60 Black Hawk were built in accordance with the whole range of requirements of that standard. The primary structure of the first generation of crashworthy helicopters consisted more or less completely of metal. In the meantime, more experience has been gathered which led to a reduction of crash requirements as well as to the application of new structural materials. Therefore, new helicopters like the Tiger (PAH2/HAP/HAC) and the NH90 are designed to a 90 and 85 percent fulfilment of MIL STD 1290 respectively. After some technology programs (ACAP, BK 117 composite airframe), they are the first helicopters whose primary fuselage structure consists nearly completely of composites: like Carbon Fiber reinforced plastic (CFRP) or Aramid Fiber Reinforced Plastic (AFRP). To identify problem areas and to verify the present design concept, simulations with KRASH85 were performed for the NH90. Due to the early state of the program, a simplified two dimensional model was judged to be the best compromise between effort and accuracy of results. After some iterations a quite good representation of the structure was found and parametric studiesGRere performed under consideration of the main crash features of composites like high specific energy absorption, lack of ductility and higher susceptibility to the loss of structural integrity in areas of energy absorption. The high potential crashworthiness of the NH90 was confirmed and the main crash design parameters were determined. ESA

N91-19089# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Helicopter Div.
NEW COMPUTER CODES FOR THE STRUCTURAL ANALYSIS OF COMPOSITE HELICOPTER STRUCTURES
HELMUT RAPP Sep. 1990 14 p Presented at the 16th European Rotorcraft Forum, Glasgow, Scotland, 18-21 Sep. 1990
(MBB-UD-0580-90-PUB; ETN-91-98830) Avail: NTIS HC/MF A03

Helicopters of the new generation will show a very high portion of structural components made of fiber composites. To take the best advantage of these materials, modern tools for structural design and analysis are necessary. With methods of structural optimization at panel level already in early design phases the best fiber orientation and laminate thicknesses can be chosen. By means of a helicopter fuselage sidewall and a sandwich panel of the horizontal stabilizer, it is shown that large weight savings can be achieved with optimal laminates. Combination of composite materials with very different Poisson's ratios in bar like components result in additional stresses perpendicular to the load direction, which may have a noticeable influence in the tension and bending stiffness. The basic theory is given and a special testbar shows the large influence these stresses may have. Investigations of a helicopter rotor blade as a typical application of such a nonhomogeneous structural part; however, shows that in this case the influence of the additional stresses is small. In future helicopter projects thickwalled composite parts for rotor components are often used. The stress and stiffness evaluation of such components require finite element analysis. To reduce the necessary effort, a computer code was developed to determine the material properties of a thick laminate and to evaluate the stresses in a single layer of this laminate due to membrane and bending forces. ESA

N91-19090# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany, F.R.).
SYSTEM DESIGN FOR THE TIGER HELICOPTER
RUDOLF SCHRANNER (Aerospatiale, Marignane, France) and G. DUFOUR Sep. 1990 7 p Presented at the 16th European Rotorcraft Forum, Glasgow, Scotland, 18-21 Sep. 1990
(MBB-UD-0581-90-PUB; ETN-91-98831) Avail: NTIS HC/MF A02

The first activities in development of the avionic system of the Tiger helicopter (PAH2/HAC, HAP) concentrated on the consolidation of system requirements and the system design. This led to the selection of suppliers for the main avionic subsystems, such as computers, displays, navigation, flight control and electronic countermeasures system. The result is a selection of advanced technologies with rather low volumes and masses of equipment, a main consideration for such weapon systems. Through the introduction of standardization requirements not only large economical benefits but also technologically advanced solutions with considerable benefit for the user in the service phase may be achieved. The actual status of the system architecture of the Tiger as resulting from the subsystem selection is presented. Some of the main features for some important subsystems and equipments such as the computing and display subsystem are given. ESA

N91-19091# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Helicopter Div.
MBB'S INVOLVEMENT IN MILITARY HELICOPTER PROGRAMMES
HELMUT HUBER Nov. 1989 49 p Presented at the 1989 USAEUR Aviation Professional Conference, Willingen, Fed. Republic of Germany, 28-30 Nov. 1989
(MBB-UD-0588-90-PUB; ETN-91-98832) Avail: NTIS HC/MF A03

A briefing of the studies, projects, and programs are reviewed. Previews and diagrammatic explanations of the following programs are given: Escort Helicopter (BSH1); PAH1 Upgrade; BO 108; HAP - PAH2/HAC; NH 90; Advanced Light Helicopter (ALH); lead concept 'HC 2000', second generation escort helicopter; and EUROFAR. The technology basis of the company is broad and is continuously extended. Future helicopter development is exclusively a subject of international cooperation and MBB is fully prepared to play an active role in this respect. ESA

N91-19092# Cranfield Inst. of Tech., Bedford (England). College of Aeronautics.
TF89 DESIGN PROJECT AIRBRAKE AND ARRESTER HOOK DESIGN M.S. Thesis
A. DODD May 1990 224 p
(ETN-91-98853) Copyright Avail: NTIS HC/MF A10

Details of the field performance calculations and a description of the aspects of Computer Aided Design (CAD) work for the airbrake and arrester hook installation of the TF89 project aircraft are presented. The airbrakes are designed to operate at any speed up to the maximum design speed of the aircraft, with the deployment angle being limited by a sophisticated control system. Finite element methods of analysis are employed as the primary design tool. Two structures are evaluated, one of conventional aluminum alloy and one of carbon composite material. The final design is a composite structure which is evaluated for static stength and fatigue stength. A suitable construction method is also investigated. The estimated weight of the airbrake installation is 64 kg. The arrester hook installation is designed to slow the aircraft to rest without damage to the aircraft structure, even at abnormally high landing weight and cable engagement speed. A dynamic analysis of an arrested landing is used to determine the nose slam characteristics of the aircraft. The installation incorporates a damping system to prevent the hook from bouncing on contact with the runway. The estimated weight of the arrester hook installation is 22 kg. The takeoff and landing distances are calculated to be 533 m and 884 m respectively. The landing distance is satisfactory, but the takeoff distance exceeds the specification distance by 33 m. CAD methods are employed in the airbrake and arrester hook design and CAD generated drawings are included. ESA

N91-19093# Cranfield Inst. of Tech., Bedford (England). Dept. of Aircraft Design.
S87 CLOSE AIR SUPPORT AIRCRAFT FATIGUE ANALYSIS M.S. Thesis
M. E. J. RENDER Sep. 1988 275 p
(ETN-91-98854) Copyright Avail: NTIS HC/MF A12

The likely operational use of the S87 aircraft during peacetime is assessed and a selection of missions are outlined by means of sortie profile codes. Using the perceived flying regime as a basis, g level exceedances spectra are derived, both vertically and laterally, arising from maneuvers, gusts and ground loads. The critical components from a fatigue viewpoint are taken to be the wing fuselage attachment lugs. The (vertical) exceedance spectrum is converted to occurrence spectra based upon the lug stresses. The occurrence spectrum are presented to a fracture mechanics program and to an S-N curve analysis. The latter method revealed an unacceptably short fatigue life well short of the aircraft's design life of 6000 hours. However, after a design change the (factored) life was satisfactory. The influence of aircraft mass on fatigue damage rates is established. A mass dependent fatigue formula, whereby damage can be readily calculated using aircraft mass(es) and the exceedance counts of discrete fatigue meter g levels, is established. ESA

N91-19094# Technische Univ., Delft (Netherlands). Dept. of Aerospace Engineering.
BULGING OF FATIGUE CRACKS IN A PRESSURIZED AIRCRAFT FUSELAGE
D. CHEN Oct. 1990 238 p
(LR-647; ETN-91-98947) Avail: NTIS HC/MF A11

Three new setups were developed for testing of sheet specimens under biaxial tensile loading, for tensile loading of sheet specimens with a curvature, and for sheet specimens with a large radius of curvature loaded by an internal air pressure and hoop stress. Studies were carried out on the fatigue crack growth behavior of thin aluminum alloy sheets and ARamid Aluminum Laminates (ARALL) under various aircraft fuselage loading conditions, including stress biaxiality, combined bending and extension and crack edge bulge out conditions. Some residual tensile strength tests were also conducted. Theories for the effect of combined bending and extension as well for the effect of bulging were developed. The theories agree well with the present test results from the literature. ESA

N91-20071*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
PROCEEDINGS OF THE X-15 FIRST FLIGHT 30TH ANNIVERSARY CELEBRATION
Washington Jan. 1991 174 p Symposium held in Edwards, CA, 8 Jun. 1989
(NASA-CP-3105; H-1622; NAS 1.55:3105) Avail: NTIS HC/MF A08 CSCL 01/3

A technical symposium and pilot's panel discussion were held on June 8, 1989, to commemorate the 30th anniversary of the first free flight of the X-15 rocket-powered research aircraft. The symposium featured technical presentations by former key government and industry participants in the advocacy, design, manufacturing, and flight research program activities. The X-15's technical contributions to the X-30 are cited. The panel discussion participants included seven of the eight surviving research pilots who flew the X-15 experimental aircraft to world altitude and speed records which still stand. Pilot's remarks include descriptions of their most memorable X-15 flight experience. The report also includes a historical perspective of the X-15.

N91-20072*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
X-15 CONCEPT EVOLUTION
WALTER C. WILLIAMS *In its* Proceedings of the X-15 First Flight 30th Anniversary Celebration p 11-26 Jan. 1991
Avail: NTIS HC/MF A08 CSCL 01/3

The historical events that led to the development of the X-15 research aircraft are presented. Some of the topics presented include: (1) manned airplane performance regions; (2) X-15 flight problems; (3) design characteristics for conceptual aircraft; (4) analysis of X-15 accident potential; (5) X-15 performance requirements; and (6) milestones in the development of the X-15. K.S.

N91-20073*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
X-15 HARDWARE DESIGN CHALLENGES
HARRISON A. STORMS, JR. *In its* Proceedings of the X-15 First Flight 30th Anniversary Celebration p 27-53 Jan. 1991
Avail: NTIS HC/MF A08 CSCL 01/3

Historical events in the development of the X-15 hardware design are presented. Some of the topics covered include: (1) drivers that led to the development of the X-15; (2) X-15 space research objectives; (3) original performance targets; (4) the X-15 typical mission; (5) X-15 dimensions and weight; (5) the propulsion system; (6) X-15 development milestones; (7) engineering and manufacturing challenges; (8) the X-15 structure; (9) ballistic flight control; (10) landing gear; (11) nose gear; and (12) an X-15 program recap. K.S.

N91-20074*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
X-15: THE PERSPECTIVE OF HISTORY
RICHARD P. HALLION *In its* Proceedings of the X-15 First Flight 30th Anniversary Celebration p 54-93 Jan. 1991
Avail: NTIS HC/MF A08 CSCL 01/3

The linkages between the Apollo 11 voyage to Tranquility Base and the 199 flights of the X-15 aircraft are discussed. Accomplishments of the X-15 program and a history of aircraft developments that led up to the X-15 are presented. K.S.

N91-20075*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
THE LEGACY OF THE X-15
CHARLES J. DONLAN *In its* Proceedings of the X-15 First Flight 30th Anniversary Celebration p 94-102 Jan. 1991
Avail: NTIS HC/MF A08 CSCL 01/3

The X-15 established such widespread confidence in aerodynamic, thermal, and structural areas that new designs for operation aircraft for any speed regime could be expected to be successfully achieved if good use was made of all pertinent test facilities and analytical methods. This philosophy guided design of the space shuttle and is the real legacy of the X-15. The accomplishments and contributions attributable to the research and development work on the X-15 that influenced the formative years of the Space Shuttle Program are presented. Author

N91-20076*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
X-15 CONTRIBUTIONS TO THE X-30
ROBERT G. HOEY *In its* Proceedings of the X-15 First Flight 30th Anniversary Celebration p 103-121 Jan. 1991
Avail: NTIS HC/MF A08 CSCL 01/3
Some of the less publicized flight test results from the X-15 program that might relate to sustained high-speed flight in the atmosphere are presented. The topics covered include: (1) energy management and range considerations; (2) the advantages of pilot-in-the-loop and redundant-emergency systems; (3) a summary of some of the aerodynamic heating problems that were encountered; and (4) some comments on the advantages of an early flight test program and gradual expansion of the flight envelope. Author

N91-20077*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
WHAT IS THE X-30
STEPHEN D. ISHMAEL *In its* Proceedings of the X-15 First Flight 30th Anniversary Celebration p 122-138 Jan. 1991
Avail: NTIS HC/MF A08 CSCL 01/3
The X-30 is envisioned to be a machine that is capable of exploring technology that is critical to single stage to orbit and to hypersonic cruise. The X-30 is comparable to a laboratory that will be able to investigate such things as the chemistry of supersonic combustion and the control of an of an integrated engine airframe, where the forebody of the airplane is the first compression surface for the propulsion. The X-30 is very ambitionous; it follows a path that is pretty well established by such programs as the X-15. This document is limited to a discussion of what is anticipated in the flight tests of the X-30 as opposed to describing the entire vehicle. Author

N91-20078# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
BRIGHTNESS INVARIANT PORT RECOGNITION FOR ROBOTIC AIRCRAFT REFUELING M.S. Thesis
RICHARD A. BENNETT 13 Dec. 1990 90 p
(AD-A230468; AFIT/GE/ENG/90D-04) Avail: NTIS HC/MF A05 CSCL 01/2
The purpose of this thesis effort was to develop and test a brightness invariant recognition algorithm that would locate and identify the half-scale mock up of a Universal Aerial Refueling Receptacle Slipway Installation (UARRSI) aerial refueling port in different lighting conditions. This was accomplished by developing a brightness invariant port recognition of identifiable attributes of the refueling port to locate and identify the UARRSI port. Based on this approach, a brightness invariant port recognition system (BIPRS) was demonstrated which identified the refueling receptacle in different lighting conditions. The BIPRS was also invariant to orientation and size of the UARRSI port. The BIPRS demonstrated the feasibility of the autonomous aircraft refueling task, and provides an incentive for additional research in autonomous robot applications. GRA

N91-20079# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
DYNAMIC ANALYSIS OF A COMBAT AIRCRAFT WITH CONTROL SURFACE FAILURE M.S. Thesis
MARC ROY Nov. 1990 133 p
(AD-A230517; AFIT/GAE/ENY/90D-24) Avail: NTIS HC/MF A07 CSCL 01/1
An investigation was performed to analyze the dynamic stability characteristic of an aircraft which has sustained damage to a primary control surface. The analysis was performed using the existing functional form of actual wind tunnel data taken on an F-16 model. Two control schemes are used for trimming an F-16 that has sustained damage to its rudder. The first control scheme represent the basic aircraft, while the second allowed the horizontal tail ailerons to move independently from the flaperons. The investigation was conducted for one flight condition representative of the aircraft at cruise speed. Region in alpha/beta (angle of attack)/(sideslip angle) space where trim can be achieved was selected as input into a linearized aircraft model. This model took into account the failed control surface. Eigenvalues of the open and closed loop models were analyzed to determine the region in alpha/beta space where the aircraft was dynamically stable. Migration of the eigenvalues for several trim conditions was also investigated to gain insight on the aircraft behavior while in an unsymmetrical orientation. For this study, the open loop eigenvalues for the trim are investigated save a stable system. When the aircraft controller was added into the system, regions of dynamic instability appeared. For rudder failure less than 20 degrees, trim could be achieved but the aircraft was dynamically unstable. GRA

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A91-29125
FIBER OPTICS FOR MILITARY AIRCRAFT FLIGHT SYSTEMS
LUIS FIGUEROA, C. S. HONG, RAYMOND W. HUGGINS, GLEN E. MILLER (Boeing High Technology Center, Bellevue, WA), ALEXANDER A. POPOFF (Boeing Commercial Airplanes, Renton, WA) et al. IEEE LCS Magazine (ISSN 1045-9235), vol. 2, Feb. 1991, p. 52-65. refs
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The technologies required to implement fiber-optic-based, or fly-by-light, flight control systems are considered. Following some historical background, the state of the art in fiber-optic position sensors is reviewed. General requirements are discussed, and wavelength-division digital, time-division digital, two-wavelength analog, chirped intensity-modulated analog, and other sensor configurations are examined. The most prominent and best-developed sensor multiplexing techniques are reviewed. Optically controlled actuators, avionic data buses, wideband transceivers, and fiber-optic cables and connectors are discussed. I.E.

A91-29132
A NONLINEAR HELICOPTER TRACKER USING ATTITUDE MEASUREMENTS
DOMINICK ANDRISANI, II, EUNG TAI KIM, JOHN SCHIERMAN (Purdue University, West Lafayette, IN), and FRANK P. KUHL (U.S. Army, Armament Research, Development, and Engineering Center, Picatinny Arsenal, NJ) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. 27, Jan. 1991, p. 40-47. refs
Copyright
Extended-Kalman-filter-based trackers are discussed for maneuvering helicopters that use body angle and rotor tip-path-plane angle measurements in addition to the usual radar position measurements. Improvements were found in tracker performance when the body rotation and rotor tip-path-plane degrees of freedom were modeled within the extended Kalman filter. Tracker performance was further improved when measurements of body angles and rotor tip-path-plane angles were made available to the tracker. I.E.

A91-29454
ELECTROSTATIC ENGINE MONITORING SYSTEM
THOMAS E. HENSEL (Sikorsky Aircraft, Stratford, CT) IN: Rotary Wing Propulsion Specialists' Meeting, Williamsburg, VA, Nov. 13-15, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 5 p.
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A review is presented of the electrostatic engine monitoring system (EEMS) concept of gas turbine health monitoring being developed for incorporation in the engines of both fixed wing and rotary wing aircraft as well as other turbine applications. This EEMS is designed to provide early warning of several forms of engine degradation that produces particulate matter or ingestion of particulate matter providing sites for the accumulation of ionically imbalanced charges in the gas path. Various combinations of aerodynamic, physical and electrical processes within the engine foster the production of ionized gas clouds in the gas path. The EEMS concept monitors for the presence of and counts the occurrence of these ionically imbalanced clouds in the gas path. R.E.P.

A91-29479
WINDSHEAR DETECTION AND RECOVERY GUIDANCE - AN EQUIPMENT MANUFACTURER'S PERSPECTIVE
HOWARD GLOVER (Sundstrand Data Control, Inc., Redmond, WA) IN: Windshear; Proceedings of the Conference, London, England, Nov. 1, 1990. London, Royal Aeronautical Society, 1990, p. 5.1-5.8.
Copyright

This paper presents the process that an avionics equipment manufacturer followed in order to design a viable wind shear detection system. The rationale used in dealing with the various constraints imposed by the laws of physics, regulatory agencies, market demands, and the methods employed to enhance the product during the course of development is discussed. The problems involved include wind shear detection means, system integration, flight path angle bias, recovery guidance, and certification procedures. The basic design concept integrates wind shear detection, wind shear recovery guidance, ground proximity warning, and altitude awareness annunciation. Performance of the system in response to wind shears in a flight simulator is described. R.E.P.

A91-29480
WINDSHEAR DETECTION AND RECOVERY GUIDANCE ON THE BAE 146
N. P. SLACK (British Aerospace /Commercial Aircraft/, Ltd., Hatfield, England) IN: Windshear; Proceedings of the Conference, London, England, Nov. 1, 1990. London, Royal Aeronautical Society, 1990, p. 7.1-7.7.
Copyright

The installation of a windshear detection and recovery guidance system (WDGS) in the BAe 146 aircraft is described and the methods employed to develop and test the system are discussed. The WDGS has two basic functions: to detect and annunciate the presence of low-level airborne wind shear; and to provide guidance, by the flight director system, to permit the pilot to control the aircraft's performance. Simulation experience has shown that an anticipation of a severe wind shear by a few seconds appreciably increases the probability of recovery. Wind shear recovery guidance, based on angle of attack and modified by radio altitude and pitch attitude, is designed to permit quick transition out of the wind shear while preventing the aircraft from dropping, and utilizing the maximum lift capability to prevent ground impact. It is concluded that forward looking wind shear systems, currently being developed, will provide an additional safety benefit. R.E.P.

A91-29499
AN INSTRUMENTED AIRCRAFT FOR ATMOSPHERIC RESEARCH IN NEW ZEALAND AND THE SOUTH PACIFIC
H. R. LARSEN, G. W. FISHER, R. A. KNOBBEN, I. S. LECHNER, and M. J. HARVEY (New Zealand Meteorological Service, Wellington) American Meteorological Society, Bulletin (ISSN 0003-0007), vol. 72, Feb. 1991, p. 192-200. refs
Copyright

A Fokker Friendship F27 twin turboprop aircraft has been instrumented by the New Zealand meteorological service to make observations in the southwest Pacific Ocean region. This aircraft makes it possible to undertake measurement programs extending over several years. The aircraft with large underwing pylons for carrying sampling probes has been employed for cloud physics, aerosol, and trace gas studies in the remote Pacific and for the study of mesoscale southerly changes off the east coast of New Zealand. A description is given of research equipment and the measurements provided by it such as dynamic variables, air state variables, cloud particle probes, gas sampling, and aerosol sampling. O.G.

A91-30360
TEST AND CALIBRATION OF THE DLR FALCON WIND MEASURING SYSTEM BY MANEUVERS
W. BOEGEL and R. BAUMANN (DLR, Institut fuer Physik der Atmosphaere, Oberpfaffenhofen, Federal Republic of Germany) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 8, Feb. 1991, p. 5-18. refs
Copyright

After a short survey of the flight maneuvers of the Falcon the high-frequency pitching and yawing oscillations are treated in detail. It is shown that nearly all measured quantities essential for turbulence can be synchronized to 0.01 s and that the sensitivity coefficients for the angles of attack and sideslip (measured by the 858 AJ probe) can be determined to about 1 percent. The effects of these angles on the static and dynamic pressure are modeled and utilized to synchronize the pressures. Author

A91-30361
ANALYSIS OF A RADOME AIR-MOTION SYSTEM ON A TWIN-JET AIRCRAFT FOR BOUNDARY-LAYER RESEARCH
MICHAEL TJERNSTROM (Uppsala University, Sweden) and CARL A. FRIEHE (California, University, Irvine) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 8, Feb. 1991, p. 19-40. U.S. Navy-supported research. refs
(Contract NFR-G-GU-2684-120; NFR-G-GU-2684-302; NFR-G-GU-1775-300)
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A 'radome gust probe' system was installed on a twin-jet aircraft for the purpose of boundary-layer research. This system provided a useful relatively low-cost method for air motion and turbulence measurements on an aircraft already equipped with an inertial navigation system (INS) and a data acquisition system. An error analysis was made for the wind measurements and gave the limitations for the present system with an unmodified airline-type INS. The major factors that limit the precision of the horizontal wind are the resolutions and accuracy of the aircraft ground speed components and the true heading. A simple method was devised to improve the heading resolution. From in-flight maneuvers, it was determined that the mean horizontal airspeed vector was accurate to less than 0.5 m/s - limited by the long-term drift and oscillation errors from the INS - and that pitch and yaw contamination of the wind was less than 5 percent. Author

A91-30362
A THREE-AIRCRAFT INTERCOMPARISON OF TWO TYPES OF AIR MOTION MEASUREMENT SYSTEMS
D. H. LENSCHOW, E. R. MILLER, and R. B. FRIESEN (NCAR, Boulder, CO) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 8, Feb. 1991, p. 41-50. refs
Copyright

Procedures are presented to evaluate air motion measurements on two or more aircraft by flying them in formation at a known lateral displacement. The analysis is applied to two formation flights involving three aircraft - the NCAR Electra, Sabreliner, and King Air - in a clear convective boundary layer to compare two types of air motion sensing probes mounted on different aircraft. Differences in means and variances, spectra and cospectra, and spatial coherences between the same velocity components measured on the different aircraft are compared. The differences are, in most cases, comparable to what is predicted on the basis of making identical measurements of the same variable laterally displaced by 30 m in a turbulent velocity field. Measurements from a constrained vane gust probe and a differential pressure gust probe mounted less than 0.2 m apart on the Electra noseboom also compared well with each other. Author

A91-30363
AN APPLICATION OF KALMAN FILTERING TO AIRBORNE WIND MEASUREMENT
B. W. LEACH and J. I. MACPHERSON (National Aeronautical Establishment, Ottawa, Canada) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 8, Feb. 1991, p. 51-65. refs
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Airborne wind measurement techniques currently being used onboard the National Aeronautical Establishment Twin Otter Atmospheric Research Aircraft are described, and their fundamental limitations are discussed. In particular, a recently acquired LTN-90-100 strapdown Inertial Reference System exhibits significant low frequency errors in its velocity components (primarily Schuler oscillation errors that can attain peak values of 2 to 3 m/s), actually degrading wind computation accuracy compared with older techniques. A new wind measurement technique, based on a Kalman filter integrated navigation approach, is shown to mitigate this problem and provide wind computation accuracy superior to previous methods. Preliminary results, based on applying the Kalman filter to Twin Otter flight test data, indicate that inertial velocity accuracies of 0.3 m/s rms (per axis) are attainable under ideal conditions, with a corresponding improvement in the accuracy of earth-referenced wind components. Author

A91-30364
EFFECTS OF AIRFLOW TRAJECTORIES AROUND AIRCRAFT ON MEASUREMENTS OF SCALAR FLUXES
WILLIAM A. COOPER and DIANA ROGERS (NCAR, Boulder, CO) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 8, Feb. 1991, p. 66-77. refs
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Potential-flow calculations of the airflow around two research aircraft are used to estimate the effects of flow distortion on measured fluxes of sensible heat and water vapor. From the calculated flow patterns, flow-distortion coefficients are determined and used to characterize biases and contamination terms in the measured fluxes. These calculations provide the basis for estimating the magnitude of the errors and in some cases for correcting the measurements. The errors in measured fluxes for typical mid-day planetary boundary layers are usually less than 5 percent, if the normal choices for sensor locations are used, but could be much larger for other possible locations. The estimated errors for realistic measurement conditions are smaller than statistical uncertainties in the flux estimates for those same flight segments, when the flight legs are about 10 min in duration. Author

A91-30373#
THE TIME-VARYING CALIBRATION OF AN AIRBORNE LYMAN-ALPHA HYGROMETER
RICHARD J. LIND and WILLIAM J. SHAW (U.S. Naval Postgraduate School, Monterey, CA) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 8, Feb. 1991, p. 186-190. refs
(Contract NSF OCE-86-03050)

Calibration of airborne Lyman-alpha hygrometer against simultaneous measurements of humidity from a dewpoint hygrometer shows that Lyman-alpha biases drift with time. Analyses of low-level flight data from four days during the 1986 Frontal Air-Sea Interaction Experiment indicate that Lyman-alpha gains are constant for each flight (about 3 h duration) but different on each day. If not explicitly accounted for, the time-varying bias can introduce a significant error in calculated humidities from the Lyman-alpha hygrometer. Author

A91-30473
TOWARDS THE 'INTELLIGENT' AIRCRAFT
GUENTER ENDRES Interavia Aerospace Review (ISSN 0020-6512), vol. 46, April 1991, p. 57-61.
Copyright

Neural networks are expected to be the next step in improving computer intelligence with smaller processors, fly-by-speech advances and integrated avionics systems accelerating the automation process. Research on neurocomputers is concentrating on image processing and target and feature recognition. Computing requirements in commercial airliners are less than for military aircraft as they are limited in general to flight management and engine control with no military inputs from fire control radar, electronic warfare and forward-looking infrared sensors. Growing computer capacity will benefit the sophistication of monitoring systems, which detect and display errors and damages necessitating maintenance. Thus, fault diagnostic data can be transmitted directly to the pilot and/or linked digitally to ground maintenance so that engineers can be ready for the necessary work before the aircraft arrives. It is projected that the next generation aircraft, FBW will be replaced by fly-by-light or fiber optic technology, in which digital signals are transmitted as light pulses along optic fibers. R.E.P.

A91-30861
DEVELOPMENT OF A SEM-E FORMAT COMPUTER - A MECHANICAL PERSPECTIVE
JEFFREY E. FARIS (Texas Instruments, Inc., Dallas) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 125-129.
Copyright

The mechanical hardware design challenges of implementing SEM-E format modules for a mission processor computer are examined. The computer consists of an air-cooled chassis, a high-density backplane, 18 digital SEM-E modules, five SEM-E format power supply modules, a power conditioner, and the internal wire harnesses. The complete computer weighs less than 78 pounds, and is approximately the size of a 3/4 ATR long chassis. The computer requires less than 400 watts of three-phase, 400-Hz AC power. A common thermal environment is provided for all modules. All modules are of surface mount construction and have aluminum covers that provide vibration, ESD (handling), and EMI (electromagnetic interference) survivability. This mission processor is designed for flightworthy applications. Formalized analysis and testing of the system verified the integrity of the processor. I.E.

A91-30863
DEVELOPMENT OF AN ADVANCED 32-BIT AIRBORNE COMPUTER
BEN FEINREICH (Lear Astronics Corp., Santa Monica, CA), STEVE WAGNER (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH), and WAYNE ROBBINS (McDonnell Aircraft Co., Saint Louis, MO) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 133-139.
Copyright

An advanced 32-bit airborne computer was developed to fulfill the needs of the ICAAS (Integrated Control and Avionics for Air Superiority) program, with applicability to other programs with similar requirements. The computer may contain up to four processors that are based on the MIPS R-3000 reduced-instruction-set microprocessor. This four-processor configuration is capable of approximately 20 million IPS throughput and 32-bit words of memory. Memory is configurable in blocks of nonvolatile electrically reprogrammable devices for program storage and RAM for read/write scratchpad. The R-3000 has been recently selected as one of two standard 32-bit architectures. A high-speed parallel system bus is used internally, for interprocessor communications, whereas two 1553 multiplex bus interfaces are used for external communications. An operating system is also in development, providing the application programmer a fully compliant Ada environment that allows the downloading and debugging of software and realtime execution without concern for hardware peculiarities. I.E.

A91-30864

AN APPLICABILITY EVALUATION OF THE MIPS R3000 AND INTEL 80960MC PROCESSORS FOR REAL-TIME EMBEDDED SYSTEMS

J. JAY KURTZ, JOHN E. THIBEAULT, and WALTER J. BRAUCKMANN (Westinghouse Electric Corp., Digital Systems Dept., Baltimore, MD) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 140-147. refs

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The Mips R3000 and Intel 80960MC are two candidate processors for use in real-time embedded architectures. The architectural features and development environment for each of these processors are described. The requirements of real-time embedded processors are discussed and related to the functions performed. Software statistics are presented for various real-time embedded applications; attention is given to typical procedure call depths, context switching, interprocess communication and synchronization, transcendental functions, parameter passing, and local and global object declarations. These computational requirements are related to the architecture features, contrasting the effects of different major design issues such as register set architecture, cache size and management, multiprocess support, exception/fault handling, debug support, virtual memory system, interrupt controller, branch handling, and functional pipelining. Trade-offs that compare the hardware to software impact relative to the real-time system requirements are identified. I.E.

A91-30868

THOUGHTS ON HIGH SPEED DATA BUS PERFORMANCE

MERRILL T. LUDVIGSON (Rockwell International Corp., Collins Government Avionics Div., Cedar Rapids, IA) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 163-168.

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The author believes that average performance calculations do not provide an adequate method for evaluating bus performance and making engineering design decisions in the presence of bursty traffic, because bursty traffic significantly changes those factors that most impact on bus performance. From recent work it appears that very subtle changes may have significant impact on bus performance in unexpected ways. An example is the choice of when to reset the token rotation timers to achieve optimum priority performance. During the PAVE PILLAR program, it was recommended that the timers be reset when the token arrives. Others recommended that the timers be reset when the token is sent. The author discusses the reasons for the original recommendation, how a simulation failed to confirm those original conclusions, and how a few simple equations have since been derived which have led to a new set of conclusions. Subtle points pertaining to high-speed data bus characteristics that affect bus performance are discussed. I.E.

A91-30869

A SEM-E MODULE AVIONICS COMPUTER WITH PI-BUS BACKPLANE COMMUNICATION

MICHAEL J. DOUGHERTY (Texas Instruments, Inc., Dallas) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 169-173.

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The author describes the system architecture of a MIL-STD-1750A-based mission processor utilizing dual VHSIC Phase 2 TM-Bus and dual VHSIC Phase 2 PI-Bus for intermodule level communication. The mission processor consists of 18 surface-mount SEM-E modules and five high-density power supplies mating with an 18 layer G-10 backplane in an air-cooled chassis. The system-level interfaces consist of a dual PI-Bus for intermodule communication, a dual TM-Bus for intermodule operational test and maintenance, an IEEE-488 interface to an external software development platform, two differential small computer system interface (SCSI) buses, three dual redundant MIL-STD-1553B serial communication buses, and several digital and analog discrete I/Os. The author presents a comparison of the defined cycle sequence of each of the basic PI-Bus messages to the observed cycle structure of these message types in the system. The impact of chaining a sequence of PI-Bus messages is examined. Finally, data on the impact of PI-Bus traffic on module performance under various conditions are examined. I.E.

A91-30870

A COMPREHENSIVE ANALYZER FOR THE JIAWG HIGH SPEED DATA BUS

H. S. ARCHER (Lockheed Sanders Co., Atlanta, GA) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 174-182.

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The author explains the HSDB (high speed data bus) protocol, describes the HSDB-A (high-speed data bus analyzer) hardware, and presents HSDB-A operation from the user's point of view. The HSDB provides 50 Mb/s maximum bandwidth, adequate throughput, and excellent fault recovery characteristics. The HSDB serves as a mission avionics bus, coordinating processes among integrated racks. To debug systems interconnected by the HSDB, engineers need a comprehensive support tool that can monitor the bus, maintain bus performance statistics, selectively capture bus traffic on error or trigger conditions, emulate nonexistent terminals, and stress the bus to the specification limits. The HSDB-A fulfills this need. I.E.

A91-30871

AN OVERVIEW OF THE FIBER-OPTIC ACTIVE STAR COUPLER PROGRAM

R. W. UHLHORN (Harris Corp., Melbourne, FL), T. A. MCDERMOTT (Lockheed Aeronautical Systems Co., Marietta, GA), and P. C. GOLDMAN (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 183-189.

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In this overview of the Fiber Optic Active Star Coupler (FOASC) program, the authors address issues surrounding the use of active rather than passive access couplers to provide connectivity for a large number of serial high-speed data bus (HSDB) users. The FOASC program consists of a detail requirements study for various aerospace platforms and HSDB configurations followed by the design, fabrication, characterization and test, and demonstration of FOASC units meeting the established requirements. The authors consider alternative configurations (topologies); bus architecture and specific aircraft issues; installation trade-offs, including power budget analyses; protocol issues, such as initialization behavior in the active star coupler environment; retiming requirements; fault-tolerance and redundancy trade-offs; and operational considerations. The design of the FOASC units includes a significant component development effort making possible a flexible, yet simple, low-power-consumption active star coupler. A test set specifically tailored to fully characterize FOASC performance has also been designed and built on this program. I.E.

A91-30872
MAINTENANCE TECHNOLOGY FOR ADVANCED AVIONICS ARCHITECTURE
BARRY A. RICH (TRW, Inc., Military Electronics and Avionics Div., Redondo Beach, CA), BRUCE E. BARTELS (Northrop Corp., Aircraft Div., Hawthorne, CA), and MERLE H. COLE (Unisys Corp., Computer Systems Div., Saint Paul, MN) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 190-196.
Copyright
The third-generation avionics architecture defined by Pave Pillar is being expanded and solidified by a variety of activities including Joint Integrated Avionics Working Group (JIAWG) and Modular Avionics System Architecture (MASA). Included are the integrated maintenance diagnostics technologies and concepts which are essential in achieving Air Force maintainability, reliability, and support objectives for the future. One approach to meeting these objectives is the application of integrated diagnostics expert systems (IDESs), time stress measurement modules (TSMMs), and interactive maintenance system (IMS) technologies to achieve 100 percent fault coverage in support of the evolving maintenance concepts and procedures. The authors describe an approach for combining these technologies and evaluating the resulting fault detection/fault isolation effectiveness. The approach is being used on the Modular Avionics Maintenance Technology Development and Demonstration (MAMTDD) program. I.E.

A91-30873#
PAVE PILLAR IN-HOUSE RESEARCH
JESSE L. BLAIR (USAF, Avionics Laboratory, Wright-Patterson AFB, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 197-202.
The concepts and technologies required to develop, integrate, and test the Pave Pillar architecture in an avionics system are considered. The architectural concepts related to line replaceable modules are as defined by the architecture specification for Pave Pillar avionics. The hardware and software issues relating to multiprocessing, multitasking, and real-time reconfiguration are discussed. The integration issues of developing and testing the VHSIC avionic modular processors (VAMPs), high-speed data bus networks, and Ada software are examined. An avionic hot bench simulation was integrated to provide a closed-loop real-time test bed called the integrated test bed (ITB) facility. The configuration and test setup for the avionic modules were selected to provide a realistic environment. There are four VAMP clusters with each cluster consisting of two high-speed data bus modules, two to four Mil-Standard 1750A CPU modules, and one Mil-Standard 1553B bus module. The results from this testing prove the concept of common modules and modular avionics while quantifying the integration issues. I.E.

A91-30877#
THE INTEGRATED COMMUNICATION NAVIGATION IDENTIFICATION AVIONICS (ICNIA) PROGRAM SUMMARY FROM A 'LESSONS LEARNED' PERSPECTIVE
DENICE S. JACOBS (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 221-226.
An attempt is made to provide both technical and managerial insight into the development of advanced avionic architectures and integrated subsystems based upon the work performed under the Integrated Communication, Navigation, Identification Avionics (ICNIA) Advanced Development Model (ADM) Program. ICNIA was one of the first systems to implement an integrated, modular architecture and support built-in-test (BIT), system reconfiguration, and signal simultaneity. The following issues are addressed: (1) identification of design problems and concerns; (2) system supportability and testability; and (3) recommended managerial tactics and control strategies. I.E.

A91-30882
DISPLAY AND SIGHT HELMET SYSTEM
OPHER NEVO (Elbit Computers, Ltd., Haifa, Israel) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 265-270.
Copyright
A description is given of DASH, a display and sight helmet system which measures the pilot's line of sight and transfers the information to other aircraft systems, thus enabling the pilot to achieve lock-on of sensors, avionics, and weapons onto a target simply by looking at it. Crucial information, such as line of sight, TD boxes, flight information, status, and warnings, is displayed directly in front of the pilot on the helmet visor, eliminating the need to glance inward at the instrument panel or head-up display. With expanded lock-on envelope, shorted aerial engagement, increased survivability, user-friendly display and HOTAS controls, the system proved to be a true revolution in air-to-air and air-to-ground combat. The author gives a technical description of the system, discusses its operational aspects, and addresses future programs and developments. I.E.

A91-30884#
IMPROVE CHARACTER READABILITY IN SPITE OF PIXEL FAILURES - A BETTER FONT
JAMES A. UPHAUS, JR., KRISTEN BARTHELEMY, and JOHN M. REISING (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 278-283. refs
Current military aircraft reflective displays (e.g. liquid crystal) may utilize a single-pixel-width 7 x 9 font, yet still achieve sunlight readability. However, use of double-pixel-width characters can substantially reduce reading errors when noncatastrophic dot-matrix display failures occur. Using a single-pixel-width font as a reference, an enhanced, 7 x 9 matrix size, two-pixel-width version was developed for testing in both degraded and undegraded forms. Probable worst-case degradation (failure of a single row or column to make one character look as much like another as possible) was applied to both font versions. Twenty-two subjects evaluated degraded and undegraded characters (both font versions) in a glance recognition test on a dot-matrix display. Test results show the double-pixel-width version to be superior in terms of reduced reading errors when simulated row/column failures occur. It is recommended that, as a minimum, two-pixel-width characters be used for military display applications. I.E.

A91-30886
PHASED ARRAY ANTENNA - IS IT WORTH THE COST ON A FIGHTER AIRCRAFT?
PHILIPPE GEORGES (Thomson-CSF, Montrouge, France) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 312-316. refs
Copyright
An airborne fire-control radar equipped with a passive plane phased-array antenna is considered. An effort is made to find the best methods for its use and to derive the technical and operational effects which stem from it. It is found that best way to use it lies not in the range domain, but mainly in the multifunctional aspect of the radar, and particularly in its contribution to the efficiency of the weapon system. I.E.

A91-30888
INTELLIGENT INTERNETTED SENSOR MANAGEMENT SYSTEMS FOR TACTICAL AIRCRAFT

PAUL G. NAGY and STEVE G. BIER (TAU Corp., Long Beach, CA) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 321-327.
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The authors propose a design of an internetted sensor management system (ISMS) and discuss the advantages and disadvantages of using such a system. Quantifiable measures of performance for assessing the benefits of internetted sensor management are defined. The effects of internetted sensor management and cooperative tactics on the intraflight data link requirements are discussed. I.E.

A91-30891
ADVANCED REFERENCE SYSTEM COCKPIT DISPLAY PROJECT
EDWARD L. FIX, WILLIAM P. MARSHAK (USAF, Armstrong Aerospace Medical Research Laboratory, Wright-Patterson AFB, OH), and DENNIS BURNSIDES (Systems Research Laboratories, Inc., Dayton, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 338-342. USAF-supported research.
Copyright

The test group engineers who originally developed the ARS (Advanced Reference System) proposed a display design which contained the necessary flight information, but in a somewhat awkward format. AAMRL proposed two alternative designs: one was a rearrangement of the test wing's design with an improved layout, and the other went beyond raw data to include a flight director. The three alternative designs were prototyped on a Silicon Graphics workstation, using variations of the FLIGHT Program available on that computer, and evaluated during simulated flying performance. Pilot subjects flew complex flight paths which included single and combined changes in heading, altitude, and airspeed. Performance measures included root mean squared deviations from nominal flight path parameters and at way points. The flight director display was superior in most categories. I.E.

A91-30904
REAL-TIME AUTOMATED DECISION-MAKING IN ADVANCED AIRBORNE EARLY WARNING SYSTEMS
CHIEN Y. HUANG (Grumman Corporate Research Center, Bethpage, NY) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 434-439. refs
Copyright

Automated decision-making techniques have been applied to the airborne early warning (AEW) environment. The techniques are developed based on emulating the decision process of the AEW operator. Two systems are defined. The threat assessment (TA) system determines a target's threat level based on available information. The tactical planning (TP) system attempts to use the strategy that achieves the optimal response. Both the TA and TP modules are easily user-modifiable to accommodate different circumstances. The systems have been successfully integrated and tested in an advanced simulation facility against several scenarios. It is shown that performance in real time can be achieved. I.E.

A91-30981
A MODULAR AVIONICS FRAMEWORK FOR UPGRADING EXISTING AVIONICS SYSTEMS
PHILIP C. MARRIOTT (CTA, Inc., Dayton, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1044-1049. refs
Copyright

An architectural approach to implementing modular avionics design concepts when existing avionics systems are being upgraded is established. Modular avionics architectures are identified, and a process for implementing these architectures during systems requirements analysis and design is proposed. A framework is established for upgrading existing avionics systems based on systems, software, and hardware architecture concepts. This framework is known as the modular avionics process, and it consists of fifteen steps described in four stages. This process enables the allocation of system requirements to subsystems, software functions, and hardware functions. It also includes an assessment of whether a modular avionics design approach is feasible. I.E.

A91-30982
AVIONICS RELIABILITY-COST (ARC) TRADE-OFF MODEL
ARVE R. SJOVOLD, RICHARD A. NORDSIECK, and GINA M. SCARANO (Tecolote Research, Inc., Santa Barbara, CA) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1050-1053.
(Contract F01620-87-D-0259)
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The avionics reliability-cost (ARC) program is configured as a design aid for advanced, cost-effective avionics implementations typified by phase-one and, ultimately, phase-two VHSIC. The model is designed to allow the study of trade-offs involving all phases of life-cycle cost. ARC facilitates design-cost trade-off analysis by modeling interactions among selected device characteristics and packaging, environmental, and operational variables. ARC carefully models device power dissipation; module thermal loads; heat conductivity as a function of module size, heat sink, and material choices; and consequent device junction temperatures and failure rates. The same device and module characteristics that are used to deduce failure rates are used to estimate module costs through calibrated engineering buildup relationships. ARC runs interactively, allowing the user to create data sets, calculate, view, and print results, and save and edit old data sets as different parameter combinations are evaluated during a single ARC session. I.E.

A91-30983
REDUCING RISK WHEN MANAGING THE DEVELOPMENT OF COMPLEX ELECTRONIC SYSTEMS
CHRISTOPHER F. DONNELLY (ZYCAD, Federal Services Group, Mount Olive, NJ) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1054-1058.
Copyright

A simulation environment and a methodology have been developed for studying the Joint Integrated Avionics Working Group (JIAWG) computer module specifications under the demonstration of avionic modules exchangeability via simulation (DAMES) program. The simulation environment enables computer systems to be integrated and tested for compliance with hardware and software specifications without actually fabricating the computer system. The methodology enables specifications to be broken down into a list of requirements for easy identification of testing requirements, possible test scenarios, and needed test results. The simulation environment is detailed, explaining how the computer systems are integrated and tested. Results from the DAMES program are discussed, identifying errors and insufficiencies with the present JIAWG computer modules and specifications. It is shown that the use of advanced simulation technology will reduce the risk when managing the development of complex electronic systems. I.E.

A91-30984
DAMES PROGRAM UPDATE - METHODOLOGY, TEST RESULTS, AND IMPACT
JAMES J. ENSELL (ZYCAD, Federal Services Group, Mount Olive, NJ) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol.

3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1059-1065.

The testing methodology that has evolved under the demonstration of avionics module exchangeability via simulation (DAMES) program, the program's accomplishments, and their impact on the DOD electronic systems procurement process are described. Test development in DAMES is defined as the process by which a comprehensive test suite is developed from an English-language specification. The DAMES specification breakdown process defines a methodology by which a complete set of requirements is extracted from a given specification. The DAMES program allows for testing and evaluation of the effectiveness of JIAWG specifications prior to fabrication. The evaluation is performed through gate-level system simulation of contractor designs using the DAMES methodology. This methodology allows for the demonstration of the effectiveness of current specifications and designs in their support of interoperability and exchangeability. I.E.

A91-30985
APPLYING ADVANCED SYSTEM SIMULATION TECHNIQUES TO INFOSEC SYSTEM DEVELOPMENT
VINCENT P. CALANDRA (ZYCAD, Federal Services Group, Mount Olive, NJ) and PETER LEAHY (Motorola, Inc., Government Electronics Group, Scottsdale, AZ) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1066-1070.

The gate-level system simulation (GLSS) methodology, developed under the demonstration of avionics module exchangeability via simulation (DAMES) program, allows integration of gate-level models to create simulatable system models that reflect actual hardware designs. The virtual integrated systems (VIS) approach expands GLSS to include the use of behavioral models, and allows system software to be developed and debugged. Advanced simulation capabilities that allow systems integration problems to be dealt with early in the design cycle are described. The evolution of advanced system simulation techniques and the way in which the VIS approach can be applied to the development of complex modular information security devices, such as the advanced avionics COMSEC unit (AACU), are described. I.E.

A91-30986
THE JIAWG INPUT/OUTPUT SYSTEM (JIOS)
JOHN NEWPORT (U.S. Navy, Naval Avionics Center, Indianapolis, IN) and CHUCK ROARK (Texas Instruments, Inc., Defense Systems and Electronics Group, Plano) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1071-1076.

The joint integrated avionics working group (JIAWG) input/output system (JIOS) provides the software/hardware interface for built-in-test (BIT) and I/O provided via the PI-Bus and TM-Bus for the JIAWG 16-bit common modules. The need for JIOS, the functionality of the JIOS, concerns related to the use of the JIOS, and a planned JIOS demonstration are presented. The JIOS is intended to be a generic software interface for BIT, as well as PI and TM buses. The hardware and software which comprise the JIOS are required to be an integral part of the module architecture so that no operational software downloads are needed. The JIOS features are specified by the JIAWG input/output built-in-test interface definition specification (IOBIDS). IOBIDS contains a complete definition of the user interface, including functions provided, calling sequences, parameter type definitions, and special user requirements. These definitions are provided as an Ada package specification with no package body, for each functional area. I.E.

A91-30987#
JIAWG DIAGNOSTIC CONCEPT AND COMMONALITY REQUIREMENTS
RICHARD S. MEJZAK (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1077-1080.
One of the major joint integrated avionics working group (JIAWG) objectives is to ensure that reliable and maintainable systems can be built from JIAWG common modules. A JIAWG diagnostic concept and initiative are discussed. A three-level diagnostic concept is described in terms of system, system element, and module management requirements. The system level is responsible for detecting, containing, and isolating faults down to the system element level. The system element level is responsible for detecting, containing, and isolating faults down to the module level. A module is assumed to be partitioned into functional areas as a convenient means of identifying a component or group of components. The module level is responsible for detecting, containing, and isolating faults down to the functional area. The corresponding JIAWG initiative is discussed with respect to requirements for developing a common methodology for deriving fault coverage metrics, as well as proof-of-concept demonstrations necessary to show compliance with JIAWG requirements. I.E.

A91-31027
IMPROVED FLIGHTLINE DIAGNOSTICS USING AN EXPERT MAINTENANCE TOOL (XMAN II)
JEFF A. FRENSTER and RONALD L. DEHOFF (Systems Control Technology, Inc., Palo Alto, CA) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1354-1357. refs

SCT has developed an expert maintenance tool (XMAN II) to assist the technician in evaluating engine monitoring system (EMS) data. The design and function of the XMAN II system are described, and a sample troubleshooting session to demonstrate the diagnostic and user interface features resident in the XMAN II program are discussed. XMAN II implements a comprehensive information analysis technology using a knowledge-based algorithmic approach. Information analysis in this context means the application of structured and unstructured methods to data recorded from remote sensors and manual tests for the purpose of deducing facts about the physical system, including actual condition, imbedded faults, and health prognosis. The information resides in databases. Methods are stored in knowledge bases. XMAN II implements a seamless integration of data, knowledge, and control. I.E.

A91-31297
FLIGHT DATA RECORDERS IN THE 1990'S
GEORGE J. NEPERENY (Science Applications International Corp., Enterprise, AL) IN: Innovations in rotorcraft test technology for the 90's; Proceedings of the AHS National Technical Specialists' Meeting, Scottsdale, AZ, Oct. 8-12, 1990. Alexandria, VA, American Helicopter Society, Inc., 1990, 9 p.

A review is presented of the development and utilization of flight data recorders (FDR) as an effective aircraft accident investigation tool in civilian and military aircraft. The volume and type of data necessary for accident investigation lends itself directly to training and records keeping applications, maintenance, cycles, loads, airframe utilization, diagnostics, service life determinations, automated records keeping, and troubleshooting areas for maintenance applications of the FDR. Consideration is also given to FDR capabilities, maintenance, training, parameter lists, sampling rates, and threshold sizes. The practical applications of the FDR system other than as an aircraft accident prevention/investigation tool can be greatly enlarged with relatively little additional expense

if the design and selection of the FDR parameter recording logic is carefully conducted prior to installation. R.E.P.

A91-31502
DEVELOPMENT TO PRODUCTION OF AN IHUM SYSTEM
A. C. GORDON (Bristow Helicopters, Ltd., Redhill, England) IN: Helicopter airworthiness in the 1990s: Health and usage monitoring systems - Experience and applications; Proceedings of the Conference, London, England, Nov. 29, 1990. London, Royal Aeronautical Society, 1990, p. 2.1-2.17.
Copyright

The principal requirements of an integrated Health and Usage Monitoring System (HUMS) are presented and the pros and cons of onboard/offboard processing of the diagnostics and the final specification principles together with the concept of the integration associated with this installation are discussed. The ground station is described beginning with the hardware selection followed by the software function and specification together with its operation. Further discussion is provided on the need for HUMS, building the specification, developing the system and the specification, control and display unit specification, and the certification plan. R.E.P.

A91-31503
HUMS - THE OPERATOR'S VIEWPOINT
MARTIN KAY and GRAHAME DANIELS (British International Helicopters, Ltd., Aberdeen, Scotland) IN: Helicopter airworthiness in the 1990s: Health and usage monitoring systems - Experience and applications; Proceedings of the Conference, London, England, Nov. 29, 1990. London, Royal Aeronautical Society, 1990, p. 3.1-3.11.
Copyright

This paper outlines the background and goals of the health monitoring trials conducted using two S61N helicopters and relates some of the experiences achieved. Based in the Shetland Islands, the two aircraft performed their normal operations in support of the offshore oil industry while conducting the trial to monitor, collect and analyze data for engines, gearboxes and rotors. The trial structure, vibration monitoring system technology, engine monitoring system, system reliability, and data collection and handling are described. It is indicated that the current trial is making major steps toward the goal of providing increased safety, improving airworthiness and contributing to reduced life cycle costs. R.E.P.

N91-19095*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
PRELIMINARY RESULTS FROM AN AIRDATA ENHANCEMENT ALGORITHM WITH APPLICATION TO HIGH-ANGLE-OF-ATTACK FLIGHT
TIMOTHY R. MOES and STEPHEN A. WHITMORE Feb. 1991 41 p Presented at the AIAA 29th Aerospace Sciences Meeting, Reno, NV, 7-10 Jan. 1990 Previously announced in IAA as A91-19405
(NASA-TM-101737; H-1691; NAS 1.15:101737) Avail: NTIS HC/MF A03 CSCL 01/4

A technique was developed to improve the fidelity of airdata measurements during dynamic maneuvering. This technique is particularly useful for airdata measured during flight at high angular rates and high angles of attack. To support this research, flight tests using the F-18 high alpha research vehicle (HARV) were conducted at NASA Ames Research Center, Dryden Flight Research Facility. A Kalman filter was used to combine information from research airdata, linear accelerometers, angular rate gyros, and attitude gyros to determine better estimates of airdata quantities such as angle of attack, angle of sideslip, airspeed, and altitude. The state and observation equations used by the Kalman filter are briefly developed and it is shown how the state and measurement covariance matrices were determined from flight data. Flight data are used to show the results of the technique and these results are compared to an independent measurement source. This technique is applicable to both postflight and real-time processing of data. Author

N91-19096# Cranfield Inst. of Tech., Bedford (England). School of Mechanical Engineering.
THE APPLICATION OF AERO GAS TURBINE ENGINE MONITORING SYSTEMS TO MILITARY AIRCRAFT M.S. Thesis
C. A. R. BURGESS Aug. 1990 187 p
(ETN-91-98852) Copyright Avail: NTIS HC/MF A09

The application of Engine Monitoring Systems (EMS) to military aircraft has not developed as rapidly as in the civil sector. Nevertheless, they offer a very significant reduction in life cycle costs including a marked improvement in flight safety. Both the operational and organizational factors which mould the military environment are considered. The development of EMS in the RAF (Royal Air Force) is described and the practical application and limitations of both new and existing methods are investigated drawing on examples of their performance in operational service. The role of ground based systems and their strengths and weaknesses are examined. Various EMS development programs are studied, in particular the manner in which timescales, funding, contractual arrangements and project organization profoundly influence the final product and the lessons that can be learnt for the future from mistakes or successes in the past. A cost analysis is undertaken to explore the order of possible savings and the role that modern EMS techniques could and do play in these savings. The effect of availability and costs of equipment unreliability is examined and areas which give the most favorable return on investment are highlighted. Assumptions made are validated as far as possible against published quantitative benefits from operational systems. ESA

N91-20082# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
AN EVALUATION OF AN ADA IMPLEMENTATION OF THE RETE ALGORITHM FOR EMBEDDED FLIGHT PROCESSORS M.S. Thesis
F. J. FANNING Dec. 1990 116 p
(AD-A230443; AFIT/GE/ENG/90D-70) Avail: NTIS HC/MF A06 CSCL 12/5

The purpose of this thesis was to design and develop an expert system shell in Ada, and to evaluate the shell's execution and size performance to determine its suitability for real-time operation on the MIL-STD-1750A embedded flight processor. The expert system shell uses the CLIPS/Ada inference engine, a forward-chaining Ada implementation of Rete. The expert system shell design is presented along with an overview of the target environment--the MIL-STD-1750A VHSIC Avionic Modular Processor (VAMP) running under the Ada Avionics Real-Time Software (AARTS) Operating System. Theoretical and empirical complexity analyses of the inference engine are presented and discussed in view of their impact on VAMP application. The performance of this inference engine was affected by five parameters of the knowledge base: (1) the number of objects in working memory; (2) the structural complexity of the objects and rules; (3) the number of rules which share object match patterns; (4) the number of match patterns per rule, and (5) the number of objects bound to a match pattern. The inference engine's execution response time was found suitable for real-time operation on the VAMP; however, its memory requirement was not. GRA

07

AIRCRAFT PROPULSION AND POWER

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

A91-29441
THE GE T700 - TURBOSHAFT OF THE FUTURE
ELFAN AP REES (International Helicopter Museum, Avon,

England) Vertiflite (ISSN 0042-4455), vol. 37, Mar.-Apr. 1991, p. 46-49.
Copyright

More than 6000 T700/CT7 turboshaft-family engines have been delivered thus far; constant performance upgrades have over the years of this production run been obtained through application of refined component technologies, so that engine output power has increased by 40 percent since the first benchruns of the prototype 25 years ago. This enhancement of safely available power ensures that the T700 will remain an attractive helicopter powerplant well into the next decade. A development and helicopter applications history is detailed; the T700 powers the AH64A Apache, the UH-60A Black Hawk, the AH-1W Super Cobra, and EH101 helicopters. A total of 6.5 million hours of flight have been logged by the engine family. O.C.

A91-29451
ROTARY WING PROPULSION SPECIALISTS' MEETING, WILLIAMSBURG, VA, NOV. 13-15, 1990, PROCEEDINGS
Meeting sponsored by AHS. Alexandria, VA, American Helicopter Society, 1990, 182 p. For individual items see A91-29452 to A91-29467.
Copyright

Topics presented include sound diffraction at a sharp trailing edge in a supersonic flow, the MTR390 turboshaft development program, progress report of the electrostatic engine monitoring system, some corrosion resistant magnesium alloys, handling severe inlet conditions in aircraft fuel pumps, and an over view of inlet protection systems for Army aircraft. Also presented are the advanced control system architecture for the T800 engine, an expert system to perform on-line controller restructuring for abrupt model changes, an enhanced APU for the H-60 series and Sh-2G helicopters, and a linear theory of the North Atlantic blocking during January 1979. R.E.P.

A91-29452* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AN UPDATE OF ENGINE SYSTEM RESEARCH AT THE ARMY PROPULSION DIRECTORATE
GEORGE A. BOBULA (NASA, Lewis Research Center; U.S. Army, Propulsion Directorate, Cleveland, OH) IN: Rotary Wing Propulsion Specialists' Meeting, Williamsburg, VA, Nov. 13-15, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 15 p. Previously announced in STAR as N91-11752. refs
Copyright

The Small Turboshaft Engine Research (STER) program provides a vehicle for evaluating the application of emerging technologies to Army turboshaft engine systems and to investigate related phenomena. Capitalizing on the resources at hand, in the form of both the NASA facilities and the Army personnel, the program goal of developing a physical understanding of engine system dynamics and/or system interactions is being realized. STER entries investigate concepts and components developed both in-house and out-of-house. Emphasis is placed upon evaluations which evolved from on-going basic research and advanced development programs. Army aviation program managers are also encouraged to make use of STER resources, both people and facilities. The STER personnel have established their reputations as experts in the fields of engine system experimental evaluations and engine system related phenomena. The STER facility has STER program provides the Army aviation community the opportunity to perform system level investigations, and then to offer the findings to the entire engine community for their consideration in next generation propulsion systems. In this way results of the fundamental research being conducted to meet small turboshaft engine technology challenges expeditiously find their way into that next generation of propulsion systems. Author

A91-29453
MTR390 TURBOSHAFT DEVELOPMENT PROGRAMME UPDATE
K. TRAPPMANN (MTU Motoren -und Turbinen-Union Muenchen GmbH, Munich, Federal Republic of Germany), J. S. DUCOS (Turbomeca, Bordes, France), and A. R. SANDERSON (Rolls-Royce, PLC, Leavesden, England) IN: Rotary Wing Propulsion Specialists' Meeting, Williamsburg, VA, Nov. 13-15, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 7 p. refs
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Detailed design of the MTR390 turboshaft engine began in 1988 after an intense period of parametric studies to optimize the configuration to take advantage of the most up to date technology and research developments. The main requirements call for ample emergency power for the one engine out condition, high alternating load capability, low fuel consumption under partial load, good acceleration characteristics, and low life cycle cost. Comprehensive instrumentation on the first test-bench engines including more than 600 measurement points has permitted the recording and analysis of considerable amounts of important data on overall performance, engine behavior, and the performance of internal systems and major components. The test results to date show that the specification targets will be achieved within the program timescale. R.E.P.

A91-29460
FULL AUTHORITY DIGITAL ENGINE CONTROL SYSTEM FOR THE CHINOOK HELICOPTER
TERRY MORRISON (Colt Industries, Chandler Evans Control Systems Div., West Hartford, CT), ROGER ALWANG (Boeing Co., Helicopters Div., Philadelphia, PA), and ROBERT ANDREJCZYK (Textron Lycoming, Stratford, CT) IN: Rotary Wing Propulsion Specialists' Meeting, Williamsburg, VA, Nov. 13-15, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 16 p.
Copyright

The design, development and introduction of full-authority digital electronic controls in Chinook helicopters are reviewed. The design rationale, functional performance, and qualification requirements of the digital electronic control system are described relative to achieving this tandem rotor helicopter's particular requirements. Also, installation and operational features of the engine control system are discussed, including maintainability, reliability, diagnostics, health monitoring, history recording, aircraft incorporation, and cost-of-ownership. All the performance and operational objectives of the program were met in the engine and flight tests. R.E.P.

A91-29461
HANDLING SEVERE INLET CONDITIONS IN AIRCRAFT FUEL PUMPS
PIUS J. NASVYTIS (Colt Industries, Chandler Evans Control Systems Div., West Hartford, CT) IN: Rotary Wing Propulsion Specialists' Meeting, Williamsburg, VA, Nov. 13-15, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 6 p. refs
Copyright

LHX requirements included operation with severely depressed fuel at the inlet to the fuel pump, representing operation without the benefit of the booster pumps in the tanks under all conditions. An overview is presented of conceptual approach, highlights on qualitative performance theory, certain construction aspects and performance of the configuration that demonstrated compliance with the new requirements. A dynamic pump with one rotating element combining a liquid ring pump and a periphery (regenerative) pump is described. It is shown that this type pump accomplishes all boost stage functions with the one rotating element and that significant reduction of rotor diameter and related size, weight and cost savings can be realized. R.E.P.

A91-29462
ELECTRICALLY DRIVEN ENGINE CONTROLS AND ACCESSORIES FOR FUTURE AIRCRAFT
WILLIAM D. JONES and M. SIMON JARVIS (GE Aircraft Engines, Lynn, MA) IN: Rotary Wing Propulsion Specialists' Meeting, Williamsburg, VA, Nov. 13-15, 1990, Proceedings. Alexandria, VA,

American Helicopter Society, 1990, 9 p. Research supported by U.S. Army and General Electric Co.
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Electric motor drives represent a new method of performing engine control and accessory functions. This paper addresses the application of electrically driven accessories to aircraft engines. The replaced hydromechanical engine functions addressed include engine starting and generating, fuel pumping, lube oil pumping, variable geometry actuation, and inlet particle separation. An engine-mounted switched reluctance starter/generator system will be discussed with some advantages and disadvantages of externally-mounted and internally-mounted starter/generator machines. Control and frequency response requirements for a motor driven fuel metering pump are included as well as a conceptual aircrafat electric power system with some potential benefits of a more electric aircraft. Author

A91-29463
OVERVIEW OF INLET PROTECTION SYSTEMS FOR ARMY AIRCRAFT
RAYMOND T. HIGGINS and DAVID B. CALE (U.S. Army, Aviation Applied Technology Directorate, Fort Eustis, VA) IN: Rotary Wing Propulsion Specialists' Meeting, Williamsburg, VA, Nov. 13-15, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 7 p. refs
Copyright

The development of inlet protection systems is now an integral part of Army helicopter engine development and is included in basic engine performance, volume and weight. Techniques and design tools have been developed to permit a substantial protection for turboshaft engines from dust, sand, ice, and foreign objects with minimum effects on engine weight and performance. On-going investigations in the development of inlet protection systems include the establishment of test specifications for grass, snow, straw and foreign objects; the investigation of advanced anti-icing; scavenge concepts as part of an electric accessories approach; and the development of better techniques and tools to predict and measure erosion patterns for engines under development and in operation. R.E.P.

A91-29464
ADVANCED CONTROL SYSTEM ARCHITECTURE FOR THE T800 ENGINE
RAYMOND C. PERRA (Colt Industries, Chandler Evans Control Systems Div., West Hartford, CT) and DENNIS M. ACHGILL (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) IN: Rotary Wing Propulsion Specialists' Meeting, Williamsburg, VA, Nov. 13-15, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 13 p.
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The full authority digital electronic control system under development for the T800-LHT-800 engine is reviewed. The dual-channel control system integrates into a FBW helicopter that takes advantage of redundant sensors previously dedicated to separate functions such as engine control and cockpit display, thus providing an extremely fault tolerant engine control system. Consideration is given to the control system architecture, advanced fault detection and accommodation, and adaptive control logic features. Extensive fault detection and accommodation logic is used to maintain automatic engine control with full capability during most failure scenarios. R.E.P.

A91-29467
ENHANCED APU FOR THE H-60 SERIES AND SH-2G HELICOPTERS
J. R. KIDWELL (Allied-Signal Aerospace Co., Garrett Auxiliary Power Div., Phoenix, AZ) IN: Rotary Wing Propulsion Specialists' Meeting, Williamsburg, VA, Nov. 13-15, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 8 p.
Copyright

A review is presented of the GTCP36-150(BH) gas turbine APU that is capable of providing simultaneous shaft power for electrical power generation and compressed air for pneumatic main engine starting and environmental control systems. The APU is made up of three major sections, the power section, the gearbox assembly, and the controls and accessories that include the electronic sequencing unit (ESU), fuel control system, lubrication system and ignition system. APU speed is regulated by the ESU, which directs delivery of the necessary quantity of fuel regardless of load requirements and ambient temperature. Overspeed protection is controlled by an electronic overspeed switch that is automatically actuated within safe limits of the hardware. R.E.P.

A91-29775*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TURBOFAN ENGINE DEMONSTRATION OF SENSOR FAILURE DETECTION
WALTER C. MERRILL, JOHN C. DELAAT, and MAHMOOD ABDELWAHAB (NASA, Lewis Research Center, Cleveland, OH) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 337-349. refs
Copyright

In the paper, the results of a full-scale engine demonstration of a sensor failure detection algorithm are presented. The algorithm detects, isolates, and accommodates sensor failures using analytical redundancy. The experimental hardware, including the F100 engine, is described. Demonstration results were obtained over a large portion of a typical flight envelope for the F100 engine. They include both subsonic and supersonic conditions at both medium and full, nonafter burning, power. Estimated accuracy, minimum detectable levels of sensor failures, and failure accommodation performance for an F100 turbofan engine control system are discussed. Author

A91-30009*# Vigyan Research Associates, Inc., Hampton, VA.
COMPUTATIONAL FLUID DYNAMICS PREDICTION OF THE REACTING FLOWFIELD INSIDE A SUBSCALE SCRAMJET COMBUSTOR
TAWIT CHITSOMBOON (Vigyan, Inc., Hampton, VA) and G. BURTON NORTHAM (NASA, Langley Research Center, Hampton, VA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Jan.-Feb. 1991, p. 44-48. Previously cited in issue 23, p. 3765, Accession no. A88-53151. refs
(Contract NAS1-17919)
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A91-30015*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EXPERIMENTAL INVESTIGATION OF PROPFAN AEROELASTIC RESPONSE IN OFF-AXIS FLOW WITH MISTUNING
ORAL MEHMED (NASA, Lewis Research Center, Cleveland, OH) and DURBHA V. MURTHY (Toledo, University, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Jan.-Feb. 1991, p. 90-98. Previously cited in issue 05, p. 628, Accession no. A89-17941. refs
Copyright

A91-30016*# *Stanford Univ., CA.*
VISCOUS-INVISCID ANALYSIS OF DUAL-JET EJECTORS
T. S. LUND (Stanford University, CA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Jan.-Feb. 1991, p. 99-107. Previously cited in issue 18, p. 2817, Accession no. A87-42426. refs
(Contract NCC2-390)
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A91-30017#
HYPERSONIC TURBOMACHINERY-BASED AIR-BREATHING ENGINES FOR THE EARTH-TO-ORBIT VEHICLE
KIMIO SAKATA, MITSUHIRO MINODA, RYOJI YANAGI, and HIROYUKI NOUSE (National Aerospace Laboratory, Tokyo, Japan) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Jan.-Feb. 1991, p. 108-114. refs
Copyright

Hypersonic air-breathing engines will make the earth-to-orbit vehicle completely different from the present one powered by rocket engines. The space plane propelled by a certain hypersonic air-breathing propulsion system is expected to appear in the next century. The turbomachinery-based engine (turboengine) is a candidate for the space plane propulsion system and will be combined with scramjet and rocket engines. Turboengines, including turboramjet, air-turboramjet, and their modifications, may be applied as the accelerators to the space plane having a high specific impulse at a rather low supersonic Mach number. Here, a conceptual study of these turboengines with preliminary system design, performance calculations, and consideration of relative merits of the engine concepts is performed for the configuration, performance, weight, and size. An engine evaluation with mission capability of the space plane for assumed requirements is made. As a result, engine performance depends on the liquid oxygen utilization, and weight and size of the engine are important factors for application to the space plane. Thus a certain optimization of the engine system itself and of a combination of the engines would be necessary. Author

A91-30184

BIFURCATION ANALYSIS OF SURGE AND ROTATING STALL IN AXIAL FLOW COMPRESSIONS

EYAD H. ABED (Maryland, University, College Park), PAUL K. HOUPT (GE Corporate Research and Development Center, Schenectady, NY), and WISHAA M. HOSNY (GE Aircraft Engines, Cincinnati, OH) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2239-2246. General Electric Co.-supported research. refs
(Contract NSF ECS-86-57561; NSF CDR-88-03012)
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The surge and rotating stall postinstability behaviors of axial flow compressors are investigated from a bifurcation-theoretic perspective. A sequence of local and global bifurcations of the nonlinear system dynamics is uncovered. This includes a previously unknown global bifurcation of a pair of large-amplitude periodic solutions. Resulting from this bifurcation are a stable oscillation (surge) and an unstable oscillation (antisurge). The latter oscillation is found to have a deciding significance regarding the particular postinstability behavior of the compressor. These results are used to reconstruct Greitzer's (1976) findings regarding the manner in which postinstability behavior depends on system parameters, and they provide valuable insight in the prediction, analysis, and control of stall instabilities in gas turbine jet engines. I.E.

A91-30212

AN EXPERIMENTAL METHOD FOR ACTIVE SOOT REDUCTION IN A MODEL GAS-TURBINE COMBUSTOR

B. A. AULT, J. BROUWER, J. E. BOBROW, and G. S. SAMUELSEN (California, University, Irvine) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2617-2621. Parker Hannifin Corp.- supported research. refs
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An active soot reduction technique using a static optimization approach was developed and implemented in a model gas-turbine combustor. The optimization approach was deemed more appropriate than a dynamic control approach because the complex nature of the combustion system prevented the determination of a unique transfer function relating the input and ouput variables over the entire operating range. The control input to the system was the nozzle atomizing the air flow rate, and feedback regarding the soot level in the combustor was obtained with a radiometer. Results indicate that substantial reductions in soot radiation levels are achieved for all operating conditions using the optimization algorithm. In fact, even for relatively clean conditions, the optimized system yields as much as a factor of two improvement in performance. I.E.

A91-30227

TRANSPUTER-BASED FAULT TOLERANT STRATEGIES FOR A GAS TURBINE ENGINE CONTROLLER

H. A. THOMPSON and P. J. FLEMING (North Wales, University College, Bangor, Wales) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2918-2923. Research supported by SERC and Rolls-Royce, PLC. refs
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A description is given of a project investigating the use of Inmos transputers in gas turbine engine control. A main objective of the work is to produce a fault-tolerant high-integrity computer module for gas turbine engine control. Two strategies which manage fault tolerance in a gas turbine engine controller are outlined: the backward error recovery/triple modular redundancy (BER/TMR) scheme, and the dual triple modular redundant (DTMR) system. The successful harnessing of parallel processing capability is an important objective; advantages and shortcomings of current versions of this hardware are revealed. I.E.

A91-30564

HIGH TEMPERATURE CORROSION CONTROL IN AIRCRAFT GAS TURBINES

PETER HANCOCK (Cranfield Institute of Technology, England) IN: Aerospace corrosion control; Proceedings of the Symposium, Auchterarder, Scotland, Feb. 28-Mar. 2, 1989. London, Sawell Publications, Ltd., 1989, 15 p. refs
Copyright

The problem of turbine component oxidation in burned aircraft kerosene at high turbine inlet temperatures is examined, and the development of oxidation-resistant materials is discussed. Attention is given to conventional surface coatings, thermal barrier coatings, and possible use of monolithic ceramic blades. The discussion also covers the role of erosion and the effect of contamination on turbine operation. It is shown, in particular, that acceptable blade lives can be obtained by using either aluminide or MCrAlY coatings in combination with proper blade cooling technologies. V.L.

A91-30899

ADVANCED ELECTRICAL SYSTEM (AES)

FRANZ L. WORTH, VIRGIL H. FORKER (Dowty Maritime Systems, Inc., Arcadia, CA), and MICHAEL J. CRONIN (Lockheed Aeronautical Systems Co., Burbank, CA) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 400-403.
Copyright

A description is given of the Advanced Electrical System (AES), a fully redundant, integrated distributed power control network consisting of remotely controlled solid-state power contactors (SSPCs), a multiprocessor-based power bus management system, microprocessor based remote terminals (RTs), a control display unit (CDU), and a MIL-STD-1553B avionics interface bus. The purpose of the system is to control and provide the operator with a status of all AC and DC powered electrical loads located through the aircraft. High load current power bus fault sensing is achieved by digitally controlled, monitored, Smart power contactors. Load fault sensing is achieved by digitally controlled, monitored, smart relays and SSPCs. Power control, bus configuration, and fault detection isolation signals are reported under the control of the microprocessor-based system in accordance with MIL-C-81883B. The AES is redundant (FAIL-OP, FAIL-SAFE) for mission critical systems. I.E.

A91-30900

AIRCRAFT NO-BREAK POWER TRANSFER REVISITED

JOSEPH S. BREIT and JAMES H. DOTY (Sundstrand Electric Power Systems, Rockford, IL) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton,

OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 410-416. refs
Copyright

No-break power transfer can be accomplished from ground power to an aircraft or between multiple sources on an aircraft with 400-Hz electrical power using a frequency reference autoparallel unit (FRAPU). The no-break function can also be included in the control functions of the feedback control system of the electrical power generating system. The parameters that are controlled to achieve this successful electric power generator system approach to no-break transfer, allowing the airframe manufacturer and operator to take advantage of this normal operating function for commercial and military mission activities are discussed. The following topics are discussed: desirability of no-break power transfer, optimal no-break power transfer, the reason for minimizing circulating watts and VARs, power flow control, other factors affecting circulating power, synchronization control, and recent means of no-break transfer. I.E.

A91-30971
AIRCRAFT FUEL SYSTEM SIMULATION
TIMOTHY G. DAVIS (Hercules Aerospace Co., Vergennes, VT) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 905-911.
Copyright

It is noted that the design, development, and test of aerospace fuel and propellant systems is becoming a more complex problem. In particular, fuel and propellant systems are being asked to perform functions such as vehicle center of gravity control, thermal management, and damage control. These flight-critical functions, combined with the progress of new fuel system controllers toward an integrated utilities rack concept, have pushed these problems to a critical point. An integrated analysis and test environment is presented as a solution to these problems. The system includes a non-real-time analysis environment providing high-fidelity dynamic simulation of aerospace vehicle fluid flow pumping and tankage system. The system is applicable to both commercial and military aircraft and space vehicles, and provides a simulation of effects such as water hammer, cavitation, and multiphase. This analytic environment is then combined with a real-time simulation and emulation platform for a complete integrated approach to fuel and utility system analysis and test. I.E.

A91-31401#
APPLICATION OF NUMERICAL ANALYSIS TO JET ENGINE COMBUSTOR DESIGN
HIDEMI TOH Ishikawajima-Harima Engineering Review (ISSN 0578-7904), vol. 30, Nov. 1990, p. 450-455. In Japanese, with abstract in English. refs

Numerical methods are applied in practice to complement and support jet engine combustor design and development; part of the conventional 'design-trial fabrication-testing performance evaluation' cycle is replaced by iterated numerical analysis applied in a preliminary cycle of 'design-evaluation', undertaken before proceeding to actual trial fabrication testing, and final evalution. Examples are presented of numerical methods applied to the design/development of a high temperature combustor of airblast fuel injector type, in which analysis is undertaken of flows through diffuser and through combustion liner, of temperature distributions, of flows through liner cooling slots, and of liner skin temperature distributions. In addition, results of three-dimensional flow analysis are applied to optimizing the design parameters of a jet-swirl combustor, and to calculation of the centrifugal force in a jet-swirl combustion liner. Author

A91-31426
OPTIMIZATION OF ROTATING BLADES WITH DYNAMIC-BEHAVIOR CONSTRAINTS
TING NUNG SHIAU (National Cheng Kung University, Tainan, Republic of China) and S. J. CHANG Journal of Aerospace Engineering (ISSN 0893-1321), vol. 4, April 1991, p. 127-144. refs
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The optimal design of rotating pretwisted blades subject to dynamic behavior constraints is studied. The restrictions on multiple blade natural frequencies and on maximum blade dynamic deflections are considered the dynamic behavior constraints. The aerodynamic forces acting on the rotating blades are simulated as harmonic excitations. Optimization techniques of the optimality-criterion method and the method of modified feasible directions have been successfully developed and applied to minimize the weight of rotating pretwisted blades. Based on these techniques, the numerical results show that the effect of setting angle on the optimal design weight for the first frequency-constraint case is more significant than that for the second frequency-constraint case. It is also shown that the changes of pretwist angle will considerably affect the optimal design weight for the second frequency-constraint case. However, the effect is not significant for the fundamental frequency-constraint case. The results also indicate that the increase of rotating speed will decrease the optimal design weight. Author

A91-31739#
THE CYCLOIDAL PROPELLER FOR TWENTY FIRST CENTURY AIRSHIPS
ROY P. GIBBENS (Gibbens and Associates, Meridian, MS) IN: AIAA Lighter-Than-Air Systems Technology Conference, 9th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 101-105. refs
(AIAA PAPER 91-1293) Copyright

After a historical evaluation of low-speed maneuverability and ground-handling problems which have always affected the operability of large airships, attention is given to the design features, operating principles, and performance characteristics of the 'cycloidal' propeller for simultaneous propulsion/control of airships. This propeller design has been adapted from its characteristic use in marine craft, and is presently studied for the case of incorporation at eight stations on the hull surface of the historical rigid airship, Shenandoah. Cycloidal propellers are judged capable of drastically reducing ground-handling crew requirements, while operating much more quietly than more conventional propulsion units. O.C.

A91-31995#
STRUCTURAL ANALYSIS AND INVESTIGATION OF GAS TURBINE LOW PRESSURE TURBINE VANE CLUSTER
SUSAN I. CONLON (Pratt and Whitney Group, East Hartford, CT) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1608-1610.
(AIAA PAPER 91-1195) Copyright

Rig tests and FEM analyses have been conducted to investigate airfoil leading-edge cracking at the outer diameter of low pressure gas turbine vane clusters. The results thus obtained have led to a blade cluster redesign incorporating core changes to increase airfoil leading edge and platform thicknesses, as well as modifications of the front leg and local undercuts. The final design's accurate modeling and analysis has led to the prediction of a 30 percent stress reduction at the airfoil outer diameter leading edge. O.C.

A91-32273
OPTIMAL TRACKING PROBLEM APPLIED TO JET ENGINE CONTROL
D. MCLEAN (Southampton, University, England) and S. MAHMOUD (Loughborough University of Technology, England) Aeronautical Journal (ISSN 0001-9240), vol. 95, Feb. 1991, p. 48-54. refs
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The principles of the optimal tracking problem (OTP) are reviewed in order to show that the response of the output vector of a linear observable system can be made to be close to some desired dynamic response. A numerical procedure for solving the problem resulting from the application of the optimal tracking problem to the linear model of the jet engine is developed. It is demonstrated that while OTP can provide the desired response within a small region of the operating envelope, no single control law can be found for the entire operating regime of the engine. It is possible, however, to make the output response of the engine correspond closely to a specified response for any specific operating point. V.T.

N91-19097*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE SELECTION OF CONVERTIBLE ENGINES WITH CURRENT GAS GENERATOR TECHNOLOGY FOR HIGH SPEED ROTORCRAFT
JOSEPH D. EISENBERG 1990 27 p Presented at the Vertical Lift Aircraft Design Conference, San Francisco, CA, 17-19 Jan. 1990; cosponsored by American Helicopter Society Previously announced in IAA as A90-46933
(NASA-TM-103774; E-6041; NAS 1.15:103774) Avail: NTIS HC/MF A03 CSCL 21/5

NASA-Lewis sponsored two studies to determine the most promising convertible engine concepts for high speed rotorcraft. These studies projected year 2000 convertible technology limited to present gas generator technology. Propulsion systems for utilization on aircraft needing thrust only during cruise and those aircraft needing both power and thrust at cruise were investigated. Mission calculations for the two contractors involved were based upon the fold tilt rotor concept. Analysis and comparison of the General Electric concepts (geared UDF, clutched fan, and Variable Inlet Guide Vane (VIGV) fan), and the Allison Gas Turbine concepts (clutched fan, VIGV fan, variable pitch fan, single rotation tractor propfan, and counter rotation tractor propfan) are presented. Author

N91-19098*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
WIND TUNNEL WALL EFFECTS IN A LINEAR OSCILLATING CASCADE
DANIEL H. BUFFUM and SANFORD FLEETER (Purdue Univ., West Lafayette, IN.) 1991 14 p Proposed for presentation at the 36th International Gas Turbine and Aeroengine Congress and Exposition, Orlando, FL, 3-6 Jun. 1991; sponsored by ASME
(NASA-TM-103690; E-5909; NAS 1.15:103690) Avail: NTIS HC/MF A03 CSCL 21/5

Experiments in a linear oscillating cascade reveal that the wind tunnel walls enclosing the airfoils have, in some cases, a detrimental effect on the oscillating cascade aerodynamics. In a subsonic flow field, biconvex airfoils are driven simultaneously in harmonic, torsion-mode oscillations for a range of interblade phase angle values. It is found that the cascade dynamic periodicity - the airfoil to airfoil variation in unsteady surface pressure - is good for some values of interblade phase angle but poor for others. Correlation of the unsteady pressure data with oscillating flat plate cascade predictions is generally good for conditions where the periodicity is good and poor where the periodicity is poor. Calculations based upon linearized unsteady aerodynamic theory indicate that pressure waves reflected from the wind tunnel walls are responsible for the cases where there is poor periodicity and poor correlation with the predictions. Author

N91-19099*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
A PROPOSED KALMAN FILTER ALGORITHM FOR ESTIMATION OF UNMEASURED OUTPUT VARIABLES FOR AN F100 TURBOFAN ENGINE
GURBUX S. ALAG (PRC Systems Services Co., Edwards, CA.) and GLENN B. GILYARD Washington Oct. 1990 32 p Presented at the AIAA/SAE/ASME/ASEE Joint Propulsion Conference, Orlando, FL, 16-18 Jul. 1990 Previously announced in IAA as A90-40558
(NASA-TM-4234; H-1639; NAS 1.15:4234) Avail: NTIS HC/MF A03 CSCL 21/5

To develop advanced control systems for optimizing aircraft engine performance, unmeasurable output variables must be estimated. The estimation has to be done in an uncertain environment and be adaptable to varying degrees of modeling errors and other variations in engine behavior over its operational life cycle. This paper represented an approach to estimate unmeasured output variables by explicitly modeling the effects of off-nominal engine behavior as biases on the measurable output variables. A state variable model accommodating off-nominal behavior is developed for the engine, and Kalman filter concepts are used to estimate the required variables. Results are presented from nonlinear engine simulation studies as well as the application of the estimation algorithm on actual flight data. The formulation presented has a wide range of application since it is not restricted or tailored to the particular application described. Author

N91-20085*# San Jose State Univ., San Francisco, CA.
THE EFFECTS OF COMPRESSOR SEVENTH-STAGE BLEED AIR EXTRACTION ON PERFORMANCE OF THE F100-PW-220 AFTERBURNING TURBOFAN ENGINE Final Report
ALISON B. EVANS Feb. 1991 29 p
(Contract NASA ORDER SA-25821)
(NASA-CR-179447; H-1679; NAS 1.26:179447) Avail: NTIS HC/MF A03 CSCL 21/5

A study was conducted to determine the effects of seventh-stage compressor bleed on the performance of the F100 afterburning turbofan engine. The effects of bleed on thrust, specific fuel consumption, fan turbine inlet temperature, bleed total pressure, and bleed total temperature were obtained from the engine manufacturer's status deck computer simulation. These effects were determined for power settings of intermediate, partial afterburning, and maximum afterburning for Mach numbers between 0.6 and 2.2 and for altitudes of 30,000, 40,000, and 50,000 ft. It was found that thrust loss and specific fuel consumption increase were approximately linear functions of bleed flow and, based on a percent-thrust change basis, were approximately independent of power setting. Author

N91-20086*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AEROPROPULSION 1991
Mar. 1991 574 p Conference held in Cleveland, OH, 20-21 Mar. 1991
(NASA-CP-10063; E-5954; NAS 1.55:10063) Avail: NTIS HC/MF A24 CSCL 21/5

For the 50th anniversary, a review was provided of recent accomplishments of the ongoing programs at Lewis Research Center. The Lewis Aeropropulsion Program has the charter to develop advanced airbreathing propulsion technology for applications of national interest. To implement this program, Lewis concentrates its basic research in the critical disciplines of internal fluid mechanics, instrumentation and control, and structures and materials. The efforts are focused on developing new science, often implemented through advanced computer codes. Carefully designed experiments provide the data required to validate the advanced codes. Recent results and planned accomplishments in these areas are reviewed. From this firm foundation technology is investigated for a number of applications including propulsion, high performance and hypersonic aircraft, rotorcraft, and general aviation.

N91-20088*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
OVERVIEW OF SUPERSONIC CRUISE PROPULSION RESEARCH
R. J. SHAW *In its* Aeropropulsion 1991 30 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 21/5

Significant advances in propulsion performance are required if supersonic transport vehicles are to become an important part of the 21st century international air transportation system. The objective of the NASA Lewis Supersonic Cruise propulsion research is to provide the critical propulsion technologies to the industry in a timely fashion to contribute to the design of economically viable

and environmentally acceptable high-speed civil transport (HSCT).
Author

N91-20089*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
OVERVIEW OF HIGH PERFORMANCE AIRCRAFT PROPULSION
PETER G. BATTERTON and THOMAS J. BIESIADNY *In its* Aeropropulsion 1991 18 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 21/5

The basic overall scope of the Lewis High Performance Aircraft Propulsion Research and Technology effort is presented. High performance fighter aircraft of interest include supersonic fighters with such capabilities as short take off and vertical landing (STOVL) and/or high maneuverability. The effort is primarily focused on component-level experimental and analytical research. This research is designed to provide databases for verification of design technology and for calibration of the CFD tools available for design use. Examples from each of the research areas are discussed, and a brief look at future directions for high performance aircraft research and technology is presented. Author

N91-20090*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FLOW VISUALIZATION AND HOT GAS INGESTION CHARACTERISTICS OF A VECTORED THRUST STOVL CONCEPT
ALBERT L. JOHNS, GEORGE H. NEINER, TIMOTHY J. BENCIC, DAVID M. FRICKER, and JEROME T. KEGELMAN (McDonnell-Douglas Research Labs., Saint Louis, MO.) *In its* Aeropropulsion 1991 17 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 21/5

Hot gas ingestion, the entrainment of heated engine exhaust into the inlet flow field, is the key development issue for advanced short takeoff and vertical landing aircraft. A 9.2 percent scale short takeoff and vertical landing (STOVL) hot gas ingestion model was designed and built by McDonnell Douglas Corporation (MCAIR) and tested in the NASA Lewis Research Center 9 by 15 foot Low Speed Wind Tunnel (LSWT). The test was conducted over a range of headwind velocities from 10 to 23 kn and nozzle exhaust temperatures from 500 to 1000 F. The model was also tested over a range of model heights above the ground plane (0.20 to 12 in.) and a range of nozzle pressure ratios from 1.3 to 4.00. A copper vapor laser was used to create an illuminated flow field for flow visualization with the model in and out of ground effects. Results are presented showing the flow field visualization which occurs when the model was in and out of ground effects. The effect of hot gas ingestion on the compressor face temperature rise and several other parameters are also presented. The environmental effects of the hot gas on the ground and its effect on the acoustic loads as a function of the model height above the ground are also presented. Author

N91-20091*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HIGH ALPHA INLETS
RICHARD R. BURLEY, BERNHARD H. ANDERSON, C. FREDERIC SMITH, and GARY J. HARLOFF (Sverdrup Technology, Inc., Cleveland, OH.) *In its* Aeropropulsion 1991 14 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 21/5

The high alpha inlet research effort at Lewis is part of the High Alpha Technology Program (HATP) within NASA. A key goal of HATP is to develop concepts that provide a high level of control and maneuverability for high performance aircraft at low subsonic speeds and angles-of-attack above 60 degrees. The approach, which consists of both experimental and computational efforts, utilizes the F-18 High Alpha Research Vehicle (HARV) as well as subscale models to obtain the experimental data base needed for validation of the computational codes. As the propulsion center within NASA, the overall objectives of the Lewis effort is to develop and enhance inlet technology that will ensure high performance and stability of the propulsion system during the aircraft maneuvers at low speeds and high angles-of-attack. An overview is presented of the existing Lewis technology for achieving high inlet performance at low subsonic speed/high angle-of-attack conditions and the plans to extend this technology to advanced, highly maneuverable aircraft. The discussion is divided into six parts: the scope of the HATP effort; the inlet challenge for highly maneuverable aircraft, the Lewis data base, the Lewis computational effort, future plans, and concluding remarks.
Author

N91-20092*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
OVERVIEW OF HYPERSONIC/TRANSATMOSPHERIC VEHICLE PROPULSION TECHNOLOGY
JOHN E. ROHDE *In its* Aeropropulsion 1991 11 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 21/5

Significant progress is being made in attaining many of the enabling technologies critical to the development of future hypersonic vehicles such as the single-stage-to-orbit National Aerospace Plane (NASP) X-30 vehicle and others. In the NASP program, slush hydrogen was safely produced and transferred in modestly large quantities. Inlet testing has demonstrated that a high-performance configuration can be developed, and configurations were developed that reduce cross-talk between engine modules and improve unstart margins. Tests of a hydrogen-fueled ramjet engine model were conducted to investigate engine operability and dynamics, and future tests are planned to demonstrate a closed-loop engine control system. Nozzle tests have identified large transonic-drag losses in the nozzle, which were then reduced significantly through the use of external burning. In other research areas, such as engine seals, advanced materials, and para-to-ortho hydrogen conversion, promising concepts were identified and continuing efforts are adding to these technologies. In the General Hypersonics program an improved understanding is being gained of the physics of inlets, combustors, and nozzles and are developing advanced materials and computational codes that predict the characteristics of both reacting flows and metal matrix composites structures. The High-Mach Turbine-Engine (HiMaTE) component technology program has identified the turboramjet and the air-turboramjet as the most promising combined-cycle engines for more detailed assessment. Efforts are continuing to define critical components for development and testing to demonstrate technology readiness and to establish cycle feasibility. Studies are being conducted to assess the potential benefit of using these combined-cycle engines to power the first stage of two-stage-to-orbit (TSTO) vehicles and other hypersonic vehicles. Author

N91-20094*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A COMPARISON OF CFD PREDICTIONS AND EXPERIMENTAL RESULTS FOR A MACH 5 INLET
LOIS J. WEIR and D. R. REDDY *In its* Aeropropulsion 1991 16 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 21/5

Flow through a high-speed, nominally two-dimensional inlet is characterized by highly complex, three-dimensional flow phenomena including strong secondary flows and shock/boundary layer interactions. Experimental and analytical data are presented for a Mach 5 mixed compression inlet that exhibits such three-dimensional flow characteristics. The two-dimensional inlet model, designed to provide performance information in the Mach 3 to 5 speed range for an over-under turbojet plus ramjet propulsion system, was also instrumented to provide computational fluid dynamic (CFD) code calibration and validation data, and, in particular, to provide some detailed data in regions where three-dimensional phenomena dominate the local flow field. Calculations of the inlet flow field presented include three-dimensional parabolized and full Navier-Stokes code analyses, with and without bleed. The CFD analyses predicted flow migration up the inlet sidewalls due to glancing shock/boundary layer interactions, which, in turn, developed patterns of vortical flow in the inlet. This vortical flow was at least partially captured by the cowl, which set up large regions of low-energy flow in the corners underneath the cowl. As the vortical flow stream passed through the strong cowl shock, its vorticity appeared to be somewhat dissipated and the low-energy flow was compressed against the cowl. Comparisons between analytical predictions and experimental results are presented for rakes located in regions of vortical flow, separation, or both in the corners between the cowl and the sidewalls. Both experimental and analytical results indicated that porous bleed upstream on the inlet sidewalls and in the corners of the cowl had little effect on the vortical flow entering the inlet; however, bleed removed farther downstream near the shoulder (after the rotational flow had passed through the cowl shock) appeared to remove the low-energy flow on the cowl and sidewalls rather effectively. Author

N91-20103*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ADVANCED AEROPROPULSION CONTROLS TECHNOLOGY
CARL F. LORENZO *In its* Aeropropulsion 1991 25 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 21/5

The NASA Lewis research activities in the area of propulsion control as driven by the trends and needs of advanced aircraft are discussed. Special emphasis is placed on research to develop design methodologies for integrated flight and propulsion control. Research thrusts in hypersonic propulsion control and dynamics in support of the National Aerospace Plane are also covered, and a new concept for system critical component life-extending control is discussed. Author

N91-20105*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PROPULSION AEROELASTICITY, VIBRATION CONTROL, AND DYNAMIC SYSTEM MODELING
BRUCE M. STEINETZ *In its* Aeropropulsion 1991 11 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 21/5

Aeropropulsion research in the Structural Dynamics Branch of Lewis Research Center is aimed at addressing two key objectives: (1) conceiving and implementing innovative structural concepts to enhance the performance of advanced aeropropulsion systems; and (2) developing and validating analytical techniques to define the limits of dynamic performance of advanced aeroengines, prior to costly full-scale testing. Aeroelasticity, vibration control, and dynamic systems are the three research areas that make up the Structural Dynamics Branch. In the aeroelasticity technical area, researchers use both analytical and experimental means to extend and define the structural performance limits of advanced propulsion systems, including future ultra-high-bypass ducted turbofans, advanced turboprops, and high power-density turbopumps. Vibration control researchers are developing and evaluating active control systems and the required high-speed robust electronic controls to minimize unwanted shaft vibration of both turbine-engines and rocket engine turbopumps. Researchers in the dynamic systems technical area are developing a new class of high-temperature dynamic engine seals required for advanced hypersonic (e.g., National Aerospace Plane) engines, as well as developing advanced space mechanism technology to enable future space missions. Central to each of the branch's technical areas is the development of advanced computational methods which, with the aid of modern computer science, will fundamentally improve solution speed and accuracy of large scale structural dynamics problems. Author

N91-20106*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
COMPUTATIONAL SIMULATION OF PROPULSION STRUCTURES PERFORMANCE AND RELIABILITY
DALE A. HOPKINS *In its* Aeropropulsion 1991 10 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 21/5

The chronicle of aeropropulsion development reveals a deliberate evolution during which new engine designs have been derived by incremental improvements of successful previous systems. Aerospace vehicles envisioned near the turn of the century and beyond demand advances in propulsion systems of more revolutionary than evolutionary significance. The systems of tomorrow require unprecedented levels of performance, durability, reliability, and operational economy. Achieving these requirements presents a significant challenge to develop enabling computational structures technology. The aim of computational structures technology is to transform the engine development process by empowering computational simulation to have the principle role. The arena of computation structures technology for aeropropulsion has produced some noteworthy recent gains, and even more extraordinary advances are still to be realized. The essential elements in this endeavor are the following: (1) fundamental theoretical models that more completely represent the complex physics governing engine structural performance; (2) computational techniques that provide accurate and efficient solutions of the governing models and which exploit the potential of emerging computer technology; and (3) integrated strategies for simulation that allow engine structural models of varying fidelity to be evaluated as a continuous and adaptive process. Author

N91-20112*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
OVERVIEW OF ROTORCRAFT AND GENERAL AVIATION PROPULSION TECHNOLOGY
JOHN J. COY and JOSEPH D. EISENBERG *In its* Aeropropulsion 1991 14 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 21/5

An overview of NASA's propulsion research that is aimed at applications for rotary winged flight and general aviation is presented. The strategic goal of this research effort is to provide innovative technologies that will strengthen the nation's competitive stance in the world market for the civil sector, and also provide superior rotorcraft for U.S. military use. The NASA Lewis tactical plan for achieving this strategic goal is the following: (1) to reduce fuel consumption of small engines by 30 percent through use of advanced cycles (including higher pressure and temperature operation) and with improved turbomachinery components technology and ceramic materials; (2) to contribute to fuel savings through weight savings and to reliability by developing advanced technology for transmissions; (3) to contribute to aircraft safety by providing advanced anti-icing and deicing technology; and (4) to achieve high-speed capability through advanced propulsion systems. Author

N91-20113*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TURBOMACHINERY AND COMBUSTOR TECHNOLOGY FOR SMALL ENGINES
LAWRENCE J. BOBER and RICHARD W. NIEDZWIECKI *In its* Aeropropulsion 1991 25 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 21/5

The goal of the Small Turbine Engine Technology Program is to significantly increase thermal efficiency, reliability, and durability of future small gas turbine engines. Significant fuel savings can be achieved through component and cycle improvements as well as through the use of regeneration and uncooled ceramic materials. Recent efforts to identify new regeneration concepts have not been successful, and as a result, no active regenerator research is in progress. Development of uncooled ceramic technology is taking place at the NASA Lewis Research Center under the Department of Energy funded Advanced Turbine Technology Applications Project (ATTAP). Component research is emphasized and includes work on the compressor, combustor, and turbine. Author

N91-20114*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ROTARY ENGINE TECHNOLOGY
EDWARD A. WILLIS and JOHN J. MCFADDEN *In its* Aeropropulsion 1991 11 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 21/5

The original goal in this program was to combine some of the better features of reciprocating and gas-turbine engines; thus, obtaining a superior powerplant for light aircraft and a host of related uses. Based on a series of engine and aircraft/mission studies conducted in the early 1980's, the rotary (Wankel) engine was perceived to have many of the desired features and was judged to be capable of considerable further development. At the time, existing automotive rotary engines had demonstratably high power outputs in a compact, smooth-running, and reliable package but were less fuel efficient than comparable reciprocating engines. Accordingly, the basic thrust of the NASA Rotary Engine Technology Enablement Program was (and is) to bring the rotary's efficiency up to the level of a comparably sized diesel, without sacrificing its other desirable features. Author

N91-20116*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
OVERVIEW OF SUBSONIC TRANSPORT PROPULSION TECHNOLOGY
JOHN F. GROENEWEG *In its* Aeropropulsion 1991 13 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 21/5

The major elements of the NASA Lewis Research Center's Subsonic Transport Propulsion Research Program are summarized. Ultra-high-bypass ratio cycles and high-efficiency cores are being investigated for propulsive and thermal efficiency improvements, respectively. Overall efficiency gains are sought subject to the constraints of noise and emissions goals. Elements of the research program including key technical issues are discussed along with the planned sequence of the activities. Author

N91-20117*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ULTRA-HIGH BYPASS RESEARCH
CHRISTOPHER J. MILLER, JAMES H. DITTMAR, and ROBERT J. JERACKI *In its* Aeropropulsion 1991 14 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 21/5

An overview of the ultra-high bypass research at the NASA Lewis Research Center is presented. Over the past decade, the program was focused on unducted rotors and precipitated several development efforts in industry. In this area, forward swept unducted rotors are the concluding effort. Forward sweep can reduce the tip vortex strength and has a potential for reducing the noise of counter-rotating unducted rotors. The aerodynamic performance can also be improved slightly over an aft-swept blade. The future direction of the program is toward ultra-high bypass ratio ducted machines, and short cowls as a particular item. Short cowls can have less aerodynamic drag and less weight, but many allow more noise to be radiated. In general, the aerodynamic research effort will be to provide higher efficiencies, sufficient flow conditioning, and attached flow at high angles of attack. Acoustically, the research is directed towards developing an understanding of fan acoustics in short ducts. The reduced duct length means that there might be insufficient duct length for acoustic cutoff. With less length and less cowl thickness, the space for acoustic treatment is limited, requiring integrated aeroacoustic designs. Author

N91-20118*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HIGH-EFFICIENCY CORE TECHNOLOGY
ROBERT M. PLENCNER and GERALD KNIP, JR. *In its* Aeropropulsion 1991 12 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 21/5

Studies were undertaken to determine the potential benefits from implementing aircraft turbine engine core technology well beyond that being developed for the next generation of long-haul subsonic transport engines (i.e., entry into service date of 1993). These core improvements, projected for year 2010 technology, include the use of very high-pressure-ratio cycles, advanced lightweight materials with minimal cooling requirements, and improved component efficiencies. The studies indicate that a large improvement is possible with engines using these advanced cores as compared to the current turbine engine designs. The results of the studies are presented, and the key challenges to achieving the predicted improvements in performance are identified. Author

N91-20119*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MULTIDISCIPLINARY RESEARCH OVERVIEW (IHPTET/NPSS)
LESTER D. NICHOLS and SUSAN M. JOHNSON *In its* Aeropropulsion 1991 20 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 21/5

The Integrated High Performance Turbine Engine Technology (IHPTET) Program and the Numerical Propulsion System Simulation (NPSS) Program are two aeropropulsion multidisciplinary efforts at NASA Lewis that complement each other. The IHPTET initiative is an experimental program to advance engine development and double propulsion system capability by the turn of the century. NASA Lewis is contributing, with the Department of Defense and seven major aerospace contractors, to the development of these advanced, military, high-performance engines in the areas of compressors, combustors, turbines, nozzles, controls, mechanical systems, instrumentation, materials, structures, and computational fluid dynamics. The NPSS effort is a computational, long-range program with the goal of reducing the cost and time of development for advanced-technology propulsion systems. This goal will be achieved through a cooperative effort of NASA, industry, universities, and other government agencies to develop the necessary technologies for integrating disciplines, components, and high-performance computing into a user-friendly simulation environment. This simulation allows for comprehensive evaluation of new concepts early ing the design phase, before a commitment to hardware is made. It also allows for rapid assessment of field-related problems, particularly where operational problems are encountered during conditions that are difficult to simulate experimentally. Data generated from the IHPTET engines will be used to help validate NPSS computations. Author

N91-20122*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
IMPAC: AN INTEGRATED METHODOLOGY FOR PROPULSION AND AIRFRAME CONTROL
SANJAY GARG, PETER J. OUZTS, CARL F. LORENZO, and DUANE L. MATTERN (Sverdrup Technology, Inc., Brook Park, OH.) 1991 28 p Prepared for presentation at the American Control Conference, Boston, MA, 26-28 Jun. 1991; sponsored in part by American Automatic Control Council
(NASA-TM-103805; E-6035; NAS 1.15:103805) Avail: NTIS HC/MF A03 CSCL 21/5

The National Aeronautics and Space Administration is actively involved in the development of enabling technologies that will lead towards aircraft with new/enhanced maneuver capabilities such as Short Take-Off Vertical Landing (STOVL) and high angle of attack performance. Because of the high degree of dynamic coupling between the airframe and propulsion systems of these types of aircraft, one key technology is the integration of the flight and propulsion control. The NASA Lewis Research Center approach to developing Integrated Flight Propulsion Control (IFPC) technologies is an in-house research program referred to as IMPAC (Integrated Methodology for Propulsion and Airframe Control). The goals of IMPAC are to develop a viable alternative to the existing integrated control design methodologies that will allow for improved system performance and simplicity of control law synthesis and implementation, and to demonstrate the applicability of the methodology to a supersonic STOVL fighter aircraft. Based on some preliminary control design studies that included evaluation of the existing methodologies, the IFPC design methodology that is emerging at the Lewis Research Center consists of considering the airframe and propulsion system as one integrated system for an initial centralized controller design and then partitioning the centralized controller into separate airframe and propulsion system subcontrollers to ease implementation and to set meaningful design requirements for detailed subsystem control design and evaluation. An overview of IMPAC is provided and detailed discussion of the various important design and evaluation steps in the methodology are included. Author

N91-20124# Institut Franco-Allemand de Recherches, Saint-Louis (France).

MEAN AND TURBULENT VELOCITY MEASUREMENTS IN A TURBOJET EXHAUST

H. J. SCHAEFER and E. W. SOMMER 12 Dec. 1989 22 p
Presented at the International Congress on Instrumentation in Aerospace Simulation Facilities, Goettingen, Fed. Republic of Germany, 18-21 Sep. 1989 Previously announced in IAA as A90-28272
(ISL-CO-244/89; ETN-91-98986) Avail: NTIS HC/MF A03

Laser Doppler velocimeter measurements were conducted in a round high speed high temperature jet exhausting from a small scale turbojet propulsion engine. A survey of the jet flow field at Mach numbers of 46, 0.67 and 0.84 and a spectral analysis of the velocity fluctuations are presented. In good agreement with the results obtained in isothermal jets, the radial distributions of the mean and root mean square velocities can be approximated by universal profiles. The spectra of the fluctuations exhibit a pronounced narrowband peak providing evidence for the existence of coherent structures in the jet flow. ESA

N91-20125# Royal Aerospace Establishment, Farnborough (England). Dept. of Propulsion.

COMBUSTOR EXIT TEMPERATURE DISTORTION EFFECTS ON HEAT TRANSFER AND AERODYNAMICS WITHIN A ROTATING TURBINE BLADE PASSAGE

S. P. HARASGAMA 26 Nov. 1990 13 p
(RAE-TM-P-1195; BR115809; ETN-91-99005) Copyright Avail: NTIS HC/MF A03

A numerical simulation of temperature distortion at inlet to a rotating turbine rotor is described. A three dimensional Navier-Stokes code and the STAN5 two dimensional boundary layer code were used. The results show that the hot gas is transported to the pressure surface of the blade and that hot gas also migrates to the blade pressure side tip. At locations greater than 50 to 60 percent axial chord the hot gas enters the tip gap and emerges over the suction side. These computations are in agreement with previous experimental results. The secondary flows within the turbine rotor are enhanced by the introduction of inlet radial temperature distortion and this is in accord with previous analytical work. It is shown that the heat flux near the tip region on the pressure side of the blade can be increased by up to 76 percent due to the redistribution on the inlet temperature distortion. ESA

N91-20126*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

PERFORMANCE OF A HIGH-WORK, LOW-ASPECT-RATIO TURBINE STATOR TESTED WITH A REALISTIC INLET RADIAL TEMPERATURE GRADIENT

ROY G. STABE and JOHN R. SCHWAB Mar. 1991 31 p
(NASA-TM-103738; E-5975; NAS 1.15:103738) Avail: NTIS HC/MF A03 CSCL 21/5

A 0.767-scale model of a turbine stator designed for the core of a high-bypass-ratio aircraft engine was tested with uniform inlet conditions and with an inlet radial temperature profile simulating engine conditions. The principal measurements were radial and circumferential surveys of stator-exit total temperature, total pressure, and flow angle. The stator-exit flow field was also computed by using a three-dimensional Navier-Stokes solver. Other than temperature, there were no apparent differences in performance due to the inlet conditions. The computed results compared quite well with the experimental results. Author

08

AIRCRAFT STABILITY AND CONTROL

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

A91-28469

STEADY STALL AND COMPRESSIBILITY EFFECTS ON HINGELESS ROTOR AEROELASTICITY IN HIGH-G TURNS

ROBERTO CELI (Maryland, University, College Park) (European Rotorcraft Forum, 16th, Glasgow, Scotland, Sept. 18-21, 1990) Vertica (ISSN 0360-5450), vol. 14, no. 4, 1990, p. 509-530. refs
(Contract DAAL03-88-C-002)
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This paper describes a numerical study of the aeroelastic stability of a hingeless rotor helicopter in steady coordinated turns. A quasi-steady aerodynamic model is used, which includes airfoil steady stall and compressibility effects. The finite element model of the rotor blades includes kinematic nonlinearities due to moderately large elastic deflections. The results show that neglecting Mach number effects may lead to underestimating the lag damping. In descending flight, the first lag mode is unstable at low turn rates, and the damping of the second lag mode decreases sharply at medium turn rates. The effect of Mach number is related to the nose-up pitching moments exhibited by the airfoil in sub-stall conditions. Strong aerodynamic nonlinearities introduce multiple trim solutions and make the predicted stability levels very sensitive to changes in pitch control settings. Author

A91-28472

RECENT RESULTS OF IN-FLIGHT SIMULATION FOR HELICOPTER ACT RESEARCH

HEINZ-JUERGEN PAUSDER and GERHARD BOUWER (DLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) (European Rotorcraft Forum, 15th, Amsterdam, Netherlands, Sept. 1989) Vertica (ISSN 0360-5450), vol. 14, no. 4, 1990, p. 557-572. refs
Copyright

The role of in-flight simulation in the development of Active Control Technology (ACT) systems is discussed. This technique yields information which allows the helicopter system dynamics to be tailored to the specific mission demands and the ability of the human pilot. It is pointed out that ACT performance evaluation is an evaluation of an integrated system and therefore a test facility is required that allows a flight examination in an environment with an acceptable fidelity. The main elements of influence which have to be considered in the development of ACT for a helicopter include the basic helicopter response characteristics, the ACT components, the pilot's controller characteristics, and the format of information displayed for the pilot. L.K.S.

A91-29466* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

AN EXPERT SYSTEM TO PERFORM ON-LINE CONTROLLER RESTRUCTURING FOR ABRUPT MODEL CHANGES

JONATHAN LITT (NASA, Lewis Research Center; U.S. Army, Propulsion Directorate, Cleveland, OH) IN: Rotary Wing Propulsion Specialists' Meeting, Williamsburg, VA, Nov. 13-15, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 10 p. refs
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This paper presents the work in progress on an expert system utilized to tune and reconfigure airframe/engine control systems on-line in real time in response to structural or battle damage failures. The closed loop system is monitored constantly for changes in performance and structure, which detection prompts the expert system to select and apply a particular control restructuring algorithm based on the severity and type of damage. Control restructuring algorithms that have been implemented handle most failure cases involving actuator damage (control mixer) and many instances where the system dynamics are altered as well (modified control mixer). R.E.P.

A91-29780#
OPTIMAL RIGID-BODY MOTIONS
EUGENE M. CLIFF, FREDERICK H. LUTZE (Virginia Polytechnic Institute and State University, Blacksburg), and RAJIV S. CHOWDHRY Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 383-390. DARPA-supported research. Previously cited in issue 23, p. 3623, Accession no. A89-52694. refs
(Contract F49620-87-C-0016)
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A91-29781#
PERFECT EXPLICIT MODEL-FOLLOWING CONTROL SOLUTION TO IMPERFECT MODEL-FOLLOWING CONTROL PROBLEMS
WAYNE C. DURHAM and FREDERICK H. LUTZE (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 391-397. Previously cited in issue 23, p. 3623, Accession no. A89-52690. refs
Copyright

A91-29788#
APPLICATION OF TOTAL ENERGY CONTROL FOR HIGH-PERFORMANCE AIRCRAFT VERTICAL TRANSITIONS
ANTHONY WARREN (Boeing Co., Seattle, WA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 447-452. Previously cited in issue 23, p. 3621, Accession no. A89-52644. refs
Copyright

A91-29789#
ANALYTICAL PREDICTION OF HEIGHT-VELOCITY DIAGRAM OF A HELICOPTER USING OPTIMAL CONTROL THEORY
KEIJI KAWACHI, AKIRA AZUMA (Tokyo, University, Japan), SHIGERU SAITO (National Aerospace Laboratory, Tokyo, Japan), and YOSHINORI OKUNO Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 453-459. refs
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The autorotative landing of a single-engine helicopter following power failure is analyzed using optimal control theory. The optimization problems are formulated to minimize the unsafe region in the height-velocity diagram under the condition that the touchdown speed is within the capability of the landing gear. Nonlinear equations of motion are described using a rigid-body dynamic model with longitudinal three degrees of freedom. The aerodynamic model of the rotor takes account of the effects of blade stall during descent and increased induced flow in the vortex ring state. The present method gives a good estimation of the height-velocity boundary in comparison with the existing flight test data. It is pointed out that the test pilot started the collective flare earlier than that occurred in the optimal solution. Author

A91-29971
FLUCTUATIONS OF BALLOON ALTITUDE [O KOLEBANIIAKH VYSOTY POLETA AEROSTATA]
E. L. ALEKSANDROV and Z. M. KOZLOVA IN: Atmospheric optics. Moscow, Gidrometeoizdat, 1990, p. 55-62. In Russian.
Copyright

Radar observations of oscillations of high-altitude balloons located at the equilibrium level are analyzed. It is shown that the experimentally observed ballon oscillations are described well by the theory of the oscillations of an isolated gas in a stably stratified atmosphere. It is concluded that, in conducting various balloon experiments, it is necessary to take into account the fact that the balloons will undergo oscillations that are damped with a characteristic time of 15-20 min after reaching the equilibrium level. L.M.

A91-30050
AIRCRAFT TRAJECTORY OPTIMIZATION WITH DIRECT COLLOCATION USING MOVABLE GRIDPOINTS
CH. JAENSCH and M. PAUS (DLR, Institut fuer Dynamik der Flugsysteme, Oberpfaffenhofen, Federal Republic of Germany) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 262-267. refs
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One of the shortcomings of the direct collocation method is addressed. The major problem area concerns the node placement, i.e., the discretization. A practical approach to improving the quality of the optimal solution with only a slight increase in computing time is to introduce movable nodes that are optimally placed by the algorithm. The principle capabilities of this method are demonstrated on some general aircraft trajectory optimization problems. In addition, solutions to some undesirable side effects that occur with a pointwise evaluation of path constraints are presented. I.E.

A91-30076
NONLINEAR ADAPTIVE CONTROL OF A TWIN LIFT HELICOPTER SYSTEM
MANOJ MITTAL, J. V. R. PRASAD, and DANIEL P. SCHRAGE (Georgia Institute of Technology, Atlanta) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 743-748. refs
(Contract DAAL03-88-C-0003)
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The tracking control problem of a twin-lift helicopter system in the presence of parametric uncertainty is considered. Based on a nonlinear model describing the dynamics of the helicopter configuration in the lateral/vertical plane, a controller is synthesized using an input-output feedback linearization technique in conjunction with an adaptation algorithm. The proposed control scheme does not require any knowledge of the bound of uncertainties present and drives the output tracking error to zero asymptotically. The performance of the controller is illustrated in a simulation of the nonlinear model of the twin-lift system. I.E.

A91-30079
ROLL AND MANEUVER LOAD ALLEVIATION CONTROL LAW DESIGN FOR A WIND TUNNEL MODEL BY LQG/LTR METHODOLOGY
MARTIN J. KLEPL (Rockwell International Corp., El Segundo, CA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 770, 771. refs
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Results of a roll and maneuver load alleviation (RMLA) control law design for the AFW (active flexible wing) are presented. The MIMO (multi-input/multi-output) design method consisted of synthesis by the loopshaping LQG/LTR method and analysis by the unstructured singular value Bode plot. Novel results include the dual control law and plant scaling to obtain special roundness. A result shows the mechanism by which excellent decoupling is achieved. I.E.

A91-30120* Washington Univ., Seattle.
TOTAL ENERGY CONTROL SYSTEM AUTOPILOT DESIGN WITH CONSTRAINED PARAMETER OPTIMIZATION
UY-LOI LY (Washington, University, Seattle) and CHRISTOPHER VOTH IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1332-1337. refs
(Contract NAG1-913)
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A description is given of the application of a multivariable control design method (SANDY) based on constrained parameter optimization to the design of a multiloop aircraft flight control system. Specifically, the design method is applied to the direct synthesis of a multiloop AFCS inner-loop feedback control system based on total energy control system (TECS) principles. The design procedure offers a structured approach for the determination of a set of stabilizing controller design gains that meet design specifications in closed-loop stability, command tracking performance, disturbance rejection, and limits on control activities. The approach can be extended to a broader class of multiloop flight control systems. Direct tradeoffs between many real design goals are rendered systematic by proper formulation of the design objectives and constraints. Satisfactory designs are usually obtained in few iterations. Performance characteristics of the optimized TECS design have been improved, particularly in the areas of closed-loop damping and control activity in the presence of turbulence. I.E.

A91-30146
LOCAL REGULATION OF NONLINEAR DYNAMICS
HARRY G. KWATNY, JORDAN BERG (Drexel University, Philadelphia, PA), and WILLIAM H. BENNETT (Techno-Sciences, Inc., Greenbelt, MD) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1707-1712. refs
(Contract F33615-88-C-3606)
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A regulator problem for nonlinear parameter-dependent dynamics is formulated and solved. It is shown that the problem is solvable except at parameter values associated with bifurcation of the equilibrium equations and that such bifurcations are inherently linked with the system zero dynamics. These results are applied to the study of the regulation of the longitudinal dynamics of aircraft. It is shown how center of gravity (CG) location affects the ability to regulate either velocity alone or velocity and flight path angle. In the former case, the migration of a real zero through the origin is associated with a static bifurcation, and it is seen clearly why the regulator problem is not solvable: the equilibrium point vanishes under perturbation of the CG location. The latter case represents an example of a bifurcation associated with the degeneracy of the transfer matrix. I.E.

A91-30158
HYPERSONIC VEHICLE AIR DATA COLLECTION - ASSESSING THE RELATIONSHIP BETWEEN THE SENSOR AND GUIDANCE AND CONTROL SYSTEM REQUIREMENTS
PHILIP D. HATTIS (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1811-1818. Charles Stark Draper Laboratory, Inc.-sponsored research. refs
Copyright
The relationship between the air data system and the flight guidance and control (G&C) system design requirements which assure proper trajectory management of air-breathing hypersonic vehicles is explored. The type and precision of onboard state measurements dictated by G&C operations are characterized. Candidate procedures for their measurement are examined including assessment of likely sensor technologies as well as models required to extract desired environment states from actual sensor measurements. Data integration schemes which allow efficient merging of overlapping information from dissimilar sensors (e.g., inertial devices and direct environment measurements) are proposed, and the implications that the resulting state measurement processes will have on G&C avionics and software architecture are considered. I.E.

A91-30174
PERFORMANCE ROBUSTNESS FOR LTI SYSTEMS WITH STRUCTURED STATE SPACE UNCERTAINTY
WANGLING YU and KENNETH M. SOBEL (City College, New York) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2039-2042. refs
(Contract F49620-88-C-0053)
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The performance robustness of a linear time-invariant (LTI) system with structured state-space uncertainty is considered by using the Gronwall lemma approach. A recent sufficient condition for stability robustness is extended to ensure that the closed-loop eigenvalues lie within chosen performance regions when the LTI system is subjected to time-invariant structured state-space uncertainty. The conservatism of the performance robustness condition is addressed by introducing a unitary weighting matrix in addition to the earlier real positive diagonal weighting. An example of the lateral dynamics of the L-1011 aircraft is presented to illustrate the new performance robustness result and the usefulness of the unitary weighting matrix in satisfying the sufficient condition. I.E.

A91-30183
NONLINEAR STABILIZATION OF HIGH ANGLE-OF-ATTACK FLIGHT DYNAMICS USING BIFURCATION CONTROL
EYAD H. ABED and HSIEN-CHIARN LEE (Maryland, University, College Park) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2235-2238. TRW Foundation-supported research. refs
(Contract NSF CDR-88-03012; NSF ECS-86-57561; AF-AFOSR-87-0073)
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The problem of designing stabilizing control laws for flight over a broad range of angles-of-attack and which serve to signal the pilot of impending stall is considered. The authors employ bifurcation stabilization coupled with more traditional linear control system design. A detailed analysis is given for a model of the longitudinal dynamics of an F-8 Crusader. I.E.

A91-30192
A FEEDBACK GUIDANCE LAW FOR TIME-OPTIMAL ZOOM INTERCEPTION
H. G. VISSER (Delft University of Technology, Netherlands) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2331-2336. refs
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An improved guidance law is presented for the terminal zoom climb in a medium-range air-to-air interception. The improvement is obtained by replacing the constant-energy model with an intermediate vehicle model. The algorithm requires some iterative computations, but these can be performed in parallel with the feedback computations and therefore have no effect on the real-time potential. A comparison with exact open-loop solutions shows that a substantial improvement can be obtained in both control behavior and payoff accuracy. I.E.

A91-30198
ROBUST AUTOPILOT DESIGN USING MU-SYNTHESIS
R. T. REICHERT (Johns Hopkins University, Laurel, MD) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2368-2373. refs
Copyright
An examination is made of the applicability of H-infinity and mu-synthesis control to the design of automatic flight control systems for highly maneuverable, tail-controlled missiles. The impact of the degree of conservatism inherent to each approach on performance is examined. It is shown that mu-synthesis provides a superior framework for the design of missile autopilots having robust performance. I.E.

A91-30209
A COMPARISON OF DIFFERENT H-INFINITY METHODS IN VSTOL FLIGHT CONTROL SYSTEM DESIGN
S. J. WILLIAMS (Cambridge Control, Ltd., England) and R. A. HYDE (Cambridge, University, England) IN: 1990 American Control

Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2508-2513. refs
Copyright

An investigation is conducted of the application of different H-infinity design methods to multivariable flight control system design for a VSTOL (vertical and short take-off and landing) aircraft. Designs are based on linearized models at an airspeed of 120 kn. Although based on linearized operating points, a key issue considered is robust stability and robust performance of designs away from the design operating points. Four different design approaches are used. Three approaches treat uncertainty as unstructured. Two of these optimize closed-loop objectives, and one specifies open-loop objectives. The fourth design uses a mu-synthesis approach which makes use of structured uncertainty information to optimize closed-loop objectives. The designs are evaluated using unstructured singular values and the structured singular value, mu. I.E.

A91-30733
FORCE SPECTRA IN AIRCRAFT CONTROL [SPEKTRA SIL V RIZENI LETOUNU]
VACLAV KAHANEK Zpravodaj VZLU (ISSN 0044-5355), no. 2, 1991, p. 87-92. In Czech. refs
Copyright

The contribution describes a method for determining out the force in particular aircraft control systems on the basis of relatively short-term flight measurements. A verification of this method by measurements on the L-410 aircraft is given. Author

A91-30906
IS AGILITY IMPLICIT IN FLYING QUALITIES?
MICHAEL E. BISE (Veda, Inc., Dayton, OH) and G. THOMAS BLACK (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 484-489. refs
Copyright

Agility is addressed from the standpoint of military specifications and standards. Aircraft response characteristics are detailed and mapped into MIL-STD-1797-A, Flying Qualities of Piloted Aircraft. Based on current literature, several agile responses are discussed. A mapping is then made of the agile responses into the flying qualities specification in order to determine if agility can be partially or totally specified within the framework of ML-STD-1797A. It is shown that any maneuver may be broken down into its component parts, which may then be mapped into the appropriate paragraphs or sections of the specification to establish specific requirements and verification criteria. The recommended values may be inserted into the requirement paragraphs, or the individual requirements may be tailored as desired for the subject aircraft. If an agile maneuver can be described, it may also be dissected and its component parts specified; the appropriate agile numbers and verification criteria are simply inserted into the existing structure of the flying qualities specification. I.E.

A91-30909
F-15 S/MTD IFPC FAULT TOLERANT DESIGN
FREDERICK L. TUTTLE, ROBERT L. KISSLINGER, and DION F. RITZEMA (McDonnell Aircraft Co., Saint Louis, MO) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 501-506.
Copyright

One of the major requirements for the F-15 STOL (short take off and landing) and maneuver technology demonstrator (S/MTD) was to develop and demonstrate an integrated flight and propulsion control (IFPC) system. The IFPC is a fly-by-wire (FBW) system that replaced the F-15 mechanical flight and engine controls. It was a USAF requirement that the IFPC be fault-tolerant and that loss-of-control not exceed once per 100,000 flights. A program goal was that the IFPC meet or exceed the reliability and maintainability of the basic F-15. The authors describe the architecture and redundancy management of the IFPC and the associated aircraft system modifications that created a robust, fault-tolerant, and maintainable flight/propulsion control system. It is concluded that the techniques used to provide the required failure management characteristics for the S/MTD resulted in a system which could withstand a significant number of failures in various parts of the system without loss of aircraft control. I.E.

A91-30910
APPLICATIONS OF POLYNOMIAL NEURAL NETWORKS TO FDIE AND RECONFIGURABLE FLIGHT CONTROL
ROGER L. BARRON, RICHARD L. CELLUCCI, PAUL R. JORDAN, III, NORMAN E. BEAM (Barron Associates, Inc., Stanardsville, VA), PAUL HESS et al. IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 507-519. refs
(Contract F33615-88-C-3615)
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Fault detection, isolation, and estimation (FDIE) functions and reconfiguration strategies for flight control systems present major technical challenges, primarily because of uncertainties resulting from limited observability and an almost unlimited variety of malfunction and damage scenarios. Attention is focused on a portion of the problem, i.e., global FDIE for single impairments of control effectors. Polynomial neural networks are synthesized using a constrained error criterion to obtain pairwise discrimination between impaired and no-fail conditions and isolation between impairment classes. The pairwise discriminators are then combined in a form of voting logic. Polynomial networks are also synthesized to obtain estimates of the amount of effector impairment. The algorithm for synthesis of polynomial networks (ASPN) and related methods are used to create the networks, which are high-order, linear or nonlinear, analytic, multivariate functions of the in-flight observables. The authors outline the design procedure, including database preparation, extraction of waveform features, network synthesis techniques, and the architecture of the FDIE system that has been studied for control reconfigurable combat aircraft (CRCA). Single-look (25-ms response time) simulation results are presented that show a 86.7 percent probability of detection and correct isolation (to canard or wing) for CRCA effector impairments exceeding 25 percent, and a 94.4 percent probability of detection and correct isolation for effector impairments exceeding 50 percent. I.E.

A91-30912
APPLICATION OF DISCRETE PROPORTIONAL PLUS INTEGRAL (PI) MULTIVARIABLE DESIGN TO THE CONTROL RECONFIGURABLE COMBAT AIRCRAFT (CRCA)
JAMIE FOELKER and JOHN J. D'AZZO (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 526-531. refs
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Multivariable control laws developed by Porter (1981) have been used to successfully perform maneuvering tracking tasks with the control reconfigurable combat aircraft (CRCA). Porter's method was used to design a discrete proportional plus integral (PI) control law. Output and selected state rate feedback were used. The results obtained in the terrain following/terrain-avoidance (TFTA) flight condition showed robust tracking control for the CRCA for five selected maneuvers. Single failures were introduced to test the ability of the fixed-gain design to successfully control the aircraft and perform the maneuvers. Time responses show that the CRCA can be made to successfully perform all five maneuvers for two of the three control surface failures investigated. For high gains, the system transfer function becomes asymptotically diagonal (the outputs are uncoupled). Based on this property, a frequency analysis was performed for each output with respect to its associated input. Phase margins in excess of 45 deg, gain margins of greater than 6 dB, and bandwidths in the range of 5-10 rad/s were the result. The results show that the discrete Porter PI design is robust for the CRCA controller, allowing successful performance of 15 out of the 20 maneuvers attempted in the TFTA flight condition. I.E.

A91-30913
STABILIZATION OF A FLIGHT CONTROL SYSTEM WITH VARYING NUMBERS OF RIGHT HALF-PLANE POLES AND ZEROS
ISAAC HOROWITZ and C. HOUPIS (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 532-538.
Copyright
Data for a linearized model of the STOL/maneuver technology demonstrator (SMTD) with stabilator used to control pitch-rate are examined. Six flight conditions were considered, ranging from 0.1 to 0.9 Mach, and from zero to 40,000 ft. The six cases comprised one with one right half-plane (RHP) zero and one RHP pole, two cases with two RHP poles, one case with one RHP zero and three RHP poles, and two cases with one RHP pole. The problem was to stabilize the system over this range of flight conditions by means of a single, fixed compensator, i.e., without any scheduling or identification. Quantitative feedback theory (QFT) was applied in a straightforward manner to obtain such a design with phase margins of 50 deg or more and gain margins of 6 dB or more (only one case with 6 db, the five others of 20 db or more) The technique is simple and systematic, with little cut-and-try. It can be applied by anyone with classical control background since the Nichols chart is the principal design tool. Time and frequency domain simulations are included. I.E.

A91-30914
ROBUSTNESS CHARACTERISTICS OF FAST-SAMPLING DIGITAL PI CONTROLLERS FOR HIGH-PERFORMANCE AIRCRAFT
B. PORTER and M. Z. OTHMAN (Salford, University, England) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 539-543. refs
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The robustness characteristics of fast-sampling error-actuated digital set-point tracking PI (proportional plus integral) controllers are established in the case of partially irregular linear multivariable plants, i.e., plants with non-null rank-defective first Markov parameters and full-rank second Markov parameters. It is shown that the plant-parameter variations tolerable by such fast-sampling error-actuated digital controllers can be expressed very simply in terms of the step-response matrices of the nominal and actual plants. These general results are illustrated by examining the robustness characteristics of a fast-sampling error-actuated digital PI controller for three flight conditions of the F-16 aircraft. I.E.

A91-30918
ARTIFICIAL NEURAL NETWORKS IN FLIGHT CONTROL AND FLIGHT MANAGEMENT SYSTEMS
GEORGE H. BURGIN and STEVEN S. SCHNETZLER (Titan Systems, Inc., San Diego, CA) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 567-573. refs
Copyright
Different types of neural networks (NNs) are surveyed and their suitability as elements in flight control and flight management systems is analyzed. Advantages of neural networks over conventional digital avionic systems include speed (especially when implemented in special hardware, taking advantage of massive parallel processing), robustness, fault tolerance, and the ability to adapt to new situations by learning. An example shows how an artificial NN can be used as a gain adjuster in a stability augmentation system. A three-layer NN receives elevator commands and the sensed resulting longitudinal aircraft motion as input. The NN recognizes certain patterns in this response which are an indication that the gain is too high and that the control system is dangerously close to the stability boundary. Another example shows how a NN can solve a complex combinatorial problem which arises in search planning. It has similarities to the traveling salesman problem. Given a number of straight-line segments, each one with a payoff assigned to it, the NN must find that arrangement of segments which will maximize the sum of all the payoffs and satisfy the constraint that the total length be less than a prescribed value. It is shown how this problem can be formulated in the form of an NN, and two methods are outlined by which the neural network representing the optimal solution of the problem can be found. I.E.

A91-30919
CONSIDERATIONS IN THE APPLICATION OF DYNAMIC PROGRAMMING TO OPTIMAL AIRCRAFT TRAJECTORY GENERATION
M. C. WALLER, J. G. RIGOPOULOS, D. R. BLACKMAN, and T. F. BERREEN (Monash University, Melbourne, Australia) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 574-579.
Copyright
The application of dynamic programming to optimal trajectory generation is reported with reference to the problems that arise in the selection of the size of the solution space, including the size of the grid spacing. Recommendations are given on the choice of the grid size and the size of the solution space boundaries to obtain the global optima. The effects of the control representation and interpolation procedures used within the algorithm on the solution are also reviewed. Results of an investigation into reducing the size of the solution space where the trajectory is to be generated are reported. Aspects of the mathematical formulation of the optimization criteria are considered. Imposing constraints, such as path curvature, results in the rejection of certain controls before the dynamic programming technique has chosen the optimal control. How the use of higher-order constraints may result in the choice of a trajectory that is not the global optimum is discussed. A modification of the mathematical procedure implemented to overcome this difficulty is discussed. I.E.

A91-30920
HORIZONTAL PLANE TRAJECTORY OPTIMIZATION FOR THREAT AVOIDANCE AND WAYPOINT RENDEZVOUS
NIRANJAN S. RAO, NATHAN L. PHILLIPS, S. JOHNNY FU, and NEAL M. CONRARDY (Boeing Co., Military Airplanes Div., Wichita, KS) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 580-583.
Copyright
The authors present research results on a method to perform waypoint rendezvous in conjunction with multiple-threat avoidance with the horizontal plane trajectory optimization algorithm. A 737-300 aircraft performance model was used to study trajectory optimization with SP/HTO (singular perturbation/horizontal trajectory optimization). The cost function used by Vian and Moore (1989) was modified to include the cost of line-of-sight angle to the destination in order to generate more flyable trajectories through regions of multiple threat envelopes. Results are presented for several scenarios in which there are multiple threats and rendezvous points. The surface-to-air threat effectiveness envelope developed and used in these mission scenarios to generate optimal trajectories is discussed. It is shown that the addition of a cost of line-of-sight angle to the destination avoids a tendency of the trajectory to immediately return to the x-axis when no threats are present in the direct path to the target; instead the trajectory leads directly to the target and is a more desirable solution. The

local approach to trajectory optimization is shown to be useful in short-range scenarios or in cases where there may be pop-up threats. I.E.

A91-31018
DEVELOPING A DEFERRED MAINTENANCE INITIATIVE FOR FAULT-TOLERANT FLIGHT CONTROL SYSTEMS
DEBORAH F. ALLINGER and FRANK J. LEONG (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1269-1274.
Copyright

A control actuation system that incorporates many of the salient features of both flight and propulsion control systems is used to illustrate the analytic techniques of a deferred maintenance initiative. This example system incorporates redundancy management via fault detection, isolation, and reconfiguration schemes as reflected in the associated coverage parameters. Analysis shows how each component of the system can be classified according to its impact on the system's ability to maintain controlled operation. Furthermore, time limits for deferred maintenance are determined. In order to realize such an initiative as a viable mode of operation, one must have a systematic method for establishing the system's vulnerability. A tractable methodology for doing so is described and illustrated. I.E.

A91-31030*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CIVIL AIR TRANSPORT - A FRESH LOOK AT POWER-BY-WIRE AND FLY-BY-LIGHT
GALE R. SUNDBERG (NASA, Lewis Research Center, Cleveland, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1365-1368. Previously announced in STAR as N90-21283.

Power-by-wire (PBW) is a key element under subsonic transport flight systems technology, with potential savings of over 10 percent in gross take off weight and in fuel consumption compared to today's transport aircraft. The PBW technology substitutes electrical actuation in place of centralized hydraulics, uses internal starter-motor/generators, and eliminates the need for variable engine bleed air to supply cabin comfort. The application of advanced fiber optics to the electrical power system controls, to built-in-test (BITE) equipment, and to fly-by-light (FBL) flight controls provides additional benefits in lightning and high-energy radio frequency (HERF) immunity over existing mechanical or even fly-by-wire controls. The program plan is reviewed and a snapshot is given of the key technologies and their benefits to future aircraft, both civil and military. Author

A91-31732#
AIRSHIP RESPONSE TO TURBULENCE - RESULTS FROM A FLIGHT DYNAMICS SIMULATION COMBINED WITH A WIND TUNNEL INVESTIGATION
SERGIO B. V. GOMES and DAVID J. SPEIRITS (Westinghouse Airship Industries, Inc., Luton, England) IN: AIAA Lighter-Than-Air Systems Technology Conference, 9th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 43-58. refs
(AIAA PAPER 91-1276) Copyright

This paper presents the results of two parallel investigations into the subject of airship response to turbulence. The first one was based upon a carefully developed wind tunnel test technique, whilst the second one employed a six degree of freedom computer simulation. The respective results thus obtained are compared and analysed, and the implications to airship certification are then discussed. Author

A91-31900*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL FLUTTER BOUNDARIES WITH UNSTEADY PRESSURE DISTRIBUTIONS FOR THE NACA 0012 BENCHMARK MODEL
JOSE A. RIVERA, BRYAN E. DANSBERRY, MOSES G. FARMER, CLINTON V. ECKSTROM, DAVID A. SEIDEL, and ROBERT M. BENNETT (NASA, Langley Research Center, Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 697-703.
(AIAA PAPER 91-1010) Copyright

The Structural Dynamics Division at NASA Langley Research Center has started a wind tunnel activity referred to as the Benchmark Models Program. The primary objective of the program is to acquire test data that will be useful for developing and evaluating aeroelastic type CFD codes currently in use of under development. This paper describes the progress achieved in testing the first model in the Benchmark Models Program. Experimental flutter boundaries are presented for a rigid semispan model (NACA 0012 airfoil section) mounted on a flexible mount system. Also, steady and unsteady pressure measurements taken at the flutter condition are presented. The pressure data were acquired over the entire model chord located at the 60 percent span station. Author

A91-31901*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A STATUS REPORT ON A MODEL FOR BENCHMARK ACTIVE CONTROLS TESTING
MICHAEL H. DURHAM, DONALD F. KELLER, ROBERT M. BENNETT, and CAROL D. WIESEMAN (NASA, Langley Research Center, Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 704-709.
(AIAA PAPER 91-1011) Copyright

This 'work-in-progress' paper presents a status report on an active controls flutter model which is currently in the design and fabrication phase. This model is a part of the Benchmark Models Program (BMP). The BMP is a NASA LaRC program that includes a series of models which will be used to study different aeroelastic phenomena and to validate aeroelastic methods. The objective of Benchmark Active Controls testing is to validate active control design tools. Flutter testing will be conducted with a pressure-instrumented rigid model attached to a flexible pitch and plunge mount system. Unsteady pressure distributions and transonic flutter boundaries will be measured with and without active control system engaged. Author

A91-32006#
AILERON BUZZ INVESTIGATED ON SEVERAL GENERIC NASP WING CONFIGURATIONS
ELLEN C. PARKER, CHARLES V. SPAIN, and DAVID L. SOISTMANN (Lockheed Engineering and Sciences Co., Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1702-1711. refs
(AIAA PAPER 91-0936)

Transonic aileron buzz characteristics are presented for several generic National Aerospace Plane (NASP) wing models with full-span ailerons. Flutter characteristics, in addition to buzz characteristics, are also presented for one of these models. The objective of this study was to observe how variations in wing geometry and aileron hinge stiffness would affect the occurrence or behavior of buzz. The effects of minimizing airflow through the gap at the aileron hinge was also investigated on two of these models. All tests were conducted in air. The Mach number, dynamic

pressure and aileron oscillation frequency when buzz (and/or flutter) was observed are provided for these wing configurations.
Author

A91-32008#
RESPONSE OF THE USAF/NORTHROP B-2 AIRCRAFT TO NONUNIFORM SPANWISE ATMOSPHERIC TURBULENCE
JOHN P. CRIMALDI, R. TERRY BRITT, and WILLIAM P. RODDEN (Northrop Corp., Pico Rivera, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1728-1741. refs
(AIAA PAPER 91-1048) Copyright

Design load requirements for random gusts prescribe a one-dimensional gust field, i.e., a field that is uniform spanwise for a vertical gust. By definition, such a gust will produce purely symmetric vehicle response with corresponding symmetric stresses. The more general case of a three-dimensional gust will cause an asymmetric response. The one-dimensional assumption can be unconservative as exemplified by the fact that at the centerline of a flying wing, symmetric shear and torsion are zero whereas the asymmetric values are not. Solution techniques based on cross-spectral methods have been applied to the USAF/Northrop B-2 aircraft to assess the nonuniform spanwise gust response characteristics. Results are presented comparing key vehicle response parameters for uniform and nonuniform gust loading. It is concluded that the uniform gust model generally produces the higher loads and that no additional design conditions are derived from the nonuniform gust loading. Author

A91-32009*# Arnold Engineering Development Center, Arnold Air Force Station, TN.
SOME SUBSONIC AND TRANSONIC BUFFET CHARACTERISTICS OF THE TWIN-VERTICAL-TAILS OF A FIGHTER AIRPLANE CONFIGURATION
STEVEN W. MOSS (USAF, Arnold Engineering Development Center, Arnold AFB, TN), STANLEY R. COLE, and ROBERT V. DOGGETT, JR. (NASA, Langley Research Center, Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1742-1750. refs
(AIAA PAPER 91-1049) Copyright

Vertical-tail buffet response data were obtained from tests in the Langley Transonic Dynamics Tunnel using a rigid, 1/6-size, full-span model of an F-18 airplane that was fitted with flexible vertical tails of two different levels of structural stiffness. Response data are presented at Mach numbers from 0.30 to 0.95 over a range of angles of attack from -10 to +40 degrees. These data indicate the following: (1) the buffet response occurs in the first bending mode; (2) the buffet response is a maximum in the angle of attack range from 30 to 40 degrees; (3) the buffet response increases with increasing dynamic pressure, but changes in response are not linearly proportional to the changes in dynamic pressure; (4) the buffet response is larger at M = 0.30 than it is at the higher Mach numbers; and (5) the maximum intensity of the buffeting is described as heavy to severe using an assessment criteria proposed by another investigator. Author

A91-32012*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
BUFFET INDUCED STRUCTURAL/FLIGHT-CONTROL SYSTEM INTERACTION OF THE X-29A AIRCRAFT
DAVID F. VORACEK and ROBERT CLARKE (NASA, Flight Research Center, Edwards, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1779-1790. refs
(AIAA PAPER 91-1053) Copyright

High-alpha flight creates unique aerodynamic phenomena which increase the level of structural mode excitation; in conjunction with high-gain digital control systems, this structural response may result in an aeroservoelastic interaction. One such interaction has been observed during high-alpha flight testing of the X-29A. Data are presented which demonstrate the enhanced modal power in this aircraft's structural accelerometers, the feedback sensors, and the command signals as a function of alpha value. The structural interaction is traced from the aerodynamic buffet to the flight-control surfaces. O.C.

A91-32016#
FUNDAMENTAL MECHANISMS OF AEROELASTIC CONTROL WITH CONTROL SURFACE AND STRAIN ACTUATION
KENNETH B. LAZARUS, EDWARD F. CRAWLEY, and CHARRISSA Y. LIN (MIT, Cambridge, MA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1817-1831. Research sponsored by General Dynamics Corp. and NSF. refs
(AIAA PAPER 91-0985) Copyright

A typical section analysis is employed to provide an understanding of the fundamental mechanisms and limitations involved in performing aeroelastic control. The effects of both articulated aerodynamic control surfaces and induced strain actuators are included in the model as forces and moments acting at the elastic axis of the typical section. The ability of these actuators to effect aeroelastic control is examined for each actuator individually as well as in various combinations. The control options available are examined for single input-single output and multiple input-multiple output classical and optimal control laws. A state cost versus control cost analysis is performed to assess the effectiveness of optimal linear quadratic regulator control laws for different actuators and actuator combinations. The cost comparisons show that strain actuation is an effective means of achieving aeroelastic control and a viable alternative to articulated control surface methods. In addition, the advantages of using multiple actuators to avoid limitations associated with single actuator systems is demonstrated. Author

A91-32017*# California Univ., Los Angeles.
TRANSONIC ADAPTIVE FLUTTER SUPPRESSION USING APPROXIMATE UNSTEADY TIME DOMAIN AERODYNAMICS
CHAN-GI PAK, PERETZ P. FRIEDMANN (California, University, Los Angeles), and ELI LIVNE (Washington, University, Seattle) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1832-1854. refs
(Contract NCC2-374; F49620-87-K-0003)
(AIAA PAPER 91-0986) Copyright

A digital adaptive controller is applied to the active flutter suppression problem of a wing under time varying flight conditions in subsonic and transonic flow. Linear quadratic controller gain at each time step is obtained using an iterative Riccati solver. The digital adaptive optimal controller is robust with respect to the unknown external loads. Flutter and divergence instabilities are simultaneously suppressed using a trailing-edge control surface and displacement sensing. A new transonic unsteady aerodynamic approximation methodology is developed which enables one to carry out the rapid calculation required for transonic aeroservoelastic applications. This approximation is based on a combination of unsteady subsonic aerodynamics combined with a transonic correction procedure. Aeroservoelastic transient time response is obtained using Roger's approximation, state transition matrices and an iterative time marching algorithm. The aeroservoelastic system in the time domain is modeled using a deterministic ARMA model together with a parameter estimator. Transonic flutter boundaries of a wing structure are computed, in the time domain, using an estimated aeroelastic system matrix and are in good agreement with experimental data for the low transonic Mach number range. Author

A91-32018#
AN APPLICATION OF THE ACTIVE FLEXIBLE WING CONCEPT TO AN F-16 DERIVATIVE WING MODEL
EDMUND PENDLETON, MARK LEE (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH), and LEE WASSERMAN (Delta Dynamics, Inc., Dayton, OH) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1855-1868. refs
(AIAA PAPER 91-0987)

This paper presents design, fabrication, and test results from an application of the Active Flexible Wing (AFW) concept (Miller, 1988) to an F-16 derivative, low-speed aeroelastic model. The baseline 1/5 scale model design was based on preliminary wing design studies conducted on a derivative wing for the F-16 fighter. Multiple-control-surface capability was provided to the model through segmenting the leading-edge control surface and adding an outboard trailing-edge control surface. Increases in control power obtained through use of the leading- and trailing-edge control surfaces in combinations are examined. The effects of using leading-edge and trailing-edge surfaces where outboard wing flexibility has been increased are also addressed. Author

A91-32019*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
IMPACT OF ACTIVE CONTROLS TECHNOLOGY ON STRUCTURAL INTEGRITY
THOMAS NOLL (NASA, Langley Research Center, Hampton, VA), EDWARD AUSTIN (U.S. Army, Aviation Research and Technology Activity, Fort Eustis, VA), SHAWN DONLEY (U.S. Navy, Naval Air Development Center, Warminster, PA), GEORGE GRAHAM (DND, Ottawa, Canada), TERRY HARRIS (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) et al. IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1869-1878. refs
(AIAA PAPER 91-0988) Copyright

This paper summarizes the findings of The Technical Cooperation Program to assess the impact of active controls technology on the structural integrity of aeronautical vehicles and to evaluate the present state-of-the-art for predicting the loads caused by a flight-control system modification and the resulting change in the fatigue life of the flight vehicle. The potential for active controls to adversely affect structural integrity is described, and load predictions obtained using two state-of-the-art analytical methods are given. Author

A91-32031*# California Univ., Los Angeles.
COUPLED ROTOR-FLEXIBLE FUSELAGE VIBRATION REDUCTION USING OPEN LOOP HIGHER HARMONIC CONTROL
I. PAPAVASSILIOU, P. P. FRIEDMANN, and C. VENKATESAN (California, University, Los Angeles) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2011-2035. refs
(Contract NAG2-477; DAAL03-86-G-0109)
(AIAA PAPER 91-1217) Copyright

A fundamental study of vibration prediction and vibration reduction in helicopters using active controls was performed. The nonlinear equations of motion for a coupled rotor/flexible fuselage system have been derived using computer algebra on a special purpose symbolic computer facility. The trim state and vibratory response of the helicopter are obtained in a single pass by applying the harmonic balance technique and simultaneously satisfying the trim and the vibratory response of the helicopter for all rotor and fuselage degrees of freedom. The influence of the fuselage flexibility on the vibratory response is studied. It is shown that the conventional single frequency higher harmonic control is capable of reducing either the hub loads or only the fuselage vibrations but not both simultaneously. It is demonstrated that for simultaneous reduction of hub shears and fuselae vibrations a new scheme called multiple higher harmonic control is required. Author

A91-32036*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ANALYSIS AND CORRELATION OF SA349/2 HELICOPTER VIBRATION
RUTH HEFFERNAN (NASA, Ames Research Center, Moffett Field, CA), DOMINIQUE PRECETTI (Service Technique des Programmes Aeronautiques, Paris, France), and WAYNE JOHNSON (Johnson Aeronautics, Palo Alto, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2082-2102. refs
(AIAA PAPER 91-1222) Copyright

Helicopter airframe vibration is examined using calculation and measurements for the SA349/2 research helicopter. The hub loads, which transmit excitation to the fuselage, are predicted using a comprehensive rotorcraft analysis and correlated with measured hub loads. The predicted and measured hub loads are then coupled with finite element models representing the SA349/2 fuselage. The resulting vertical acceleration at the pilot seat is examined. Adjustments are made to the airframe structural models to examine the sensitivity of predicted vertical acceleration to the model. Changes of a few percent to the damping and frequency of specific modes lead to large reductions in predicted vibration and to major improvements in the correlations with measured pilot seat vertical acceleration. Author

A91-32037#
STABILIZING PYLON WHIRL FLUTTER ON A TILT-ROTOR AIRCRAFT
JOHN G. VORWALD (U.S. Navy, David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) and INDERJIT CHOPRA (Maryland, University, College Park) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2103-2114. U.S. Navy-supported research. refs
(AIAA PAPER 91-1259)

The pylon whirl flutter speed of a tilt-rotor aircraft is increased by incorporating a multiple-input multiple-output controller. Pylon whirl flutter is modeled with a semispan wing and a three-bladed proprotor. The semispan wing has beamwise bending, chordwise bending, and torsion motion. The blades are rigid and undergo flap and lag motions. Aerodynamic loads of the wing and the proprotor are obtained from quasi-steady strip theory. Flap and lag motions are shown to be significant. The controller is a linear quadratic regulator of the uncoupled, stable, modal variables. To reduce the influence of external disturbances and measurement noise, the modal variables are estimated with a Kalman-bucy filter. An example shows feedback of vertical wing motion can increase the stability speed of the Bell XV-15 wind tunnel model by twenty percent. Author

A91-32156#
THEORETICAL INVESTIGATION OF GLIDING PARACHUTE TRAJECTORY WITH DEADBAND AND NON-PROPORTIONAL AUTOMATIC HOMING CONTROL
YILI LI and HUABAO LIN (Chinese Academy of Space Technology, Beijing, People's Republic of China) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 42-47.
(AIAA PAPER 91-0834) Copyright

An analytical method of homing trajectory of gliding parachute system with non-proportional automatic homing control with a deadband is discussed in this paper. The iteration equations of trajectory calculation of gliding parachute system in this type of control is given in the wind-fixed axis system. The method presented in this paper is suitable for the trajectory calculation of gliding parachute system in this type of control for case of arbitrary wind field. Author

N91-19037*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
NEURAL NETWORKS IN NONLINEAR AIRCRAFT CONTROL
DENNIS J. LINSE *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1989-1990 p 151-161 Dec. 1990
Avail: NTIS HC/MF A09 CSCL 01C

Recent research indicates that artificial neural networks offer interesting learning or adaptive capabilities. The current research focuses on the potential for application of neural networks in a nonlinear aircraft control law. The current work has been to determine which networks are suitable for such an application and how they will fit into a nonlinear control law. Author

N91-19101# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Helicopter Div.
I'M ALL 'LIGHT' JACK
GERHARD KISSEL and ALAN FAULKNER Sep. 1990 15 p
Presented at the 16th European Rotorcraft Forum, Glasgow, Scotland, 18-21 Sep. 1990
(MBB-UD-0576-90-PUB; ETN-91-98826) Avail: NTIS HC/MF A03

The case for using optical data transmission for helicopter flight control systems FBL (Fly By Light) concluding that the technology is mature for the introduction into future helicopters is presented. Though FBW (Fly By Wire) is able to meet current specification needs, FBL may be a more cost effective solution in the future owing to the increasing EMI (electrical magnetic interference) requirements. The experience gained during the development and experimental flight test program is presented and discussed. Details of the computing technology and hardware installation, the use of 'smart' sensors and 'smart' actuators is given together with the current activities since completion of flight testing. The results of new developments in microcomponents to replace existing accelerometers, rate gyros, and position sensors are shown. ESA

N91-19810# Joint Publications Research Service, Arlington, VA.
CONSTRUCTING MATHEMATICAL MODEL OF ADAPTIVE ANTI-FLUTTER SYSTEM Abstract Only
B. O. KACHANOV, S. I. OVCHARENKO, and A. T. PONOMAREV *In its* JPRS Report: Science and Technology. USSR: Physics and Mathematics p 12-13 31 Oct. 1990 Transl. into ENGLISH from Prikladnaya Mekhanika (Kiev, USSR), v. 26, no. 1, Jan. 1990 p 113-119
Avail: NTIS HC/MF A03

A linear mathematical model of an anti-flutter system for aircraft is constructed on the basis of an approximate finite-dimensional mathematical description of perturbed aircraft motion and its stability analysis in accordance with the Mikhaylov's aeroelasticity criterion. For simplification of the iterative calculation process, the aerodynamic and kinematic parameters are assumed to vary harmonically at the stagnation point. To make the system adaptive, the model includes algorithms of identification, estimation, and optimal control based on that simplified aeroelasticity model. Practical application is demonstrated on suppression of symmetric flutter of a hypothetical transport plane during depletion of fuel. It is assumed that the fuel is carried in tanks under the wings and that the rudders have a surface area constituting one quarter of the aileron surface that extend almost to the tip of the wings. Three coefficients most sensitive to fuel depletion were selected for adaptive control by sensitivity analysis of the critical flutter velocity and frequency to variation of coefficients in the model equation. The other coefficients were assumed to remain constant at their design values corresponding to the basic plane load. Author

N91-20128*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A CONTROLS ENGINEERING APPROACH FOR ANALYZING AIRPLANE INPUT-OUTPUT CHARACTERISTICS
P. DOUGLAS ARBUCKLE Washington Apr. 1991 22 p
(NASA-TP-3072; L-16798; NAS 1.60:3072) Avail: NTIS HC/MF A03 CSCL 01/3

An engineering approach for analyzing airplane control and output characteristics is presented. State-space matrix equations describing the linear perturbation dynamics are transformed from physical coordinates into scaled coordinates. The scaling is accomplished by applying various transformations to the system to employ prior engineering knowledge of the airplane physics. Two different analysis techniques are then explained. Modal analysis techniques calculate the influence of each system input on each fundamental mode of motion and the distribution of each mode among the system outputs. The optimal steady state response technique computes the blending of steady state control inputs that optimize the steady state response of selected system outputs. Analysis of an example airplane model is presented to demonstrate the described engineering approach. Author

N91-20130*# Washington Univ., Seattle. Dept. of Mechanical Engineering.
MULTIRATE SAMPLED-DATA YAW-DAMPER AND MODAL SUPPRESSION SYSTEM DESIGN Final Report, 1 Sep. 1989 - 31 Dec. 1990
MARTIN C. BERG and GREGORY S. MASON Dec. 1990 101 p
(Contract NAG1-1055)
(NASA-CR-188017; NAS 1.26:188017) Avail: NTIS HC/MF A06 CSCL 01/3

A multirate control law synthesized algorithm based on an infinite-time quadratic cost function, was developed along with a method for analyzing the robustness of multirate systems. A generalized multirate sampled-data control law structure (GMCLS) was introduced. A new infinite-time-based parameter optimization multirate sampled-data control law synthesis method and solution algorithm were developed. A singular-value-based method for determining gain and phase margins for multirate systems was also developed. The finite-time-based parameter optimization multirate sampled-data control law synthesis algorithm originally intended to be applied to the aircraft problem was instead demonstrated by application to a simpler problem involving the control of the tip position of a two-link robot arm. The GMCLS, the infinite-time-based parameter optimization multirate control law synthesis method and solution algorithm, and the singular-value based method for determining gain and phase margins were all demonstrated by application to the aircraft control problem originally proposed for this project. Author

N91-20131# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
AUTOMATIC FLIGHT CONTROL SYSTEM DESIGN FOR AN UNMANNED RESEARCH VEHICLE USING DISCRETE QUANTITATIVE FEEDBACK THEORY M.S. Thesis
DAVID G. WHEATON Dec. 1990 275 p
(AD-A230364; AFIT/GE/ENG/90D-66) Avail: NTIS HC/MF A12 CSCL 01/4

This thesis presents the application of non-minimum phase (NMP) w'-plane discrete MIMO (multiple-input-multiple-output) Quantitative Feedback Theory (QFT) to the design of a three-axis rate-commanded automatic flight control system for an unmanned research vehicle (URV). The URV model used has seven inputs and three outputs derived from the small-angle perturbation equations of motion. Plant parameter uncertainty consists of six flight conditions derived from variations in the aircraft center of gravity, airspeed, and gross weight. A weighting matrix delta is used to post-multiply the plants for blending the seven effector inputs into three effective rate-command inputs and resulting in an effective plant Pe = P delta. Second order effector models and first order feedback sensor models are included in the plant. A time-scaled recursive algorithm is used to transform the continuous plant models to the w'-plane thereby avoiding the numeric problems associated with an intermediate z-plane representation. All the URV plant elements are minimum phase (MP). The transformation produces, however, a sampling NMP zero and one other NMP zero due to the three pole excess actuator/sensor model elements. These NMP elements limit the available loop bandwidth. Standard QFT design is used, with plant templates P = (P(jv)) which quantitatively express the plant uncertainty. Due to the loop bandwidth limitations, only stability bounds are derived. GRA

N91-20132# Sparta, Inc., Laguna Hills, CA.
METHODOLOGY FOR DEVELOPMENT AND VERIFICATION OF FLIGHT CRITICAL SYSTEMS Final Report, Jan. - Jun. 1990
P. DEFEO and D. MANN Oct. 1990 33 p
(Contract F33615-89-C-3608)
(AD-A229800; WRDC-TR-90-3066) Avail: NTIS HC/MF A03 CSCL 12/6

The technology needs are addressed of Vehicles Management Systems (VMS) during the critical phases of architecture definition and preliminary design. VMS are flight systems which are highly integrated for enhancing maneuvering performance, weapon delivery and fault tolerance. SPARTA has developed and demonstrated a powerful and flexible rapid prototyping environment, Transputer base Advanced Development Environment or TRADE, where VMS architectures can be rapidly emulated and evaluated. The environment includes a SUN workstation and a network of transputers. Transputers are single chip computers which provide extensive processing and communication capabilities at very low cost. The environment enables the system designer, via a graphic based User Interface (UI), to: rapidly and easily modify the VMS architecture as well as the structure of the software embedded in each VMS processor and control the entire environment. Evaluation tools which address system level issues are also included in the environment, so that the relative merits of competing architectures can be quantitatively evaluated. GRA

N91-20133*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A METHOD FOR PARTITIONING CENTRALIZED CONTROLLERS
PHILLIP SCHMIDT, SANJAY GARG (Sverdrup Technology, Inc., Brook Park, OH.), and CARL F. LORENZO Apr. 1991 9 p
(NASA-TM-4276; E-5800; NAS 1.15:4276) Avail: NTIS HC/MF A02 CSCL 01/3

The notion of controller partitioning is described. Conditions are developed under which the input/output behavior of a multi-input multi-output centralized controller can be exactly matched by two separate subsystem controllers interconnected through output crossfeed. A systematic method is developed for determining a controller partitioning which best approximates the input/output behavior of the centralized controller for the general case when the exact matching conditions are not satisfied. The controller partitioning procedure is demonstrated for a centralized integrated flight/propulsion controller designed in a previous study. Author

N91-20134# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
MULTI-INPUT MULTI-OUTPUT FLIGHT CONTROL SYSTEM DESIGN FOR THE YF-16 USING NONLINEAR QFT AND PILOT COMPENSATION M.S. Thesis
RUSSELL B. MILLER Dec. 1990 150 p
(AD-A230465; AFIT/GE/ENG/90D-42) Avail: NTIS HC/MF A07 CSCL 01/4

Nonlinear Quantitative Feedback Theory (QFT) and pilot compensation techniques are used to design a 2x2 flight control system for the YF-16 aircraft over a large range of plant uncertainty. The design is based on numerical input-output time histories generated with a FORTRAN implemented nonlinear simulation of the YF-16. The first step of the design process is the generation of a set of equivalent linear time-invariant (LTI) plant models to represent the actual nonlinear plant. It has been proven that the solution to the equivalent plant problem is guaranteed to solve the original nonlinear problem. Standard QFT techniques are then used in the design synthesis based on the equivalent plant models. A detailed mathematical development of the method used to develop these equivalent LTI plant models is provided. After this inner loop design, pilot compensation is developed to reduce the pilot's workload. This outer loop design is also based on a set of equivalent LTI plant models. This is accomplished by modeling the pilot parameters that result in good handling qualities ratings, and developing the necessary compensation to force the desired system responses. GRA

N91-20135# Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.
INITIAL REVIEW OF RESEARCH INTO THE APPLICATION OF MODIFIED STEPWISE REGRESSION FOR THE ESTIMATION OF AIRCRAFT STABILITY AND CONTROL PROCEDURES Quarterly Report No. 1
M. V. COOK and H. A. HINDS Jan. 1989 33 p
(CRANFIELD-AERO-8903; ISBN-1-871564-05-0; ETN-91-99010) Avail: NTIS HC/MF A03; Cranfield Inst. of Technology, Coll. of Aeronautics, Cranfield, Bedford MK43 0AL, England, HC 8 sterling pounds

Research on applying Modified Stepwise Regression (MSR) to a simple four degrees of freedom model to confirm the method for the estimation of aircraft stability and control parameters for complex models is reported. The MSR technique and an example of its application, where a data set was created using a fourth order Runge-Kutta integration computer program with a stepsize of 0.0001, are summarized. The wind tunnel, model suspension system, electronic control unit, aircraft model and data analysis of the High Incidence Research Model (HIRM) are outlined. Theoretical development objectives of MSR theory for parameter estimation, data processing algorithms and a mathematical model of the dynamic wind tunnel model aircraft are described. Equations describing longitudinal and lateral motion of an aircraft are considered. An assessment of the research stage and short term goals is given. ESA

N91-20136# Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.
MEASUREMENT OF THE LONGITUDINAL STATIC STABILITY AND THE MOMENTS OF INERTIA OF A 1/12TH SCALE MODEL OF A B.AE HAWK Quarterly Report No. 6
H. A. HINDS and M. V. COOK May 1990 61 p
(CRANFIELD-AERO-9009; ISBN-1-871564-07-7; ETN-91-99015) Avail: NTIS HC/MF A04; Cranfield Inst. of Technology, Coll. of Aeronautics, Cranfield, Bedford MK43 0AL, England, HC 8 sterling pounds

As part of a program to investigate the use of a Modified Stepwise Regression (MSR) procedure to estimate the stability and control parameters of a small British Aerospace Hawk aircraft model flown in a dynamic wind tunnel facility, work carried out on the Hawk model and dynamic rig facility is reported. Measurement of the model moments of inertia is described. Details of the analysis of the longitudinal stability of the model are presented. Various scaling laws are reviewed and some full scale and model Hawk parameters are given. A BASIC program to convert recorded data to the ASCII format required by the MSR program, which includes a numerical method to generate attitude angle rate data by the numerical differentiation of specified channels, is presented. The progress made with their data acquisition system is described. ESA

N91-20137# Cranfield Inst. of Tech., Bedford (England). Coll. of Aeronautics.
STEADY-STATE EXPERIMENTS FOR MEASUREMENTS OF AERODYNAMIC STABILITY DERIVATIVES OF A HIGH INCIDENCE RESEARCH MODEL USING THE COLLEGE OF AERONAUTICS WHIRLING ARM
M. J. M. MULKENS and A. O. ORMEROD Aug. 1990 118 p
(CRANFIELD-AERO-9014; ISBN-1-871564-11-5; ETN-91-99017)

Avail: NTIS HC/MF A06; Cranfield Inst. of Technology, Coll. of Aeronautics, Cranfield, Bedford MK43 OAL, England, HC 10 sterling pounds

Work for a high incidence research project is presented. Measurements of the effects of steady pitching and yawing on HIRM (High Incidence Research Model) 1 and 2 are described. The development of the (internal) strain gauge balance and models used in these tests is described. Additional work, not reported, involved transient experiments using the whirling arm. The specially designed model and balance system were mounted on the whirling arm rig, as used for other projects. The signals coming from the balance were measured and processed, deriving the three moments, side and normal force acting on the model. Further processing by computer programs provided the aerodynamic coefficients and stability derivatives. A five hole nose probe mounted on the model was used in some tests, to give improved data on angle of attack and dynamic pressure. Geometric incidence information was obtained from a linear transducer linked to the incidence changing mechanism. ESA

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RESEARCH AND SUPPORT FACILITIES (AIR)

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

A91-29026#
BEHIND THE SECRETS OF WIND TUNNEL TECHNOLOGY - THE MOST PROMINENT AIRCRAFT OF EUROPE UNDERGO INITIAL FLIGHT TESTING IN THE DA LOW-SPEED TUNNEL
New-Tech News (ISSN 0935-2694), no. 4, 1990, p. 17-19.
Copyright

The development of wind-tunnel testing, the evolution of wind-tunnel technology, and its benefits are outlined. The Deutsche Airbus wind tunnel in Bremen, Germany is described, and attention is focused on some airflow-physics related issues resolved at the facility, including the prevention of engine damage caused by ice particles on the engine's compressor blades during flights in freezing-weather conditions. Emphasis is placed on the development and production of strain-gage wind-tunnel balances, the use of a turbine-powered simulator, and the investigation of perceptible vibrations in the cabin interior under certain flight conditions. V.T.

A91-29400#
AERODYNAMIC/COMBUSTION TESTS IN HIGH SPEED DUCT FLOWS AT UNIVERSITY KOMABA FACILITY
TOSHIO NAGASHIMA, MICHIKATA KONO, MASARU HIRATA, and YOSHIMICHI TANIDA (Tokyo, University, Japan) Tokyo, University, Faculty of Engineering, Journal, Series B (ISSN 0563-7937), vol. 40, Sept. 1990, p. 283-293.

An overview is presented of aerodynamic/combustion experiments being carried out in a high-speed wind tunnel at the Research Center for Advanced Science and Technology (RCAST) at the Komaba campus of the University of Tokyo. A description of the facility is presented, along with a brief overview of the joint research in progress between the Department of Aeronautics and RCAST which is related to basic studies on combustion and aerodynamic aspects in ramjet and scramjet propulsion for advanced transatmospheric vehicles. Experimental results are presented to show the effects of transverse He/N2 gas injection across parallel side walls upon Mach 1.8 supersonic airflows in a rectangular duct test section. Some of the complex interaction flow features between the injected gas layer and the induced shock waves are presented from observations made by schlieren photographs and from the static pressure distribution along the side walls of the duct. S.A.V.

A91-30998#
ROBOTIC AIRCRAFT REFUELING - A CONCEPT DEMONSTRATION
M. B. LEAHY, JR., V. W. MILHOLEN, and R. SHIPMAN (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1145-1150. USAF-sponsored research. refs

A testbed has been developed to support experimental evaluation of the enabling technologies necessary for autonomous refueling. The goal of the refueling research project was to demonstrate the component technologies for a robotic-refueling concept. The project was divided into two areas: visual servoing and compliant control. The research accomplishments that lead to a successful concept demonstration are described. The refueling testbed is outlined. Visual servoing research is reviewed. Implementation and analysis of compliant control of the nozzle is presented. Research directions are discussed. Initial evaluations have successfully demonstrated algorithms for port detection, visual servoing, and compliant control of nozzle motion and insertion. I.E.

A91-31016#
INTEGRATED LABORATORY 'REAL-TIME INTERACTIVE COMMUNICATIONS SIMULATION'
DANA L. HOWELL (USAF, Avionics Laboratory, Wright-Patterson AFB, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1254-1258.

The avionics laboratory at Wright-Patterson Air Force Base, OH is developing the capability to perform research and development (R&D) test and evaluation (T&E) of advanced avionics technologies. The integrated electromagnetic system simulator (IESS), integrated test bed (ITB), and the integrated defensive avionics laboratory (IDAL) are key avionics laboratory facilities that enable development of these capabilities. IESS supports R&D/T&E of integrated communication, navigation, identification (CNI) systems. ITB supports R&D/T&E of advanced avionics architectures. IDAL supports R&D/T&E of advanced electronic warfare (EW) electronic countermeasures (ECM) technologies. The integration of these facilities to provide a realistic, interactive communications simulation that produces real, dynamic, radio frequency signals to evaluate approaching integrated avionics technologies including integrated communication, navigation, identification avionics (ICNIA), PAVE PILLAR, PAVE PACE, and integrated electronic warfare system (INEWS) is described. I.E.

A91-31285
T800 ENGINE TEST FACILITIES OF THE GARRETT ENGINE DIVISION - A DIVISION OF THE ALLIED-SIGNAL AEROSPACE COMPANY
MARK A. CAMPOLO, KENT S. HURST, PETE LEONARD, and GLEN B. LOCKWOOD (Allied-Signal Aerospace Co., Propulsion Engines Laboratory, Phoenix, AZ) IN: Innovations in rotorcraft test technology for the 90's; Proceedings of the AHS National Technical Specialists' Meeting, Scottsdale, AZ, Oct. 8-12, 1990. Alexandria, VA, American Helicopter Society, Inc., 1990, 8 p.
Copyright

This paper describes the new facility designed and built to hold two T800 base-level test cells, an inspection area, an assembly area, and a support area for the test engineers supporting the program. Details of the facility are provided for the base level cells, specialized test platforms, test facilities and equipment, and the data collection and monitoring systems. Specific tests to be conducted encompass performance, endurance, mechanical, environmental and ingestion tests, and altitude tests. R.E.P.

A91-31293
FACILITY FOR HELICOPTER CONTROL SYSTEMS DEVELOPMENT
JIM BLAETZ (McDonnell Douglas Helicopter Co., Mesa, AZ) IN:

Innovations in rotorcraft test technology for the 90's; Proceedings of the AHS National Technical Specialists' Meeting, Scottsdale, AZ, Oct. 8-12, 1990. Alexandria, VA, American Helicopter Society, Inc., 1990, 6 p.
Copyright

This paper describes a helicopter flight controls laboratory test facility that will be capable of open and closed loop testing, and utilized for the development, integration and qualification of helicopter flight controls. A functional mockup steel structure holds the rotorcraft controls and hydraulic power systems in their proper XYZ coordinates and permits easy access for testing. Data are recorded utilizing a pulse code modulated system similar to the flight test data system. The facility can accomplish a wide range of testing from single components to a completely new system while providing a safe, well instrumented environment to develop and qualify flight control systems. R.E.P.

A91-31306* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HIGH-SPEED QUIET TUNNELS
IVAN E. BECKWITH (NASA, Langley Research Center, Hampton, VA) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 1. New York, Springer-Verlag, 1990, p. 49-51.
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The adverse effect of wind-tunnel noise on boundary-layer transition is considered, and the development of Pilot Quiet Tunnels exhibiting low noise levels in upstream regions of the test rhombus to high values of the stream unit Reynolds number is covered. Advances in quiet nozzle and tunnel designs are discussed, including a new Mach-8 nozzle and modifications to an existing conical nozzle in one of the helium tunnels at NASA Langley. Attention is focused on the final engineering design of a large-scale high-speed low-disturbance tunnel expected to accommodate nozzles of various lengths with Mach numbers ranging from 2 to 6. V.T.

A91-31309
DOMINANCE OF 'NOISE' ON BOUNDARY LAYER TRANSITION IN CONVENTIONAL WIND TUNNELS - A PLACE FOR THE 'QUIET' BALLISTIC RANGE IN FUTURE STUDIES
SAMUEL R. PATE (Sverdrup Technology, Inc., Tullahoma, TN) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 1. New York, Springer-Verlag, 1990, p. 77-87.
Copyright

Selected boundary-layer-transition experimental studies are reviewed, along with the major contributions from 1905 to 1988 that have led to significant advances in boundary-layer-transition predictions. The development process is divided into four major phases: the beginning era (1905-1930), basic growth era (1930-1960), advanced era (1960-1990), and future phase. It is concluded that in order to generate new and meaningful data in the future, boundary-layer stability and transition data should be generated in disturbance-free environments. Out of several options, ballistic ranges are shown to offer such desirable features as the ability to generate a wide range of Mach numbers, unit Reynolds numbers, and temperature ratios in a noise-free test environment. V.T.

A91-31315* Cambridge Univ. (England).
THE ROLE OF THE LOW-SPEED WIND TUNNEL IN TRANSITION RESEARCH
MICHAEL GASTER (Cambridge, University, England) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 1. New York, Springer-Verlag, 1990, p. 150-152.
(Contract NAS1-18605)
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The study addresses the present transition research directed to the prediction of transition on the wings of modern transonic aircraft and concentrates on the stability of the types of boundary layers that arise on real swept wings in compressible flow. The need to perform experiments to get better insights into such aspects of transition as receptivity, types of nonlinear interaction, development of irregular chaotic motion, and the final breakdown stage is emphasized. The use of low-speed wind tunnel is discussed, and focus is placed on control, surface quality, and instrumentation. V.T.

A91-32274
CALCULATION OF SUPPORT INTERFERENCES ON THE AERODYNAMIC COEFFICIENTS FOR A WINDTUNNEL CALIBRATION MODEL
D. STEINBACH (DLR, Institut fuer Theoretische Stroemungsmechanik, Goettingen, Federal Republic of Germany) Aeronautical Journal (ISSN 0001-9240), vol. 95, Feb. 1991, p. 55-63. refs
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An AGARD calibration model has been tested in the subsonic cryogenic windtunnel (KKK) of DLR Koeln. Model support interferences are calculated in the form of corrections to the aerodynamic coefficients. Two different model support systems are investigated: a model mounted on a horizontal sting, and a model mounted on a vertical sting. Since for these configurations earlier experiments already exist, the corrections obtained are applied to these measurements for further verification. Furthermore, sting effects on the longitudinal static stability of the model are investigated in more detail. A three-dimensional-panel method is used which allows simultaneous calculation of several displacing and lifting bodies of nearly arbitrary shapes in the flow. The aerodynamic coefficients are obtained by numerical integration of the surface pressure distribution on the model. Author

N91-19035*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
FLIGHT SIMULATION FOR WIND SHEAR ENCOUNTER
SANDEEP S. MULGUND *In* NASA, Langley Research Center, Joint University Program for Air Transportation Research, 1989-1990 p 133-139 Dec. 1990
Avail: NTIS HC/MF A09 CSCL 14B

A real-time piloted flight simulator is under development in the Laboratory for Control and Automation at Princeton University. This facility will be used to study piloted flight through a simulated wind shear. It will also provide a testbed for real-time flight guidance laws. The hardware configuration and aerodynamic model used are discussed. The microburst model to be incorporated into the simulation is introduced, and some proposed cockpit display concepts are described. Author

N91-19102# Surface Dynamics, Inc., Bloomfield Hills, MI.
SMOOTHNESS CRITERIA FOR RUNWAY REHABILITATION AND OVERLAYS Final Report
ELSON B. SPANGLER, ANTHONY G. GERARDI, and DONALD R. YAGER Jul. 1990 174 p
(Contract DTFA01-86-C-00035)
(DOT/FAA/RD-90/23) Avail: NTIS HC/MF A08

Modern aircraft, due to their large size, structural flexibility, and higher take-off and landing speeds, can be excited into a resonant condition by runway profile roughness. Forces generated by the interaction of the aircraft and the runway can produce poor aircraft ride quality, and cause damaging stresses both in the aircraft structure and the runway pavement itself. Wavelength components in the runway profile that cause aircraft resonance often are difficult to identify, isolate, and repair. Advancements in high speed profile measuring systems and the development of a computer simulation of an aircraft responding to the measured runway profile have now provided the ability to identify runway elevation profile features contributing to poor aircraft ride quality. The research effort evaluates the measuring capability of one high speed profile measuring system, evaluates the methods of analysis developed in the project, and applies the measuring and analysis methods to the rehabilitation of a General Aviation Airport runway. Author

N91-19106# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Abt. Forschung und Entwicklung.
AIRPORT APRON RESEARCH AND DEVELOPMENT [FLUGHAFENVORFELD FORSCHUNG UND ENTWICKLUNG]
1990 256 p In GERMAN Presented at Expertengespraech, Bad Toelz, Fed. Republic of Germany, 4-6 Apr. 1990
(MBB-Z-0168-90-PUB; OTN-027673; ISSN-0931-9757; ETN-91-98836) Copyright Avail: NTIS HC/MF A12

Discussions were centered on aircraft ground interface and airport aircraft interface. Subjects covered were safety and control in airports, technical aspects of airport activities, simulation of air traffic, existing difficulties and how to solve them, and infrastructure problems. Scenarios were presented to draw the attention of public authorities to the present and future dramatic changes of apron conditions.

N91-19107# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Zentralbereich Technik.
AIRPORT SYSTEM TECHNICAL ASPECTS [SYSTEMTECHNISCHE ASPEKTE ZUM FLUGHAFEN]
G. BAUER *In its* Airport Apron Research and Develoment p 15-26 1990 In GERMAN
Copyright Avail: NTIS HC/MF A12

The airport system is examined from the passenger point of view. The various activities such as aircraft maintenance, cleaning, energy supply, customs, ground control and safety are examined. Increasing touristic activities and environment problems are also considered. The increasing delays and environmental pollution show that changes and improvements are necessary. ESA

N91-19108# Airbus Industrie, Blagnac (France). Entwicklung.
AIRCRAFTS, REQUIREMENTS FOR GROUND INSTALLATIONS FROM THE AIRCRAFT POINT OF VIEW [FLUGZEUGE, ANFORDERUNGEN VON SEITEN DES FLUGZEUGES AN DIE BODENINSTALLATIONEN]
SCHMITT *In* MBB, Airport Apron Research and Development p 27-64 1990 In GERMAN
Copyright Avail: NTIS HC/MF A12

The market development, servicing, taxiing, starting runways, noise emission and data communication are examined. The air transport system, passenger kilometer growth rate, trips per inhabitants of selected countries in relation to economic development, frequency limited airports, slot allocation, jet aircraft, fleet status to the year 2006, typical life cycle of a civil aircraft program, fuel price, A320 servicing, towing and taxiing, airport noise, objectives of airbus industry are tabulated or illustrated. ESA

N91-19109# Deutsche Lufthansa A.G., Hamburg (Germany, F.R.). Management Engineering.
AIRCRAFT STANDSTILL, REQUIREMENTS FOR GROUND HANDLING FROM THE POINT OF VIEW OF AIRCRAFT OPERATION [FLUGZEUGHALTER, ANFORDERUNGEN AN DAS HANDLING AM BODEN AUS DER SICHT DES FLUGBETRIEBES]
L. KILCHERT *In* MBB, Airport Apron Research and Development p 65-90 1990 In GERMAN
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The taxi system is described. The problems are stated: landing conditions, position determination on the runway, transfer from runway to taxiway, position determination on taxiway, use of hybrid sensors, Global Positioning System (GPS). GPS is to be integrated into the cockpit of Boeing aircrafts. ESA

N91-19110# Deutsche Airbus G.m.b.H., Hamburg (Germany, F.R.).
AIR TRAFFIC SIMULATION WITH A VIEW TO SYSTEM INTERPRETATION [SIMULATION DES LUFTVERKEHRS IM SINNE DER SYSTEMAUSLEGUNG]
J. SCHUMACHER *In* MBB, Airport Apron Research and Development p 91-120 1990 In GERMAN
Copyright Avail: NTIS HC/MF A12

The necessity of the simulation of the general air traffic system is underlined. Influences of economy, energy and environment are underlined. The system requirements for worldwide 21st century air transportation are determined. The impact of aircraft design on airports and airspace is stated. Its consequences on airspace utilization, airspace capacity, runway capacity, apron terminal size, payload handling, and ground maneuverability are addressed. ESA

N91-19111# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
AN EXPERIMENTAL STUDY OF A STING-MOUNTED SINGLE-SLOT CIRCULATION CONTROL WING M.S. Thesis
MICHAEL E. PELLETIER Dec. 1990 75 p
(AD-A229867; AFIT/GAE/ENY/90D-18) Avail: NTIS HC/MF A04 CSCL 01/1

This wind tunnel study investigated the feasibility of using a sting and force balance to measure the aerodynamic forces and moments on a circulation control wing. A 20 percent thick, 8.5 percent camber, single blowing slot, rectangular wing was designed, built, and tested in the Air Force Institute of Technology (AFIT) 5-ft wind tunnel. Lift and drag coefficients were referenced to the stability axis. The Reynolds number for all tests was 950,000; angle of attack was varied from -6 to +6 degrees. Trends in the data were similar to two dimensional data, with the exception of high drag coefficients with increased blowing. Results show it is feasible to test three dimensional wings using a sting and force balance if appropriate data corrections are applied. GRA

N91-20121*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
RECENT ADVANCES IN LEWIS AEROPROPULSION FACILITIES
FRANK J. KUTINA, JR. *In its* Aeropropulsion 1991 12 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 14/2

Guided by the aeropropulsion strategic plan, Lewis Research Center was systematically refurbishing and upgrading its aeropropulsion facilities through a combination of research and development and construction of facilities funding. Currently, much of the work is accomplished as a part of the NASA Aeronautical Facility Revitalization Program. The total effort is addressing issues of improved flight simulation, improved productivity, capability to support advanced aeropropulsion systems, increased computational capability, and recertification. An overview of the changes brought about by this effort is presented. Author

N91-20144# National Aerospace Lab., Tokyo (Japan).
INVESTIGATION OF ATP BLADES, PART 1
M. SATO, H. KANDA, N. SUDANI, Y. OGUNI, S. BABA, H. MIWA, I. KAWAMOTO, H. SHOJI, K. OTAKE, Y. ICHIKAWA et al. Nov. 1989 51 p In JAPANESE; ENGLISH summary
(DE91-750103; NAL-TM-615) Avail: NTIS HC/MF A04

This is a description of 2-D transonic wind tunnel used for the present test and devices for measuring stresses exerted on the test airfoils of NACA16-202 type and NACA16-204 type, in addition to a method for processing data obtained by wind tunnel test. The test airfoil of NACA16-202 type is put to vibration test. Vibration modes obtained by this test are compared with those calculated by use of a certain Finite Element Method Model. A preliminary test is made to examine stresses exerted on the airfoils under various aerodynamic conditions. The wind tunnel test is applied to the airfoils, holding Reynolds number at 8 x 10(exp 4), and varying Mach number and angles of attack from 0.6 to 1.0 and from -10 to 16 degs, respectively. Aerodynamic characteristics of the above airfoils, which are obtained by the test, are given in detail as a series of diagrams presenting each of the relations between the following pairs of quantities; C (sub l) and alpha c, C (sub d) and C (sub l), C (sub m) and C (sub l), C (sub l)/C (sub d) and C (sub l), C (sub l) and M with constant alpha, C (sub d) and M with constant C (sub l), C (sub d) and M with constant alpha, C (sub m) and M with constant C (sub l), and C (sub m) and M with constant alpha. Here C (sub l), C (sub m), C (sub d), M, alpha and alpha c denote lift coefficient, pitching moment, drag coefficient, Mach number, angle of attack and corrected angle of attack, respectively. DOE

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ASTRONAUTICS

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

A91-30159* Virginia Polytechnic Inst. and State Univ., Blacksburg.
A SINGULAR PERTURBATION APPROACH TO PITCH-LOOP DESIGN
EUGENE M. CLIFF (Virginia Polytechnic Institute and State University, Blacksburg) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1819-1823.
(Contract NAG1-946)
Copyright

It is shown that it is possible to construct a controller for the inner loop which is consistent with the performance index used in shaping the trajectory. Although the complete analysis has been carried out only for a model without an RCS, the resulting pitch-loop control is of interest. The gains depend on the system only through the parameter Omega and do not depend on the outer performance index in any way. I.E.

A91-30161* Princeton Univ., NJ.
AEROSPACE PLANE GUIDANCE USING GEOMETRIC CONTROL THEORY
MARK A. VAN BUREN and KENNETH D. MEASE (Princeton University, NJ) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1829-1838. refs
(Contract NAG1-907)
Copyright

A reduced-order method employing decomposition, based on time-scale separation, of the 4-D state space in a 2-D slow manifold and a family of 2-D fast manifolds is shown to provide an excellent approximation to the full-order minimum-fuel ascent trajectory. Near-optimal guidance is obtained by tracking the reduced-order trajectory. The tracking problem is solved as regulation problems on the family of fast manifolds, using the exact linearization methodology from nonlinear geometric control theory. The validity of the overall guidance approach is indicated by simulation. I.E.

A91-30903
COMPLEX ENVIRONMENT GENERATION FOR INTEGRATED CNI TERMINALS
R. BRUCE MARCUM, GREGORY D. SMITH, and FRED B. ZEHRING (TRW, Inc., Military Electronics and Avionics Div., Dayton, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 430-433.
Copyright

Large-scale test facilities produced by TRW Military Electronics and Avionics Division for support of various integrated communication, navigation, and identification (CNI) avionics terminals now under development are described. The two most recent versions of the CNI support facility represent a substantial capital investment in modular avionics technology, as well as an important advancement in real-time test, evaluation, and demonstration capability. The facilities enable the generation of a complex stimulus environment to fully stress and evaluate terminals under test, and offer the advantages of a controllable, repeatable test scenario as a practical adjunct to flight testing. An overview is given of the test facilities, including their purpose, features, and usage. The functions, subsystems, and interfaces are then described. Finally, the operating modes of the system are briefly discussed. I.E.

A91-31750
NASP AS AN AMERICAN ORPHAN - BUREAUCRATIC POLITICS AND THE DEVELOPMENT OF HYPERSONIC FLIGHT
JOAN JOHNSON-FREESE and ROGER HANDBERG (Central Florida, University, Orlando, FL) Spaceflight (ISSN 0038-6340), vol. 33, April 1991, p. 134-137. refs
Copyright

The development of the NASP program is summarized and the current politics associated with the hypersonic program are reviewed. It is noted that the two agencies most likely to sponsor the NASP program, NASA and DOD, are reluctant to sponsor any expensive research and development program in a constrained fiscal environment. For this reason, it is argued that the continued existence of the NASP program is contingent upon winning the support of the military, particularly the Air Force. Significant applications of a hypersonic airplane with sustained cruise capability between Mach 5 and 14 are given. These include a hypersonic plane to carry out interdiction, reconnaissance, surveillance, and precision targeting and weapons guidance missions; a hypersonic bomber for strategic bombing operations; and a hypersonic transport for strategic airlift missions. It is noted that, according to NASP program officials, an aerospace plane deployed at just six bases around the world could deploy anywhere in 45 minutes or less. L.K.S.

A91-31775#
PEAK VALUES [SPITZENWERTE]
MICHAEL K. E. HAUGER Flug Revue/Flugwelt International (ISSN 0015-4547), April 1991, p. 70-74. In German.

Progress being made in the Saenger project development of an aircraft able to fly in outer space is discussed. The results of wind tunnel simulations on the Hypersonic Technology Experiment (HYTEX) aircraft are shown and described. Cooperative efforts with Sweden are reviewed. C.D.

N91-19115*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AUTOMATIC CONTROL STUDY OF THE ICING RESEARCH TUNNEL REFRIGERATION SYSTEM
ARTHUR W. KIEFFER and RONALD H. SOEDER Washington Feb. 1991 27 p
(NASA-TM-4257; E-5588; NAS 1.15:4257) Avail: NTIS HC/MF A03 CSCL 13/2

The Icing Research Tunnel (IRT) at the NASA Lewis Research Center is a subsonic, closed-return atmospheric tunnel. The tunnel includes a heat exchanger and a refrigeration plant to achieve the desired air temperature and a spray system to generate the type of icing conditions that would be encountered by aircraft. At the present time, the tunnel air temperature is controlled by manual adjustment of freon refrigerant flow control valves. An upgrade of this facility calls for these control valves to be adjusted by an automatic controller. The digital computer simulation of the IRT refrigeration plant and the automatic controller that was used in the simulation are discussed. Author

N91-19124# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.
SPACE VEHICLE FLIGHT MECHANICS
N. X. VINH (Michigan Univ., Ann Arbor.) Nov. 1990 16 p
Symposium held in Luxembourg, 13-16 Nov. 1989
(AGARD-AR-294; ISBN-92-835-0570-0; AD-A230434) Copyright

Avail: NTIS HC/MF A03; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

In recent years, manned flights into low earth orbits were made both for scientific study and for the placement of unmanned satellites into geosynchronous orbits and also into interplanetary orbits. Efforts of many nations are currently under way to place man into orbit on a semipermanent basis through the use of a space station. At the same time, the aerospace industry worldwide is considering the extension from supersonic flight of advanced fighter aircraft to the hypersonic flight of a future aerospace plane. To meet the challenges of the many technical problems to be solved in this new area, the flight mechanics of vehicles in space and in the upper layer of the atmosphere are identified and the areas of technology relevant to the Flight Mechanics Panel are identified. Author

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CHEMISTRY AND MATERIALS

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

A91-29044#

FIRE RULE CHANGES AIRCRAFT MATERIALS MIX

ALAN S. BROWN Aerospace America (ISSN 0740-722X), vol. 29, March 1991, p. 20-24.

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An overview is presented of recent and ongoing FAA rules and regulations mandating low-heat and low-smoke release materials, and the resulting economic impact of these changes to the airline industry. The combination of heat and smaoke release limits have reduced or eliminated the utilization of such aircraft interior standbys as polycarbonate, reinforced epoxy, and even conventional phenolic resins. A typical cabin interior aircraft panel now costs aircraft builders at least $35/sq ft versus $16.50/sq ft before the new regulations took effect. Processing accounts for a much larger share of the total part cost than the raw material itself, and the processing of thermosets such as phenolic laminates is both time-consuming and labor-intensive. The FAA has nine active projects that could lead to further alterations in the materials permitted in commercial aircraft over the next ten years. Investigation of more active systems is planned, such as a fire-advisory system that utilizes computers and sensors to help aircrews assess fire severity, and a fine interior misting system to water down the cabin after a crash. R.E.P.

A91-29459

CORROSION RESISTANT MAGNESIUM ALLOYS

GORDON A. FOWLER, JOHN F. KING, and PAUL LYON (Magnesium Elektron, Ltd., Swinton, England) IN: Rotary Wing Propulsion Specialists' Meeting, Williamsburg, VA, Nov. 13-15, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 11 p. refs

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Data are presented on two developed alloys: AZ91E, which is suitable for prolonged use at temperatures up to 240 F, and WE43, a high-strength alloy with long-term stability up to 480 F. Surface protection schemes are described that have been developed to supplement the intrinsic corrosion resistance of these alloys. Continuing development work on RST magnesium alloys is reviewed to show that magnesium based alloy materials with even greater corrosion resistance may become available. R.E.P.

A91-29940

EFFECT OF THE SEPARATION ZONE LENGTH ON THE COMPLETENESS OF COMBUSTION IN SUPERSONIC FLOW [VLIIANIE DLINY OTRYVNOI ZONY NA POLNOTU SGORANIIA V SVERKHZVUKOVOM POTOKE]

V. L. KRAINEV IN: Molecular gas dynamics and the mechanics of inhomogeneous media. Moscow, Izdatel'stvo Nauka, 1990, p. 196-199. In Russian.

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The effect of the separation zone length on hydrogen combustion stabilized by the front separation zone ahead of a blunt body with a needle was investigated experimentally in a wind tunnel at M = 2. The model had the shape of a 30-mm-diameter cylinder with a stainless steel needle (external diameter, 6mm; internal diameter, 4 mm) along the cylinder axis for hydrogen injection in the direction opposite to the incoming flow; a solid fuel charge was used to ignite the hydrogen. Diagrams are presented which relate the completeness of hydrogen combustion in the separation zone to the hydrogen flow rate. V.L.

A91-29941

FLOW GAS DYNAMICS DURING THE MIXING AND COMBUSTION OF SUPERSONIC FLOWS [GAZODINAMIKA TECHENIIA PRI SMESHENII I GORENII SVERKHZVUKOVYKH POTOKOV]

V. A. ZABAIKIN IN: Molecular gas dynamics and the mechanics of inhomogeneous media. Moscow, Izdatel'stvo Nauka, 1990, p. 212-215. In Russian.

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The effect of the gasdynamic flow structure on hydrogen combustion was investigated experimentally, with an opto-mechanical scanner used to monitor the OH radical, one of the intermediate products of hydrogen oxidation. It is shown that, in jet flows, the completeness of hydrogen combustion is largely determined by compression shocks and rarefaction waves. The effect of the discrete change of hydrogen ignition sites, which is possible in supersonic flows only, has been observed. V.L.

A91-30004#

HIGH TEMPERATURE KINETICS OF SOLID BORON GASIFICATION BY B2O3(G) - CHEMICAL PROPULSION IMPLICATIONS

R. ZVULONI, A. GOMEZ, and D. E. ROSNER (Yale University, New Haven, CT) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Jan.-Feb. 1991, p. 9-13. refs

(Contract AF-AFOSR-84-0034; AF-AFOSR-89-0223)

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New flow reactor measurements are reported of the intrinsic kinetics of the gasification of solid boron by each of these important vapors: $B_2O_3(g)$, $O_2(g)$, $CO_2(g)$, and $H_2O(g)$ at surface temperatures between 1330 and 2050 K. For illustrative purposes, data for the remarkably efficient $B_2O_3(g)/B(s)$ reaction and the $O_2(g)/B(s)$ reaction are used to discuss the expected sequence of rate-controlling processes for the combustion of individual B(s) particles in air under typical ramjet conditions. A diagram of (log-) particle diameter vs (log-) chamber pressure is shown to be particularly useful for this purpose, as well as to display the onset of noncontinuum behavior and the locus of expected particle extinction due to passivation associated with the kinetically controlled onset of condensed B_2O_3 on the gas/solid interface. Whereas most previous boron particle combustion and extinction laboratory experiments have been performed in the regime of gas-phase diffusion control, under conditions of actual ramjet interest the gas/solid kinetics for the efficient $B_2O_3(g)/B(s)$ reaction and the slower $O_2(g)/B(s)$ reaction, as well as noncontinuum transport effects, become rate-limiting. Author

A91-30008#

IGNITION AND COMBUSTION OF BORON PARTICLES IN THE FLOWFIELD OF A SOLID FUEL RAMJET

B. NATAN and A. GANY (Technion - Israel Institute of Technology, Haifa) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Jan.-Feb. 1991, p. 37-43. Previously cited in issue 20, p. 3192, Accession no. A87-45368. refs

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A91-30571
THE DEVELOPMENT OF IMPROVED AIRCRAFT PROTECTION SCHEMES
C. J. E. SMITH (Royal Aerospace Establishment, Materials and Structures Dept., Farnborough, England) IN: Aerospace corrosion control; Proceedings of the Symposium, Auchterarder, Scotland, Feb. 28-Mar. 2, 1989. London, Sawell Publications, Ltd., 1989, 12 p. refs
Copyright

The protection of military aircraft against corrosion and deterioration is reviewed with refrence to procedures currently employed in the United Kingdom. These procedures include pretreatments; sacrificial metal coatings; and paints for aluminum alloys, steels, and magnesium. The research currently conducted at the Royal Aerospace Establishment, aimed at developing more effective and environmentally acceptable protective schemes, is summarized. V.L.

A91-30728
COATINGS AGAINST CORROSION
ROGER BLACKFORD (ICI Aerospace and Defence Coatings, Slough, England) Aerospace Composites and Materials (ISSN 0954-5832), vol. 3, Mar.-Apr. 1991, p. 12-14.
Copyright

This paper addresses the part that paint has to play in the combination of measures designed to protect against corrosion, and what effects changes required by safety, health and environmental regulations may have. A commercial airliner fleet survey was found to have a high percentage of the internal metal surfaces initially adequately protected; following a combination of pretreatment, paint and supplementary temporary protective, within the terms of maintenance and manufacturing practices. Various examples of corrosion evolution are described, including intergranular corrosion, pitting and exfoliation and filiform corrosion. Consideration is given to the requirement for meaningful corrosion tests so that coatings manufacturers can develop their products. It is concluded that more emphasis should be given to intergranular corrosion testing for internal schemes, and the development of a more consistent salt-initiated filiform corrosion test for external schemes. R.E.P.

A91-31537#
TURBULENT COMBUSTION DATA ANALYSIS USING FRACTALS
WARREN C. STRAHLE (Georgia Institute of Technology, Atlanta) AIAA Journal (ISSN 0001-1452), vol. 29, March 1991, p. 409-417. refs
(Contract AF-AFOSR-88-0001)
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This paper investigates several types of data analysis, based upon fractal geometry concepts, using time series generated in turbulent combustion research. The techniques are quite general and may be used for other turbulent flows. Investigated are the generalized fractal dimension, multifractal probability density function, fractal filtration, multifractal spectrum, and fractal interpolation and its possible connection with chaotic dynamics. It is concluded that several of the techniques are useful for (1) new visual depiction of the data, (2) discrimination of portions of data traces as noise-contaminated, (3) separation of wanted and unwanted high- or low-frequency events, and (4) interpolation between sparse data points in either short run time or low data acquisition rate situations. Author

A91-31745* Pratt and Whitney Aircraft, East Hartford, CT.
CERAMIC THERMAL BARRIER COATINGS FOR COMMERCIAL GAS TURBINE ENGINES
SUSAN MANNING MEIER, DINESH K. GUPTA, and KEITH D. SHEFFLER (Pratt and Whitney Group, Materials Engineering Dept., East Hartford, CT) JOM (ISSN 1047-4838), vol. 43, March 1991, p. 50-53. refs
(Contract NAS3-23944; N00140-90-C-1846)
Copyright

The paper provides an overview of the short history, current status, and future prospects of ceramic thermal barrier coatings for gas turbine engines. Particular attention is given to plasma-sprayed and electron beam-physical vapor deposited yttria-stabilized (7 wt pct Y_2O_3) zirconia systems. Recent advances include improvements in the spallation life of thermal barrier coatings, improved bond coat composition and spraying techniques, and improved component design. The discussion also covers field experience, life prediction modeling, and future directions in ceramic coatings in relation to gas turbine engine design. V.L.

A91-31746
THE OXIDATION RESISTANCE OF MOSI2 COMPOSITES
E. W. LEE, J. COOK, A. KHAN, R. MAHAPATRA, and J. WALDMAN (U.S. Navy, Naval Air Development Center, Warminster, PA) JOM (ISSN 1047-4838), vol. 43, March 1991, p. 54-57. DARPA-supported research. refs
Copyright

Recent work at the Naval Air Development Center demonstrates that the oxidation resistance of $MoSi_2$ is not significantly reduced by XD compositing. The $MoSi_2$ + SiC material exhibited an oxidation resistance equal to or better than that of base $MoSi_2$. This excellent oxidation resistance, in conjunction with the enhanced high-temperature strength provided by XD particles, makes these materials highly attractive for use as future gas turbine engine materials. The problem of low room-temperature ductility and fracture toughness will be approached by incorporating other types of reinforcement phases. Author

A91-32138
MMCS VIA TITANIUM-ALUMINIDE FOILS
S. C. JHA, J. A. FORSTER, A. K. PANDEY, and R. G. DELAGI (Texas Instruments, Inc., Attleboro, MA) Advanced Materials and Processes (ISSN 0882-7958), vol. 139, April 1991, p. 87-90. refs
Copyright

Metal-matrix compounds (MMCs) based on matrix alloys of titanium-aluminide (Ti_3Al) intermetallic compounds reinforced by continuous silicon-carbide (SiC) fibers are the optimal choice for use in high temperature (above 700 C) applications, such as advanced aircraft turbine engines and airframes. These materials have high specific strengths and moduli, as well as improved high-temperature oxidation resistance, and offer a use temperature of over 810 C with the use of a high-temperature coating. Obstacles preventing production and fabrication exist however, such as poor room-temperature ductility of Ti_3Al compounds due to their ordered crystal structure. Currently, alloy modification is being used in an attempt to overcome these obstacles and processes are under development to produce MMCs based on these materials by taking advantage of their enhanced ductility. The use of cold-rolled titanium-aluminide foils to produce MMCs and honeycomb structure is discussed as a viable, cost-effective manufacturing process. L.K.S.

A91-32165#
THE EFFECT OF ACCELERATED AGING ON THE PERFORMANCE OF URETHANE COATED KEVLAR USED IN RAM AIR DECELERATORS
GAIL W. TUTT, ROBERT V. PHUNG, LOUIS A. VITA, ARTHUR J. FIORELLINI, and WALTER H. KOENIG (U.S. Army, Armament Research, Development, and Engineering Center, Dover, NJ) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 130-136. U.S. Army-supported research. refs
(AIAA PAPER 91-0847)

Ram air decelerators made from several types of polyurethane coated Kevlar were conditioned at elevated temperature and humidity over a sixteen week period. The conditioned decelerators were then subjected to both traditional and newly developed tests, and the results analyzed. Due to experimental limitations insufficient data was obtained for adequately predicting the long term performance of these materials. However, recommendations are made for future use of adhesion, blocking, hydrostatic resistance, hot inflation, and wind tunnel testing. Author

A91-32270
SELECTING MATERIALS FOR COMPLEX AIRCRAFT STRUCTURES
Aerospace Engineering (ISSN 0736-2536), vol. 11, April 1991, p. 15-17.
Copyright
The parameters affecting the validity of a design are outlined, and emphasis is placed on the capacity to sustain the required design loads, high temperatures, and exposure to liquids such as jet fuel, hydraulic oil, and antiicing fluid. The correlation between weight and load capability for any given part is stressed, along with production and operational costs. Selection of design requirements and goals is discussed, and this approach is illustrated by a case of selecting materials and processing methods for the design of several components incorporated into the fan duct/thrust reverser section of an engine nacelle. V.T.

N91-19241*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DEVELOPMENT OF A FATIGUE-LIFE METHODOLOGY FOR COMPOSITE STRUCTURES SUBJECTED TO OUT-OF-PLANE LOAD COMPONENTS
MARK SUMICH and KEITH T. KEDWARD (California Univ., Santa Barbara.) Feb. 1991 23 p
(NASA-TM-102885; A-91014; NAS 1.15:102885) Avail: NTIS HC/MF A03 CSCL 11/4
The efforts to identify and implement a fatigue life methodology applicable to demonstrate delamination failures for use in certifying composite rotor blades are presented. The RSRA/X-Wing vehicle was a proof-of-concept stopped rotor aircraft configuration which used rotor blades primarily constructed of laminated carbon fiber. Delamination of the main spar during ground testing demonstrated that significant interlaminar stresses were produced. Analysis confirmed the presence of out-of-plane load components. The wear out (residual strength) methodology and the requirements for its implementation are discussed. Author

N91-19245# Bristol Univ. (England). Dept. of Aerospace Engineering.
AN EXPERT SYSTEM FOR LAMINATED PLATE DESIGN USING COMPOSITE MATERIALS
J. P. H. WEBBER and S. K. MORTON Nov. 1989 39 p
Previously announced in IAA as A91-20334
(BU-406; ETN-91-98858) Avail: NTIS HC/MF A03
Fiber reinforced composite materials are introduced as suitable for aircraft design, and the need for computerizing the design process is explained. Following an exposition of the linear theory of composite laminated plates, a prototype expert system for the design of simple load carrying plates or panels is described. The automatic assessment of the relative merits of designs of different materials using uncertainty reasoning techniques is discussed. The semantics and logic calculus and inference of the artificial intelligence systems programming language FRIL are described. ESA

N91-19246# Bristol Univ. (England). Dept. of Aerospace Engineering.
MINIMUM WEIGHT OPTIMIZATION OF COMPOSITE LAMINATED STRUTS
C. M. L. WU and J. P. H. WEBBER Jan. 1990 55 p Sponsored by Science Research Council, England
(BU-409; ETN-91-98860) Avail: NTIS HC/MF A04
A formulation for minimum weight optimization for composite laminated struts is given. The minimum weight strut satisfies failure criterion of local buckling, overall buckling and maximum strain or maximum stress. Seven types of strut shapes, six composite materials and aluminum alloy are considered. The formulation requires the evaluation of the buckling coefficient for both ends with one side simply supported and one side free for composite laminated plates of high aspect ratio. The method of evaluation is given. A computer program OPTSTRUT for carrying out the optimization procedure is described. Examples of strut design are carried out using this program and compared with existing designs. It was found that these results compared well with those from past investigators. ESA

N91-20110*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ADVANCED HIGH TEMPERATURE ENGINE MATERIALS TECHNOLOGY PROGRAM
HUGH R. GRAY *In its* Aeropropulsion 1991 28 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 11/4
NASA's Advanced High Temperature Engine Materials Technology Program (HITEMP) is directed towards generating the technology for revolutionary advances in structural materials and analysis to enable the development of 21st century civil aeronautics propulsion systems. Major consideration is being given to propulsion systems that will be economical via reducing fuel consumption per passenger mile, reducing direct operating costs, extending life, and improving reliability. To achieve revolutionary advances in propulsion systems for 21st century transports, high temperatures materials have been identified as the key technology to be addressed. The HITEMP Program is focusing on lightweight composite materials to gain revolutionary advances in the operating temperatures of advanced engines compared to the current state of the art. Emphasis is placed on polymer matrix composites for potential use in fans, casings, and engine control systems. Intermetallic/metal matrix composites are under investigation for application in such areas as compressor and turbine disks, blades, and vanes and in the exhaust nozzle. For extremely high temperature applications, ceramic matrix composites are being explored. Initial applications may include liners for the combustor and exhaust nozzle, and turbine vanes and ultimately turbine blades and disks, or blisks. Author

N91-20271# Boeing Helicopter Co., Philadelphia, PA.
AIRCRAFT QUALITY HIGH TEMPERATURE VACUUM CARBURIZING Final Report, Apr. 1982 - Feb. 1990
R. J. CUNNINGHAM and R. J. DRAGO Nov. 1990 211 p
(Contract DAAG46-82-C-0034)
(AD-A229980; MTL-TR-90-42) Avail: NTIS HC/MF A10 CSCL 11/6
Development of a high temperature vacuum carburizing procedure for 9310 gear steel was accomplished during this program. Use of this procedure significantly reduced processing time of gears, which can lead to a reduction in acquisition costs. The procedure was utilized to process surface contact fatigue, single tooth bending fatigue, scoring, spur, and spiral bevel test gears. The data obtained from the testing and evaluation of these components was equal to or greater than similar data from conventionally carburized material. No significant variation in the vacuum carburized test data was observed from two mill heats of material. Following evaluation of these test gears, a spiral bevel input pinion gear was produced, vacuum carburized, and then tested in an actual helicopter transmission. Metallurgical evaluation of the tested gear showed that it met the same performance standards required of a conventionally carburized gear. In addition, a vacuum carburization procedure was investigated for the Vasco X2M alloy. Although a procedure for Vasco X2M was developed, it was not optimized. The data generated for this alloy is presented. GRA

N91-20319# Sievers Research, Inc., Boulder, CO.
A NEW INSTRUMENTAL TECHNIQUE FOR THE ANALYSIS OF HIGH ENERGY CONTENT FUELS Final Report, Apr. - Dec. 1986
RIC HUTTE Jul. 1990 29 p
(Contract F33615-86-C-2609)
(AD-A230130; WRDC-TR-89-2018) Avail: NTIS HC/MF A03 CSCL 21/4
This technical effort was directed at determining the feasibility of using the redox chemiluminescence detector (RCD) for the selective detection of cycloalkanes and antioxidants in jet fuels.

Three catalysts (gold, palladium, and platinum) were prepared and evaluated at several reaction temperatures. The gold catalyst at 300 C produced the best selectivity for cycloalkanes (40:1 for hexane and 3:1 for nonane). However, as temperature was increased, the selectivity for cycloalkanes decreased. The palladium and platinum catalysts did not demonstrate adequate selectivity under the examined test conditions. Overall, the metal catalysts examined in this study did not exhibit sufficient selectivity to permit detection of cycloalkanes versus acyclic alkanes. The selectivity of the RCD for easily oxidized compounds (e.g., phenols) versus hexane was typically 104 to 106. GRA

N91-20322# Sandia National Labs., Albuquerque, NM.
ADVANCED THERMALLY STABLE JET FUELS DEVELOPMENT PROGRAM ANNUAL REPORT. VOLUME 1: MODEL AND EXPERIMENT SYSTEM DEVELOPMENT Interim Report, Jun. 1989 - Jun. 1990
ELMER KLAVETTER, TIM OHERN, BILL MARSHALL, JR., RAY MERRILL, and GREG FRYE Sep. 1990 81 p
(Contract FY1455-89-N-0635)
(AD-A229692; WRDC-TR-90-2079-VOL-1) Avail: NTIS HC/MF A05 CSCL 21/4

Aviation turbine fuel thermal stability is of concern because of the potential operational problems arising from the degradation of fuels when used to cool aircraft components. Within this program, investigations are proceeding to develop candidate advanced thermally stable fuels, kinetic models of fuel degradation and to measure parameters for computational fluid dynamic models to predict the degradation of fuel under various conditions. This report summarized efforts in the first year of the program to identify specific processes and parameters involved in fuel thermal degradation and to develop diagnostic instrumentation and experiment apparatus that can be used to obtain data for model development. GRA

N91-20323# Pennsylvania State Univ., University Park. Dept. of Materials Science and Engineering.
ADVANCED THERMALLY STABLE JET FUELS DEVELOPMENT PROGRAM ANNUAL REPORT. VOLUME 2: COMPOSITIONAL FACTORS AFFECTING THERMAL DEGRADATION OF JET FUELS Interim Report, Jul. 1989 - Jun. 1990
SEMIH ESER, CHUNSHAN SONG, HAROLD SCHOBERT, PATRICK HATCHER, and RONALD COPENHAVER Sep. 1990 98 p
(Contract FY1455-89-N-0635)
(AD-A229693; WRDC-TR-90-2079-VOL-2) Avail: NTIS HC/MF A05 CSCL 21/4

Model hydrocarbon compounds and jet fuels derived from both petroleum and coal liquids were thermally stressed in microautoclave reactors at temperatures of 350 to 500 C. Regardless of starting material, alkylated benzenes, alkylated naphthalenes, biphenyls, and complex polycyclic aromatics are formed by this thermal stressing. The concentration of these intermediates depends on the starting material and the experimental conditions. The formation of solids is directly related to high concentrations of alkylbenzenes and polycyclic aromatics in the liquid phase. Solid products consist primarily of large polycyclic aromatics with varying aliphatic substitution and their composition depends on the compound and the thermal conditions. Analysis of the solids showed anisotropic structures consistent with pseudo-nematic liquid crystalline mesophase. From these experiments a preliminary ordering of compound stability based on structure has been established. GRA

12

ENGINEERING

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

A91-28401
AVIOPTICS - THE APPLICATION OF FIBER OPTICS IN A MILITARY AIRCRAFT
WILLIAM P. WALSH, JR. (Vitro Corp., Warminster, PA) Vitro Technical Journal, vol. 9, Winter 1991, p. 38-47. refs
Copyright

This paper focuses on current military work to develop fiber-optic standards and systems for enhancements to existing aircraft platforms and the implementation of state-of-the-art avionics and airborne sensor systems in next-generation fighters. Aircraft applications of fiber optics presently focus on the technology's ability to provide enhanced physical characteristics, greater bandwidth, and better channel integrity. The lighter weight and smaller size of fiber cables are a primary consideration for utilizing a fiber medium. The physical advantages of fiber versus wire cables include enhanced durability and flexibility of the fiber, while channel integrity is improved by a fiber's nonconductive composition. The application of fiber optics in an airborne stores management system is described which can be effectively implemented to demonstrate many aspects of fiber-optic technology in aircraft. R.E.P.

A91-28548#
STRESS ANALYSIS OF CENTRIFUGAL FAN IMPELLER BY FINITE ELEMENT METHOD
M. G. BHAT and D. V. BHOPE (Walchand College of Engineering, Sangli, India) Institution of Engineers (India), Journal, Mechanical Engineering Division (ISSN 0020-3408), vol. 70, March 1990, p. 111-113.
Copyright

Theoretical and the experimental methods do not provide satisfactory solutions to the problem of stress analysis of fan impellers. Hence, it is necessary to use finite element method. This paper describes the use of 18 direction-of-force triangular shell elements for the stress analysis of impellers. With this type of elements the impeller is treated as an integral unit. Stresses developed in the backsheet, conesheet, and blades only due to centrifugal loads have been discussed. Author

A91-28584
NUMERICAL SIMULATION OF UNSTEADY AEROELASTIC BEHAVIOR
B. DONG and D. T. MOOK (Virginia Polytechnic Institute and State University, Blacksburg) IN: *Developments in theoretical and* applied mechanics. Vol. 15 - Proceedings of the 15th Southeastern Conference on Theoretical and Applied Mechanics, Atlanta, GA, Mar. 22, 23, 1990. Atlanta, GA, Georgia Institute of Technology, 1990, p. 102-110. refs
(Contract AF-AFOSR-90-0032)
Copyright

A numerical model simulating the motion of a two-dimensional rigid airfoil mounted on a nonlinear elastic support is developed. The aerodynamic model for calculating loads acting on the airfoil is nonlinear, and the equations of motion are nonlinear. For the linear spring, the critical flutter velocity obtained here is close to the result of Fung. The static angle of attack influences the critical speed, amplitudes, and frequency spectra of the oscillations. The cubic term of a nonlinear moment spring can make the vertical motion larger and the rotary motion smaller. The results demonstrate the potential of the method. C.D.

A91-29033
ESTIMATING THE IMPORTANCE OF CYCLIC THERMAL LOADS IN THERMO-MECHANICAL FATIGUE
S. E. CUNNINGHAM and J. H. GRIFFIN (Carnegie-Mellon University, Pittsburgh, PA) International Journal of Fracture (ISSN 0376-9429), vol. 47, Feb. 1, 1991, p. 161-180. refs
(Contract AF-AFOSR-86-0142)
Copyright

A method for evaluating the effect of cyclic thermal loading on crack tip stress fields is developed. In its development, advantage is taken of the periodic nature of fatigue loading and only harmonic loadings are evaluated. Formulating the problem in this way permits the extraction of time as an explicit variable and replaces its role with a dependence of the frequency of the thermal loading. The means for evaluating the effect of periodic loadings on crack tip stress fields is the stress intensity factor which is calculated from numerically defined stress and displacement fields using a path independent integral. Results obtained indicate that stress intensity factors of cracked components exposed to thermal fatigue conditions have a significant dependence on the frequency of the thermal cycle and the crack geometry. Numerical estimates for mode I thermal stress intensity have been obtained using thermal fatigue test data for a titanium alloy and can be as high as 25 percent of the critical mode I mechanical stress intensity. Author

A91-29047#
PULTRUSION GETS A SECOND LOOK
ALAN S. BROWN Aerospace America (ISSN 0740-722X), vol. 29, March 1991, p. 36, 37.
Copyright

Innovative processes that improve properties and economics and extend the technique to thermoplastic composites in the fabrication of aerospace composites parts are enhancing the development of pultrusion technology. The technique is virtually automatic and excels at producing low-cost parts in high-volume runs that can be utilized without additional treating or forming, or they can be machined and drilled for more complex structures. Two new pultrusion techniques are under development, boosting advanced thermoplastic composite run speeds as high as 8 ft/min from mere inches and eliminating the prepregging step. As there is no limit on the width or length of a pultrusion, potential aerospace applications range from interior panels to wing and structural components. R.E.P.

A91-29048
QUALITY INDICATORS FOR MAGNETIC PARTICLE INSPECTION
DONALD J. HAGEMAIER (Douglas Aircraft Co., Long Beach, CA) Materials Evaluation (ISSN 0025-5327), vol. 49, March 1991, p. 346-350.
Copyright

A series of tests has been performed to determine shim sensitivity discrimination for circular and longitudinal magnetization by utilizing alternating current and full-wave rectified alternating current. These shims, called quantitative quality indicators (QQIs),are used most frequently during the development of test procedures, where they help indicate the relative strength and direction of a magnetic field for a particular part configuration. Test equipment and procedures are described in detail. The data evaluated are shown to verify the quantitative aspects of the flawed-shim QQIs. R.E.P.

A91-29124
THE FIBER-OPTIC HIGH-SPEED DATA BUS FOR A NEW GENERATION OF MILITARY AIRCRAFT
ROGER W. UHLHORN (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IEEE LCS Magazine (ISSN 1045-9235), vol. 2, Feb. 1991, p. 36-45. refs
Copyright

The avionic suite for the next generation of military aircraft is being designed with component and module commonality in mind in order to control recurring costs and capitalize on economy of scale. The backbone of the suite fashioned out of these modular building blocks is the fiber-optic bit-serial time-division multiplexed high-speed data bus (HSDB), operating at 50 Mb/s, which provides command and control communications among most of the aircraft subsystems and can be used to provide communications for a fly-by-light flight-control system or for the block transfer of data between mass memories and data processors. The fiber-optic HSDB is examined from the top down, beginning with an overview of the evolution of avionic architectures. A review is given of the standardization activity associated with development of the network, the protocols chosen to implement the desired communication functions, configuration options, and the fiber-optic components used in the bus interfaces or other active nodes of the network. It is believed that the utility of the bus extends beyond aircraft to spacecraft, ships, and land vehicles. I.E.

A91-29126
FAULT TOLERANT TOPOLOGIES FOR FIBER OPTIC NETWORKS AND COMPUTER INTERCONNECTS OPERATING IN THE SEVERE AVIONICS ENVIRONMENT
ANDREW S. GLISTA, JR. (U.S. Navy, Naval Air Systems Command, Washington, DC) IEEE LCS Magazine (ISSN 1045-9235), vol. 2, Feb. 1991, p. 66-78. refs
Copyright

The history of fiber optics technology development for naval aircraft is reviewed, and the current status of network and fly-by-light flight control development is examined. Fiber-optic component selection for aircraft is addressed, covering fiber and cables, optical sources, couplers, and connectors. Novel fault-tolerant network topologies for both analog and digital fiber optic transmission, which will permit both packet- and circuit-switched operation of robust fiber optic networks are discussed. The application of smart skin technology, i.e., fibers embedded in composite materials, to optical computer backplanes is briefly considered. I.E.

A91-29455* Boeing Helicopter Co., Philadelphia, PA.
BOEING HELICOPTERS ADVANCED ROTORCRAFT TRANSMISSION (ART) PROGRAM STATUS
JOSEPH W. LENSKI, JR. (Boeing Co., Helicopters Div., Philadelphia, PA) IN: Rotary Wing Propulsion Specialists' Meeting, Williamsburg, VA, Nov. 13-15, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 15 p. U.S. Army-supported research.
(Contract NAS3-25421)
Copyright

A review is presented of a program structured to incorporate key emerging component and material technologies into an advanced rotorcraft transmission with the intent of making significant improvements in the state-of-the-art (SOA). The specific goals of this program include a reduction of transmission weight by 25 percent relative to SOA trends, a reduction of transmission noise by 10 dB relative to SOA, and improvment of transmission life and reliability while extending the mean time between removal to 5000 hours. Attention is given to comparisons and trade studies between transmission configurations, component development testing, improved bearing technology, and the aircraft selection process for the program. R.E.P.

A91-29456* Textron Bell Helicopter, Fort Worth, TX.
PRELIMINARY DESIGN AND ANALYSIS OF AN ADVANCED ROTORCRAFT TRANSMISSION
Z. S. HENRY (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: Rotary Wing Propulsion Specialists' Meeting, Williamsburg, VA, Nov. 13-15, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 14 p. U.S. Army-supported research. refs
(Contract NAS3-25455)
Copyright

Future rotorcraft transmissions of the 1990s and beyond the year 2000 require the incorporation of key emerging material and component technologies using advanced and innovative design practices in order to meet the requirements for a reduced weight-to-power ratio, a decreased noise level, and a substantially increased reliability. The specific goals for future rotocraft transmissions when compared with current state-of-the-art transmissions are a 25 percent weight reduction, a 10-dB reduction in the transmitted noise level, and a system reliability of 5000 hours mean-time-between-removal for the transmission. This paper presents the results of the design studies conducted to meet the stated goals for an advanced rotorcraft transmission. These design studies include system configuration, planetary gear train selection, and reliability prediction methods. Author

A91-29457* McDonnell-Douglas Helicopter Co., Mesa, AZ.
ADVANCED ROTORCRAFT TRANSMISSION (ART) PROGRAM STATUS
ROBERT BOSSLER (Lucas Western, Inc., Applied Technology Div., City of Industry, CA) and GREGORY HEATH (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: Rotary Wing Propulsion Specialists' Meeting, Williamsburg, VA, Nov. 13-15, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 8 p. U.S. Army-supported research.
(Contract NAS3-25454)
Copyright

This paper presents the current status of the ART program for the Future Attack Airvehicle. Consideration is given to the general configuration, the weights methodology, the reliability methodology, the noise evaluation, and materials analyses. It is shown that the methodologies developed for weights analysis and reliability will be useful in future design concept evaluations and that the noise prediction methodology under development can provide an indication of noise levels during the design process. R.E.P.

A91-29458* Sikorsky Aircraft, Stratford, CT.
ADVANCED ROTORCRAFT TRANSMISSION (ART) PROGRAM REVIEW
JULES KISH (Sikorsky Aircraft, Stratford, CT) IN: Rotary Wing Propulsion Specialists' Meeting, Williamsburg, VA, Nov. 13-15, 1990, Proceedings. Alexandria, VA, American Helicopter Society, 1990, 11 p. U.S. Army-supported research. refs
(Contract NAS3-25423)
Copyright

This paper summarizes the work accomplished to date on the NASA/Army Advanced Rotorcraft Transmission (ART) program. A 23-percent weight reduction has been demonstrated for a high output reduction ratio split path transmission compared to an aggressive program goal of 25-percent. Greater than 10 dB noise reduction in the cabin is achieved by the use of high contact ratio spur and double helical gears. In addition, mean times between transmission removals have been increased by almost four fold. These performance gains have been achieved by application of advanced transmission technology concepts. Technology areas are being explored which offer high gain but at relatively high risk in such areas as composites, split power gear concepts, double helical gears, new gear materials, high speed spring clutches, and ceramic rolling element bearings. Author

A91-29469*# Texas A&M Univ., College Station.
TEST RESULTS FOR ROTORDYNAMIC COEFFICIENTS OF THE SSME HPOTP TURBINE INTERSTAGE SEAL WITH TWO SWIRL BRAKES
D. W. CHILDS, ERIAN BASKHARONE, and CHRISTOPHER RAMSEY (Texas A & M University, College Station) ASME and STLE, Joint Tribology Conference, Toronto, Canada, Oct. 7-10, 1990. 7 p. refs
(Contract NAG3-181)
(ASME PAPER 90-TRIB-45)

Test results are presented for the HPOTP Turbine Interstage Seal with both the current and an alternate, aerodynamically designed, swirl brake. Tests were conducted at speeds out to 16,000 rpm, supply pressures up to 18.3 bars, and the following three inlet-tangential-velocity conditions: (1) no preswirl, (2) intermediate preswirl in the direction of rotation, and (3) high preswirl in the direction of rotation. The back pressure can be controlled independently and was varied to yield the following four pressure ratios: 0.4, 0.45, 0.56, and 0.67. The central and simplest conclusion to be obtained from the test series is that the alternate swirl brake consistently outperforms the current swirl brake in terms of stability performance. The alternate swirl-brake's whirl-frequency ratio was generally about one-half or less than corresponding values for the current design. In many cases, the alternate design yielded negative whirl-frequency-ratio values in comparison to positive values for the current design. The alternate design can be directly substituted into the space currently occupied by the current design. There is no change in leakage performance. Author

A91-29470#
ROTORDYNAMIC COEFFICIENTS FOR PARTIALLY TAPERED ANNULAR SEALS. I - INCOMPRESSIBLE FLOW
J. K. SCHARRER (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) and C. C. NELSON (Texas A & M University, College Station) ASME and STLE, Joint Tribology Conference, Toronto, Canada, Oct. 7-10, 1990. 5 p. refs
(ASME PAPER 90-TRIB-25)

An analysis of partially tapered incompressible flow annular seals is utilized to create a parametric study on the effect of taper length and clearance taper on the performance of smooth and rough seals. The seal configuration studied is similar to that of the Space Shuttle Main Engine high pressure oxygen turbopump preburner pump rear wear ring seal. It is shown that the maximum direct stiffness occurred for smooth and rough seals with a taper length which is 80 percent of the seal length. Also, the cross-coupled stiffness of smooth and rough seals is less for tapered seals than straight seals. R.E.P.

A91-30351
VORTEX METHODS AND VORTEX MOTION
KARL E. GUSTAFSON, ED. (Colorado, University, Boulder) and JAMES A. SETHIAN, ED. (California, University, Berkeley) Philadelphia, PA, Society for Industrial and Applied Mathematics, 1991, 223 p. For individual items see A91-30352 to A91-30359.
Copyright

Vortex phenomena in fluid flows and the experimental, theoretical, and numerical methods used to characterize them are discussed in reviews by leading experts. Chapters are devoted to an overview of vortex methods, the convergence of vortex methods, graphic displays from numerical simulations, physical vortex visualizations, the four principles of vortex motion, the visualization and computation of hovering-mode vortex dynamics, turbulence and vortices in superfluid He, and statistical-mechanics approaches to vortices and turbulence. Extensive photographs and sample computer graphics are provided. D.G.

A91-30355
PHYSICAL VORTEX VISUALIZATION AS A REFERENCE FOR COMPUTER SIMULATION
PETER FREYMUTH (Colorado, University, Boulder) IN: Vortex methods and vortex motion. Philadelphia, PA, Society for Industrial and Applied Mathematics, 1991, p. 65-94. refs
(Contract F49620-84-C-0065)
Copyright

Results from experimental flow-visualization studies of two- and three-dimensional vortex flows on airfoils are presented in extensive photographs and characterized. The aim is to provide reference data and new challenges for computer simulations based on vortex methods. Consideration is given to (1) the limitations which must be imposed on the selection of mathematical and experimental approaches if meaningful comparisons are to be obtained, and (2) the methods employed in generating single-frame and movie-sequence visualizations (mainly $TiCl_4$ vortex tagging in air). D.G.

A91-30356
FOUR PRINCIPLES OF VORTEX MOTION
KARL E. GUSTAFSON (Colorado, University, Boulder) IN: Vortex methods and vortex motion. Philadelphia, PA, Society for Industrial and Applied Mathematics, 1991, p. 95-141. refs
Copyright

The generation, evolution, dynamics, and limits of vortex motion (VM) in an incompressible viscous fluid are considered theoretically and illustrated with diagrams and graphics from numerical simulations. Four general principles are advanced: (1) that VMs continue to be generated to fill up all available region space, (2) that VMs self-organize according to local (semigroup) properties and global (self-consistent) constraints, (3) that VMs adjust the content of the flow according to parity rules governing acceptable (e.g., bifurcation) state selection, and (4) that the first three principles define the limits within which the flow is guided, via spectral refinement, to its final (steady, periodic, aperiodic, or turbulent) states. D.G.

A91-30357
VISUALIZATION AND COMPUTATION OF HOVERING MODE VORTEX DYNAMICS
PETER FREYMUTH, KARL E. GUSTAFSON, and ROBERT LEBEN (Colorado, University, Boulder) IN: Vortex methods and vortex motion. Philadelphia, PA, Society for Industrial and Applied Mathematics, 1991, p. 143-169. refs
(Contract F49620-84-C-0065)
Copyright
Results from experimental and numerical simulations of the unsteady hovering flight of small birds or insects are presented in extensive photographs and computer graphics and discussed in detail. In the flow-visualization experiments, an airfoil in combined pitching and plunging motion is used to generate a thrusting jet in still air, producing in addition a vortex street with rotation opposite to that of a Karman street. The numerical studies are based on an extension of the robust multigrid method of Gustafson and Leben (1986 and 1988) to hovering-mode vortex dynamics. The derivation of the governing equations is outlined, and it is shown that the numerical and experimental results are in good qualitative agreement. D.G.

A91-30531
MULTI-POINT EXCITATION OF DAMPED MODES IN A SINE DWELL MODAL TEST AND THEIR TRANSFORMATION TO REAL MODES
H. WITTMEYER Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 15, Feb. 1991, p. 49-55. refs
Copyright
A change of the traditional modal test method is proposed: Instead of exciting the real modes of the undamped structure, the 'damped' modes of the damped structure are excited. A procedure for finding a suitable multi-point-excitation is given. Finally the damped modes are transformed to the real ones. For the necessary accurate determination of natural frequencies and structural dampings a procedure is given too. Simulated tests give satisfying results. Author

A91-30565
CORROSION AND NON-DESTRUCTIVE TESTING
HAROLD G. BUNCE IN: Aerospace corrosion control; Proceedings of the Symposium, Auchterarder, Scotland, Feb. 28-Mar. 2, 1989. London, Sawell Publications, Ltd., 1989, 20 p.
Copyright
Some advantages and disadvantages associated with the application of nondestructive testing to corrosion detection in the aviation industry are considered with particular reference to radiographic, ultrasonic, and eddy-current inspections. It is noted that, despite certain limitations of these methods with respect to aircraft maintenance and overhaul, the principal NDT methods can still contribute to corrosion detection and measurement. The potential for a further contribution exists, particularly in the case of the eddy-current method. V.L.

A91-30566
DETECTION OF CORROSION IN NON FERROUS AIRCRAFT STRUCTURE BY EDDY CURRENT METHOD
N. B. DAYARAM (Hocking NDT, Ltd., Saint Albans, England) IN: Aerospace corrosion control; Proceedings of the Symposium, Auchterarder, Scotland, Feb. 28-Mar. 2, 1989. London, Sawell Publications, Ltd., 1989, 19 p.
Copyright
The use of the eddy current method to assess the severity of corrosion in aircraft structures is discussed. First, some of the types of corrosion that are commonly encountered in aircraft structures are briefly reviewed, including surface corrosion, galvanic or dissimilar metal corrosion, integranular corrosion, exfoliation corrosion, and stress corrosion. An overview is then presented of the inspection procedure for the location of corrosion in single- and multiple-layer structures using eddy current phase analysis. Some inspection results are examined as an example. V.L.

A91-30567
INSPECTION OF CORROSION AND CORROSION CRACKING ON AIRFRAMES
MANFRED TIETZE (Institut Dr. Foerster, Reutlingen, Federal Republic of Germany) IN: Aerospace corrosion control; Proceedings of the Symposium, Auchterarder, Scotland, Feb. 28-Mar. 2, 1989. London, Sawell Publications, Ltd., 1989, 13 p.
Copyright
The use of the eddy current method to detect open or concealed corrosion in airframes and to assess the damage caused by fatigue or corrosion cracking is reviewed. Inspection with meter type equipment is discussed, and a new impedance plane instrument is described which allows static and dynamic detection of metal thinning due to corrosion, metal spacing, and subsurface cracks as well as fast inspection of fastener holes. Some new signal processing techniques for displaying flaw dimension through imaging procedures are also described. V.L.

A91-30569
AVOIDING STRESS CORROSION BY SURFACE PRE-STRESSING
P. O'HARA IN: Aerospace corrosion control; Proceedings of the Symposium, Auchterarder, Scotland, Feb. 28-Mar. 2, 1989. London, Sawell Publications, Ltd., 1989, 15 p. refs
Copyright
Controlled surface prestressing as a method of reducing the stress corrosion of aerospace components is examined with particular reference to the shot peening treatment. The principal parameters of the shot peening process are discussed, including the media used, surface coverage, process intensity, and mechanization. It is shown that controlled shot peening can effectively prevent the stress corrosion cracking of aluminum alloys, alloy steels, and titanium by keeping the resultant surface stress (i.e., the algebraic sum of the residual and applied stress) below the threshold level. V.L.

A91-30575*# Boeing Helicopter Co., Philadelphia, PA.
ADVANCED ROTORCRAFT TRANSMISSION PROGRAM - A STATUS REPORT
RAYMOND J. DRAGO and JOSEPH W. LENSKI, JR. (Boeing Helicopters, Philadelphia, PA) American Gear Manufacturers Association, Fall Technical Meeting, Toronto, Canada, Oct. 30, 1990, Technical Paper. 16 p.
(Contract NAS3-25421)
The work being conducted under the first phase of the joint Army/NASA Advanced Rotorcraft Transmission program is reviewed. The work includes the selection of the Tactical Tilt Rotor (TTR) system and the development plans for assessing advanced component technologies. The TTR drive-system arrangement is outlined, and the comparisons and trade studies of self-aligning bearingless planetary, split torque, and conventional single-stage planetary configurations are presented. The effects of transmission improvements are evaluated, and component development testing is discussed, including noise reduction by active force cancellation, hybrid bidirectional tapered roller bearings, and precision net forged spur gears. V.T.

A91-30730
WORKING ON THE SURFACE
GEORGE MARSH Aerospace Composites and Materials (ISSN

0954-5832), vol. 3, Mar.-Apr. 1991, p. 20-22.
Copyright

Surface engineering is an advanced form of coating in which the metal surface is modified to form an engineered phase-graded surface zone rather than simply providing a surface covering. The ion vapor deposition (IVD) process used in aerospace for coating components with high-purity aluminum for corrosion protection was first developed to replace cadmium, which has toxicity problems. Coating treatment of steel, aluminum, titanium, aluminum alloys, and other metals and nonmetallics with sizes from very small superconducting magnets to components of 5 x 10 ft, is conducted under vacuum in a 6 ft diameter by 12 ft long chamber. IVD, unlike electroplating, provides a theoretically unlimited coating thickness, does not overheat and substrate above critical temperatures, does not introduce hydrogen embrittlement, and due to the superclean vacuum atmosphere, results in a superior adhesive coating. Consideration is given to processes such as laser coating and hardening, plasma spraying, plasma nitriding and carburizing, as well as ion coating. It is envisaged that by the end of the decade almost 75 percent of gas turbine components will be surface-engineered to meet the increasing demands being placed on materials. R.E.P.

A91-30765
ACCURATELY GAUGE RADAR STABILITY WITH BAW DELAYS
P. A. SORRELL (Westinghouse Electric Corp., Baltimore, MD), L. A. GORE, and E. K. KIRCHNER (Teledyne Microwave, Mountain View, CA) Microwaves & RF (ISSN 0745-2993), vol. 30, March 1991, p. 116, 118, 121, 122, 124. refs
Copyright

The use of bulk-acoustic-wave (BAW) time-delay lines in stability testing equipment for S- and L-band MTI radars is discussed. The importance of radar stability for MTI performance and the need for time delays in stability testing are explained; the disadvantages of using echo returns from known targets are reviewed; and it is pointed out that BAW devices operating at S or L band have a maximum delay time of 15 microsec. Calculations are presented which demonstrate that this delay is adequate for accurate stability measurements. The BAW-based system has been applied successfully to an airport surveillance radar, a terminal Doppler weather radar, and a NEXRAD weather radar; its compact design makes it suitable for inclusion in built-in test equipment. D.G.

A91-30805
MODELLING RESIDUAL STRESSES AND FATIGUE CRACK GROWTH AT COLD-EXPANDED FASTENER HOLES
G. CLARK (Defence Science and Technology Organisation, Aeronautical Research Laboratory, Melbourne, Australia) Fatigue and Fracture of Engineering Materials and Structures (ISSN 8756-758X), vol. 14, no. 5, 1991, p. 579-589. refs
Copyright

A model for predicting residual stresses and crack growth in residual stress fields is presented and applied to the analysis of crack growth from cold-worked fastener holes in thick-section aircraft components. A comparison with experimental data demonstrates that the model provides correct predictions of the maxima and minima in the crack growth rate for cracks from cold-expanded holes. The model also accounts for the observed symmetry in cracking from cold-worked fastener holes. V.L.

A91-30819
GROSS SPATIAL STRUCTURE OF LAND CLUTTER
S. P. TONKIN and R. A. MCCULLOCH (Smith Associates, Ltd., Guildford, England) IEE Proceedings, Part F: Radar and Signal Processing (ISSN 0956-375X), vol. 138, no. 2, April 1991, p. 99-108. Ministry of Defence Procurement Executive-supported research. refs
Copyright

The paper describes the development of a statistical characterization of the gross structure of clutter visibility (e.g., as a function of terrain type) for use in radar performance modeling. The proposed approach makes use of the theory of binary Markov random fields. As an application, the approach is applied to a radar system which has a 95-percent single scan probability of detecting targets of a particular type at a distance of 8 km in cluttered regions and 25 km in uncluttered regions. L.M.

A91-30860
PERFORMANCE EVALUATION OF MOTION COMPENSATION METHODS IN ISAR BY COMPUTER SIMULATION
ZHAODA ZHU and XIAOQING WU (Nanjing Aeronautical Institute, People's Republic of China) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 120-124. Aeronautical Science Foundation of China-supported research.
Copyright

Three methods of motion compensation are considered: the scatterer point referencing method, the track-the-target centroid method, and the maximum likelihood (ML) image formation and motion compensation method. Computer simulations of imaging an aircraft in straight flight by a ground-based ISAR (inverse synthetic aperture radar) were carried out. The SNR performance, the susceptibility to target scintillation, and the computational complexity of the three methods are evaluated and compared. It is shown that the scatterer point referencing method is simple in computation, but is susceptible to target scintillation. The track-the-target centroid method and the ML method are able to greatly reduce the track loss arising from target scintillation at the cost of a higher computational load. The SNR performance of the track-the-target centroid method is poorer than that of the other two methods. The ML method suffers from the largest computational complexity among the three methods. Nevertheless, the ML method can provide the best SNR performance of the three methods. I.E.

A91-30883
A NOVEL LARGE AREA COLOR LCD BACKLIGHT SYSTEM
D. L. JOSE, R. G. STEWART, and W. R. ROACH (David Sarnoff Research Center, Princeton, NJ) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 275-277. refs
Copyright

The authors describe a field sequential color system in which video information for each primary color is loaded into the liquid crystal array, one complete color field at a time. The liquid crystal cells will synchronously modulate the light from a corresponding temporally sequenced three-color light source. With a high enough sequencing rate, a viewer will see a full color image with a color gamut that is limited by the chromaticity coordinates of the three-color light sources. There will be no light attenuation resulting from the presence of a filter, and each picture element corresponds to a single liquid crystal cell instead of a group of three or more cells which form a color filter pixel. This display will, therefore, have much higher brightness and resolution than a color filter liquid crystal display for a given power input and display size. Experiments on this novel concept are described. I.E.

A91-30978
IMPLEMENTING AN AVIONICS INTEGRITY PROGRAM - A CASE STUDY
EDWARD F. PELLO (Harris Corp., Government Aerospace Systems Div., Palm Bay, FL) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1028-1033.
Copyright

The methods, procedures, issues, and lessons learned from the implementation of an avionics integrity program (AVIP) on the global positioning system (GPS) digital analog converter program are reviewed. The integrity process required a change to conventional reliability design. The tasks required on the program provide an emphasis on environment and use of the equipment, understanding of parts/materials life capability, durability assessment of a design, corrosion control, and life-based maintenance. The avionic integrity approach required a cultural change in design, and basic shifts in reliability and maintainability approaches. The basic tools and methodologies required to implement the various AVIP program tasks already exist. The disciplined participation of the various design functions necessary to conduct the effort are discussed. I.E.

A91-31032
1990 ANNUAL RELIABILITY AND MAINTAINABILITY SYMPOSIUM, LOS ANGELES, CA, JAN. 23-25, 1990, PROCEEDINGS
Symposium sponsored by IEEE, ASME, AIAA, et al. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, 624 p. For individual items see A91-31033 to A91-31084.
Copyright
Theoretical and practical aspects of reliability and maintainability (R&M) analysis are discussed in reviews and reports. Sections are devoted to R prediction, trend analysis, R testing and environmental stress screening, product assurance management, system R modeling, the R of fiber optics and electrooptic equipment, R growth, product support, R evaluation and statistical methods, the R of mechanical equipment, testability and built-in test, the R of devices, maintainability, software R, software tools for R&M analysis, and R analysis. Also included are cumulative indices (by author, institution, key words, and paper number) of papers given at these annual conferences during the period 1980-1990. T.K.

A91-31033
USING TEST DATA TO PREDICT AVIONICS INTEGRITY
GLEN E. BENZ (Teledyne Controls, Los Angeles, CA) IN: 1990 Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 23-25, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1-4. refs
Copyright
Published data on avionic fatigue life and high-temperature endurance were used to develop straight-line relationships between stress amplitudes and life at given amplitudes for four part types: a chassis, a plated-through hole, an IC, and a non-IC piece part. Design-life-distributions for four accelerated reliability test programs were derived for the same item categories using the same straight-line relationships between stress and life. The tests involved 15 specimens and approximately 40,000 accelerated test hours. A test-life observation was multiplied by the ratio between predicted usage life mean for the design configuration and predicted test-life mean for the test configuration being observed. A product limit technique was used to treat censorship (observations of test end without relevant failure). The resulting test data distribution was used to predict the failure-free operating period and the mean time between failures for the new design. I.E.

A91-31041
STRESS SCREENING OF ELECTRONIC MODULES - INVESTIGATION OF EFFECTS OF TEMPERATURE RATE OF CHANGE
JAMES M. KALLIS, WILLIAM K. HAMMOND, and EDWIN B. CURRY (Hughes Aircraft Co., El Segundo, CA) IN: 1990 Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 23-25, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 59-66. Hughes Aircraft Co.-supported research. refs
Copyright
A study was conducted to investigate the effects of temperature rate of change on the environmental stress screening of printed wiring assemblies (PWAs). The related effects of chamber air velocity and temperature dwell time on module temperature response were evaluated. The effects of varying thermal cycling parameter levels were investigated. The effects of various chamber air temperature rates of change and velocity levels on the temperature responses of two vastly different PWAs were measured. A thermal-cycling analysis of a PWA of the same construction as one of the two PWAs tested in the present investigation also was performed. The results of a portion of the test are compared with the analytical predictions, validating the thermal response trends predicted by the mathematical model. I.E.

A91-31048
MTBF WARRANTY/GUARANTEE FOR MULTIPLE USER AVIONICS
FRANK J. MORENO (Harris Corp., Government Communication Systems Div., Melbourne, FL) IN: 1990 Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 23-25, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 113-119.
Copyright
A MTBF (mean time between failures) warranty/guarantee situation is modeled for an avionics unit installed on different platforms and subjected to varying levels of operational stress. The demand for warranty repairs is approached by structuring submodels and solving these submodels using linked spreadsheets. The spares guarantee is modeled using the MTBF parameter and the expected number of units installed on the various platforms. The spreadsheets contain the essence of the math models/calculations and are a form of self-documentation. I.E.

A91-31049
RELIABILITY MODELING FOR SYSTEMS REQUIRING MISSION RECONFIGURABILITY
JAMES N. YOO and GEORGE SMITH, II (TRW, Inc., Military Electronics and Avionics Div., San Diego, CA) IN: 1990 Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 23-25, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 133-139.
Copyright
Guidelines for reliability engineers are presented in which reconfiguration is used to determine a mission's mean time between critical failures (MTBCF). MTBCF refers to the mean operating time until a critical failure occurs, starting with a fault-free system. This method has been used to evaluate reliability on the integrated communication, navigation, and identification avionics program, which has multiple mission profiles and the ability to reconfigure common modules through software initiation. Strengths and weaknesses in the military standard for this type of evaluation are pointed out, and the use of a mathematical technique, familiar to most reliability engineers, for evaluating systems with common reconfigurable modules is discussed. I.E.

A91-31058*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STATE REDUCTION FOR SEMI-MARKOV RELIABILITY MODELS
ALLAN L. WHITE and DANIEL L. PALUMBO (NASA, Langley Research Center, Hampton, VA) IN: 1990 Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 23-25, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 280-285.
Trimming, a method of reducing the number of states in a semi-Markov reliability model, is described, and an error bound is derived. The error bound uses only three parameters from the semi-Markov model: (1) the maximum sum of rates for failure transitions leaving any state, (2) the maximum average holding time for a recovery-mode state, (3) and the operating time for the system. The error bound can be computed before any model generation takes places, which means the modeler can decide immediately whether the model can be trimmed. The trimming has a precise and simple description and thus can be easily included in a program that generates reliability models. The simplest version of the error bound for trimming is presented. More accurate versions can be obtained by requesting more information about the system being modeled. I.E.

A91-31061
RELIABILITY ANALYSIS OF REDUNDANT AIRCRAFT SYSTEMS WITH POSSIBLE LATENT FAILURES

TILAK C. SHARMA and BENYAMIN ZILBERMAN (Boeing Co., Seattle, WA) IN: 1990 Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 23-25, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 303-308. refs
Copyright

A methodology has been developed to calculate unreliability of redundant airplane systems containing latent failures with differing inspection intervals. The usual assumption that all components are unfailed at the start of a flight is not valid for the airplane systems investigated. The analysis method consists of representing a redundant system either as a fault tree or a reliability block diagram. The bottom-up approach is recommended for the fault-tree representation where one starts from the lowest AND gate and calculates failure probability. The number obtained for the top fault-tree gate would represent the system failure probability in which the system logic and latency have been appropriately considered. Alternatively, for a system represented by a reliability block diagram, the top-down approach is recommended. I.E.

A91-31062
A CORROSION PREVENTION AND CONTROL (CPC) PROGRAM
MICHAEL A. YOUNG (Arinc Research Corp., Annapolis, MD) IN: 1990 Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 23-25, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 309-314. refs
Copyright

Corrosion is discussed as a serious threat to aviation readiness and safety. To prevent or minimize aircraft corrosion, the U.S. Army Aviation Systems Command (AVSCOM) has developed and is implementing a corrosion prevention and control (CPC) program that incorporates the following actions: (1) properly coating exposed metal, (2) isolating dissimilar metals, (3) using corrosion-resistant metal alloys, (4) using proper sealants and water-displacing compounds, (5) avoiding poor design features, (6) and increasing awareness of corrosion. Hence the AVSCOM program is divided into five major elements that incorporate CPC: management, design, maintenance, training, and awareness. I.E.

A91-31066
BIT BLUEPRINT - TOWARD MORE EFFECTIVE BUILT IN TEST
GEORGE LEE DAUGHERTY, JR. and MICHAEL L. STEINMETZ (Martin Marietta Electronics Systems, Orlando, FL) IN: 1990 Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 23-25, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 353-360.
Copyright

Information is provided concerning built-in test (BIT) and its importance to the military user. The paper is directed at the engineers who design the mission equipment. The discussion points to the need for greater availability in development of weapon systems To most designers, availability is an unknown and unquantifiable metric that is often ignored. Availability must be defined in terms more easily understood by the design community. I.E.

A91-31068#
ADVANCED MAINTENANCE DIAGNOSTICS FOR AIR FORCE FLIGHT CONTROL
GARY M. SMITH and JOHN B. SCHROEDER (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: 1990 Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 23-25, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 394-399. refs

Current and planned applications of advanced computer concepts to the onboard, in-flight fault-detection problem for reduction of cannot-duplicate-type faults are described. Also discussed is progress in computer-aided, ground-based troubleshooting for the further assistance of maintenance personnel to reduce the retest-OK problem. Demonstration of the F-16 maintenance diagnostic system has shown that a complex flight control system can be modeled to troubleshoot all the aspects of the flight-control systems including lowest replaceable units (LRUs), sub-LRUs, wiring, and connectors. I.E.

A91-31069
BREAK RATE - A RELIABILITY PARAMETER FOR SURGE OPERATIONS
JAMES K. SEGER (Lockheed Aeronautical Systems Co., Burbank, CA) IN: 1990 Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 23-25, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 400-403.
Copyright

A method for measuring the break rate (BR) of an individual system is described. The method is convenient early in the design process and accounts for item criticality, redundancy, task deferrability, and when deferred tasks are repaired. Also introduced is a new criterion of effectiveness, sortie loss rate, as an alternative to BR. Sortie loss rate has the benefit of measuring the total number of potential sorties missed due to unscheduled maintenance. BR is calculated as the number of sorties missed divided by the number of sorties attempted. An alternative way to compute BR is one minus the ratio of actual sorties launched to attempted sorties. I.E.

A91-31212#
ELECTROMAGNETIC TOPOLOGY - JUNCTION CHARACTERIZATION METHODS
J. P. PARMANTIER (Dassault Aviation, Vaucresson, France), G. LABAUME, J. C. ALLIOT (ONERA, Chatillon, France), and P. DEGAUQUE (Lille I, Universite, Villeneuve-d'Ascq, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 5, 1990, p. 71-82. refs
Copyright

The electrical characterization of topological network junctions using a formalism in accordance with electromagnetic topology is discussed. It is shown how the characteristic impedance of the network in which the junction is located can be chosen to treat several physical cable connection and termination configurations. Junctions which represent the separation of a conductor into other conductors are used as an example. C.D.

A91-31286
FIBER OPTIC STRAIN MEASUREMENT USING A POLARIMETRIC TECHNIQUE
RICHARD R. FENGLER (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: Innovations in rotorcraft test technology for the 90's; Proceedings of the AHS National Technical Specialists' Meeting, Scottsdale, AZ, Oct. 8-12, 1990. Alexandria, VA, American Helicopter Society, Inc., 1990, 4 p. refs
Copyright

A polarimetric technique is described that used 'bulk optics', i.e., separate lenses and polarizers, to obtain strain measurements in composite structures. Other objectives of this research were to acquire experience in constructing composite coupons with embedded fiber optics, and to acquire experience in the design and utilization of photonics hardware. The coupon was constructed and attached to the fiber optic signal conditioner, and a load test was conducted to compare the output of the fiber optic strain sensor with the output of the resistive strain gage. It is concluded that the 'bulk optics' as employed in this particular technique are not suitable for utilization in helicopter applications due to its sensitivity to vibration. R.E.P.

A91-31287
EVOLUTION AND INNOVATION FOR SHAFT TORQUE AND RPM MEASUREMENT FOR THE 1990S AND BEYOND
JAMES R. PARKINSON (Simmonds Precision Products, Inc., Aircraft Systems Div., Vergennes, VT) IN: Innovations in rotorcraft test technology for the 90's; Proceedings of the AHS National

Technical Specialists' Meeting, Scottsdale, AZ, Oct. 8-12, 1990. Alexandria, VA, American Helicopter Society, Inc., 1990, 4 p.
Copyright

This paper reviews the performance and related technological advances in engine and aircraft design that require innovation in shaft torque and rpm instrumentation technologies and materials. It is shown that magneto-optic sensing techniques and the proper utilization of composite power shafts supply the reliability, accuracy, weight reduction, and systems compatibility that future aircraft will demand. Future system requirements include the ability to maintain a better than one percent system accuracy, reduced system weight, and a system sensing technique that will be compatible with optical harnessing and signal processing techniques. A torque and speed measurement system being developed that uses magneto-optic sensing techniques and composite shaft technology is described. R.E.P.

A91-31288
USE OF A RELIABILITY MODEL IN THE FATIGUE SUBSTANTIATION OF HELICOPTER DYNAMIC COMPONENTS
DAVID O. ADAMS, AUDBUR E. THOMPSON, and JOHN R. HERTER (Sikorsky Aircraft, Stratford, CT) IN: Innovations in rotorcraft test technology for the 90's; Proceedings of the AHS National Technical Specialists' Meeting, Scottsdale, AZ, Oct. 8-12, 1990. Alexandria, VA, American Helicopter Society, Inc., 1990, 14 p. refs
Copyright

The methodology generally utilized by helicopter manufacturers for the determination of 'safe-life' retirement times of fatigue-loaded flight-critical dynamic components does not quantify structural reliability either on an absolute basis or on a relative basis. This paper presents the results of evaluations utilizing an improved methodology of the absolute structural reliability of selected composite and metal UH-60A dynamic components. Issues of strength distribution, flight load distribution and degraded strength are examined. It is shown that an accurate evaluation of component reliability require a statistical knowledge of aircraft usage and individual helicopter usage monitors are necessary to supply this information. R.E.P.

A91-31289
COMPOSITE STRUCTURES DESIGNED FOR IMPULSIVE PRESSURE LOADS
GLENN T. ROSSI (Boeing Helicopters, Philadelphia, PA) IN: Innovations in rotorcraft test technology for the 90's; Proceedings of the AHS National Technical Specialists' Meeting, Scottsdale, AZ, Oct. 8-12, 1990. Alexandria, VA, American Helicopter Society, Inc., 1990, 10 p.
(Contract DAAJ02-89-C-0012)
Copyright

A design approach to the problem of lightweight composite structures exposed to gun blast impingement is presented. An effective and accurate modeling method was developed and successfully utilized for the analysis of gun blast effects in close proximity to composite panels that are representative of rotorcraft minimum gauge structure. Two curved and three flat composite panel designs were fabricated utilizing graphite fiber and glass fiber reinforced thermoplastic composites that were manufactured using out-of-autoclave processes wherever feasible. Panel performance was excellent as all panels survived without damage at 12 inches stand-off distance against at least one of the three tested guns (20, 25 and 30 mm). R.E.P.

A91-31343* Illinois Univ., Urbana.
MODULATIONAL STABILITY OF ROTATING-DISK FLOW
DANIEL N. RIAHI (Illinois, University, Urbana) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 2. New York, Springer-Verlag, 1990, p. 160-170. refs
(Contract NAS1-18605)
Copyright

The problem of modulational primary stability of rotating-disk boundary layer flow for stationary modes was studied by using the method of multiple scales. The system of equations for infinitesimal disturbances is solved by linear stability theory to determine the modulated solution which represents the time and azimuthal variations of the wave pattern. The solution for the amplitude of the most critical disturbance indicates that the disturbance spreads out as the flow time increases and grows exponentially at the center. Author

A91-31345
ON THE CLASSIFICATION OF UNSTABLE MODES IN BOUNDED COMPRESSIBLE MIXING LAYERS
T. L. JACKSON and C. E. GROSCH (Old Dominion University, Norfolk, VA) IN: Instability and transition; Proceedings of the Workshop, Hampton, VA, May 15-June 9, 1989. Vol. 2. New York, Springer-Verlag, 1990, p. 187-198. refs
Copyright

Theoretical results of Chimonas (1970) are presented which extend certain incompressible theorems to include compressibility. Selected numerical results are then presented on the inviscid temporal stability of a bounded parallel compressible mixing layer. Three families of unstable modes are identified, and it is shown that the classification remains valid as the Mach number increases. For subsonic disturbances, the unstable modes are nearly identical to those found in the unbounded case, which is attributed to the fact that the subsonic disturbances decay exponentially away from the shear layer. It is suggested that, for very large wavenumbers, a WKB approximation may be useful. V.L.

A91-31424
FREE STREAMLINE AND JET FLOWS BY VORTEX BOUNDARY INTEGRAL MODELING
R. I. LEWIS (Newcastle upon Tyne, University, England) International Journal of Heat and Fluid Flow (ISSN 0142-727X), vol. 12, March 1991, p. 77-84. refs
Copyright

The surface vorticity method is extended in order to deal with flows that involve free shear layers or jets. Such flows include free streamline modeling of separated flow, deflection of jets by an oblique surface, flow past a lifting body situated in a jet with consequent jet reaction, and models for the inverse design of airfoils or cascades. A numerical framework is presented to estimate free streamline and jet flows. The analysis is also applied to the simulation of an airfoil situated in an open jet wind tunnel. L.K.S.

A91-31579*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
STRUCTURAL EFFICIENCY STUDY OF GRAPHITE-EPOXY AIRCRAFT RIB STRUCTURES
ZAFER GURDAL (Virginia Polytechnic Institute and State University, Blacksburg), JAMES H. STARNES, JR. (NASA, Langley Research Center, Hampton, VA), and GARY D. SWANSON (Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 1, p. 85-97) Journal of Aircraft (ISSN 0021-8669), vol. 27, Dec. 1990, p. 1011-1020. Previously cited in issue 12, p. 1902, Accession no. A88-32186. refs
Copyright

A91-31580#
ASTROS - A MULTIDISCIPLINARY AUTOMATED STRUCTURAL DESIGN TOOL
D. J. NEILL (Northrop Corp., Hawthorne, CA), E. H. JOHNSON (MacNeal Schwendler Corp., Los Angeles, CA), and R. CANFIELD (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) Journal of Aircraft (ISSN 0021-8669), vol. 27, Dec. 1990, p. 1021-1027. refs
(Contract F33615-83-C-3232)
Copyright

ASTROS (Automated Structural Optimization System) is a multidisciplinary software system that can be used in the preliminary design of aerospace structures. The approach taken in this development project was to blend proven engineering tools into an efficient unified system through the use of a specifically designed software environment. ASTROS has reached the stage at which significant test cases have been performed that have demonstrated the power and versatility of the system. This paper first presents background information that motivated the development of this new system, followed by a discussion of the engineering technologies that have been integrated into ASTROS. Emphasis is placed on some of the more novel features, such as the treatment of flutter constraints and the linking of physical design variables. This discussion is then followed by two representative test cases. Author

A91-31585#
APPLICATIONS OF STRUCTURAL OPTIMIZATION SOFTWARE IN THE DESIGN PROCESS
TORSTEN BRAMA and RAGNAR ROSENGREN (Saab-Scania, AB, Linkoping, Sweden) (ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1, p. 40-44) Journal of Aircraft (ISSN 0021-8669), vol. 27, Dec. 1990, p. 1057-1059. Previously cited in issue 09, p. 1448, Accession no. A91-24310.
Copyright

A91-31700
SENSITIVITY OF FREE VIBRATION CHARACTERISTICS OF CANTILEVER PLATES TO GEOMETRIC PARAMETERS
A. JOSHI and B. S. MADHUSUDHAN (National Aeronautical Laboratory, Bangalore, India) Journal of Sound and Vibration (ISSN 0022-460X), vol. 145, March 22, 1991, p. 489-494.
Copyright
The possibility has been investigated of developing a design tool which permits a reasonable assessment to be made of the probable dynamic characteristics of an aircraft at the design stage. In the analysis, a swept and tapered cantilever plate of uniform thickness and homogeneous material is taken to represent a wing structure. The results provide free vibration results for this type of geometry in a simple algebraic form. C.D.

A91-31755#
INFLUENCE OF THE AERODYNAMIC LOAD MODEL ON GLIDER WING FLUTTER [WPLYW MODELU OBCIAZEN AERODYNAMICZNYCH NA FLATTER SKRZYDLA SZYBOWCA]
ROBERT KOLODZIEJCZYK and JOZEF PIETRUCHA (Warszawa, Politechnika, Warsaw, Poland) Politechnika Slaska, Zeszyty Naukowe, Mechanika (ISSN 0434-0817), no. 99, 1990, p. 155-161. In Polish. refs
A simple mathematical model of a glider wing is described, based on the fundamental uncoupled bending and torsion wing modes. Strip theory is used for calculation of aerodynamic loads with regard to different airflow models from steady through variants of quasi-steady to unsteady. Test calculations were performed for SZD 51-1 Junior glider wing based on data calculated with the finite element method. Author

A91-31809
STRESS ANALYSIS OF INTERFERENCE-FIT FASTENER HOLES USING A PENALTY FINITE ELEMENT METHOD
M. HELLER and R. P. CAREY (Defence Science and Technology Organization, Aircraft Structures Div., Melbourne, Australia) Computers and Structures (ISSN 0045-7949), vol. 39, no. 1-2, 1991, p. 73-81. refs
Copyright
Fatigue life enhancement systems such as interference-fit fasteners are assuming increasing importance for aircraft structures. A penalty finite element method is formulated for the stress analysis of this type of problem. The method is initially demonstrated by considering two benchmark problems. Subsequently, experimental and finite element results for a plate with two closely-spaced interference-fit fasteners are also presented. Author

A91-31814
FINITE ELEMENT ANALYSIS OF COMPOSITE PANEL FLUTTER
I. LEE and M. H. CHO (Korea Advanced Institute of Science and Technology, Seoul, Republic of Korea) Computers and Structures (ISSN 0045-7949), vol. 39, no. 1-2, 1991, p. 165-172. refs
Copyright
The finite element method based on the shear deformable theory is developed to analyze the composite panel flutter in supersonic flow. The computational results of the vibration and flutter analysis agree well with those given in the available references. Guyan reduction and the normal mode method are used to reduce the computational time. The plate length ratio, the flow direction and the fiber orientation greatly affect the flutter boundaries of trapezoidal laminated plates. Flutter boundaries have been calculated for both simply supported and clamped boundaries in order to determine the effect of boundary conditions. Author

A91-31826
AIAA/ASME/ASCE/AHS/ASC STRUCTURES, STRUCTURAL DYNAMICS, AND MATERIALS CONFERENCE, 32ND, BALTIMORE, MD, APR. 8-10, 1991, TECHNICAL PAPERS. PTS. 1-4
Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. Pt. 1, 924 p.; pt. 2, 829 p.; pt. 3, 764 p.; pt. 4, 668 p. For individual items see A91-31827 to A91-32131.
Copyright
Various papers on structures, structural dynamics, and materials are presented. The general topics addressed include: material characterization and evaluation, modeling of materials and processes, shape memory alloys, structural optimization, composite materials design optimization, optimization methods, aircraft design optimization, integrated structures and controls optimization, design optimization tools, shape optimization, buckling of composites, analysis techniques for composites, analysis of composite beams, impact damage of composites, damage and fracture of composites, probabilistic analysis of structures, reliability method, structural analysis and testing, thermal mechanical analysis. Also discussed are: advanced analysis methods, finite element methods, advanced structural applications, structural design, aging aircraft, hypersonic structures and materials, aeroelasticity, aeroservoelasticity and active control, unsteady aerodynamics, panel flutter, rotor aeroelasticity and vibration, composite wings and active control, adaptive structures, system identification, damping, dynamics analysis, multibody dynamics, random and nonlinear dynamic analysis, spacecraft dynamics, control of space structure, space structure on orbit test, composite materials dynamics. C.D.

A91-31855*# Lockheed Engineering and Sciences Co., Hampton, VA.
SENSITIVITY-BASED SCALING FOR CORRELATING STRUCTURAL RESPONSE FROM DIFFERENT ANALYTICAL MODELS
KWAN J. CHANG (Lockheed Engineering and Sciences Co., Hampton, VA), RAPHAEL T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg), GARY L. GILES (NASA, Langley Research Center, Hampton, VA), and PI-JEN KAO (Analytical Services and Materials, Inc., Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 238-246. refs
(Contract NAG1-224)
(AIAA PAPER 91-0925) Copyright
This paper presents a sensitivity-based linearly varying scale factor used to reconcile results from simple and refined models for analysis of the same structure. The improved accuracy of the linear scale factor compared to a constant scale factor as well as the commonly used tangent approximation is demonstrated. A wing box structure is used as an example, with displacements, stresses and frequencies correlated. The linear scale factor could permit the use of a simplified model in an optimization procedure during preliminary design to approximate the response given by a refined model over a considerable range of design changes. Author

A91-31857*# Agency for Defense Development, Daejon (Republic of Korea).

MINIMUM-WEIGHT DESIGN OF LAMINATED COMPOSITE PLATES FOR POSTBUCKLING PERFORMANCE

DONG KU SHIN (Agency for Defense Development, Taejon, Republic of Korea), ZAFER GURDAL, and O. HAYDEN GRIFFIN, JR. (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 257-266. refs
(Contract NAG1-643; NAG1-675)
(AIAA PAPER 91-0969) Copyright

Minimum-weight design of simply-supported, symmetrically laminated, thin, rectangular, specially orthotropic laminated plates for buckling and postbuckling strength is investigated. The postbuckling analysis is based on an Marguerre-type energy method. The failure load of laminates is calculated by the maximum strain failure criterion based on the in-plane strains. Design variables are individual layer thicknesses with specified fiber orientations. Optimization with discrete valued design is achieved by introducing additional penalty terms to the regular pseudoobjective function of sequential unconstrained minimization technique. The proposed optimization technique is applied to the design of rectangular laminates with various aspect ratios loaded by axial compressive loads. Author

A91-31861#

APPLICATION OF MULTIPLIERS METHOD IN MULTILEVEL STRUCTURAL OPTIMIZATION FOR LAMINATED COMPOSITES

INE-WEI LIU (Chung Shan Institute of Science and Technology, Taichung, Republic of China) and CHIEN-CHANG LIN (National Chunghsing University, Taichung, Republic of China) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 293-302. refs
(AIAA PAPER 91-0974) Copyright

In order to avoid the additional computational effort involved with a fully design variables, the Schuldt's Method of Multipliers for large laminated composite structures is presented, and a suitable multilevel approach for use in element/lower-level optimization is developed. The minimization process is carried out in a double scheme at element level, one a weight penalty function and the other a strain energy penalty function, where ply thickness and fiber directions are designed separately at these two independent levels of optimization. Three examples are presented to demonstrate the algorithm's effectiveness as a pure weight minimization routine for laminated composites design. A further example of an aircraft vertical stabilizer laminated composite plate is constructed to illustrate the effect of the layer number upon the optimum solution. Author

A91-31865#

APPLICATION OF NEURAL NETWORKS TO PRELIMINARY STRUCTURAL DESIGN

R. A. SWIFT and S. M. BATILL (Notre Dame, University, IN) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 335-343. USAF-supported research. refs
(AIAA PAPER 91-1038) Copyright

A neural network application to preliminary structural design is presented. This application involves the training of a neural network(s) to effectively represent the design space of a given structure, so that determinations about structural characteristics and trends in structural response behavior due to perturbations in structural geometry and material systems can be made. This approach is applied to three structural design problems; a configurational design of a 5 bar truss for minimum weight, a configurational and material design of a 10 bar truss for minimum weight, deflection, and cost, and the configurational design of a light-aircraft wingbox with weight, displacement, and natural frequency as the objective functions. In each example, design information obtained from a set of Fully-Stressed Designs (FSD) is used to train the neural network representation of the design space. The ability of the neural network to accurately and efficiently predict structural behavior was demonstrated. Author

A91-31872#

CONTINUUM DESIGN SENSITIVITY ANALYSIS OF EIGENVECTORS USING RITZ VECTORS

SEMYUNG WANG and KYUNG K. CHOI (Iowa, University, Iowa City) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 406-412. refs
(AIAA PAPER 91-1092) Copyright

In this paper, a unified continuum-based sizing design sensitivity analysis (DSA) of eigenvectors, which can be obtained without differentiating matrices, is developed by taking design derivatives of the variational equation of eigenvalue problems. This method is an extension of Fox and Kapoor's eigenvector expansion idea. The efficiency and accuracy is improved by adding load dependent Ritz vectors (LDRV) to the minimal eigenbasis. The error of the explicit and implicit methods is derived. Two numerical examples are presented to demonstrate efficiency and accuracy of the method. Examples treated in this paper indicate that adding 2 LDRVs to the basis vectors is recommended. Author

A91-31876#

MULTIDISCIPLINARY AEROELASTIC ANALYSIS AND DESIGN USING MSC/NASTRAN

ERWIN H. JOHNSON and MICHAEL A. REYMOND (MacNeal-Schwendler Corp., Los Angeles, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 438-446. Construcciones Aeronauticas, S.A.-supported research. refs
(AIAA PAPER 91-1097) Copyright

An overview is given of how the MSC/Nastran computer procedure is being enhanced to provide aeroelasticity within its multidisciplinary analysis and optimization capability. How this large-scale finite element-based software system is being enhanced to performed multidisciplinary design optimization is discussed. The methodology being employed in the calculation of the sensitivities of aeroelastic responses is examined. C.D.

A91-31942#

A MODEL FOR PREDICTING THE BEHAVIOR OF IMPACT-DAMAGED MINIMUM GAGE SANDWICH PANELS UNDER COMPRESSION

PIERRE J. MINGUET (Boeing Co., Helicopters Div., Philadelphia, PA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1112-1122. refs
(AIAA PAPER 91-1075) Copyright

A model is formulated for the compressive behavior of sandwich panels whose thin-gage facesheet has undergone low-velocity impact. The facesheet is considered to be a plate with an initial indentation, and the damage region in the core beneath the surface impact site is included. Results obtained for typical stress distributions in the core and face surrounding the impact area are compared with previously reported experimental data. Good correlation is obtained, and it is noted that the core's crush strength is an important parameter. The predicted failure mode is an unstable propagation of the initial dent across the width of the panel, in keeping with experimental observations. O.C.

A91-31949#
INTERLAMINAR FRACTURE CHARACTERISTICS OF BONDING CONCEPTS FOR THERMOPLASTIC PRIMARY STRUCTURES
JOHN C. FISH, MARCIA L. VITLIP, STEPHEN P. CHEN (McDonnell Douglas Helicopter Co., Mesa, AZ), and KWANG S. SHIN (Arizona State University, Tempe) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1173-1180. refs
(AIAA PAPER 91-1143) Copyright

The fracture characteristics of candidate bonding concepts for thermoplastic structures (APC-2) are evaluated. Mode I and mode II static fracture tests were conducted with double cantilever beam and end notched flexure test specimens. The bonding materials include PEEK film, PEI film, and a film adhesive. Strain energy release rates for crack initiation were calculated for both fracture modes. Propagation values for mode I crack growth were also determined for larger crack lengths. Author

A91-31969*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECT OF STIFFNESS CHARACTERISTICS ON THE RESPONSE OF COMPOSITE GRID-STIFFENED STRUCTURES
DAMODAR R. AMBUR (NASA, Langley Research Center, Hampton, VA) and LAWRENCE W. REHFIELD (California, University, Davis) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1349-1356. refs
(AIAA PAPER 91-1087) Copyright

A study of the effect of stiffness discontinuities and structural parameters on the response of continuous-filament grid-stiffened flat panels is presented. The buckling load degradation due to manufacturing-introduced stiffener discontinuities associated with a filament cut-and-add approach at the stiffener intersections is investigated. The degradation of buckling resistance in isogrid flat panels subjected to uni-axial compression and combined axial compression and shear loading conditions and induced damage is quantified using FEM. The combined loading case is the most critical one. Nonsolid stiffener cross sections, such as a foam-filled blade or hat with a 0-deg dominant cap, result in grid-stiffened structures that are structurally very efficient for wing and fuselage applications. The results of a study of the ability of grid-stiffened structural concepts to enhance the effective Poisson's ratio of a panel are presented. Grid-stiffened concepts create a highly effective Poisson's ratio, which can produce large camber deformations for certain elastic tailoring applications. Author

A91-31994#
A SURVEY AND COMPARISON OF ENGINEERING BEAM THEORIES FOR HELICOPTER ROTOR BLADES
DONALD L. KUNZ (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1597-1607. refs
(AIAA PAPER 91-1194) Copyright

The present development history of beam theories applicable to helicopter rotors notes that these have gone through several major phases. After incorporating bending flexibility in linear analyses of rotating beams, torsional bending and nonlinear coupling terms for the bending and torsion of rotating beams were added; the consequent complexity entailed the introduction of ordering schemes. Such schemes have more recently been supplanted by exact equations of motion. State-of-the-art treatments encompass the effects of warping and anisotropy due to the use of composites in both blade structures and bearingless rotor flexbeams. It is anticipated on the basis of current trends that future composite-beam analyses will employ FEM to calculate warping functions and cross-sectional characteristics. O.C.

A91-32003#
RANDOM EIGENVALUES AND AGING AIRCRAFT STRUCTURAL DYNAMIC MODELS - AN INVERSE PROBLEM
HAYM BENAROYA and DARRELL MOSS (Rutgers University, Piscataway, NJ) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1676-1682. Rutgers University-supported research. refs
(AIAA PAPER 91-0954) Copyright

An approach is presented for the analysis of inverse vibration problems encountered in the dynamic characteristics of aging aircraft, where eigenvalues and eigenfunctions change over the course of many flight/landing cycles. Some of the parameters of the vibrations in question must be modeled as random variables. Attention is given to both the 'random eigenvalue' and discrete inverse-vibration problems. A perturbation method is suggested as an approach to inverse problems where 'small' randomness exists. O.C.

A91-32007# California Univ., Los Angeles.
A NEW APPROACH TO COMPUTATIONAL AEROELASTICITY
ODDVAR O. BENDIKSEN (California, University, Los Angeles) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1712-1727. refs
(Contract NAS3-25574; NCC2-374)
(AIAA PAPER 91-0939) Copyright

A novel computational method for aeroelastic stability and structural response calculations is presented in which the entire fluid-structure system is treated as one continuum dynamics problem, by using a mixed Eulerian-Lagrangian formulation and switching from an Eulerian to a Lagrangian description at the fluid-structure boundary. This method effectively eliminates the phase integration errors associated with previous methods, where the fluid and the structure are integrated sequentially by different schemes; it also provides a systematic method for coupling finite element structural codes to finite volume fluid dynamics codes, in a manner that leads to highly vectorizable overall codes. The method is applied to transonic flutter calculations for wings and cascades, using simple finite element models. These results suggest that the method is capable of reproducing the energy exchange between the fluid and the structure with much less error that existing methods. Author

A91-32013*#
A PARAMETRIC SENSITIVITY AND OPTIMIZATION STUDY FOR THE ACTIVE FLEXIBLE WING WIND-TUNNEL MODEL FLUTTER CHARACTERISTICS
MASOUD RAIS-ROHANI IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1791-1795. refs
(Contract NAG1-224)
(AIAA PAPER 91-1054) Copyright

In this paper an effort is made to improve the analytical open-loop flutter predictions for the Active Flexible Wing wind-tunnel model using a sensitivity based optimization approach. The sensitivity derivatives of the flutter frequency and dynamic pressure of the model with respect to the lag terms appearing in the Roger's unsteady aerodynamics approximations are evaluated both analytical and by finite differences. Then, the Levenberg-Marquardt method is used to find the optimum values for these lag-terms. The results obtained here agree much better with the experimental (wind tunnel) results than those found in the previous studies. Author

A91-32027*# Old Dominion Univ., Norfolk, VA.
A VECTOR UNSYMMETRIC EIGENEQUATION SOLVER FOR NONLINEAR FLUTTER ANALYSIS ON HIGH-PERFORMANCE COMPUTERS
JIANGNING QIN, CHUH MEI (Old Dominion University, Norfolk, VA), and CARL E. GRAY, JR. (NASA, Langley Research Center, Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1971-1980. Old Dominion University-supported research. refs
(Contract NAS1-18584; NAG1-858)
(AIAA PAPER 91-1169)
A finite element approach is presented for determining the nonlinear flutter characteristics of composite panels using unsteady, third-order piston theory aerodynamics. Both nonlinear structural (large-amplitude) and nonlinear aerodynamics terms are considered in the finite element formulation. Solution procedures are presented to solve the nonlinear panel flutter and the large-amplitude free vibration finite element equations. Nonlinear aerodynamic and linear structural finite element flutter results for composite panels are also presented. An efficient, vector-version generalized unsymmetric eigenequation solver is developed for large-amplitude vibration and nonlinear panel flutter analyses on high-performance computers. Author

A91-32029*#
NONLINEAR PANEL FLUTTER IN A RAREFIED ATMOSPHERE - AERODYNAMIC SHEAR STRESS EFFECTS
HUGO B. RESENDE IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1992-2001. refs
(Contract NGL-05-020-243)
(AIAA PAPER 91-1172) Copyright
The panel flutter phenomenon is studied assuming free-molecule flow. This kind of analysis is relevant in the case of hypersonic flight vehicles traveling at high altitudes, especially in the leeward portion of the vehicle. In these conditions the aerodynamic shear can be expected to be considerably larger than the pressure at a given point, so that the effects of such a loading are incorporated into the structural model. This is accomplished by introducing distributed longitudinal and bending moment loads. The former can lead to buckling of the panel, with the second mode in the case of a simply-supported panel playing a important role, and becoming the dominant mode in the solution. The presence of equivalent springs in the longitudinal direction at the panel's ends also becomes of relative importance, even for the evaluation of the linear flutter parameter. Finally, the behavior of the system is studied in the presence of applied compressive forces, that is, classical buckling. Author

A91-32030*# Old Dominion Univ., Norfolk, VA.
FINITE ELEMENT ANALYSIS OF NONLINEAR FLUTTER OF COMPOSITE PANELS
IAIN R. DIXON and CHUH MEI (Old Dominion University, Norfolk, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2002-2010. Research supported by Universities Space Research Association and Old Dominion University. refs
(Contract NAS1-18584)
(AIAA PAPER 91-1173) Copyright
A finite element formulation is developed to analyze large-amplitude panel flutter of arbitrary laminated plates. The plates considered are anisotropic composite, thin rectangular panels. The equations of motion for an oscillating plate are determined and solved by linearizing the nonlinear stiffness matrices. The solution procedure is presented to determine the limit-cycle motions which are caused by the large deflections and vibrations induced by the areodynamic load. The aerodynamic load is defined by the first-order piston theory. Examples studied include cross-ply laminates with various numbers of layers and three-layer angle-ply laminates with different lamination angles. The effects of simply supported and clamped boundary conditions of a cross-ply laminate are also examined. Author

A91-32032*# Michigan Univ., Ann Arbor.
AEROELASTIC MODAL CHARACTERISTICS OF MISTUNED BLADE ASSEMBLIES - MODE LOCALIZATION AND LOSS OF EIGENSTRUCTURE
CHRISTOPHE PIERRE (Michigan, University, Ann Arbor) and DURBHA V. MURTHY (NASA, Lewis Research Center, Cleveland; Toledo, University, OH) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2036-2050. refs
(Contract NAG3-1163)
(AIAA PAPER 91-1218) Copyright
An investigation of the effects of small mistuning on the aeroelastic modes of bladed-disk assemblies with aerodynamic coupling between blades is presented. The cornerstone of the approach is the use and development of perturbation methods that exhibit the crucial role of the interblade coupling and yield general findings regarding mistuning effects. It is shown that blade assemblies with weak aerodynamic interblade coupling are highly sensitive to small blade mistuning, and that their dynamics is qualitatively altered in the following ways: the regular pattern that characterizes the root locus of the tuned aeroelastic eigenvalues in the complex plane is totally lost; the aeroelastic mode shapes become severely localized to only a few blades of the assembly and lose their constant interblade phase angle feature; curve veering phenomena take place when the eigenvalues are plotted versus a mistuning parameter. Author

A91-32040#
FREE VIBRATION AND AEROELASTIC DIVERGENCE OF AIRCRAFT WINGS MODELLED AS COMPOSITE THIN-WALLED BEAMS
O. SONG and L. LIBRESCU (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2128-2136. refs
(AIAA PAPER 91-1187) Copyright
This paper deals with the analysis of the free vibration and aeroelastic divergence of aircraft wings modeled as thin-walled anisotropic beams. A number of non-classical effects featuring the behavior of composite thin-walled beams of closed contour are incorporated and their implications are emphasized. The results which concern the vibrational characteristics obtained in the paper present an evident importance toward obtaining more reliable predictions of the dynamic response and flutter instability of aeronautical/aerospace structures, in general, and of their lifting surfaces in particular. As concerns the results associated with the divergence instability, these could have a significative role in a more efficient design of forward-swept wing aircraft for which this aeroelastic instability is the most critical one. Author

A91-32082#
AN INCLUSION PRINCIPLE FOR THE RAYLEIGH-RITZ BASED SUBSTRUCTURE SYNTHESIS
LEONARD MEIROVITCH and MOON K. KWAK (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2515-2522. refs
(Contract F49620-89-C-0045)
(AIAA PAPER 91-1058) Copyright
This paper is concerned with the convergence characteristics of a Rayleigh-Ritz based substructure synthesis developed earlier.

According to this substructure synthesis, the motion of every substructure is modeled in terms of quasi-comparison functions, which are linear combinations of admissible functions capable of satisfying all the boundary conditions. A consistent kinematical procedure permits the aggregation of the various substructures and ensures compatibility without the need of imposing constraints. The computed eigenvalues satisfy the inclusion principle, which in turn can be used to demonstrate uniform convergence of the approximate solution. A numerical example illustrates the inclusion principle. Author

A91-32097*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

A FREQUENCY BASED APPROACH TO DYNAMIC STRESS INTENSITY ANALYSIS

STEPHEN A. RIZZI (NASA, Langley Research Center, Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2677-2684. refs

(AIAA PAPER 91-1176)

A hybrid finite element/modal analysis/spectral analysis method is presented for the extraction of frequency dependent strain energy release rates and stress intensity factors. The approach is based on the crack closure technique and is formulated directly in the frequency domain. It is demonstrated for a center cracked panel subject to static in-plane and acoustic loading. Author

A91-32105*# Lockheed Engineering and Sciences Co., Hampton, VA.

NONLINEAR STATIC AND DYNAMIC FINITE ELEMENT ANALYSIS OF AN ECCENTRICALLY LOADED GRAPHITE-EPOXY BEAM

EDWIN L. FASANELLA (Lockheed Engineering and Sciences Co., Hampton, VA), KAREN E. JACKSON (U.S. Army, Aerostructures Directorate, Hampton, VA), and LISA E. JONES (NASA, Langley Research Center, Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2766-2771. refs

(AIAA PAPER 91-1227) Copyright

The Dynamic Crash Analysis of Structures (DYCAT) and NIKE3D nonlinear finite element codes were used to model the static and implulsive response of an eccentrically loaded graphite-epoxy beam. A 48-ply unidirectional composite beam was tested under an eccentric axial compressive load until failure. This loading configuration was chosen to highlight the capabilities of two finite element codes for modeling a highly nonlinear, large deflection structural problem which has an exact solution. These codes are currently used to perform dynamic analyses of aircraft structures under impact loads to study crashworthiness and energy absorbing capabilities. Both beam and plate element models were developed to compare with the experimental data using the DYCAST and NIKE3D codes. Author

A91-32126*# Georgia Inst. of Tech., Atlanta.

USE OF SYSTEM IDENTIFICATION TECHNIQUES FOR IMPROVING AIRFRAME FINITE ELEMENT MODELS USING TEST DATA

SATHYA V. HANAGUD, WEIYU ZHOU, JAMES I. CRAIG, and NEIL J. WESTON (Georgia Institute of Technology, Atlanta) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2986-2995. refs

(Contract NAG1-1007; DAAG29-82-K-0094)

(AIAA PAPER 91-1260) Copyright

A method for using system identification techniques to improve airframe finite element models using test data has been developed and demonstrated. The method uses linear sensitivity matrices to relate changes in selected physical parameters to changes in the total system matrices. The values for these physical parameters were determined using constrained optimization with singular value decomposition. The method was confirmed using both simple and complex finite element models for which pseudo-experimental data was synthesized directly from the finite element model. The method was then applied to a real airframe model which incorporated all of the complexities and details of a large finite element model and for which extensive test data was available. The method was shown to work, and the differences between the identified model and the measured results were considered satisfactory. Author

A91-32133*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

STRUCTURAL DYNAMIC AND AEROELASTIC CONSIDERATIONS FOR HYPERSONIC VEHICLES

F. W. CAZIER, JR., ROBERT W. DOGGETT, JR., and RODNEY H. RICKETTS (NASA, Langley Research Center, Hampton, VA) AIAA, ASME, ASCE, AHS, and ASC, Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991. 15 p. refs

(AIAA PAPER 91-1255) Copyright

Structural dynamic and aeroelastic considerations applicable to hypersonic vehicles are discussed. Emphasis is given to aerospace plane configurations. The definition of aerothermoelasticity and the operational flight environment are reviewed, and structural dynamic and aeroelastic areas of concern are individually discussed, including vibration, landing and taxiing, propellant dynamics, acoustics, lifting surface flutter, panel flutter, control surface buzz, buffeting, gust response, and static aeroelasticity. Recent research results from all-moveable delta-wing aerolastic studies, engine inlet lip aeroelastic analysis, and studies of thermal effects on vibration frequencies, aerodynamic heating effects on flutter, and active control of aeroelastic response are reviewed. C.D.

N91-19435*# Ohio State Univ., Columbus. Dept. of Mechanical Engineering.

VIBRATION TRANSMISSION THROUGH ROLLING ELEMENT BEARINGS IN GEARED ROTOR SYSTEMS Ph.D. Thesis Final Report

RAJENDRA SINGH and TEIK CHIN LIM Washington, D.C. NASA Nov. 1990 232 p

(Contract NAG3-773)

(NASA-CR-4334; AVSCOM-TR-90-C-019; E-5716; NAS 1.26:4334)

Avail: NTIS HC/MF A11 CSCL 13/9

A new mathematical model is proposed to examine the vibration transmission through rolling element bearings in geared rotor systems. Current bearing models, based on either ideal boundary conditions for the shaft or purely translational stiffness element description, cannot explain how the vibratory motion may be transmitted from the rotating shaft to the casing. Experimental results have shown that the casing plate motion is primarily flexural. Here, this issue is clarified qualitatively and quantitatively by developing a comprehensive bearing stiffness matrix of dimension 6 to model precision rolling element bearings using basic principles. The proposed bearing stiffness matrix is partially verified using available analytical and experimental data, and is completely characterized. The study extends the proposed bearing formulation to analyze the overall geared rotor system dynamics including casing and mounts. The bearing stiffness matrix is included in discrete system models using lumped parameter and/or dynamic finite element techniques. Author

N91-19438*# Akron Univ., OH.

LIFE AND DYNAMIC CAPACITY MODELING FOR AIRCRAFT TRANSMISSIONS Final Report

MICHAEL SAVAGE Washington NASA Jan. 1991 139 p

(Contract NAG3-55; DA PROJ. 1L1-62211-A-47-A)

(NASA-CR-4341; E-5824; NAS 1.26:4341; AVSCOM-TR-90-C-027)

Avail: NTIS HC/MF A07 CSCL 13/9

A computer program to simulate the dynamic capacity and life of parallel shaft aircraft transmissions is presented. Five basic configurations can be analyzed: single mesh, compound, parallel, reverted, and single plane reductions. In execution, the program prompts the user for the data file prefix name, takes input from a ASCII file, and writes its output to a second ASCII file with the same prefix name. The input data file includes the transmission configuration, the input shaft torque and speed, and descriptions of the transmission geometry and the component gears and bearings. The program output file describes the transmission, its components, their capabilities, locations, and loads. It also lists the dynamic capability, ninety percent reliability, and mean life of each component and the transmission as a system. Here, the program, its input and output files, and the theory behind the operation of the program are described. Author

N91-19443*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HEAT TRANSFER IN ROTATING SERPENTINE PASSAGES WITH TRIPS NORMAL TO THE FLOW
J. H. WAGNER, B. V. JOHNSON, R. A. GRAZIANI (Pratt and Whitney Aircraft, East Hartford, CT.), and F. C. YEH 1991 15 p Proposed for presentation at the 36th International Gas Turbine and Aeroengine Congress and Exhibition, Orlando, FL, 3-6 Jun. 1991; sponsored by ASME
(Contract NAS3-23691)
(NASA-TM-103758; E-6015; NAS 1.15:103758) Avail: NTIS HC/MF A03 CSCL 13/2

Experiments were conducted to determine the effects of buoyancy and Coriolis forces on heat transfer in turbine blade internal coolant passages. The experiments were conducted with a large scale, multipass, heat transfer model with both radially inward and outward flow. Trip strips on the leading and trailing surfaces of the radial coolant passages were used to produce the rough walls. An analysis of the governing flow equations showed that four parameters influence the heat transfer in rotating passages: coolant-to-wall temperature ratio, Rossby number, Reynolds number, and radius-to-passage hydraulic diameter ratio. The first three of these four parameters were varied over ranges which are typical of advanced gas turbine engine operating conditions. Results were correlated and compared to previous results from stationary and rotating similar models with trip strips. The heat transfer coefficients on surfaces, where the heat increased with rotation and buoyancy, varied by as much as a factor of four. Maximum values of the heat transfer coefficients with high rotation were only slightly above the highest levels obtained with the smooth wall model. The heat transfer coefficients on surfaces, where the heat transfer decreased with rotation, varied by as much as a factor of three due to rotation and buoyancy. It was concluded that both Coriolis and buoyancy effects must be considered in turbine blade cooling designs with trip strips and that the effects of rotation were markedly different depending upon the flow direction. Author

N91-19457# Oxford Univ. (England). Dept. of Engineering Science.
THE SELECTION OF WINDOW FUNCTIONS FOR THE CALCULATION OF TIME DOMAIN AVERAGES ON THE VIBRATION OF THE INDIVIDUAL GEARS IN AN EPICYCLIC GEARBOX
P. D. MCFADDEN 1990 31 p Sponsored by Science Research Council, England
(OUEL-1818/90; ETN-91-98953) Avail: NTIS HC/MF A03

An existing technique which enables the estimation of the time domain averages of the tooth meshing vibration of the individual planet and sun gears in an epicycling gearbox from measured vibration signals is revised. A key feature of the existing technique is the sampling of the vibration signal within a rectangular window in the time domain when one of the planet gears is close to the vibration transducer. The revised technique permits the use of other window functions, and a detailed analysis shows that the errors in the estimate of the time domain average can be expressed in terms of the window function. Several suitable window functions which enable a reduction in the level of the errors are demonstrated by numerical examples and by the analysis of data from a test on a helicopter gearbox with deliberate damage to one of the planet gears. ESA

N91-19460# Dayton Univ., OH. Analytical and Experimental Systems Group.
RESEARCH ON ADVANCED NDE METHODS FOR AEROSPACE STRUCTURES Final Technical Report, 1 Sep. 1986 - 31 Aug. 1989
BRIAN G. FROCK, ROBERT J. ANDREWS, RICHARD W. MARTIN, PRASANNA KARPUR, MARK J. RUDDELL, JEFFERY A. FOX, EDWARD L. KLOSTERMAN, and MARY L. PAPP Sep. 1989 188 p
(Contract F33615-86-C-5016; AF PROJ. 2418)
(AD-A226858; UDR-TR-89-81; WRDC-TR-89-4134) Avail: NTIS HC/MF A09 CSCL 14/4

This Final Report describes investigations of the capabilities and limitations of several digital ultrasonic NDE techniques for imaging defects in advance aerospace materials. The goal of these investigations was to determine the feasibility and practicality of transitioning these techniques from the laboratory to field use. Studies of new digital data collection techniques, signal processing, image enhancement, and image restoration techniques revealed that their use can significantly improve the resolution of features in ultrasonic images. The use of narrow software gates to collect data from digitized rf A-scans improved the resolution in C-scan images of closely-spaced planes in advanced composite materials. That technique was used to simultaneously generate C-scan images of (1) material defects throughout the entire thickness of several 32-ply thick, graphite-epoxy composite materials. The depth resolution of ultrasonic B-scan images was improved by generating the images from axially deconvolved A-scans and from axially power-spectrum-equalized A-scans rather than from the rf A-scans. Lateral resolution in C-scan images was significantly improved by collecting data for the images from Wiener-deconvolved A-scan and from the power-spectrum-equalized A-scan rather than from the rf A-scans. GRA

N91-19464*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NDE STANDARDS FOR HIGH TEMPERATURE MATERIALS
ALEX VARY 1991 20 p Presented at the Symposium on Nondestructive Testing Standards 2: New Opportunities for Increased World Trade Through Accepted Standards for NDT and Quality, Gaithersburg, MD, 9-11 Apr. 1991; sponsored by ASTM, NIST, the American Society of Nondestructive Testing, and The American Welding Society
(NASA-TM-103761; E-6023; NAS 1.15:103761) Avail: NTIS HC/MF A03 CSCL 14/4

High temperature materials include monolithic ceramics for automotive gas turbine engines and also metallic/intermetallic and ceramic matrix composites for a range of aerospace applications. These are materials that can withstand extreme operating temperatures that will prevail in advanced high-efficiency gas turbine engines. High temperature engine components are very likely to consist of complex composite structures with three-dimensionality interwoven and various intermixed ceramic fibers. The thermomechanical properties of components made of these materials are actually created in-place during processing and fabrication stages. The complex nature of these new materials creates strong incentives for exact standards for unambiguous evaluations of defects and microstructural characteristics. NDE techniques and standards that will ultimately be applicable to production and quality control of high temperature materials and structures are still emerging. The needs range from flaw detection to below 100 micron levels in monolithic ceramics to global imaging of fiber architecture and matrix densification anomalies in composites. The needs are different depending on the processing stage, fabrication method, and nature of the finished product. The standards are discussed that must be developed in concert with advances in NDE technology, materials processing research, and fabrication development. High temperature materials and structures that fail to meet stringent specifications and standards are unlikely to compete successfully either technologically or in international markets. Author

N91-19469# National Aerospace Lab., Tokyo (Japan).
STRENGTH TEST OF CFRP BOX BEAM MODEL
Feb. 1990 25 p In JAPANESE; ENGLISH summary
(NAL-TR-1057; ISSN-0389-4010) Avail: NTIS HC/MF A03

The main goal was to obtain basic design data and technical information on applying advanced composites to primary structures of an aircraft for weight saving. Static and fatigue tests were performed on CFRP spar rib models with corrugated web and four types of CFRP joint assembly models which are typical joints for a tailplane structure. Strength tests of a CFRP Box Beam model with sweptback angle were conducted. The purpose of the tests was to evaluate ultimate strength and strain distributions in critical parts, as well as to investigate behavior of deformation initiation of damages, and sequence of failure. The model and the results of the tests are described. It was concluded that utilization of CFRP as primary structural elements for a tailplane is promising. Author

N91-19475*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CASCADE FLUTTER ANALYSIS WITH TRANSIENT RESPONSE AERODYNAMICS
MILIND A. BAKHLE, APARAJIT J. MAHAJAN, THEO G. KEITH, JR. (Ohio Aerospace Inst., Brook Park.), and GEORGE L. STEFKO Feb. 1991 40 p Previously announced in IAA as A91-19448
(Contract NAG3-1137)
(NASA-TM-103746; E-5991; NAS 1.15:103746) Avail: NTIS HC/MF A03 CSCL 20/11

Two methods for calculating linear frequency domain aerodynamic coefficients from a time marching Full Potential cascade solver are developed and verified. In the first method, the Influence Coefficient, solutions to elemental problems are superposed to obtain the solutions for a cascade in which all blades are vibrating with a constant interblade phase angle. The elemental problem consists of a single blade in the cascade oscillating while the other blades remain stationary. In the second method, the Pulse Response, the response to the transient motion of a blade is used to calculate influence coefficients. This is done by calculating the Fourier Transforms of the blade motion and the response. Both methods are validated by comparison with the Harmonic Oscillation method and give accurate results. The aerodynamic coefficients obtained from these methods are used for frequency domain flutter calculations involving a typical section blade structural model. An eigenvalue problem is solved for each interblade phase angle mode and the eigenvalues are used to determine aeroelastic stability. Flutter calculations are performed for two examples over a range of subsonic Mach numbers. Author

N91-19478*# McDonnell-Douglas Helicopter Co., Mesa, AZ.
DEVELOPMENT AND APPLICATIONS OF A MULTI-LEVEL STRAIN ENERGY METHOD FOR DETECTING FINITE ELEMENT MODELING ERRORS
MOSTAFA HASHEMI-KIA, KEVIN L. KILROY, and G. PARKER Oct. 1990 54 p
(Contract NAS1-17498)
(NASA-CR-187447; NAS 1.26:187447) Avail: NTIS HC/MF A04 CSCL 20/11

A computational procedure is described which can be used efficiently in identifying modeling errors which may arise from development of a structural finite element model. The procedure, which is referred to as the multi-level strain energy check, is set up in the form of a set of NASTRAN DMAP alters which provide sufficient information about the modeling errors at G-Set, N-Set, and F-Set levels. This technique was applied to two NASTRAN models, namely, the AH-64A and AH-1G models. Two modeling errors were identified for the AH-1G, which were then corrected. Author

N91-19479*# Sverdrup Technology, Inc., Brook Park, OH.
THE EFFECT OF STEADY AERODYNAMIC LOADING ON THE FLUTTER STABILITY OF TURBOMACHINERY BLADING Final Report
TODD E. SMITH and JAIKRISHNAN R. KADAMBI (Case Western Reserve Univ., Cleveland, OH.) Dec. 1990 11 p Proposed for presentation at the 36th International Gas Turbine and Aerospace Congress and Exposition, Orlando, FL, 3-6 Jun. 1991; sponsored by ASME
(Contract NAS3-25266)
(NASA-CR-187055; E-5929; NAS 1.26:187055) Avail: NTIS HC/MF A03 CSCL 20/11

An aeroelastic analysis is presented which accounts for the effect of steady aerodynamic loading on the aeroelastic stability of a cascade of compressor blades. The aeroelastic model is a two degree of freedom model having bending and torsional displacements. A linearized unsteady potential flow theory is used to determine the unsteady aerodynamic response coefficients for the aeroelastic analysis. The steady aerodynamic loading was caused by the addition of airfoil thickness and camber and steady flow incidence. The importance of steady loading on the airfoil unsteady pressure distribution is demonstrated. Additionally, the effect of steady loading on the tuned flutter behavior and flutter boundaries indicates that neglecting either airfoil thickness, camber or incidence could result in nonconservative estimates of flutter behavior. Author

N91-19494# Technische Univ., Delft (Netherlands). Dept. of Aerospace Engineering.
DESIGN AND TESTING OF A CIRCUMFERENTIAL AND LONGITUDINAL JOINT OF THE A320 FUSELAGE SECTION 13/14 IN GLARE
B. VANWIMERSMAGREIDANUS Oct. 1990 64 p
(LR-645; ETN-91-98946) Avail: NTIS HC/MF A04

Recently a feasibility study on the application of aerospace ARALL (Aramid Aluminum Laminates) in the A320 fuselage was performed. This study, limited to fuselage section 13/14, indicates that a weight reduction of 26 percent can be obtained by using GLARE for the fuselage skin and stringers. No reinforcements are needed at the locations of the stringers. Whether reinforcements at the locations of the joints are necesary in the fuselage design in GLARE is investigated by performing static and fatigue tests on two highly loaded joints. The material properties of the skin (GLARE-3 consisting of three layers of 0.2 mm aluminum 2024-T3 and two layers of 0.25 mm crossply glass prepeg) are discussed and compared with those of aluminum 2024-T3. The decisive loading data for the joints is given, and the type of rivets to be applied to the joints is chosen. The strength of the chosen rivets in the GLARE-3 skin material is determined. The choice of the splice plate material and the geometry of the joints are discussed. Conclusions about the joints of the A320 fuselage design in GLARE are drawn. ESA

N91-19495# Oxford Univ. (England). Dept. of Engineering Science.
TIME-FREQUENCY DOMAIN ANALYSIS OF VIBRATION SIGNALS FOR MACHINERY DIAGNOSTICS. 1: INTRODUCTION TO THE WIGNER-VILLE DISTRIBUTION
P. D. MCFADDEN and W. WANG 1990 41 p Sponsored by Science Research Council, England
(OUEL-1859/90; ETN-91-98957) Avail: NTIS HC/MF A03

The definition and some of the properties of the Wigner-Ville distribution for both continuous and discrete signals are reported. A digital computer program implementing the discrete Wigner-Ville distribution is described and its performance is demonstrated by the analysis in the time frequency domain of a series of numerically generated test signals, showing the form of the Wigner-Ville distribution and the interference terms which can be generated due to its nonlinear behavior. The program is then applied to the analysis in the time frequency domain of experimentally measured time domain averages of the vibration of damaged gears in industrial and helicopter gearboxes, in order to detect early signs of impending mechanical failure. It is shown that the damage to the gears can be detected by visual inspection of the changes which occur in the pattern of the Wigner-Ville distribution, but that the damage can be detected more quickly and easily using an existing narrow band enhancement technique. ESA

N91-19801# Joint Publications Research Service, Arlington, VA.
LAWS OF HEAT TRANSFER IN THREE-DIMENSIONAL VISCOUS SHOCK LAYER OF STREAM FLOWING PAST BLUNT BODIES AT SOME ANGLES OF ATTACK AND GLIDE Abstract Only
A. I. BORODIN and S. V. PEYGIN *In its* JPRS Report: Science and Technology. USSR: Physics and Mathematics p 1 31 Oct. 1990 Transl. into ENGLISH from Inzhenerno-Fizicheskiy Zhurnal (Minsk, USSR), v. 58, no. 2, Feb. 1990 p 200-206
Avail: NTIS HC/MF A03

Heat transfer in a three-dimensional thin viscous shock layer of a supersonic stream flowing past blunt bodies is analyzed by solving the applicable system of three dimensionless partial differential transfer equations, specifically for a stream flowing past triaxial ellipsoids of various proportions with the angles of attack and glide included as two additional parameters of the problem. The ellipsoidal body is described in a rectangular Cartesian system of coordinates with the origin at the stagnation point, with two axes of coordinates on the body surface and the third one normal to it. The stagnation point is a singular one for that system of equations and the two sets of coordinates on the body surface are generated, both features being explicated by a change to appropriate new independent and dependent variables. The boundary conditions for the system of equations are adhesion to an impermeable body surface and generalized Rankin-Hugoniot conditions at the shock wave. Such a boundary value problem is solved numerically by the method of finite differences. Calculations on a BESM-6 high-speed computer were made for ellipsoids with both transverse semiaxes b and c varied from 0.3 to 3 (longitudinal semiaxis a=1), the angle of attack varied from 0 to pi/2, the angle of glide varied from 0 to pi/4, and the Reynolds number varied from 100 to 500,000. Author

N91-20095*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
INTERNAL FLUID MECHANICS RESEARCH
LONNIE REID and LOUIS A. POVINELLI *In its* Aeropropulsion 1991 3 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 20/4

The Internal Fluid Mechanics Division is responsible for computational and experimental research on the internal aerothermodynamics of aeronautical and space propulsion systems. The research focuses on advancing the understanding of the relevant physics associated with improving the state of technology for propulsion system components. Research consists of the development of fast and accurate computational tools and models, the verification of these CFD tools and models through benchmark experiments, and their application to realistic propulsion system components. Advanced computational technologies are used to enhance, accelerate, and integrate computational and experimental research. The presentations summarize ongoing work and indicate emphasis in three major research thrusts, namely, inlets, ducts, and nozzles; turbomachinery; and chemical reacting flows. Author

N91-20096*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
INLETS, DUCTS, AND NOZZLES
JAMES R. SCOTT and JOHN M. ABBOTT *In its* Aeropropulsion 1991 27 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 20/4

The internal fluid mechanics research program in inlets, ducts, and nozzles is a balanced effort between the development and application of computational tools and the conduct of experimental research. The computational effort involves the development and validation of advanced computational fluid dynamics (CFD) codes through comparison with data, the modification of existing codes to extend their range and accuracy, and the application of codes to practical problems to demonstrate their value in design. The experimental research involves both simplified and realistic complex geometries and is used for developing flow physics understanding, for validating advanced numerical analysis codes, and for developing physical models of flow phenomena. The inlet, duct, and nozzle research program is described according to three major classifications of flow phenomena: highly three-dimensional flow fields; shock and high-speed-mixing flow fields; and shear flow control. Specific examples of current and future elements of the research program are described for each of these phenomena. In particular, the highly three-dimensional flow field phenomenon is highlighted by describing the experimental and computational research program in transition ducts having a round-to-rectangular area variation. In the case of shock and high-speed-mixing flow fields, both experimental and computational results are presented for the mixing of a high-speed stream injected into a second high-speed stream. For shear flow control, research in the use of aerodynamic excitation to enhance the jet mixing process is described. In addition, results that stem from using small tabs protruding into a nozzle exit flow stream to enhance mixing are also presented. A three-dimensional, unsteady viscous code development effort that will provide a well-documented, user-friendly flow solver for computing inlet, duct, and nozzle flow fields in the future is described. Author

N91-20100*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PROPULSION INSTRUMENTATION RESEARCH
WILLIAM C. NIEBERDING, DANIEL J. LESCO, and W. DAN WILLIAMS *In its* Aeropropulsion 1991 21 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 14/2

As was stated in the overview, the goal of the Propulsion Instrumentation Research Program is to provide the instrumentation technology advances needed to support future aeropropulsion research and development. A hallmark of this work is that the sensors and measurement systems being developed are not intended to be used on operational propulsion systems. The systems are aimed at experiments for engine development, component development, and analytical code validation. Although sensors and/or systems for operational engines sometimes grow out of this work, they are not the goal. A further characteristic of this work is that it is frequently blind about whether the application is for aero or space propulsion. Some of the following examples are currently being developed for space propulsion systems, but they are also applicable to aeropropulsion. Author

N91-20101*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HIGH TEMPERATURE ELECTRONICS
GARY T. SENG *In its* Aeropropulsion 1991 13 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 09/3

In recent years, the aerospace propulsion and space power communities have acknowledged a growing need for electronic devices that are capable of sustained high-temperature operation. Aeropropulsion applications for high-temperature electronic devices include engine ground test instrumentation such as multiplexers, analog-to-digital converters, and telemetry systems capable of withstanding hot section engine temperatures in excess of 600 C. Uncooled operation of control and condition monitoring systems in advanced supersonic aircraft would subject the electronics to temperatures in excess of 300 C. Similarly, engine-mounted integrated electronic sensors could reach temperatures which exceed 500 C. In addition to aeronautics, there are many other areas that could benefit from the existence of high-temperature electronic devices. Space applications include power electronic devices for space platforms and satellites. Since power electronics require radiators to shed waste heat, electronic devices that operate at higher temperatures would allow a reduction in radiator size. Terrestrial applications include deep-well drilling instrumentation, high power electronics, and nuclear reactor instrumentation and control. To meet the needs of the applications mentioned previously, the high-temperature electronics (HTE) program at the Lewis Research Center is developing silicon carbide (SiC) as a high-temperature semiconductor material. Research is focused on developing the crystal growth, growth modeling, characterization, and device fabrication technologies necessary to produce a family of SiC devices. Interest in SiC has grown dramatically in recent years due to solid advances in the technology. Much research remains to be performed, but SiC appears ready to emerge as a useful semiconductor material. Author

N91-20104*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
OVERVIEW OF STRUCTURES RESEARCH
LARRY D. PINSON *In its* Aeropropulsion 1991 9 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 20/11

The development of aeronautical and space propulsion systems structures technology is the mission of the Structures Division. The technology required to achieve reliable, high-performance, lightweight structures needed for aerospace propulsion is among the most complex and challenging facing the design engineer. The division staff performs both fundamental and applied research in structural mechanics, fatigue and fracture, structural dynamics, and structural integrity. Research programs include probabilistic analysis and design, nonlinear material properties, symbolic logic, composite micromechanics, aeroelasticity, fatigue and fracture of composite structures, life prediction, and aspects of nondestructive evaluation. These programs, which for the most part are analytically based, are experimentally verified and are used to develop computer codes necessary for the design of complex engine structures. An overview of some of these programs is presented. Author

N91-20108*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PROGRESS IN MODELING DEFORMATION AND DAMAGE
ALAN D. FREED and STEVEN M. ARNOLD *In its* Aeropropulsion 1991 9 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 20/11

In hypersonic aircraft, for example, high temperature structures (such as leading edges, inlet cowls, combustor liners, and nozzles) are subjected to thermomechanical deformations. It is believed that such deformations will be a primary cause of structural failure in these components. They arise from large thermal gradients across structural skins that are constrained from free thermal expansion. In order to assess structural life and performance, the material's thermomechanical behavior must be incorporated into the structural design. The laboratories of the Fatigue and Fracture Branch of Lewis Research Center are dedicated to observing the evolution of deformation and damage in laboratory specimens under thermomechanical loading conditions. These observations are used within the branch to guide the development of deformation and life-assessing models. Author

N91-20115*# Army Aviation Systems Command, Cleveland, OH. Propulsion Directorate.
ADVANCED ROTORCRAFT TRANSMISSION TECHNOLOGY
DAVID G. LEWICKI *In* NASA, Lewis Research Center, Aeropropulsion 1991 15 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 13/9

The NASA Lewis Research Center and the Propulsion Directorate of the U.S. Army Aviation Systems Command are involved in a joint research program to advance the technology of rotorcraft transmissions. The program consists of analytical and experimental efforts to achieve the overall goals of reducing transmission weight and noise, while increasing life and reliability. The work includes in-house studies and tests, university grants, industry contracts, and joint programs with other military organizations. Highlights of recent activities in the areas of transmission and related component research are presented. Three major activities are highlighted: (1) the advanced rotorcraft transmission (ART) program; (2) a comprehensive transmission noise reduction program; and (3) a transmission diagnostics research effort. Results of recent activities are presented along with future research plans. Author

N91-20337# Federal Aviation Administration, Atlantic City, NJ.
DATA LINK TEST AND ANALYSIS SYSTEM/TCAS MONITOR USER'S GUIDE
JOHN VANDONGEN and LEO WAPELHORST Feb. 1991 53 p
(Contract FAA-T2001-F)
(DOT/FAA/CT-TN90/62) Avail: NTIS HC/MF A04

This document is a user's guide for the Data Link Test and Analysis System (DATAS) Traffic Alert and Collision Avoidance System (TCAS) monitor. It provides a brief overall hardware description of DATAS configured as a TCAS monitor, and the applications software. Author

N91-20363# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
PREDICTING THE PERFORMANCE OF AIRBORNE ANTENNAS IN THE MICROWAVE REGIME M.S. Thesis
DAVID P. CARROLL Dec. 1990 109 p
(AD-A230501; AFIT/GE/ENG/90D-10) Avail: NTIS HC/MF A06 CSCL 20/14

This study investigated the application of a high-frequency model (Uniform Geometrical Theory of Diffraction) of electromagnetic sources mounted on a curved surface of a complex structure. In particular, the purpose of the study was to determine if the model could be used to predict the radiation patterns of cavity-backed spiral antennas mounted on aircraft fuselages so that the optimum locations for the antennas could be chosen during the aircraft design phase. A review of literature revealed a good deal of work in modeling communications, navigation, identification antennas (blade monopoles and aperture slots) mounted on a wide variety of aircraft fuselages and successful validation against quarter-scale model measurements. This study developed a monopole-array model of a spiral antenna's radiation at vertical polarization and an ellipsoid-plate model of the FB-111A. Using the antenna and aircraft models, the existing Uniform Geometrical Theory of Diffraction model generated radiation patterns which agreed favorably with full-scale measured data. The study includes plots of predicted and measured radiation patterns from 2.5 to 15 Gigahertz. GRA

N91-20369# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
DETECTION OF HIGH ALTITUDE AIRCRAFT WAKE VORTICES USING INFRARED DOPPLER LIDAR: AN ASSESSMENT M.S. Thesis
MICHAEL J. ESTES Dec. 1990 149 p
(AD-A230534; AFIT/GEO/ENP/90D-1) Avail: NTIS HC/MF A07 CSCL 17/5

The feasibility is studied of air-to-air detection of high altitude aircraft wake vortices at long ranges using infrared Doppler lidar. The purpose of this technique is to detect otherwise stealthy aircraft. Three laser wavelengths were analyzed: 1.064, 2.091, and 9.115 microns. Analysis revealed that the spectral width of the return signal from an aircraft wake presented a good signature for detection. Based on the analysis, a minimum signal-to-noise ratio of 0 db was established. Detection performance was then analyzed using signal-to-noise ratio calculations for backscatter by ambient atmospheric aerosols, jet engine exhaust soot particles, and condensation trail ice particles. Results indicated that atmospheric aerosols alone were not sufficient for detection in clean atmospheric regions. Backscatter enhancement by soot particles did, however, appear to be sufficient for detection out to 80 km. Enhancement by condensed ice particles in wake contrails provided detection well beyond 100 km in range. Interestingly, the shorter wavelength lidars did not perform as well as the 9.115 micron lidar due to degradations from shot noise, wavefront mismatch, refractive turbulence, and atmospheric extinction. GRA

N91-20378# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
CHARACTERIZATION OF AN AIR-TO-AIR OPTICAL HETERODYNE COMMUNICATION SYSTEM M.S. Thesis

REBECCA N. SEEGER Dec. 1990 126 p
(AD-A230681; AFIT/GE/ENG/90D-55) Avail: NTIS HC/MF A07
CSCL 20/6

The primary goal of this research was to determine the feasibility of air-to-air optical communications systems using coherent detection in a turbulent environment. Secondary goals were to determine: (1) the signal-to-noise ratio (SNR) degradation due to turbulence, and (2) the effect of varying the wavelength (1.5, 830, 904 nm), altitude (5000 to 12500 m), path length (40 to 160 km) and aperture side length (1 to 15 cm) on the turbulence affected SNR. The research was conducted under the following assumptions: (1) ideal transmitter and receiver, (2) equally sized, uniformly weighted, square transmitter and receiver apertures, (3) ideal tracking by the receiver, and (4) zero losses due to beam steering, beam spreading and scintillation. It was shown that the SNR efficiency (defined as the ratio of the turbulence affected SNR to the non-turbulence affected SNR) ranged from 0.16 to 67.2 percent. The 67.2 percent efficiency was achieved for a wavelength of 904 nm, path length of 40 km, altitude of 5000 m and aperture side length of 1 cm. GRA

N91-20384# Royal Aerospace Establishment, Farnborough (England).
RAE BEDFORD'S EXPERIENCE OF USING DIRECT VOICE INPUT (DVI) IN THE COCKPIT
N. COOKE 6 Jun. 1990 27 p Presented at the Voice Systems Worldwide Conference Military Applications Session, London, England, May 1990
(RAE-TM-FM-43; BR115495; ETN-91-99008) Copyright Avail: NTIS HC/MF A03

Research of automatic speech recognition in an aircraft cockpit is described. A BAC 1-11 aircraft was used and research concerned the civil flight deck. Lessons learned are outlined and referred to military operations. Trials underway using a Tornado GR1 are described. DV1 is shown to be feasible in the relative quiet of the civil cockpit and possible improvements, which are essential for military viability are given. Tables listing the recognition results are provided. ESA

N91-20385# Royal Aerospace Establishment, Farnborough (England).
EVALUATION OF VIRTUAL COCKPIT CONCEPTS DURING SIMULATED MISSIONS
M. G. KAYE, JUDITH INESON, D. N. JARETT, and G. WICKHAM 9 Apr. 1990 16 p Presented at the SPIE Helmet-Mounted Displays 2 Conference, Orlando, FL, 12-20 Apr. 1990
(RAE-TM-MM-36; BR115970; ETN-91-99009) Copyright Avail: NTIS HC/MF A03

The Virtual Environment Integration Laboratory (VEIL) of the Royal Aerospace Establishement (RAE) is described. The VEIL program is intended to provoke appropriate technological developments by exploring the human requirements of operating within a virtual cockpit whilst conducting demanding missions. Under construction is a lightweight binocular, color helmet mounted display with a wide field of view, driven by a versatile parallel architecture computer graphic system which accommodates simulated sensor images from a camera and terrain model. Prototypes of suitable display formats will be developed using a bench mounted stereoscopic viewing rig which will also facilitate investigation of critical psychophysical issues. The complete VEIL hardware will integrate eye and head position sensors, three dimensional sound, direct voice input, and tactile sensors with the binocular display system. When allied to the ground attack, helicopter and air combat simulator facilities of Mission Management Department, it will enable the practicality of operating virtual cockpit systems in a wide variety of missions and tasks to be addressed. ESA

N91-20409# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
ADAPTIVE FILTERING AND SMOOTHING FOR TRACKING A HYPERSONIC AIRCRAFT FROM A SPACE PLATFORM M.S. Thesis
KENNETH A. GOTSKI Dec. 1990 129 p
(AD-A230603; AFIT/GA/ENY/90D-6) Avail: NTIS HC/MF A07
CSCL 17/11

This study took a previously developed six state Kalman filter (designed for space-based tracking of a hypersonic transatmospheric vehicle), tuned it, and performed a Monte Carlo analysis. Three multiple model adaptive filters were then developed, with sub-filters designed for quiescent periods and periods with apparent acceleration. Next, a smoother was developed using the six state filter as the forward filter and a form of that same filter as the backward filter. The smoother and all of the above filters were compared for their ability to most accurately estimate the transatmospheric vehicle's state, with special emphasis on the acceleration states. This emphasis was motivated by a desire to evaluate the Kalman filter's usefulness as a real-time intelligence gathering tool. From the data generated, it was concluded that neither the adaptive filters nor the smoother improved upon the performance of the six state Kalman filter. GRA

N91-20418*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HYPERVELOCITY ATMOSPHERIC FLIGHT: REAL GAS FLOW FIELDS
JOHN T. HOWE Nov. 1990 249 p
(NASA-RP-1249; A-90143; NAS 1.61:1249) Avail: NTIS HC/MF A11 CSCL 20/4

Flight in the atmosphere is examined from the viewpoint of including real gas phenomena in the flow field about a vehicle flying at hypervelocity. That is to say, the flow field is subject not only to compressible phenomena, but is dominated by energetic phenomena. There are several significant features of such a flow field. Spatially, its composition can vary by both chemical and elemental species. The equations which describe the flow field include equations of state and mass, species, elemental, and electric charge continuity; momentum; and energy equations. These are nonlinear, coupled, partial differential equations that were reduced to a relatively compact set of equations of a self-consistent manner (which allows mass addition at the surface at a rate comparable to the free-stream mass flux). The equations and their inputs allow for transport of these quantities relative to the mass-averaged behavior of the flow field. Thus transport of mass by chemical, thermal, pressure, and forced diffusion; transport of momentum by viscosity; and transport of energy by conduction, chemical considerations, viscosity, and radiative transfer are included. The last of these complicate the set of equations by making the energy equation a partial integrodifferential equation. Each phenomenon is considered and represented mathematically by one or more developments. The coefficients which pertain are both thermodynamically and chemically dependent. Solutions of the equations are presented and discussed in considerable detail, with emphasis on severe energetic flow fields. For hypervelocity flight in low-density environments where gaseous reactions proceed at finite rates, chemical nonequilibrium is considered and some illustrations are presented. Finally, flight where the flow field may be out of equilibrium, both chemically and thermodynamically, is presented briefly. Author

N91-20419*# North Carolina State Univ., Raleigh. Dept. of Mechanical and Aerospace Engineering.
NONEQUILIBRIUM RADIATIVE HEATING PREDICTION METHOD FOR AEROASSIST FLOWFIELDS WITH COUPLING TO FLOWFIELD SOLVERS Ph.D. Thesis
LIN C. HARTUNG 1991 175 p
(NASA-CR-188112; NAS 1.26:188112) Avail: NTIS HC/MF A08
CSCL 20/4

A method for predicting radiation adsorption and emission coefficients in thermochemical nonequilibrium flows is developed. The method is called the Langley optimized radiative nonequilibrium code (LORAN). It applies the smeared band approximation for molecular radiation to produce moderately detailed results and is intended to fill the gap between detailed but costly prediction methods and very fast but highly approximate methods. The optimization of the method to provide efficient solutions allowing

coupling to flowfield solvers is discussed. Representative results are obtained and compared to previous nonequilibrium radiation methods, as well as to ground- and flight-measured data. Reasonable agreement is found in all cases. A multidimensional radiative transport method is also developed for axisymmetric flows. Its predictions for wall radiative flux are 20 to 25 percent lower than those of the tangent slab transport method, as expected, though additional investigation of the symmetry and outflow boundary conditions is indicated. The method was applied to the peak heating condition of the aeroassist flight experiment (AFE) trajectory, with results comparable to predictions from other methods. The LORAN method was also applied in conjunction with the computational fluid dynamics (CFD) code LAURA to study the sensitivity of the radiative heating prediction to various models used in nonequilibrium CFD. This study suggests that radiation measurements can provide diagnostic information about the detailed processes occurring in a nonequilibrium flowfield because radiation phenomena are very sensitive to these processes.
Author

N91-20441# European Space Agency, Paris (France).
GENERALISED SIMILARITY SOLUTIONS FOR THREE DIMENSIONAL, LAMINAR, STEADY COMPRESSIBLE BOUNDARY LAYER FLOWS ON SWEPT, PROFILED CYLINDERS
VIKTOR SALJNIKOV and UWE DALLMANN (Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen, Germany, F.R.) Jan. 1991 119 p Transl. into ENGLISH of Verallgemeinerte Aehnlichkeitsloesungen fuer Dreidimensionale, Laminare, Stationaere, Kompressible Grenzschichstroemungen an Schiebenden Profilierte Zylindern (Goettingen, Fed. Republic of Germany, DLR) Original language document was announced as N90-13725
(ESA-TT-1190; DLR-FB-89-34; ETN-91-98967) Avail: NTIS HC/MF A06; original German version available from DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, HC 34.50 DM

Solutions for the laminar, steady, compressible, three dimensional boundary layer equations for flows over swept wings are derived using the method of generalized similarity. The model configuration is that of an infinitely long, swept, profiled cylinder in an ideal gas flow whose dynamic viscosity is a linear function of temperature. The pressure distribution, Pr (Prandtl) and Ma (Mach) numbers, as well as the angle of sweep (beta) and the temperature (T) boundary condition can be chosen arbitrarily. A universal mathematical model which can be integrated numerically is derived. With reference to transonic swept wings, the numerical calculations are performed for values in the vicinity of Pr = 0.72, Ma = 0.82, beta = 21 degrees, T(sub w)/T(sub 0) = 0.98 (isothermal wall). The influences of variations in Ma number, angle of sweep and wall temperature on the characteristic boundary layer properties between the stagnation point and the separation point are presented.
ESA

N91-20450*# Old Dominion Univ., Norfolk, VA. Dept. of Electrical and Computer Engineering.
NEW DEVICES FOR FLOW MEASUREMENTS: HOT FILM AND BURIAL WIRE SENSORS, INFRARED IMAGERY, LIQUID CRYSTAL, AND PIEZO-ELECTRIC MODEL Final Report, period ending 15 May 1990
GRIFFITH J. MCREE, JR. and A. SIDNEY ROBERTS, JR. Feb. 1991 208 p
(Contract NAG1-735)
(NASA-CR-187911; NAS 1.26:187911) Avail: NTIS HC/MF A10 CSCL 14/2

An experimental program aimed at identifying areas in low speed aerodynamic research where infrared imaging systems can make significant contributions is discussed. Implementing a new technique, a long electrically heated wire was placed across a laminar flow. By measuring the temperature distribution along the wire with the IR imaging camera, the flow behavior was identified.

N91-20452*# Old Dominion Univ., Norfolk, VA.
TWENTY-FIVE YEARS OF AERODYNAMIC RESEARCH WITH IR IMAGING: A SURVEY
EHUD GARTENBERG and A. SIDNEY ROBERTS, JR. *In its* New Devices for Flow Measurements: Hot Film and Burial Wire Sensors, Infrared Imagery, Liquid Crystal, and Piezo-Electric Model 20 p Feb. 1991 Presented at Thermosense 13: An International Conference on Thermal Applications and Image Diagnostic, Orlando, FL, 3-5 Apr. 1991
(Contract NAS1-18584)
(SPIE-1467-59) Avail: NTIS HC/MF A10 CSCL 14/2

Infrared imaging used in aerodynamic research evolved during the last 25 years into a rewarding experimental technique for investigation of body-flow viscous interactions, such as heat flux determination and boundary layer transition. The technique of infrared imaging matched well its capability to produce useful results, with the expansion of testing conditions in the entire spectrum of wind tunnels, from hypersonic high-enthalpy facilities to cryogenic transonic wind tunnels. With unique achievements credited to its past, the current trend suggests a change in attitude towards this technique: from the perception as an exotic, project-oriented tool, to the status of a routine experimental procedure.
Author

N91-20457*# Georgia Inst. of Tech., Atlanta. School of Chemical Engineering.
FREQUENCY RESPONSE OF A SUPPORTED THERMOCOUPLE WIRE: EFFECTS OF AXIAL CONDUCTION Progress Report, Oct. 1990 - Mar. 1991
L. J. FORNEY, E. L. MEEKS, and G. C. FRALICK (National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.) Apr. 1991 58 p Sponsored in part by Arnold Engineering Development Center, Arnold AFB, TN
(Contract NCC3-135)
(NASA-CR-188069; E19-666-2; NAS 1.26:188069) Avail: NTIS HC/MF A04 CSCL 14/2

Theoretical expressions are derived for the steady-state frequency response of a supported thermocouple wire. In particular, the effects of axial heat conduction are demonstrated for both a supported one material wire and a two material wire with unequal material properties across the junction. For the case of a one material supported wire, an exact solution is derived which compares favorably with an approximate expression that only matches temperatures at the support junction. Moreover, for the case of a two material supported wire, an analytical expression is derived that closely correlates numerical results. Experimental data were taken with a type K supported thermocouple. The test thermocouple was constructed with dimensions to demonstrate the effects of axial heat conduction assuming constant physical properties across the junction.
Author

N91-20497# Aeronautical Research Labs., Melbourne (Australia).
ENSURING THE INTEGRITY AND VERACITY OF AN INTERACTIVE FAULT DIAGNOSIS AND ISOLATION SYSTEM FOR A GAS TURBINE ENGINE
G. A. WALLACE Aug. 1990 41 p
(AD-A230724; ARL-PROP-TM-471; DODA-AR-006-124) Avail: NTIS HC/MF A03 CSCL 21/5

The tasks involved in developing a fault diagnosis expert system for a gas turbine engine are examined. Particular attention is given to the options available to maximize the quality of the advice given by the expert system. All phases of system development from knowledge acquisition, through system support are covered. A general example of diagnosis by engineering analysis is given to demonstrate the concepts involved. Using acquired knowledge, a limited qualitative fault model of the TF30-P3 gas turbine engine afterburner has been developed, and application to some fault case examples is described.
GRA

N91-20504# Technische Hogeschool, Delft (Netherlands). *Faculty of Aerospace Engineering.*
FATIGUE, STATIC TENSILE STRENGTH, AND STRESS CORROSION OF AIRCRAFT MATERIALS AND STRUCTURES. PART 1: TEXT
J. SCHIJVE Mar. 1990 230 p Revised
(PB91-114553; LR-630-PT-1) Avail: NTIS HC/MF A11 CSCL 20/11

Chapters on stress concentrations, the stress intensity at crack tips, and residual stresses are presented. Knowledge about these subjects is essential for the discussion in subsequent chapters on static tensile strength, stress corrosion, and fatigue. The chapter on failure in tension covers the material tensile strength, the blunt notch strength (strength of notched elements), fracture toughness, and the residual strength of the cracked parts. Aspects of stress corrosion are discussed. The main emphasis is on fatigue of materials and structures. The fatigue life is divided into two periods: the crack initiation period and the crack growth period. The significance of the two periods for practical problems is emphasized and used in the discussion of several effects on fatigue. Separate chapters are presented on fatigue under constant-amplitude loading, fatigue under variable-amplitude loading, fatigue of joints, fatigue loads on aircraft structures, and fatigue of aircraft structures. GRA

N91-20709*# South Dakota Univ., Vermillion. Human Factors Lab.
ENHANCING THE USABILITY OF CRT DISPLAYS IN TEST FLIGHT MONITORING
MICHAEL M. GRANAAS and VICTORIA E. SREDINSKI *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 529-534 Jan. 1991
(Contract NAG2-492)
Avail: NTIS HC/MF A14 CSCL 14/2

Enhancing the usability of Mission Control Center (MCC) CRT displays stands to improve the quality, productivity, and safety of flight-test research at the NASA Ames-Dryden Flight Research Facility. The results of this research suggests that much can be done to assist the user and improve the quality of flight research through the enhancement of current displays. This research has applications to a variety of flight data monitoring displays. Author

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GEOSCIENCES

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

A91-29013
AN EXPERIMENTAL STUDY OF THE PRODUCTION OF ICE CRYSTALS BY A TWIN-TURBOPROP AIRCRAFT
ROBERT D. KELLY and GABOR VALI (Wyoming, University, Laramie) Journal of Applied Meteorology (ISSN 0894-8763), vol. 30, Feb. 1991, p. 217-226. refs
(Contract NSF ATM-86-11185)
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Results are described of experiments in which a twin-turboprop research aircraft was used to determine whether or not, and under what cloud and aircraft operating conditions, a twin-turboprop aircraft can itself produce ice crystals during passage through clouds which contain supercooled liquid water. The results suggest that the aircraft produced the ice particles only in a limited range of cloud and aircraft operating conditions. These include temperatures from -3 to 25 C, the liquid-water contents up to 0.5 g/cu m, the mean drop diameters from 7 to 20 microns and the maximum drop diameters up to 30 microns, true airspeeds from 80 to 110 m/sec, engine speeds from 1700 to 1900 rpm, and low to heavy airframe icing. The mechanism responsible for the generation of the 'aircraft produced ice particles' is discussed. I.S.

N91-20591# Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
A STUDY OF DRY MICROBURST DETECTION WITH AIRPORT SURVEILLANCE RADARS
M. A. MEISTER 29 Nov. 1990 53 p
(Contract DTFA01-83-4-10579)
(AD-A230060; ATC-176; DOT/FAA/NR-90/5) Avail: NTIS HC/MF A04 CSCL 04/2

This report evaluates the capability of Airport Surveillance Radars (ASRs) for the detection of low altitude wind shear associated with the outflows of dry microbursts. It describes results of simulations of dry microburst observations by the ASR. These simulations incorporated weather and clutter data collected by the FL-2 pencil-beam Doppler weather radar at Denver Stapleton Airport in 1988 and 1989 and clutter data collected by the FL-3 ASR-9 emulation radar at Huntsville, Alabama. The impact of signal strength, overhanging precipitations, and ground clutter on both observability and algorithmic performance are assessed. Principal results of study are the following: (1) Overhanging precipitation and weak signal strength do not, by themselves, prohibit detection of dry outflows; however, occurrence of false alarms and biases in velocity estimates indicate that improvements in the dual beam estimator that was evaluated would be required for reliable detection of these events. (2) Ground clutter tends to obscure dry outflows in regions where the difference between median effective clutter reflectivity and weather reflectivity exceeds 17 to 20 dB. A method for predicting the percentage of missed microburst detections due to ground clutter is used to estimate overall microburst detection probabilities for a dry environment such as Denver. Using simulated Denver clutter, overall detection probability is 91 percent. GRA

N91-20595# Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
CLUTTER REJECTION FOR DOPPLER WEATHER RADARS WITH MULTIRATE SAMPLING SCHEMES
M. H. GOLDBURG 11 Dec. 1990 132 p
(Contract DTFA01-L-83-10579)
(AD-A229762; ATC-149) Avail: NTIS HC/MF A07 CSCL 04/2

Reliable weather parameter estimates are required of radars such as the Terminal Doppler Weather Radar (TDWR) which will automatically detect hazardous weather phenomena in the vicinity of an airport. Velocity and range aliasing will degrade the quality of these estimates, as will contamination by ground clutter. For radars which operate at short ranges and at low elevation angles, as the TDWR will to detect windshears at the airport surface, clutter contamination is an especially severe problem. Multirate pulse trains can extend both the unambiguous velocity and range of a Pulsed Doppler Radar beyond those afforded by pulse trains with a constant intersample spacing; but the usual properties of conventional clutter filter architectures change radically when applied to data collected with a multirate sampling scheme. The Pulse-Pair spectral moment estimators are presented, followed by a discussion of frequency domain clutter rejection techniques for Batch PRT (Pulse Repetition Time) sequences. The main topic of the report is clutter suppression for Staggered PRT sequences in which the PRT alternates from pulse to pulse. The Staggered PRT scheme has the advantage over the Batch PRT scheme of spatial coherency for estimates of the radar return signal's autocorrelation function at the lags corresponding to the two PRT's. A time varying filter architecture with multiple transfer functions is presented and analyzed, and its interaction with the Pulse Pair estimators is explored. 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.

A91-29104
CURVED PATH APPROACHES AND DYNAMIC INTERPOLATION
JOSEPH W. JACKSON (Honeywell, Inc., Commercial Flight Systems Group, Glendale, AZ) and PETER E. CROUCH (Arizona State University, Tempe) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 6, Feb. 1991, p. 8-13. refs
Copyright
It is shown that to simplify the specification of a desired trajectory for some subset of the variables of a dynamic control system, it may be advantageous to designate a set of intercept points that the trajectory is required to pass through. The system controls can then be computed in terms of a spline function to meet these requirements for dynamic interpolation. Optimization of a cost function under continuity constraints can be imbedded in the determination of spline coefficients to obtain certain desirable geometric properties of the resulting trajectory. The optimal trajectories determined under the additional constraint of constant speed are useful in determining the acceptability of the results of dynamic interpolation. I.E.

A91-29432
MAINTENANCE AND DEVELOPMENT OF SOFTWARE; PROCEEDINGS OF THE CONFERENCE, LONDON, ENGLAND, OCT. 23, 1990
London, Royal Aeronautical Society, 1990, 55 p. For individual items see A91-29433 to A91-29435.
Copyright
The maintenance and development of software are discussed from an airline's perspective, and the standardization aspects of software are examined. The need for software quality is addressed and the issues of computer software in aircraft, avionics software support in the Royal Air Force, software systems enhancement, and airworthiness certification aspects of software are considered. L.K.S.

A91-29433
COMPUTER SOFTWARE IN AIRCRAFT
J. P. POTOCKI DE MONTALK (Airbus Industrie, Blagnac, France) IN: Maintenance and development of software; Proceedings of the Conference, London, England, Oct. 23, 1990. London, Royal Aeronautical Society, 1990, p. 3.1-3.12.
Copyright
The environment, system, and production of airborne software are discussed. The issues of risk reduction in aviation-related software, design for safety, the place of software in the system, and the standards and tools used in its production are addressed. Particular attention is given to software requirements, system safety analyses, and software standards. The issues of critical system software, software tools, and dissimilar redundancy are also addressed. L.K.S.

A91-29434
AVIONIC SOFTWARE SUPPORT IN THE ROYAL AIR FORCE
M. J. S. PALMER (RAF, London, England) IN: Maintenance and development of software; Proceedings of the Conference, London, England, Oct. 23, 1990. London, Royal Aeronautical Society, 1990, p. 5.1-5.5.
Copyright
The historical background to the support policy for operational software provided by the Royal Air Force (RAF) is reviewed and current policies are summarized. The RAF has supplied support for fixed and deployable air defense systems since the mid 1960s, with the first avionic support team set up in 1968. The prime objective of RAF involvement in software support was to achieve faster and cheaper implementation of software changes and maintain a high standard of quality support work. The current policy for software support is outlined and support options are listed and assessed, including total service support, total industry support, and joint service/industry support. Skill level and quality control are discussed and some of the current driving factors in the software support program are detailed, including tools, techniques, and processes; integrated logic support; CAD/CAM/CIM; manpower, transition to war and war; and interrelated systems and risk. L.K.S.

A91-29947
ASYMPTOTIC METHODS IN PROBLEMS OF OPTIMAL DESIGN AND MOTION CONTROL [ASIMPTOTICHESKIE METODY V ZADACHAKH OPTIMAL'NOGO PROEKTIROVANIIA I UPRAVLENIIA DVIZHENIEM]
ANATOLII N. PANCHENKOV, GENNADII M. RUZHNIKOV, ALEKSEI V. DANEEV, G. F. SIGALOV, V. I. NESHCHERET et al. Novosibirsk, USSR, Izdatel'stvo Nauka, 1990, 272 p. In Russian. refs
Copyright
The theory and applications of asymptotic methods are discussed with emphasis on optimal design and motion control problems. A class of ill-posed boundary value problems in variational calculus and mechanics is considered in which ill-posedness is associated with the deviation from the strong Legendre condition. Some boundary value problems in the theory of optimal axisymmetric aerodynamic shapes are examined, including: optimization of axisymmetric shapes in supersonic and hypersonic gas flows; optimal shapes of axisymmetric bodies with minimal heat flows toward their surface; multicriterial problems in the theory of optimal axisymmetric aerodynamic shapes; and optimization of the shape of elongated bodies in transonic flows at freestream Mach greater than 1. The discussion also covers asymptotic algorithms in motion control problems and differential games as well as asymtotic methods and algorithms in problem-oriented program systems. V.L.

A91-30026
1990 AMERICAN CONTROL CONFERENCE, 9TH, SAN DIEGO, CA, MAY 23-25, 1990, PROCEEDINGS. VOLS. 1-3
Conference sponsored by American Automatic Control Council. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. Vol. 1, 1067 p.; vol. 2, 1091 p.; vol. 3, 1124 p. For individual items see A91-30027 to A91-30033, A91-30035 to A91-30109, A91-30111 to A91-30231, A91-30233 to A91-30244.
Copyright
The present conference discusses discrete-event systems, control applications to military systems, adaptive control systems, modeling and control for microelectronics processing, pole-placement in linear control, nonlinear controls, control of lightweight robotic systems, analysis and control of redundant manipulators, aerospace vehicle guidance and trajectory optimization, intelligent vehicle highway systems, modeling and realization, experimental control of flexible structures, complexity and uncertainty in control system design, decentralized and large scale systems, robust control of complex systems, modeling and control of stochastic systems, automatic aids for ATC, and robust adaptive control. Also discussed are reactor control, linear and nonlinear robust control, control of flexible manipulator arms, robust robot control, aircraft and missile control, optimal control, robust feedback design, robust H2/H-infinity control design, manufacturing processes control, digital control, space systems control, control of active suspension systems, intelligent and fuzzy control, neural network control, large space structures, aerospace trajectory optimization, nonlinear process control, robot kinematics, flexible manipulators, and batch process control. O.C.

A91-30043* Akron Univ., OH.
PARTITIONING METHODS FOR GLOBAL CONTROLLERS
PHILLIP SCHMIDT (Akron, University, OH), SANJAY GARG

(Sverdrup Technology, Inc., Cleveland, OH), and CARL LORENZO (NASA, Lewis Research Center, Cleveland, OH) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 167, 168. refs
Copyright

A procedure for partitioning a global (centralized) controller into interconnected decentralized subcontrollers is presented. It is shown that the controller partitioning problem is different than controller order reduction. An example is presented to demonstrate a procedure wherein an integrated flight/propulsion controller is partitioned into separate airframe and engine subcontrollers. Results show that the assembled partitioned subcontrollers closely match the response of the centralized controller in the frequency domain. I.E.

A91-30077
ROBUSTNESS OF EIGENSTRUCTURE ASSIGNMENT APPROACH IN FLIGHT CONTROL SYSTEM DESIGN
J. C. JUANG, H. M. YOUSSEF, and H. P. LEE (Lockheed Aeronautical Systems Co., Burbank, CA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 749-754. refs
Copyright

Robustness and parameter sensitivity issues of eigenstructure assignment approach are investigated. Eigenvalue sensitivity due to parameter variations is formulated as an optimization problem and solved using a projection algorithm. A good compromise between eigenvalue sensitivity and eigenvector achievablity is obtained. The problem of unmodeled dynamics is addressed using a robustifying procedure. The proposed algorithms are computationally attractive, and both yield more transparent designs. I.E.

A91-30089
OUTPUT APPROXIMATE LOOP TRANSFER RECOVERY FOR FIXED ORDER DYNAMIC COMPENSATORS
ANTHONY J. CALISE and EDWARD V. BYRNS, JR. (Georgia Institute of Technology, Atlanta) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 919-923. refs
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The approximate loop transfer recovery method is extended for fixed-order dynamic compensators to the problem of robustness at the plant output. Full state gains are first designed for the dual system, which is the equivalent of designing a full-order observer. The loop characteristics at the dual system input are then approximated with an observer or controller canonical compensator. Finally, the optimal gains are implemented in the dual compensator to ensure robustness and tracking performance at the plant output. A theorem which further justifies the performance index used in the approximate loop transfer recovery formulation is presented. An example demonstrates the robust compensator design and implementation. This design addresses the problem of helicopter longitudinal flight control. I.E.

A91-30142
POLE PLACEMENT EXTENSIONS FOR MULTIVARIABLE SYSTEMS - A SURVEY
S. K. SPURGEON (Loughborough University of Technology, England) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1660-1665. refs
Copyright

Four techniques which extend control design philosophies based purely on pole placement are reviewed. The first enables the engineer to choose a desired right eigenvector structure is the form of the eigenvector is constrained by the prescribed eigenvalue and the linear system description. The second uses a parametric approach to organize the nonuniqueness of the solution in order to prescribe an efficient and explicit way of modifying the dynamic response of the system. The third assigns linearly independent right eigenvectors corresponding to the desired poles such that the matrix of eigenvectors is as well conditioned as possible. This ensures that the closed-loop response is minimally sensitive to perturbations in the system matrices. The fourth is developed using singular perturbation theory and uses zero and pole assignment to ensure that an appropriate eigenstructure is assigned to the closed-loop system. The extensions and limitations of the methods for the case of output feedback where the design freedom is further restricted are discussed. The design philosophies are compared by considering development of an advanced longitudinal multimode scheme for a dynamically unstable aircraft. I.E.

A91-30143
OPTIMAL EIGENSTRUCTURE ASSIGNMENT FOR MULTIPLE DESIGN OBJECTIVES
S. P. BURROWS and R. J. PATTON (York, University, England) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1678-1683. SERC-sponsored research. refs
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Consideration is given to the application of eigenstructure assignment in the design of multicriteria on controllers with a gradient-based numerical optimization procedure using analytically derived gradients. Emphasis is placed on the design of output feedback control laws which possess certain additional desirable properties. By allowing the closed-loop eigenvalues to be selected (where appropriate) from regions of the complex plane, extra design freedom is introduced which can be used to achieve, for example, robust eigenvalue assignments and a low norm control law more easily. I.E.

A91-30175* Mississippi State Univ., Mississippi State.
DELAY COMPENSATION IN INTEGRATED COMMUNICATION AND CONTROL SYSTEMS. I - CONCEPTUAL DEVELOPMENT AND ANALYSIS
ROGELIO LUCK (Mississippi State University, Mississippi State) and ASOK RAY (Pennsylvania State University, University Park) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2045-2050. refs
(Contract NAG3-823; NSF DMC-87-07648)
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A procedure for compensating for the effects of distributed network-induced delays in integrated communication and control systems (ICCS) is proposed. The problem of analyzing systems with time-varying and possibly stochastic delays could be circumvented by use of a deterministic observer which is designed to perform under certain restrictive but realistic assumptions. The proposed delay-compensation algorithm is based on a deterministic state estimator and a linear state-variable-feedback control law. The deterministic observer can be replaced by a stochastic observer without any structural modifications of the delay compensation algorithm. However, if a feedforward-feedback control law is chosen instead of the state-variable feedback control law, the observer must be modified as a conventional nondelayed system would be. Under these circumstances, the delay compensation algorithm would be accordingly changed. The separation principle of the classical Luenberger observer holds true for the proposed delay compensator. The algorithm is suitable for ICCS in advanced aircraft, spacecraft, manufacturing automation, and chemical process applications. I.E.

A91-30176* Mississippi State Univ., Mississippi State.
DELAY COMPENSATION IN INTEGRATED COMMUNICATION AND CONTROL SYSTEMS. II - IMPLEMENTATION AND VERIFICATION
ROGELIO LUCK (Mississippi State University, Mississippi State) and ASOK RAY (Pennsylvania State University, University Park) IN: 1990 American Control Conference, 9th, San Diego, CA, May

23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2051-2055. refs
(Contract NAG3-823; NSF DMC-87-07648; NSF DMC-86-04412)
Copyright

The implementation and verification of the delay-compensation algorithm are addressed. The delay compensator has been experimentally verified at an IEEE 802.4 network testbed for velocity control of a DC servomotor. The performance of the delay-compensation algorithm was also examined by combined discrete-event and continuous-time simulation of the flight control system of an advanced aircraft that uses the SAE (Society of Automotive Engineers) linear token passing bus for data communications. I.E.

A91-30195* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
INTEGRATION OF MOTION AND STEREO SENSORS IN PASSIVE RANGING SYSTEMS
BANAVAR SRIDHAR and RAYMOND SUORSA (NASA, Ames Research Center, Moffett Field, CA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2349-2355. refs
Copyright

A recursive approach is described for processing a sequence of stereo images. It will be the basis for an integrated stereo and motion method to provide more accurate range information using a passive ranging system. Results based on motion sequences of stereo images are presented. The approach is also applicable to other autonomous systems and in robotics. I.E.

A91-30208
H-INFINITY FLIGHT CONTROL DESIGN WITH LARGE PARAMETRIC ROBUSTNESS
R. Y. CHIANG, M. G. SAFONOV, and J. A. TEKAWY (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2496-2501. refs
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Promising results have been reported involving the design of H-infinity robust control systems with frequency dependent unstructured uncertainties. However, poor structured parametric robustness often occurs in this standard mixed-sensitivity approach due to the LHP (left hand plane) pole-zero cancellation property of H-infinity controllers. This issue becomes critical when designing H-infinity flight control systems for modern supermaneuverable fighters because these fighters have an expanded manuever envelope that is characterized by models with lightly damped poles having significantly large levels of structured parametric uncertainty. This problem is analyzed, and the authors propose several enhancements to the standard H-infinity approach. A flight control design case study is employed to show that the parametric robustness can be greatly increased without invoking other complicated design procedures such as diagonally scaled H-infinity synthesis. I.E.

A91-30240* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A SCHEME FOR THEORETICAL AND EXPERIMENTAL EVALUATION OF MULTIVARIABLE SYSTEM STABILITY ROBUSTNESS
VIVEK MUKHOPADHYAY, ANTHONY S. POTOTZKY (NASA, Langley Research Center, Hampton, VA), and MATTHEW E. FOX IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 3046, 3047.
Copyright

A scheme for theoretical and experimental evaluation of multivariable system stability robustness measures is described. The experimental scheme is based on the estimation of frequency responses from power-spectra analyses of a set of time responses due to sine-sweep excitation at each input and then computation of the appropriate singular values. The procedure can also be used on an open-loop stable system to predict the closed-loop stability before closing the loop. Classical Nyquist diagrams can also be constructed to determine one-loop-at-a-time gain or phase margins. The scheme has been implemented in a wind tunnel test for singular-value evaluation of digital flutter suppression control laws and compared with theory. The singular values at the plant input and output of the actual system and the theoretical model are qualitatively similar but have some discrepancies. I.E.

A91-30911
EVOLUTION OF A MAINTENANCE DIAGNOSTIC SYSTEM
JOHN MEISNER, PAUL BURSCH, and HARRY FUNK (Honeywell Systems and Research Center, Minneapolis, MN) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics *Conference, Dayton*, OH, May 21-25, 1990. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 520-525. refs
(Contract F33615-85-C-3613)
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The ongoing development of a maintenance diagnostic system for an F-16A aircraft flight control system is described. During the course of this development the diagnostic system has grown from a small knowledge-based prototype system into a comprehensive diagnostic system that is currently being field tested. The changing constraints and technology base encountered during the development of this flight control maintenance diagnostic system are discussed. The modifications and enhancements to the maintenance diagnostic system that resulted from these changing parameters are described. I.E.

A91-30926
REQUIREMENTS MODELING FOR REAL-TIME SOFTWARE DEVELOPMENT
TIMOTHY W. BUESCHER and RAGAN T. WILKINSON (TRW/ASG Sacramento Engineering and Technology Applications Laboratory, CA) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 613-617. USAF-sponsored research. refs
Copyright

The requirements modeling techniques that were successfully applied to the development of a facility to perform software development and integration testing of aircraft embedded software are described. This facility mimics the dynamic environment experienced by the software executing within actual avionics hardware. The requirements for each software component in the system are modeled from three perspectives: processing, information, and behavior. The process view treats the system as a planned response system. Events that require a system response are identified and assigned a process. Processes are decomposed to minimize interfaces, and are grouped to preserve the stimulus-response structure. The information view identifies data retained by the system and the system interfaces. Retained data attributes are defined in entity relationship diagrams. Interfaces between components are identified by grouping data into data structures. The behavioral view identifies system modes of operation and control. State transition diagrams are used to identify each system state and the events in which transitions occur. The behavioral view is linked to the process model by control specifications. Application of this approach improves communication to development groups by reducing complexity. It is amenable to both functional and object-oriented design approaches. I.E.

A91-30929
MODULAR EMBEDDED COMPUTER SOFTWARE FOR ADVANCED AVIONICS SYSTEMS
MARC J. PITARYS (USAF, Avionics Laboratory, Wright-Patterson AFB, OH) and RICHARD E. NEESE (Analytic Sciences Corp., Reading, MA) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25,

1990. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 628-633.
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The authors discuss the research being conducted by the Wright Research and Development Center (WRDC) concerning technologies for rapid design and maintenance of advanced avionics systems software. They describe the modular embedded computer software (MECS) effort being conducted by The Analytic Sciences Corporation for WRDC's Software Concepts Group. Point solutions for the major elements of software development/maintenance environment for advanced avionics systems are defined. A prototype modular embedded computer software design architecture for advanced avionics systems is presented. In addition, elements of a prototype software tool-suite currently under development are described. Specific tools include the Ada software design environment, the expert resource mapper, the performance analyzer, and the reliability analyzer. Finally, plans for proof-of-concept demonstrations for the prototype design methodology and tools are summarized. I.E.

A91-30933#
SOFTWARE ENGINEERING TOOLS FOR AVIONICS EMBEDDED COMPUTER RESOURCES
ROBERT L. HARRIS and OTHEUS JACKSON (USAF, Avionics Laboratory, Wright-Patterson AFB, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 652-657. refs

Common characteristics of current computer-aided software engineering (CASE) tools are reviewed from the viewpoint of real-time avionics software. Guidelines for optimum tools are discussed, and some current technology programs that will affect future tool development are outlined. It is argued that avionics software engineering tools are extremely important because they impose an organizational discipline on software development that is generally lacking for large-scale, unprecedented systems, where teams of technical workers must cooperate. This discipline forces controls that aid in the management of software projects. I.E.

A91-30937#
REALTIME SOFTWARE DEVELOPMENT IN MULTI-PROCESSOR, MULTI-FUNCTION SYSTEMS
MARK E. MINGES (USAF, Avionics Laboratory, Wright-Patterson AFB, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 675-680.

It is pointed out that the real-time requirements placed on embedded avionics systems are large and, to avoid costly redesigns of the code (especially during integration and test of the system), a sound development strategy during the design of the system is paramount. The use of systems analysis, both manually and via simulation, will help guarantee the success of the hardware/software partnership. The Integrated Communication, Navigation, Identification, Avionics (ICNIA) system is considered as a model for the development. The real-time interaction of multiple functions running in the ICNIA multiprocessor system is examined. The critical importance of developing a system simulation that can provide timing and sizing data is demonstrated. If the simulation is developed early in the program, there is a valuable opportunity to keep it up to date and use it effectively in static and dynamic systems analyses. These analyses are critical for system optimization and, in turn, are the key to efficient time and resource expenditure. The data provided by the simulator are most valuable during the integration and test phase of the project. I.E.

A91-30943
FLIGHT SIMULATION BENCHMARK FOR PARALLEL ADA
DAVID H. WHITTINGTON (Boeing Computer Services, Seattle, WA) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 712-718. refs
Copyright

A benchmark suite was developed for the parallel Ada environment which could be utilized to measure multiprocessor speedup with varying frequency of intertask synchronization and across various vendor architectures. The benchmark suite centered around the development of a multitask aircraft/avionics airliner simulation. This flight simulation models such modules as aerodynamics, kinematics, engines, autothrottles, pitch and roll autopilots, and a simplified flight management computer. These modules are represented as twelve separate tasks that communicate via global shared memory in one version and with individual messages in another. In addition to the required calculation load, a calibrated but variable load of floating point processing was added to modulate the frequency of task synchronization which was implemented via the Ada rendezvous. This was important due to the expected degradation in system performance as the frequency of synchronization was increased. Some general-purpose processors that there were included in the study included the Sequent Symmetry, the Alliant FX-8, the Encore Multimax, the Harris Nighthawk, and the BiiN 60. Results of the benchmark testing point to the speedup that is available, but with reservations as to the linearity with addition CPUs. Several of the vendors utilized UNIX system calls for implementing the Ada rendezvous, which led to considerable overhead as the number of CPUs was increased, especially when the task synchronization frequency was relatively high (every 10 milliseconds). I.E.

A91-30944
REALTIME, ADA-BASED, AVIONICS PROCESSING
DON BATE, GRANVILLE OTT, and BOB MORTON (Texas Instruments, Inc., Dallas) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 719-722.
Copyright

It is noted that next-generation, embedded avionics systems are demanding an order-of-magnitude higher performance, faster responsiveness, information security protection, and configurable components to deal with the exploding information content modern battlefields. Moreover, they require customizable reusability and a high degree of programmability to keep pace with rapidly changing tactical environments. Architectures which seek to satisfy these demands use multiple embedded controllers, RISC (reduced instruction set computer) processors, cached memories, and programmable signal processors. They rely heavily on embedded Ada runtime technology to meet their goals. The authors describe a RISC-based multiprocessor architecture and associated Ada operating system that support these next-generation avionics concepts while providing enhanced system integrity and information security support features. I.E.

A91-30945
REAL-TIME ADA SOFTWARE EXPERIMENTS
STEVEN M. WAGNER (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) and DAVID G. COBB (McDonnell Aircraft Co., Saint Louis, MO) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 723-728.
Copyright

Experiments have been conducted to investigate key issues involved in developing real-time embedded Ada software and to associate experimental data and results with some often-debated features, styles, and techniques. In order to realistically estimate the impact of these Ada features, actual code from the USAF/MCAIR Ada-based integrated control system (ABICS) and integrated control and avionics for air superiority (ICAAS) programs was used in developing the experiments. The features evaluated in these experiments were chosen based on their relevance to future real-time Ada applications. The issues addressed included data typing, range constraints, compilation and link times, pragmas, parameter passing, floating point data representation, and bit manipulation. Results are presented and recommendations are made regarding several real-time Ada features and techniques relevant to future real-time, embedded Ada development. I.E.

A91-30992
A SENSOR MANAGEMENT EXPERT SYSTEM FOR MULTIPLE SENSOR INTEGRATION (MSI)
BERNIE MCBRYAN, SUZANNE M. MEYER, and MARLIN D. KNABACH (McDonnell Aircraft Co., Saint Louis, MO) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1107-1112. McDonnell Aircraft Co.- sponsored research.
Copyright
An artificial intelligence (AI) expert system for the sensor management functions for an advanced fighter aircraft are described. The system was implemented using the ART (automated reasoning tool) development framework and LISP (List Processing) language. Even with its current moderate-size rule base (60 rules and functions), the system exhibits useful sensor management behavior. Throughout the process attention was focused on an air-to-air combat air patrol scenario for searching and tracking strategies and an air-to-surface night strike mission for interleaved sensor cuing strategies. An efficient and flexible simulation environment that contains all of the features needed to address the MSI problem is presented. The problem, the approach, design methodology, and the expert system behavior are reviewed. I.E.

A91-30993
AEROSPACE APPLICATIONS OF CASE-BASED REASONING
LESLIE A. WHITAKER and MARVIN L. THORDSEN (Klein Associates, Inc., Yellow Springs, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1113-1116. refs
(Contract DAAH01-88-C-0341)
Copyright
Case-based reasoning (CBR) has been proposed as an expert system approach that may overcome a number of limitations of standard rule-based expert systems. A generic CBR shell that runs on a Zenith 386 PC with expanded memory has been developed. A case-based reasoning system uses innovative techniques in the storage and retrieval of data. Cases are retrieved via specified attributes, or characteristics of the case. A CBR shell which allows fast retrieval of multiple cases from a large number of stored cases, named PROSPER (problem solving using prior experience and reasoning), has been developed. Several applications are described: a project to estimate the survivability/vulnerability of underground concrete structures, a study showing the feasibility of using CBR to help aeronautical design engineers identify and retrieve prior designs, a project to use CBR to estimate cost and effort for manufacturing parts, and a study of the feasibility of using CBR to estimate manpower, personnel, and training (MPT) requirements for new systems early in preconcept design. I.E.

A91-31001#
NEURAL NETWORK BASED HUMAN PERFORMANCE MODELING
EDWARD FIX (USAF, Armstrong Aerospace Medical Research Laboratory, Wright-Patterson AFB, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1162-1165. refs
A neural network architecture, derived from recurrent backpropagation, which learns to mimic human behavior and performance in a sample task is presented. It shows operating characteristics similar to those of human subjects, and even makes the same kinds of mistakes. The goal of this task was to develop a neural network which, when trained on data derived from a human subject performing a task, emulates that subject's performance and style. The task was to be interactive, and the conditions controlled. The task the subjects performed is a computer generated display showing a two-lane circular track and five cars. One car is controlled by the subject, and the other four are controlled by the computer. The cars all travel in a counter-clockwise direction. The perspective is adjusted so that the subject's car is always at the 3 o'clock position on the track, and everything else moves relative to the controlled car. The subject's task was to drive his car around the track, switching lanes and adjusting speed as necessary to avoid collisions. I.E.

A91-31014
A COMPARISON OF COMPILED REASONING SYSTEMS AND MODEL-BASED REASONING SYSTEMS AND THEIR APPLICABILITY TO THE DIAGNOSIS OF AVIONICS SYSTEMS
JAMES K. MCDOWELL, JAMES F. DAVIS (Ohio State University, Columbus), MAHMOUD A. ABD-ALLAH, and MOSTAFA AREF (Central State University, Wilberforce, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1243-1249. Miami Valley Research Institute-supported research.
Copyright
The two approaches to diagnostic knowledge-based systems, model-based reasoning and compiled reasoning systems, are compared. The focus of this comparison is the basic problem-solving strategies and knowledge representation issues involved in these two broad categories of diagnostic reasoners. The investigation highlights the differences in the approaches. Two representative shells are used to build prototype diagnostic systems for the same device, using the same experts. The compiled knowledge shell used in this study is CSRL, a generic task tool developed at the Ohio State University. The model-based shell used was the fault isolation system (FIS), a tool developed by the US Navy specifically for the diagnosis of electronic and analog devices. The device for this study was a black-and-white TV. The compiled-knowledge and model-based approaches are compared based on run-time behavior, knowledge requirements, knowledge acquisition, training utility, and potential integration with avionics systems. I.E.

A91-31015
INERTIAL NAVIGATION SYSTEM INTELLIGENT DIAGNOSTIC EXPERT (INSIDE)
LORI ATTIAS and JOSEPH SVEITIS (McDonnell Aircraft Co., Saint Louis, MO) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1250-1253.
Copyright
A troubleshooting expert system has been designed to provide repair and diagnostic information for aircraft inertial navigation systems (INS). The inertial navigation system intelligent diagnostic expert (INSIDE) is used to diagnose faults in an INS system, and to train new operators on the troubleshooting of an INS system, thus freeing up the experienced engineer for other projects. INSIDE leads a new engineer through the conventional fault paths and step-by-step through repairs, thus alleviating the primary training and greatly diminishing the part-time training. The IN intelligent diagnostic expert uses a fault path algorithm. The fault tree is traversed by a rules-based inference engine written in the Level5 expert system shell. It is comprised of one main, executive knowledge base and five more detailed knowledge bases. The system supports graphics, and interfaces with a BASIC program to perform simple, pertinent computations on the request of the operator. I.E.

A91-31029
XMAN II - A REAL TIME MAINTENANCE TRAINING AID
LAWRENCE MILLER, DAMON LEWIS, and RONALD L. DEHOFF (Systems Control Technology, Inc., Palo Alto, CA) IN: NAECON

90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1360-1364.
Copyright

The experience gained through two separate applications of an expert troubleshooting tool to USAF and Marine aircraft is described. The tool used is XMAN II. XMAN II can be used to evaluate the data from the onboard engine monitoring systems (EMS) and, at the same time, assist the maintenance technician in troubleshooting reported discrepancies. XMAN II is resident on a portable microcomputer at the maintenance sites. The XMAN II software interfaces directly with the EMS and upline, maintenance management information systems. The major issues encountered as the system was fielded and highlights of the training benefits to the maintenance unit are presented. Recommendations, in the form of lessons learned, form the roadmap for the use of expert systems as maintenance training aids in organizational level on-the-job training programs. I.E.

A91-31070
ANALYSIS OF MAINTENANCE CONTROL CENTER OPERATIONS
ROBERT LOH and PETER WROBLEWSKI (Mitre Corp., McLean, VA) IN: 1990 Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 23-25, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 404-409. refs
Copyright

The FAA has recommended a nation-wide maintenance automation system (MAS), which will include Maintenance Control Centers (MCCs). Three operational concepts were developed to consolidate the real-time monitoring, coordination, and remote maintenance at the MCCs. The three concepts were then evaluated both qualitatively and quantitatively. Surveys and questionnaires were used to develop the qualitative criteria for evaluation of the concepts and included such concerns as the service to air traffic controllers and the users of the National Airspace System, impact on the maintenance workforce and, impact on risks and costs. The remote-maintenance workload was then assigned to the MCC or the local work centers in order to compare the staffing implications. The results suggest an MCC starting with an initial staff-type facilitator MCC performing only monitoring and coordination and evolving into a super MCC responsible for most remote maintenance and control functions. I.E.

A91-31578*# Florida Univ., Gainesville.
APPLICATION OF GLOBAL SENSITIVITY EQUATIONS IN MULTIDISCIPLINARY AIRCRAFT SYNTHESIS
P. HAJELA, C. L. BLOEBAUM (Florida, University, Gainesville), and JAROSLAW SOBIESZCZANSKI-SOBIESKI (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Dec. 1990, p. 1002-1010. Zonta International Foundation-supported research. refs
(Contract NAG1-850)
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The present paper investigates the applicability of the Global Sensitivity Equation (GSE) method in the multidisciplinary synthesis of aeronautical vehicles. The GSE method provides an efficient approach for representing a large coupled system by smaller subsystems and accounts for the subsystem interactions by means of first-order behavior sensitivities. This approach was applied in an aircraft synthesis problem with performance constraints stemming from the disciplines of structures, aerodynamics, and flight mechanics. Approximation methods were considered in an attempt to reduce problem dimensionality and to improve the efficiency of the optimization process. The influence of efficient constraint representations, the choice of design variables, and design variable scaling on the conditioning of the system matrix was also investigated. Author

A91-31581#
AEROELASTIC DESIGN OPTIMIZATION PROGRAM
A. J. DODD, K. E. KADRINKA, M. J. LOIKKANEN, B. A. ROMMEL, G. D. SIKES (Douglas Aircraft Co., Long Beach, CA) et al. Journal of Aircraft (ISSN 0021-8669), vol. 27, Dec. 1990, p. 1028-1036. refs
Copyright

A major programming effort to produce an interdisciplinary optimization program for the static, dynamic, and aeroelastic analysis of finite element models has been underway at Douglas Aircraft Company since 1985. The data handling utilities, a high-level array and function manipulation language, and many basic analysis modules are in place and have been tested. The current status of the program is described together with test and production applications and plans for future developments. Author

A91-31590#
FITTING ATMOSPHERIC PARAMETERS USING PARABOLIC BLENDING
SALVATORE ALFANO (U.S. Air Force Academy, Colorado Springs, CO) and AKSHAI M. GANDHI Journal of Aircraft (ISSN 0021-8669), vol. 27, Dec. 1990, p. 1087-1089.

The computer-graphics technique known as 'parabolic blending' (PB) is presently explored as an alternative method for fitting of atmospheric data. Relative to the Chebyshev polynomial expansion, PB is distinctive in its ability to be user-tailored to work over any range of altitudes; this yields faster results while accurately fitting the atmospheric table values for pressure and density. The model can be easily updated as more empirical data become available, or rapidly changed if an entirely different atmosphere is desired. O.C.

A91-31731#
LTASIM - A DESKTOP NONLINEAR AIRSHIP SIMULATION
HENRY R. JEX, RAYMOND E. MAGDALENO, and WALTER A. JOHNSON (Systems Technology, Inc., Hawthorne, CA) IN: AIAA Lighter-Than-Air Systems Technology Conference, 9th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 34-42. refs
(AIAA PAPER 91-1275) Copyright

A comprehensive nonlinear 6 DOF simulation model for modern airships has been developed (LTASIM) using the TUTSIM-6 program for use on PC-compatible computers. The model includes nonlinear aerodynamics and buoyancy effects, various thrustor types, important virtual mass and inertia tensor terms, non-constant wind effects, stability and trim control-system, airship-to-target relative motions. On a fast 25 MHz 486-type computer, it will run much faster than the simulated time interval, thereby offering possibilities for use in real-time simulation devices. Author

A91-31889*# McDonnell-Douglas Helicopter Co., Mesa, AZ.
A CASE STUDY IN MULTI-COMPONENT SOFTWARE DEVELOPMENT
KARAN SANGHA and FRIEDRICH STRAUB (McDonnell Douglas Helicopter Co., Mesa, AZ) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 569-577.
(Contract NAS2-12343)
(AIAA PAPER 91-1205) Copyright

McDonnell Douglas Helicopter Company has been actively involved in the development of the U.S. Army sponsored Second Generation Comprehensive Helicopter Analysis System (2GCHAS) over the last five years. This paper describes the multidisciplinary nature of the software, the multicontractor and multi-site environment within which the development took place, the development standards used and evolution of the final product. Valuable lessons were learned during this task that can be used in future developments. Author

A91-32049*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONTROLLING PANEL FLUTTER USING ADAPTIVE MATERIALS
R. C. SCOTT (NASA, Langley Research Center, Hampton, VA) and T. A. WEISSHAAR (Purdue University, West Lafayette, IN) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2218-2229. refs
(AIAA PAPER 91-1067) Copyright

The effectiveness of using adaptive materials to control panel flutter is examined. Adaptive materials are those whose strain or mechanical properties can be controlled by the application of an external stimulus. Two such material types are piezoelectric (ceramics or polymers) and shape memory alloys. These materials experience controllable strain when subjected to applied voltage and heat, respectively. The present study investigates the use of both material types to modify the flutter characteristics of a simply supported panel in supersonic flow. Piezoelectric materials respond quickly to applied voltages and can be used with feedback control for active vibration suppression. The adaptive process of the shape memory alloy used in this study (geometry and stiffness change) is a relatively low frequency phenomenon; therefore, it is considered for passive (on/off) control schemes only. Nondimensional parameters for these adaptive materials are used with linear panel models, yielding results which allow for a better understanding of their capabilities in controlling aeroelastic responses. Author

A91-32054#
APPLICATION OF NEURAL NETWORKS TO SMART STRUCTURES
CHARLIE D. TURNER (Nichols Research Corp., Huntsville, AL) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2261-2268. refs
(AIAA PAPER 91-1235) Copyright

The paper discusses the integration of the sensor, actuator, control, (software), and structure utilizing a hybrid neural network architecture. This architecture which is the focus of the paper provides for the control of a distributed sensor/actuator system which includes the ability to monitor the health of both the network and the structure. The system is adaptive in that it can reconfigure itself if a neuron, data path, sensor, actuator, or structure fails or is damaged. Analytical techniques developed in order to support future modeling and analysis requirements are presented. Author

N91-19731# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Guidance and Control Panel.
COMPUTER AIDED SYSTEM DESIGN AND SIMULATION
GEORGE T. SCHMIDT (Draper, Charles Stark Lab., Inc., Cambridge, MA) Nov. 1990 25 p The 50th symposium was held in Cesme/Izmir, Turkey, 22nd - 25th May 1990
(AGARD-AR-283; ISBN-92-835-0596-6; AD-A230433) Copyright Avail: NTIS HC/MF A03; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

As guidance and control systems have become more complex, the role of computers in their design and development has become increasingly important. Computer aided design finds application at all stages of development. Topics addressed include: computer aided system design; simulation technology for missile and aircraft applications; hardware-in-the-loop simulation; systems applications; and pilot-in-the-loop simulations. B.G.

N91-19742*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
REAL-TIME APPLICATION OF ADVANCED THREE-DIMENSIONAL GRAPHIC TECHNIQUES FOR RESEARCH AIRCRAFT SIMULATION
STEVEN B. DAVIS Dec. 1990 21 p
(NASA-TM-101730; H-1642; NAS 1.15:101730) Avail: NTIS HC/MF A03 CSCL 09/2

Visual aids are valuable assets to engineers for design, demonstration, and evaluation. Discussed here are a variety of advanced three-dimensional graphic techniques used to enhance the displays of test aircraft dynamics. The new software's capabilities are examined and possible future uses are considered. Author

N91-19750*# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
USE OF SYSTEM IDENTIFICATION TECHNIQUES FOR IMPROVING AIRFRAME FINITE ELEMENT MODELS USING TEST DATA Final Report
SATHYA V. HANAGUD, WEIYU ZHOU, JAMES I. CRAIG, and NEIL J. WESTON Mar. 1991 221 p
(Contract NAG1-1007)
(NASA-CR-188041; NAS 1.26:188041) Avail: NTIS HC/MF A10 CSCL 09/2

A method for using system identification techniques to improve airframe finite element models was developed and demonstrated. The method uses linear sensitivity matrices to relate changes in selected physical parameters to changes in total system matrices. The values for these physical parameters were determined using constrained optimization with singular value decomposition. The method was confirmed using both simple and complex finite element models for which pseudo-experimental data was synthesized directly from the finite element model. The method was then applied to a real airframe model which incorporated all the complexities and details of a large finite element model and for which extensive test data was available. The method was shown to work, and the differences between the identified model and the measured results were considered satisfactory. Author

N91-20708*# Georgia State Univ., Atlanta. Center for Human-Machine Systems Research.
OFMSPERT: AN ARCHITECTURE FOR AN OPERATOR'S ASSOCIATE THAT EVOLVES TO AN INTELLIGENT TUTOR
CHRISTINE M. MITCHELL *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 522-526 Jan. 1991
(Contract NAG2-413; NAG5-1044)
Avail: NTIS HC/MF A14 CSCL 09/2

With the emergence of new technology for both human-computer interaction and knowledge-based systems, a range of opportunities exist which enhance the effectiveness and efficiency of controllers of high-risk engineering systems. The design of an architecture for an operator's associate is described. This associate is a stand-alone model-based system designed to interact with operators of complex dynamic systems, such as airplanes, manned space systems, and satellite ground control systems in ways comparable to that of a human assistant. The operator function model expert system (OFMspert) architecture and the design and empirical validation of OFMspert's understanding component are described. The design and validation of OFMspert's interactive and control components are also described. A description of current work in which OFMspert provides the foundation in the development of an intelligent tutor that evolves to an assistant, as operator expertise evolves from novice to expert, is provided. Author

N91-20759# Dayton Univ., OH.
COMPUTER MENU TASK PERFORMANCE MODEL DEVELOPMENT Final Report, Sep. 1987 - Feb. 1990
BYRON J. PIERCE, STANLEY R. PARKINSON, and NORWOOD SISSON Nov. 1990 81 p
(Contract F33615-90-C-0005)
(AD-A230278; AFHRL-TR-90-26) Avail: NTIS HC/MF A05 CSCL 12/5

This report provides a review of literature on computer menu interface design and related performance factors. Implications for the design of the user/system interface for aircraft simulator instructional support systems are considered. A criterion-based search model that makes predictions as to how the number of alternatives on menu pages affects the search process and the pattern of errors that will result is evaluated. The literature on theoretical and empirical work suggests two additional factors that are recommended for inclusion into the search model: (1) user-perceived relationships among target items sought and menu alternatives available for selection, and (2) the probability of an omission situation where the target items is not subsumed under any of the alternatives available for selection. An experiment was conducted to test the effect that all three of these factors have on menu task performance. Results showed that all three factors significantly influenced menu search and response accuracy. A two-criterion menu model was proposed as a means to explicate the performance results of the menu experiment. GRA

N91-20806# National Aerospace Lab., Tokyo (Japan).
PARALLEL PROCESSING USING MULTITASKING ON CRAY X-MP SYSTEM
KINUYO NAKAMURA and MASAHIRO FUKUDA Jun. 1990 23 p In JAPANESE; ENGLISH summary
(NAL-TR-1069; ISSN-0389-4010) Avail: NTIS HC/MF A03
The authors investigated parallel processing, using the CRAY X-MP/216 system, which is a supercomputer with multiple vector processors. Multitasking is a microprocessor computer operation mode that executes two or more parts of a single program in parallel. It is one method of high-speed processing. The FORTRAN programs under investigation are those for a subsonic flow over an airfoil, an unsteady transonic flow over a wing, and an inviscid compressible flow through a two-dimensional cascade. These programs were rewritten so that they could be effectively executed on two central processing units (CPUs). The computing times of the original programs with one CPU, multitasked programs with one CPU, and multitasked programs with two CPUs, are discussed. Also covered is the ratio of computing times of the multitasked programs to those of the original program. 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.

A91-30423
SIMPLE RESPONSE METRICS FOR MINIMIZED AND CONVENTIONAL SONIC BOOMS
D. N. MAY and R. A. SOHN (McDonnell Douglas Corp., Long Beach, CA) Journal of Sound and Vibration (ISSN 0022-460X), vol. 145, March 8, 1991, p. 225-238. refs
Copyright
Simple metrics are developed by which the perceived loundess and C-weighted sound exposure level of minimized sonic booms can be calculated directly from their waveform parameters. The minimized booms are the 'overpressure minimized' and 'front shock minimized' waveforms proposed by Seebass and George. Conventional 'N wave' booms were also studied. The simple metrics show excellent agreement with more complex loudness level calculations (e.g., by Johnson and Robinson) on the one hand, and with the full C-weighted sound exposure level calculation on the other. The simple metrics were derived to assist in preliminary design studies of boom-minimized supersonic transport aircraft. Author

A91-31052
PROGRESS IN FIBER OPTIC RELIABILITY AND MAINTAINABILITY
DAVID A. FOLLOWELL (McDonnell Aircraft Co., Saint Louis, MO) IN: 1990 Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 23-25, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 160-163. refs
Copyright
Results from tests of connectors from several manufacturers are presented. Tests included preparation time, insertion loss, thermal shock, humidity cycling, thermal life aging, and durability. Results were generally very promising. Testing was also performed on an improved pot and polish connector which is being used in the AV-8B digital map set. This connector requires approximately 15 min to terminate, an improvement over the 2 h required for the previous connector. The new connector uses an epoxy that is preinstalled in the contact and is thicker than the previous epoxy. This results in reduced termination time, because the epoxy does not have to be mixed and injected into the contact. I.E.

A91-31534#
ACOUSTIC WAVEFORM SINGULARITIES FROM SUPERSONIC ROTATING SURFACE SOURCES
VALANA L. WELLS (Arizona State University, Tempe) AIAA Journal (ISSN 0001-1452), vol. 29, March 1991, p. 387-394. Previously cited in issue 13, p. 2051, Accession no. A89-33763. refs
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N91-19823*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
J-85 JET ENGINE NOISE MEASURED IN THE ONERA S1 WIND TUNNEL AND EXTRAPOLATED TO FAR FIELD
PAUL T. SODERMAN, ALAIN JULIENNE (Office National d'Etudes et de Recherches Aerospatiales, Paris, France), and ADOLPH ATENCIO, JR. Washington Jan. 1991 181 p
(NASA-TP-3053; A-89265; NAS 1.60:3053) Avail: NTIS HC/MF A09 CSCL 20/1
Noise from a J-85 turbojet with a conical, convergent nozzle was measured in simulated flight in the ONERA S1 Wind Tunnel. Data are presented for several flight speeds up to 130 m/sec and for radiation angles of 40 to 160 degrees relative to the upstream direction. The jet was operated with subsonic and sonic exhaust speeds. A moving microphone on a 2 m sideline was used to survey the radiated sound field in the acoustically treated, closed test section. The data were extrapolated to a 122 m sideline by means of a multiple-sideline source-location method, which was used to identify the acoustic source regions, directivity patterns, and near field effects. The source-location method is described along with its advantages and disadvantages. Results indicate that the effects of simulated flight on J-85 noise are significant. At the maximum forward speed of 130 m/sec, the peak overall sound levels in the aft quadrant were attentuated approximately 10 dB relative to sound levels of the engine operated statically. As expected, the simulated flight and static data tended to merge in the forward quadrant as the radiation angle approached 40 degrees. There is evidence that internal engine or shock noise was important in the forward quadrant. The data are compared with published predictions for flight effects on pure jet noise and internal engine noise. A new empirical prediction is presented that relates the variation of internally generated engine noise or broadband shock noise to forward speed. Measured near field noise extrapolated to far field agrees reasonably well with data from similar engines tested statically outdoors, in flyover, in a wind tunnel, and on the Bertin Aerotrain. Anomalies in the results for the forward quadrant and for angles above 140 degrees are discussed. The multiple-sideline method proved to be cumbersome in this application, and it did not resolve all of the uncertainties associated with measurements of jet noise close to the jet. The simulation was complicated by wind-tunnel background noise and the propagation of low frequency sound around the circuit. Author

N91-19824*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
LARGE-SCALE AEROACOUSTIC RESEARCH FEASIBILITY AND CONCEPTUAL DESIGN OF TEST-SECTION INSERTS FOR THE AMES 80- BY 120-FOOT WIND TUNNEL

PAUL T. SODERMAN and LARRY E. OLSEN Dec. 1990 50 p
(NASA-TP-3020; A-88007; NAS 1.60:3020) Avail: NTIS HC/MF A03 CSCL 20/1

An engineering feasibility study was made of aeroacoustic inserts designed for large-scale acoustic research on aircraft models in the 80 by 120 foot Wind Tunnel at NASA Ames Research Center. The advantages and disadvantages of likely designs were analyzed. Results indicate that the required maximum airspeed leads to the design of a particular insert. Using goals of 200, 150, and 100 knots airspeed, the analysis indicated a 30 x 60 ft open-jet test section, a 40 x 80 ft open jet test section, and a 70 x 100 ft closed test section with enhanced wall lining, respectively. The open-jet inserts would be composed of a nozzle, collector, diffuser, and acoutic wedges incorporated in the existing 80 x 120 test section. The closed test section would be composed of approximately 5 ft acoustic wedges covered by a porous plate attached to the test section walls of the existing 80 x 120. All designs would require a double row of acoustic vanes between the test section and fan drive to attenuate fan noise and, in the case of the open-jet designs, to control flow separation at the diffuser downstream end. The inserts would allow virtually anechoic acoustic studies of large helicopter models, jets, and V/STOL aircraft models in simulated flight. Model scale studies would be necessary to optimize the aerodynamic and acoustic performance of any of the designs. In all designs studied, the existing structure would have to be reinforced. Successful development of acoustically transparent walls, though not strictly necessary to the project, would lead to a porous-wall test section that could be substituted for any of the open-jet designs, and thereby eliminate many aerodynamic and acoustic problems characteristic of open-jet shear layers. The larger size of the facility would make installation and removal of the insert components difficult. Consequently, scheduling of the existing 80 x 120 aerodynamic test section and scheduling of the open-jet test section would likely be made on an annual or longer basis. The enhanced wall-lining insert would likely be permanent. Although the modifications are technically feasible, the economic practicality of the project was not evaluated. Author

N91-19825*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

UNSTEADY BLADE PRESSURE MEASUREMENTS FOR THE SR-7A PROPELLER AT CRUISE CONDITIONS

L. J. HEIDELBERG and M. NALLASAMY (Sverdrup Technology, Inc., Brook Park, OH.) 1990 17 p Presented at the 13th Aeroacoustics Conference, Tallahassee, FL, 22-24 Oct. 1990; sponsored by AIAA Previously announced in IAA as A91-12533
(Contract NAS3-24105)
(NASA-TM-103606; E-5754; NAS 1.15:103606; AIAA-90-4022)
Avail: NTIS HC/MF A03 CSCL 20/1

The unsteady blade surface pressures were measured on the SR-7A propeller. The freestream Mach no., inflow angle, and advance ratio were varied while measurements were made at nine blade stations. At a freestream Mach no. of 0.8, the data in terms of unsteady pressure coefficient vs. azimuth angle are compared to an unsteady 3-D Euler solution, yielding very encouraging results. The code predicts the shape (phase) of the waveform very well, while the magnitude is over-predicted in many cases. At tunnel Mach nos. below 0.6, an unusually large response on the suction surface at 0.15 chord and 0.88 radius was observed. The behavior of this response suggests the presence of a leading edge vortex. The midchord measuring stations on the suction surface exhibit a response that leads the forcing function while most other locations show a phase lag. Author

N91-19826*# Army Aviation Research and Development Command, Moffett Field, CA. Aeroflightdynamics Directorate.

EULER SOLUTIONS TO NONLINEAR ACOUSTICS OF NON-LIFTING HOVERING ROTOR BLADES

J. D. BAEDER Feb. 1991 17 p Presented at the 16th European Rotorcraft Forum, Glasgow, Scotland, 18-21 Sep. 1990
(NASA-TM-103837; A-91063; NAS 1.15:103837; USAAVSCOM-TM-90-A-007) Avail: NTIS HC/MF A03 CSCL 20/1

For the first time a computational fluid dynamics (CFD) method is used to calculate directly the high-speed impulsive (HSI) noise of a non-lifting hovering rotor blade out to a distance of over three rotor radii. In order to accurately propagate the acoustic wave in a stable and efficient manner, an implicit upwind-biased Euler method is solved on a grid with points clustered along the line of propagation. A detailed validation of the code is performed for a rectangular rotor blade at tip Mach numbers ranging from 0.88 to 0.92. The agreement with experiment is excellent at both the sonic cylinder and at 2.18 rotor radii. The agreement at 3.09 rotor radii is still very good, showing improvements over the results from the best previous method. Grid sensitivity studies indicate that with special attention to the location of the boundaries a grid with approximately 60,000 points is adequate. This results in a computational time of approximately 40 minutes on a Cray-XMP. The practicality of the method to calculate HSI noise is demonstrated by expanding the scope of the investigation to examine the rectangular blade as well as a highly swept and tapered blade over a tip Mach number range of 0.80 to 0.95. Comparisons with experimental data are excellent and the advantages of planform modifications are clearly evident. New insight is gained into the mechanisms of nonlinear propagation and the minimum distance at which a valid comparison of different rotors can be made: approximately two rotor radii from the center of rotation. Author

N91-19828# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.).

NOISE LEVEL REDUCTION INSIDE HELICOPTER CABINS

ECKEHARD LAUDIEN and GEORGE NIESL Sep. 1990 12 p Presented at the 16th European Rotorcraft Forum, Glasgow, Scotland, 18-21 Sep. 1990
(MBB-UD-0578-90-PUB; ETN-91-98828) Avail: NTIS HC/MF A03

A number of measures to reduce the noise level in helicopter cabins are discussed. Laboratory test results of various panellings are presented as well as the insulation capacities of different panel mounts. Experiments in acoustic facilities (anechoic chamber and reverberation room) with the original cabin door and its frame led to an optimization of the transmission losses of door components such as window, sealing, and frame. The reduction of the cabin noise level by adding absorption is illustrated in the case of a honeycomb bulkhead with Helmholtz resonators. These sound absorption elements were designed to damp discrete gearbox frequencies. Resonators were also used for noise attenuation of an oil cooler fan. Cabin noise comfort can be improved by eliminating discrete frequencies. This was achieved in an experimental set up where properly tuned resonators were placed as close as possible to the passenger's ear in the headrest of the seat. In order to reduce structureborne transmission system noise, ground and flight test data of gearbox strut impedance were used for the design of specially tuned vibration absorbers. ESA

N91-20102*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

FIBER-OPTIC-BASED CONTROLS

GARY T. SENG *In its* Aeropropulsion 1991 11 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 20/6

The challenge of those involved in control-system hardware development is to accommodate an ever-increasing complexity in aircraft control, while limiting the size and weight of the components and improving system reliability. A technology that displays promise towards this end is the area of fiber optics. The primary advantages of employing optical fibers, passive optical sensors, and optically controlled actuators over conventional control systems are greater immunity from electromagnetic effects, weight and volume reduction, non-radiating characteristics, superior bandwidth capabilities, and freedom from short circuits and sparking contacts. Since 1975, NASA Lewis has been performing in-house, contract, and grant research in fiber-optic sensors, high-temperature electro-optic switches, and fly-by-light control system architecture. Passive optical sensor development is an essential yet challenging area of work and has therefore received much attention during this period. A major effort to develop and demonstrate fly-by-light control system technology, known as the fiber optic control system integration (FOCSI) program, was initiated in 1985. Phase 1 of FOCSI, A NASA-DOD effort completed in 1986, was aimed at the design of a fiber optic propulsion/flight control system. Phase 2, a NASA Navy effort currently in progress, will provide the system design, subcomponent and system development, and system ground tests. Phase 3, flight demonstration, was also initiated and will culminate in full FOCSI system flight tests. In addition to a summary of the benefits of fiber optics, the FOCSI program, sensor advances, and future directions in the NASA Lewis program are discussed. Author

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A91-29052

ICAO STUDY ESTIMATES ECONOMIC IMPACT OF NEWLY-ADOPTED NOISE RESOLUTION

UPALI K. WICKRAMA (International Civil Aviation Organization, Forecasting and Economic Planning Section, Montreal, Canada) ICAO Journal (ISSN 0018-8778), vol. 45, Nov. 1990, p. 9-11. Copyright

The economic impact on the air transport industry of the noise resolution adopted by ICAO in 1990 is examined. Future operating limitations on Chapter 2 aircraft would depend greatly on the number of countries and airports introducing operating restrictions. As the way in which the aircraft would be phased in over the 7-year period could vary in each country, it is assumed that the effect of the phase-in would fall between the impact of a total ban imposed in 1995 and one introduced in 2002. Basically, the impact of an operating restriction is to accelerate the ongoing fleet modernization process, thus reducing the value of the assets of the operators involved, and requiring them to make capital commitments sooner than planned from purely commercial and economic considerations. It is estimated that taking all of the factors into account, the cost of compliance could be between 4.3 and 6.3 billion dollars. R.E.P.

A91-30972

SOME CONSIDERATIONS FOR DATA GATHERING FOR SIMULATION DATA BASES

ROGER W. FOSTER and JAMES E. KESTER (SofTech, Inc., Fairborn, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 912-917. Copyright

Simulations and simulators require a variety of data categories. The authors discuss the contents of categories such as aerodynamic properties; features and specifics of avionics down to pulse width, frequency, and color of items on the cockpit panels; logistic concerns, such as Weibull distribution parameters for failure rate computations, cost of spares, and mean-time-to-repair (MTTR) figures; order of battle; and natural environment. Specifics depend on whether the simulation is at a coarse, medium, or fine level of emulation. Coarse models use mathematical formulas, while fine models may use Monte Carlo techniques and Eulerian/Lagrangian schemes to build up valid long-term statistics from individual case simulations. The authors examine the relative importance of data items to the simulation, and the considerations and pitfalls of various sources of data. Model sensitivity and the possibility of substituting heuristic models for actual data are examined. Methods of validation and the choice of test data versus operational data are discussed. The enhancement of the general data archive and the enhancement of the documentation of the characteristics and errors in known models and archives are also considered. I.E.

A91-31046#

BARRIERS TO TOTAL QUALITY MANAGEMENT IN THE DEPARTMENT OF DEFENSE

HAL A. RUMSEY and PHILLIP E. MILLER (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: 1990 Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 23-25, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 95-99.

Reliability and maintainability are discussed as subsets of the assurance sciences. Total Quality Management (TQM) covers all of the assurance sciences, with significant emphasis on the human and organizational systems underlying all production processes. When the Air Force Logistics Command initiated TQM, a number of challenges had to be overcome to achieve the full potential of the program. These barriers included a lack of worker motivation, opposition of existing management, and lack of effective communication. I.E.

A91-31047#

R&M 2000 PROCESS - A CORNERSTONE TO THE TOTAL QUALITY MOVEMENT

JAMES F. GUZZI (USAF, Systems Command, Andrews AFB, MD) IN: 1990 Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 23-25, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 106-108. refs

The U.S. DOD Total Quality Management (TQM) campaign to support continuous process improvement is discussed. Reliability, maintainability, and producibility (RM&P) are discussed as key building blocks of TQM and the continuous quality improvement of weapon systems. This relationship supports the strategic importance of R&M 2000 in the TQM movement and clearly supports the R&M 2000 goals. The strategic relationship of the R&M 2000 process is reviewed. To demonstrate the conceptual relationships defined by the R&M 2000 process and TQM, the R&M quality team concept is used. The R&M quality team concept is the first TQM initiative to support the R&M 2000 process. The concept has been successfully used in the design of the C-17A airlifter. I.E.

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GENERAL

N91-20087*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

LEWIS AEROPROPULSION TECHNOLOGY: REMEMBERING THE PAST AND CHALLENGING THE FUTURE

NEAL T. SAUNDERS and ARTHUR J. GLASSMAN *In its* Aeropropulsion 1991 21 p Mar. 1991
Avail: NTIS HC/MF A24 CSCL 05/4

It was on January 23, 1941, less than two years after the first flight of a jet-propelled aircraft, that ground was broken in Cleveland for the NACA Aircraft Engine Research Laboratory (AERL). Originally envisioned as a laboratory for fundamental research on piston engines, the new NACA laboratory never actually fulfilled this role. From the first test in 1942 until the end of the war in 1945, primary emphasis was on trouble-shooting to solve the problems of engines in production for the war effort. By the end of the war, the transition from piston to jet propulsion was well underway, and with it went the direction of the laboratory's program.

Some of the major accomplishments over the past fifty years are reviewed and the challenges of the future examined. From piston engines through environmentally acceptable high-speed propulsion systems, efforts have included and will continue to include discipline, component, and engine activities along with provision of facilities to carry out the programs. Author

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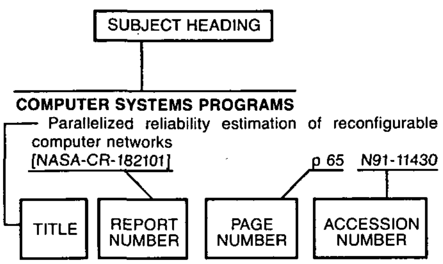

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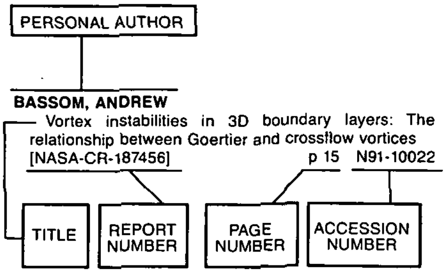

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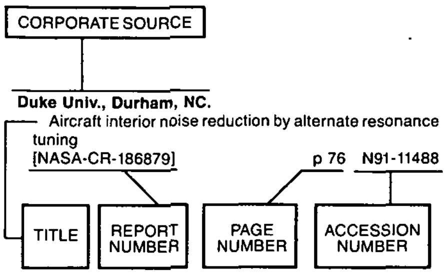

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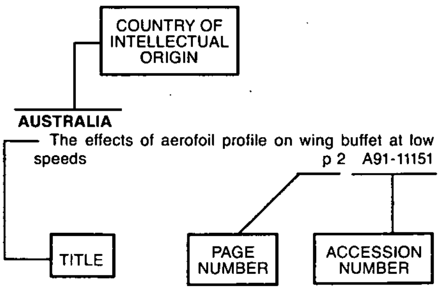

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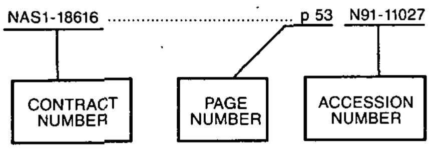

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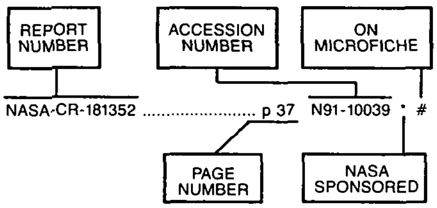

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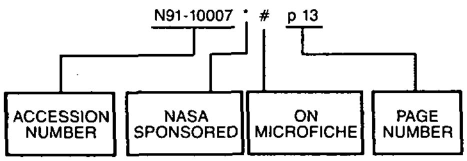

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