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P-168

NASA SP-7037 (295)
September 1993

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(NASA-SP-7037(295)) AERONAUTICAL ENGINEERING: A CONTINUING BIBLIOGRAPHY WITH INDEXES (SUPPLEMENT 295) (NASA) 168 p

N94-16480

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AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

National Aeronautics and Space Administration
Scientific and Technical Information Program
Washington, DC 1993

This publication was prepared by the NASA Center for AeroSpace Information,
800 Elkridge Landing Road, Linthicum Heights, MD 21090-2934, (301) 621-0390.

INTRODUCTION

This issue of *Aeronautical Engineering — A Continuing Bibliography with Indexes* (NASA SP-7037) lists 581 reports, journal articles, and other documents recently announced in the NASA STI Database.

Accession numbers cited in this issue include:

Scientific and Technical Aerospace Reports (STAR) (N-10000 Series)	N93-29047 — N93-31039
International Aerospace Abstracts (IAA) (A-10000 Series)	A93-39901 — A93-43875

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 1993 will be published in early 1994.

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

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Category 01 Aeronautics 855

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

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

Category 04 Aircraft Communications and Navigation 881
Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

Category 05 Aircraft Design, Testing and Performance 889
Includes aircraft simulation technology.

Category 06 Aircraft Instrumentation 895
Includes cockpit and cabin display devices; and flight instruments.

Category 07 Aircraft Propulsion and Power 897
Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and onboard auxiliary power plants for aircraft.

Category 08 Aircraft Stability and Control 905
Includes aircraft handling qualities; piloting; flight controls; and autopilots.

Category 09 Research and Support Facilities (Air) 910
Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tubes; and aircraft engine test stands.

Category 10 Astronautics 913
Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; space communications, spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

Category 11 Chemistry and Materials 915
Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; propellants and fuels; and materials processing.

Category 12 Engineering 924
Includes engineering (general); communications and radar; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

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Category 13 Geosciences 936
Includes geosciences (general); earth resources and remote sensing; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

Cateogory 14 Life Sciences N.A.
Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and space biology.

Category 15 Mathematical and Computer Sciences 938
Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

Category 16 Physics 943
Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

Category 17 Social Sciences 944
Includes social sciences (general); administration and management; documentation and information science; economics and cost anaylsis; law, political science, and space policy; and urban technology and transportation.

Category 18 Space Sciences N.A.
Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.

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TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED
ON MICROFICHE

ACCESSION NUMBER → **N93-10098 * #** Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics. ← CORPORATE SOURCE

TITLE → **NAVIER-STOKES DYNAMICS AND AEROELASTIC COMPUTATIONS FOR VORTICAL FLOWS, BUFFET AND AEROELASTIC APPLICATIONS Progress Report, 1 Oct. 1991 - 30 Sept. 1992**

AUTHOR → OSAMA A. KANDIL Sep. 1992 38 p ← PUBLICATION DATE

CONTRACT NUMBER → (Contract NAG1-648)

REPORT NUMBER → (NASA-CR-190692; NAS 1.26:190692) Avail: CASI HC A03/MF A01 ← AVAILABILITY AND PRICE CODE

The accomplishments achieved during the period include conference and proceedings publications, journal papers, and abstracts which are either published, accepted for publication or under review. Conference presentations and NASA highlight publications are also included. Two of the conference proceedings publications are attached along with a Ph.D. dissertation abstract and table of contents. In the first publication, computational simulation of three-dimensional flows around a delta wing undergoing rock and roll-divergence motions is presented. In the second publication, the unsteady Euler equations and the Euler equations of rigid body motion, both written in the moving frame of reference, are sequetially solved to simulate the limit-cycle rock motion of slender delta wings. In the dissertation abstract, unsteady flows around rigid or flexible delta wings with and without oscillating leading-edge flaps are considered. L.R.R.

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

ACCESSION NUMBER → **A93-12007 *** National Aeronautics and Space Administration. Langley Research Center, Hampton, VA. ← CORPORATE SOURCE

TITLE → **NUMERICAL SIMULATIONS OF HIGH-SPEED FLOWS ABOUT WAVERIDERS WITH SHARP LEADING EDGES**

AUTHORS → KEVIN D. JONES and F. C. DOUGHERTY (Colorado Univ., Boulder) ← AUTHORS' AFFILIATION

JOURNAL TITLE → Journal of Spacecraft and Rockets (ISSN 0022-4650) vol. 29, no. 5

PUBLICATION DATE → Sept.-Oct. 1992 p. 661-667. Research supported by Univ. of Colorado and DLR refs

CONTRACT NUMBER → (Contract NAG1-880)

Copyright

A procedure is developed for the numerical simulation of stagnation-free inviscid supersonic and hypersonic flows about waveriders with sharp leading edges. The numerical approach involves the development of a specialized grid generator (named HYGRID), an algebraic solution-adaptive grid scheme, and a modified flow solving method. A comparison of the results obtained for several waverider geometries with exact solutions, other numerical solutions, and experimental results demonstrated the ability of the new procedure to produce stagnation-free Euler solutions about sharp-edged configurations and to describe the physics of the flow in these regions. I.S.

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 295)

September 1993

01

AERONAUTICS (GENERAL)

A93-40661
ULTRA-HIGH PRESSURE WATER JET TECHNOLOGY - AN OVERVIEW OF A NEW PROCESS FOR AEROSPACE PAINT STRIPPING
SPENCER T. JOHNSON (Jet Edge, Inc., Minneapolis, MN) Jun. 1992 13 p. Society of Manufacturing Engineers, Maintaining and Supporting an Aircraft Fleet Conference, Dayton, OH, June 9-11, 1992 refs
(SME PAPER AD92-196) Copyright

New technology used to develop water pressures of over 50,000 psi is reviewed. The technology uses ultra-high pressure waterjet equipment capable of removing the toughest coating from delicate substrates without damage, using only water. AIAA

A93-40662
ROBOTIC AIRCRAFT PAINTING WITH SAFARI
HENRY K. BERRY and JOHN D. MATTHEWS (Engineering, Inc., Hampton, VA) Jun. 1992 11 p. Society of Manufacturing Engineers, Maintaining and Supporting an Aircraft Fleet Conference, Dayton, OH, June 9-11, 1992
(SME PAPER AD92-198) Copyright

This paper discusses concept through installation and operating results of robotic aircraft painting at Robins AFB using a SAFARI to wash, prep, and paint F-15 aircraft with polyurethane and waterborne high-solid paints. The paper includes a discussion of how the same robotic system can be used for stripping aircraft. Author

A93-40663
SENSOR-ADAPTIVE CONTROL FOR AIRCRAFT PAINT STRIPPING
RICHARD J. WENIGER and ERNEST A. FRANKE (Southwest Research Inst., San Antonio, TX) Jun. 1992 10 p. Society of Manufacturing Engineers, Maintaining and Supporting an Aircraft Fleet Conference, Dayton, OH, June 9-11, 1992
(Contract F33615-86-C-5044)
(SME PAPER AD92-200) Copyright

The difficulty of removing paint from aircraft varies greatly due to factors such as the number of coats, age and condition of paint, and the presence of other coverings such as decals. Efficient automation of paint stripping requires adaptive process control based on sensors that can distinguish between substrate and coating material. This paper describes a sensor for identification of the type and condition of aircraft materials based on the analysis of optical reflectance spectra. The performance of a recently installed robotic depainting system using this sensor for adaptive control of the paint stripping also is described. Author

A93-40665
ROBOTIC INSPECTION AND REFURBISHMENT OF AIRCRAFT CANOPY TRANSPARENCIES
JAMES A. LUCKEMEYER and ERNEST A. FRANKE (Southwest Research Inst., San Antonio, TX) Jun. 1992 9 p. Society of Manufacturing Engineers, Maintaining and Supporting an Aircraft Fleet Conference, Dayton, OH, June 9-11, 1992
(Contract F42650-86-C-3276)
(SME PAPER AD92-203) Copyright

Refurbishment of aircraft canopies requires determining the location and severity of flaws followed by the removal of transparency material in a way that will not introduce optical distortion. A three-robot cell to automate this process includes robot-mounted stereovision cameras to locate flaws and robot-manipulated grinding/polishing heads for flaw removal. The system has been in operation at Hill AFB for over two years and information on the effectiveness and reliability has been collected. This paper includes a brief overview of the workcell technology and a summary of the performance of the system in a production environment. Author

A93-40667
AUTOMATED LASER PAINT STRIPPING (ALPS)
PHILIP A. BARONE (International Technical Associates, Santa Clara, CA) Jun. 1992 18 p. Society of Manufacturing Engineers, Maintaining and Supporting an Aircraft Fleet Conference, Dayton, OH, June 9-11, 1992
(SME PAPER AD92-206) Copyright

An Automated Laser Paint Stripping program developed by International Technical Associates, Santa Clara, California is described. The program is aimed at designing and fabricating two mobile robot-based laser stripping systems for removing paint from metallic and composite substrates of fighter-sized aircraft. *Emphasis is placed on the major cell elements of the ALPS system* which include a laser, a robot, a multispectral camera, a rastering system, an end effector, a waste management system, a cell controller, and a safety system. AIAA

A93-40668
THE EFFECTS OF HIGH-PRESSURE WATER ON THE MATERIAL INTEGRITY OF SELECTED AIRCRAFT COATINGS AND SUBSTRATES
DARCY J. HARBAUGH and M. A. STONE (USBI Co., Huntsville, AL) Jun. 1992 6 p. Society of Manufacturing Engineers, Maintaining and Supporting an Aircraft Fleet Conference, Dayton, OH, June 9-11, 1992
(Contract F33615-91-C-5708)
(SME PAPER AD92-207) Copyright

USBI is developing high-pressure water as an alternative technology to replace the current chemical stripping process for aircraft. A critical component for the high-pressure water process is the nozzle assembly. An extensive evaluation of both commercially available and in-house designed nozzle configurations has been done to select nozzles which meet the stringent paint stripping requirements. This paper presents the results of the nozzle optimization work and the materials evaluations performed. Author

A93-41362
TEST RESULTS OF THE EFFECTS OF AIR IONIZATION ON CIGARETTE SMOKE PARTICULATE LEVELS WITHIN A COMMERCIAL AIRPLANE
SCOTT HENDREN and JAMES R. GILLIS (Boeing Co., Seattle, WA) Jul. 1992 9 p. SAE, International Conference on

Environmental Systems, 22nd, Seattle, WA, July 13-16, 1992 refs
(SAE PAPER 921183) Copyright

Passengers and flight attendants often notice a haze of smoke under the overhead stowage bins in aircraft cabins when cigarette smoking is allowed. As normally operated, the ventilation system in Boeing 737/757 aircraft does not rapidly remove this smoke haze. Air ionization systems from three vendors were tested in a 10 foot long Boeing 737/757 cabin test section with a cruise condition ventilation rate and two cigarette smoking rates to assess their effectiveness in removing smoke haze from the local breathing areas of passengers and flight attendants. Smoke particulate densities were monitored at five breathing areas and at an exit grill in the test section. All of the ionization systems significantly increased the rate of smoke removal after smoking had stopped, increasing the removal rate by about 25 percent. None of the systems showed a statistically significant reduction of smoke levels at the individual monitoring points while cigarettes were being smoked. However, one system did show a statistically significant reduction when the results were averaged over the entire breathing area. Author

A93-42577
WORKSHOP ON HYPERSONIC FLOWS FOR REENTRY PROBLEMS JANUARY 22-25TH 1990 (ANTIBES) - INAUGURAL ADDRESS
J. CARPENTIER *In* Hypersonic flows for reentry problems. Vol. 1 Berlin and New York Springer-Verlag 1991 p. 7-11.
Copyright

A development history is presented for the use of wind tunnel investigations, flight tests by experimental vehicles, and CFD to characterize the phenomena of hypersonic flow. Attention is given to the validations of theoretical models for hypersonic flows that have been conducted in ONERA wind tunnels. AIAA

A93-42655
AIRBUS OR THE REVIVAL OF EUROPEAN CIVIL AVIATION [AIRBUS OU LA RECONSTRUCTION DE L'AERONAUTIQUE CIVILE EUROPEENE]
ROGER BETEILLE (Airbus Industrie, Blagnac, France) Nouvelle Revue d'Aeronautique et d'Astronautique no. 1 April 1993 p. 13-21. In FRENCH refs
Copyright

The history of Airbus evolution is reviewed. It is noted that the highly advanced version of the 150-seater A320 was to meet with immediate success, unprecedented for an aircraft produced in Europe. In parallel with the natural development of this formula (A321/A319), Airbus next opened up the long-haul sector with the launch of two versions A340/A330, which also met with great success. It is concluded that the present Airbus series is a major element showing that the revival of Europe's civil aviation industry is taking place. AIAA

A93-42853
R&M 2000 FIELD DATA REQUIREMENTS FOR A SPO OPERATION
PHILLIP HERMES (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 767-773.

Traditional and modern perspectives on field data systems are compared, with emphasis on the R&M 2000 and total quality management initiatives which stress operational impacts and customer satisfaction. The Tactical Air Command reporting system is used to illustrate how to develop a user-driven field data system where TAC's top-level metrics (break rate, fix rate, ground abort rate, and mission capable rate) are used as reference points for all levels of data collection, processing, and output reports. A matrix of output reports is reviewed which illustrates three levels of reports (summary, detail, and raw) for each TAC metric. This matrix approach establishes an integrated systems approach to field data systems wherein all reports are interrelated to provide a complete picture to the SPO decision makers. Selected output displays are reviewed using field data obtained from the TICARRS (F-16 CDS) data system. A baseline change request is being processed by the REMIS SPO to incorporate this approach into the REMIS data system. a.

A93-43101
METHODS AND EQUIPMENT FOR DATA PROCESSING AND ACQUISITION IN INFORMATION MANAGEMENT SYSTEMS [METODY I SREDSTVA OBRABOTKI I POLUCHENIYA DANNYKH V INFORMATSIONNO-UPRAVLYAYUSHCHIKH SISTEMAKH]
V. M. POLUBOYAROV, ED. and V. V. ZUEV, ED. Leningrad Leningradskij Institut Aviatsionnogo Priborostroeniya 1990 124 p. In RUSSIAN For individual items see A93-43102 to A93-43116
Copyright

The papers presented in this volume provide an overview of recent advances and current and future trends in the design and analysis of information management systems. Topics discussed include synthesis of a data processing and measuring system for flight vehicle control systems, fast methods of adaptive spectral estimation for data processing and measuring systems, approximation of the flight vehicle trajectory using Walsh functions, and increasing the reliability of air traffic control radio systems. Papers are also presented on improving the accuracy characteristics of electromechanical angle transducers, solving problems in the mathematical modeling of control systems using a microcomputer network, and major trends in solving problems of the automation of the technical monitoring of large systems. AIAA

A93-43109
ESTIMATION OF THE SERVICE PERIODS FOR COMPLEX SYSTEMS IN THE CASE OF A PRIORI INDETERMINACY OF SYSTEM RELIABILITY DATA [OTSENKA PERIODICHNOSTI OBSLUZHIVANIYA SLOZHNYKH SISTEM V USLOVIYAKH APRIORNOJ NEOPREDELENNOSTI INFORMATSII OB IKH NADEZHNOSTI]
S. I. BURAVLEV, I. D. KULTYSHEV, and A. A. OVODENKO *In* Methods and equipment for data processing and acquisition in information management systems Leningrad Leningradskij Institut Aviatsionnogo Priborostroeniya 1990 p. 67-70. In RUSSIAN refs
Copyright

The service periods for the radio electronic equipment of an onboard navigation and landing system are estimated during the design of the system by using a computer simulation of the dynamics of the technical condition of the equipment during its operation. The imput data include a list of radio electronic system parameters specified by the developer and probabilities of deviations beyond the specified limits for each of the parameters based on reliability testing of the components. Details of the simulation procedure are discussed. AIAA

A93-43625
ARPA STARTS PUSH FOR JOINT-SERVICE ASTOVL
BILL SWEETMAN Interavia/Aerospace World (ISSN 0983-1592) vol. 48 May 1993 p. 68-70.
Copyright

A joint-service advanced short-take-off, vertical landing (ASTOVL) fighter project is reviewed. A series of rig, model, and simulator tests will be conducted in the Advanced Research Projects Agency to prepare the construction and testing of a full-scale ASTOVL prototype. AIAA

A93-43650
TRENDS IN AIR POWER - NEW SYSTEMS, OLD PLATFORMS?
BENJAMIN S. LAMBETH (RAND, Santa Monica, CA) Cockpit (ISSN 0742-1508) Jan.-Mar. 1993 p. 4-12.
Copyright

While the reaching of physical pilot limits in maneuvering, and of speed and altitude extremes, has placed a general emphasis

on such factors as stealth and supersonic cruise capability, the present evaluation of development trends and emerging requirements for military aircraft notes the fallacy of assuming that purely incremental improvements in airframe development will suffice. This view must nevertheless be balanced against the realization that most developmental problems are associated with the final ten percent of the performance improvement being sought over current aircraft. Superior methods are required for separating necessary developmental efforts from those that are merely desirable. AIAA

N93-30673*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NASA/FAA HELICOPTER SIMULATOR WORKSHOP
WILLIAM E. LARSEN, ed. (Federal Aviation Administration, Moffett Field, CA.), ROBERT J. RANDLE, JR., ed. (Sverdrup Technology, Inc., Moffett Field, CA.), RICHARD S. BRAY, ed. (Sverdrup Technology, Inc., Moffett Field, CA.), and JOHN ZUK, ed. Apr. 1992 187 p Workshop held in Santa Clara, CA, 23-26 Apr. 1991
(Contract DTFA01-88-Z-02015)
(NASA-CP-3156; A-92020; NAS 1.55:3156; DOT/FAA/RD-92-2)
Avail: CASI HC A09/MF A02

A workshop was convened by the FAA and NASA for the purpose of providing a forum at which leading designers, manufacturers, and users of helicopter simulators could initiate and participate in a development process that would facilitate the formulation of qualification standards by the regulatory agency. Formal papers were presented, special topics were discussed in breakout sessions, and a draft FAA advisory circular defining specifications for helicopter simulators was presented and discussed. A working group of volunteers was formed to work with the National Simulator Program Office to develop a final version of the circular. The workshop attracted 90 individuals from a constituency of simulator manufacturers, training organizations, the military, civil regulators, research scientists, and five foreign countries.

N93-30674*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PART 1: EXECUTIVE SUMMARY
WILLIAM E. LARSEN (Federal Aviation Administration, Moffett Field, CA.), ROBERT J. RANDLE, JR. (Sverdrup Technology, Inc., Moffett Field, CA.), RICHARD S. BRAY (Sverdrup Technology, Inc., Moffett Field, CA.), and JOHN ZUK *In its* NASA/FAA Helicopter Simulator Workshop p 1-11 Apr. 1992
Avail: CASI HC A03/MF A02

A workshop was convened by the FAA and NASA for the purpose of providing a forum at which leading designers, manufacturers, and users of helicopter simulators could initiate and participate in a development process that would facilitate the formulation of qualification standards by the regulatory agency. Formal papers were presented, special topics were discussed in breakout sessions, and a draft FAA advisory circular defining specifications for helicopter simulators was presented and discussed. A working group of volunteers was formed to work with the National Simulator Program Office to develop a final version of the circular. The workshop attracted 90 individuals from a constituency of simulator manufacturers, training organizations, the military, civil regulators, research scientists, and five foreign countries. A great amount of information was generated and recorded verbatim. This information is presented herein within the limits of accuracy inherent in recording, transcribing, and editing spoken technical material. Author

N93-30677*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ROTORCRAFT MASTER PLAN
PETER V. HWOSCHINSKY *In its* NASA/FAA Helicopter Simulator Workshop p 39-44 Apr. 1992
Avail: CASI HC A02/MF A02

The Rotorcraft Master Plan contains a comprehensive summary of active and planned FAA vertical flight research and development. Since the Master Plan is not sufficient for tracking project status and monitoring progress, the Vertical Flight Program Plan will provide that capability. It will be consistent with the Master Plan and, in conjunction with it, will serve to ensure a hospitable environment if the industry presents a practical vertical-flight initiative. Author

02

AERODYNAMICS

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

A93-39942
NEWTONIAN AND HYPERSONIC FLOWS OVER OSCILLATING BODIES OF REVOLUTION. I - CIRCULAR CONES
HAMDI T. HEMDAN (King Saud Univ., Riyadh, Saudi Arabia) Acta Astronautica (ISSN 0094-5765) vol. 29, no. 4 April 1993 p. 263-269. refs
Copyright

This paper presents unsteady Newtonian and hypersonic perturbation theories for the flow past slender pointed-nose bodies of revolution performing small-amplitude pitching oscillations about any pivot position at zero incidence. By extending and perturbing recently developed steady flow theories for such bodies of revolution, systems of approximate equations for unsteady hypersonic and Newtonian flows are obtained. However, solutions are given only for Newtonian flow past circular cones. Thus, simple closed-form formulas for the unsteady pressure and the aerodynamic derivatives are found. It is shown that pitching oscillations of circular cones are always dynamically stable. Author

A93-40405
AN EXISTENCE THEOREM FOR A FREE BOUNDARY PROBLEM OF HYPERSONIC FLOW THEORY
VINCENT GIOVANGIGLI (CNRS, Centre de Mathematiques Appliquees; Ecole Polytechnique, Palaiseau, France) SIAM Journal on Mathematical Analysis (ISSN 0036-1410) vol. 24, no. 3 May 1993 p. 571-582. refs
Copyright

The author considers a free boundary problem arising in hypersonic flow theory. The model describes an axisymmetric thin viscous shock layer in the vicinity of the stagnation point of a blunt body. The governing equations on the symmetry line reduce to a two-point boundary value problem with four unknowns and a free boundary. The free boundary problem is reduced to a nonlinear eigenvalue problem through a change of variable. Existence of a solution is achieved by deriving a priori estimates and by using the Leray-Schauder topological degree theory. Author

A93-40430
STUDY OF MIXING FLOW FIELD OF A JET IN A SUPERSONIC CROSS FLOW. I - EXPERIMENTAL FACILITIES AND PRELIMINARY EXPERIMENTS
KAZUHIKO TOSHIMITSU, YUZO INOKUCHI, NOBUHIKO YAMASAKI, and MASANOBU NAMBA Kyushu University, Technology Reports (ISSN 0023-2718) vol. 65, no. 6 Dec. 1992 p. 631-636. In JAPANESE refs

The interaction of a jet with a supersonic cross flow is one of the important fluid dynamics problems concerned with supersonic combustion ramjet engines. This paper describes a supersonic wind tunnel which has been newly constructed for measuring a density distribution of such a mixing flow field. In particular, an optical system of this experimental facility comprises a Mach-Zehnder interferometer and an image processor system. Furthermore, some results of Mach-Zehnder and schlieren visualization experiments are presented. Author (revised)

A93-40431
THE EXPERIMENTAL STUDY OF THE EFFECT OF SWEPTBACK ANGLES AND THE FRONT SHAPE OF THE FIN ON REDUCTION OF SHOCK WAVE/TURBULENT BOUNDARY LAYER INTERACTION REGION
SHIGERU ASO, SYOZO MAEKAWA, and SHIGEHIDE NAKAO Kyushu University, Technology Reports (ISSN 0023-2718) vol. 65, no. 6 Dec. 1992 p. 637-644. In JAPANESE refs

Shock wave/turbulent boundary layer interactions regions induced by sweptback fins with various sweptback angles have been experimentally investigated. Experiments are performed under the near-adiabatic wall conditions, at Mach 4, total pressure of 1.2 MPa, total temperature of 280 K and Reynolds Number of 2.7 x 10 exp 7. The surface flows are visualized by the oil flow technique and the wall pressure distributions are measured for sweepback angles of 0, 15, 30 and 45 deg. Attention is given to the effect of sweptback angle of the sharp fin on the interaction regions. The effect of sweptback angle significantly reduces interaction regions and maximum peak pressure. As compared with blunt fin, the interaction region induced by a sharp fin is much smaller, and maximum peak pressure is again reduced. The geometric parameters of the front edge of the fin are therefore the most important parameters, and improving the front shape of the fin brings an immediate result on reducing the interaction regions.
Author (revised)

A93-40444
PASSIVE CONTROL OF A SHOCK WAVE/TURBULENT BOUNDARY LAYER INTERACTION IN A TRANSONIC FLOW
R. BUR (ONERA, Chatillon, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X) no. 6 1992 p. 11-30. refs
Copyright

A detailed analysis of an interaction subjected to passive control was performed in a transonic channel, with consideration of the following parameters: shock location with respect to the cavity, porosity and hole diameter of the perforated plate, cavity depth. The flow was qualified by Schlieren visualizations, wall pressure measurements and 2D laser velocimetry probing. The momentum balance was computed in the control region, to find configurations in which the friction drag was less than that of the reference case without control. Then the flow was analyzed theoretically, with a boundary layer type approach using the first-order Prandtl equations. The turbulent field was computed by considering equilibrium and non-equilibrium models. Passive control affects both the mean field, by way of a transpiration velocity existing on the porous surface, that creates a nonzero boundary layer condition, and the turbulent field. This effect is represented by introducing a modified Van Driest damping function. Comparison with experimental results obtained in a control case is instructive as concerns the validity of the turbulence models and how those models should be modified to take the passive control into account.
Author

A93-40470
AN AERODYNAMIC MODEL FOR FLAPPING-WING FLIGHT
J. D. DELAURIER (Toronto Univ., Downsview, Canada) Aeronautical Journal (ISSN 0001-9240) vol. 97, no. 964 April 1993 p. 125-130. Research supported by NSERC refs
Copyright

A design-oriented model for the unsteady aerodynamics of a flapping wing has been developed using a modified strip theory approach. Within this constraint, vortex-wake effects are accounted for as well as partial leading edge suction and post stall behavior. Also, the contributions of sectional mean angle of attack, camber, and friction drag are added, which allows this model to be used for the calculation of the average lift, as well as the thrust, power required, and propulsive efficiency of a flapping wing in equilibrium flight. An example of such calculations is presented in the performance prediction of a mechanical flying pterosaur replica.
Author

A93-40714*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A STUDY OF THE INTERACTION BETWEEN A WAKE VORTEX AND AN ENCOUNTERING AIRPLANE
E. C. STEWART (NASA, Langley Research Center, Hampton, VA) Aug. 1993 11 p. AIAA, Atmospheric Flight Mechanics Conference, Monterey, CA, Aug. 9-11, 1993 refs
(AIAA PAPER 93-3642)

An analytical study of the mutual interaction between a wake vortex and an encountering airplane has been conducted. The interaction was calculated on the basis of conservation of angular momentum of the wake vortex and the encountering airplane in the roll axis. For the nominal conditions assumed in the study, the interaction reduced the roll response in the lust second by 20 percent compared to the classical method of calculating the response. However, depending on the conditions assumed, the reduction varied from 0 to 30 percent which could be highly significant in determining separation standards for airplanes. Controlled experiments are needed to determine the exact amount of interaction.
Author

A93-41049*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF THE MULTIGRID SOLUTION TECHNIQUE TO HYPERSONIC ENTRY VEHICLES
FRANCIS A. GREENE (NASA, Langley Research Center, Hampton, VA) Jul. 1993 12 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-2721) Copyright

A multigrid solution procedure has been incorporated in a version of the Langley Aerothermodynamic Upwind Relaxation Algorithm. The multigrid scheme is based on the Full Approximation Storage approach and uses Full Multigrid to obtain a well defined fine mesh starting solution. Predictions were obtained using standard transfer operators and a 'V-cycle' was used to control grid sequencing. Computed hypersonic flow solutions compared with experimental data for a 15 degree sphere cone, blended-wing body, and shuttle-like geometries are presented. It is shown that the algorithm accurately predicts heating rates, and when compared with the single grid algorithm computes solutions in one-third the computational time.
Author

A93-41050*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HIGHER-ORDER VISCOUS SHOCK-LAYER SOLUTIONS FOR HIGH ALTITUDE FLOWS
ROOP N. GUPTA (NASA, Langley Research Center, Hampton, VA), SUDHEER N. NAYANI, KAM-PUI LEE (Vigyan, Inc., Hampton, VA), and ERNEST V. ZOBY (NASA, Langley Research Center, Hampton, VA) Jul. 1993 20 p. AIAA, Thermophysics Conference, 28th, Orlando, FL, July 6-9, 1993 refs
(AIAA PAPER 93-2724) Copyright

A higher-order viscous shock-layer (HVSL) method has been developed and is used to obtain physically consistent results under varying degrees of low-density conditions for perfect-gas and nonequilibrium flows past long slender bodies. This method is implemented with higher-order body and shock slip conditions. Detailed comparisons with the direct simulation Monte Carlo (DSMC) method and Navier-Stokes (NS) calculations establish HVSL as a computationally efficient code for the low-density calculations. Further, it is shown that the deficiencies in the standard viscous shock-layer (VSL) method when predicting low-density flows lie in the governing equations and not with the slip boundary conditions as considered by earlier researchers.
Author

A93-41053*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPARISON OF COORDINATE-INVARIANT AND COORDINATE-ALIGNED UPWINDING FOR THE EULER EQUATIONS
PETER M. HARTWICH (Vigyan, Inc., Hampton, VA) Jul. 1993 12 p. AIAA, Computational Fluid Dynamics Conference, 11th,

Orlando, FL, July 6-9, 1993 refs
(Contract NAS1-18585)
(AIAA PAPER 93-3306)

A floating-shock fitting method for the Euler equations has been developed that uses one-sided spatial differences along and across streamlines. This method has been applied to unsteady shocked flow in a duct with a ramp, to supercritical flow over a circular cylinder, and to transonic flow over airfoils. Compared to methods using coordinate-aligned upwind differencing, the coordinate-invariant upwinding generally required fewer grid points to produce crisp shocks and shears. For transonic airfoils, coordinate-invariant upwind differencing advances the agreement between computations and experiment, and it reduces the grid dependency of the computed results for strong shocks. The computational expenditure is comparable to that of coordinate-aligned upwind methods for the Euler equations.
Author (revised)

A93-41056*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SYMMETRY BREAKING IN VORTICAL FLOWS OVER CONES - THEORY AND NUMERICAL EXPERIMENTS
PETER M. HARTWICH (Vigyan, Inc., Hampton, VA) Aug. 1993 12 p. AIAA, Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993 refs
(Contract NAS1-18585)
(AIAA PAPER 93-3408)

A stability analysis suggests that inviscid incompressible flow, independent from angle of attack and regardless whether attached or separated, over slender cones is only marginally stable in regions of decelerating circumferential flow. Reducing slenderness or surface curvature lowers the energy level of harmonic perturbations, and, thus, reduces their impact on the overall stability of flows over slender cones. Associating the notion of instabilities in such flows with the onset of vortex asymmetries provides a model for explaining a variety of flow phenomena in Navier-Stokes simulations of laminar incompressible flows over three right circular cones at moderate to high angles of attack. Author (revised)

A93-41057*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RAREFIED-FLOW SHUTTLE AERODYNAMICS FLIGHT MODEL
ROBERT C. BLANCHARD (NASA, Langley Research Center, Hampton, VA), KEVIN T. LARMAN, and CHRISTINA D. MOATS (Lockheed Engineering & Sciences Co., Hampton, VA) Aug. 1993 13 p. AIAA, Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993 refs
(AIAA PAPER 93-3441) Copyright

A model of the Shuttle Orbiter rarefied-flow aerodynamic force coefficients has been derived from the ratio of flight acceleration measurements. The in-situ, low frequency, low level acceleration measurements are made during atmospheric reentry. The experiment equipment designed and used for this task is the High Resolution Accelerometer Package (HiRAP), one of the sensor packages in the Orbiter Experiments Program. To date, 12 HiRAP reentry mission data sets spanning a period of about 10 years have been processed. The HiRAP derived aerodynamics model is described in detail. The model includes normal and axial hypersonic continuum coefficient equations as functions of angle-of-attack, body flap deflection, and elevon deflection. Normal and axial free molecule flow coefficient equations as a function of angle-of-attack are also presented, along with flight derived rarefied-flow transition bridging formulas. Comparisons are made between the aerodynamics model and data from the Orbiter Operational Aerodynamic Design Data Book, and applicable computer simulations and wind-tunnel data. Author (revised)

A93-41058*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
VORTEX FEATURES OF F-106B AIRCRAFT AT SUBSONIC SPEEDS
JOHN E. LAMAR, JAY BRANDON (NASA, Langley Research Center, Hampton, VA), and THOMAS D. JOHNSON, JR. (Lockheed Engineering & Sciences Co., Hampton, VA) Aug. 1993 13 p. AIAA, Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993 refs
(AIAA PAPER 93-3471) Copyright

A NASA Langley Research Center flight-research experiment to study the vortex-flow structure and separated-flow origins over an F-106B aircraft wing is described and subsonic 1 g data from various techniques are presented. Off-surface techniques, such as vapor screen, image enhancement, photogrammetry, and computer graphics are integrated to analyze vortex-flow systems. The spatial location of vortex cores and their tracks over the wing are derived from this analysis as a function of angle of attack and Reynolds number. Multiple vortices are observed and are likely attributed to small surface distortions in the wing leading-edge region. Comparisons of off-surface determined vortex core location and reattachment point approximation from the vapor-screen technique are made with those from the on-surface techniques of static pressure and oil flow and show generally good agreement. Wind-tunnel vortex features showed reasonably good agreement with flight results over the forward part of the wing for angles of attack from 16 to 20 deg. Author (revised)

A93-41736
THE NUMERICAL MODEL OF SUPERSONIC AIR FLOW FIELD WITH HYDROGEN TRANSVERSE INJECTION
SHOUMEI ZHU, LING LIU (Northwestern Polytechnical Univ., Xian, China), and JINGHUA LIU (31st Research Inst., China) Journal of Propulsion Technology (ISSN 1001-4055) no. 2 April 1993 p. 1-7. In CHINESE refs

In this paper, MacCormack explicit time-split scheme and Baldwin-Lomax advanced algebraic turbulent model are employed to solve the 2D compressible N-S and hydrogen equations for numerical simulation of the supersonic air flowfield with hydrogen transverse injection. The results show the profiles of the velocity vector, the static pressure contour, the static temperature contour, and the hydrogen mass fraction contour and describe the size of two recirculating zones ahead of and behind bases of the jet where ignition is likely to occur. This capability should provide theoretical guidance in ongoing scramjet engine design.
Author (revised)

A93-41776* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NATURAL LAMINAR FLOW AND LAMINAR FLOW CONTROL
R. W. BARNWELL, ED. (NASA, Langley Research Center, Hampton, VA) and M. Y. HUSSAINI, ED. (ICASE; NASA, Langley Research Center, Hampton, VA) New York Springer-Verlag 1992 417 p. For individual items see A93-41777 to A93-41783
(ISBN 0-387-97737-6) Copyright

The present volume discusses the development history and basic concepts of laminar flow control, laminar flow flight experiments, subsonic laminar-flow airfoils, and a design philosophy for long-range laminar flow-control commercial transports with advanced supercritical airfoils. Also discussed are the relationship of wave-interaction theory to laminar flow control, supersonic laminar flow control, and the NASA-Langley 8-ft Transonic Pressure Tunnel. AIAA

A93-41777* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LAMINAR FLOW CONTROL - INTRODUCTION AND OVERVIEW
JERRY N. HEFNER (NASA, Langley Research Center, Hampton, VA) *In* Natural laminar flow and laminar flow control New York Springer-Verlag 1992 p. 1-21. refs
Copyright

A development history and a development-trends evaluation are presented for laminar flow controlled airfoil technologies and design concepts, including the search for 'natural' laminar flow and actively controlled flow via suction through small pores on the airfoil surface. While most NASA activities in this field have been concerned with subsonic aircraft, it has been projected that the control of boundary layer turbulence may be even more critical

to the aerodynamic efficiency of supersonic aircraft. Developmental programs for these techniques have been conducted with several modified conventional aircraft. AIAA

A93-41780* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SUBSONIC NATURAL-LAMINAR-FLOW AIRFOILS
DAN M. SOMERS (NASA, Langley Research Center, Hampton, VA) *In* Natural laminar flow and laminar flow control New York Springer-Verlag 1992 p. 143-176. refs
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An account is given of the development history of natural laminar-flow (NLF) airfoil profiles under guidance of an experimentally well-verified theoretical method for the design of airfoils suited to virtually all subcritical applications. This method, the Eppler Airfoil Design and Analysis Program, contains a conformal-mapping method for airfoils having prescribed velocity-distribution characteristics, as well as a panel method for the analysis of potential flow about given airfoils and a boundary-layer method. Several of the NLF airfoils thus obtained are discussed. AIAA

A93-41781* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
WAVE INTERACTION THEORY AND LFC
PHILIP HALL (Exeter Univ., United Kingdom; ICASE; NASA, Langley Research Center, Hampton, VA) *In* Natural laminar flow and laminar flow control New York Springer-Verlag 1992 p. 223-232. refs
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Attention is drawn to the influence of preexisting finite-amplitude instabilities on the growth of other disturbances; current design tools for LFC take no notice of this kind of interaction. When a rational accounting is accomplished for the evolution of incoming disturbances in finite-amplitude solutions of the equations of motion, future transition-prediction methods will need to take these wave interactions into account. Attention is given here to interactions in the presence of crossflow vortices and interactions involving Goertler vortices. AIAA

A93-41782* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SUPERSONIC LAMINAR FLOW CONTROL
D. M. BUSHNELL (NASA, Langley Research Center, Hampton, VA) *In* Natural laminar flow and laminar flow control New York Springer-Verlag 1992 p. 233-245. refs
Copyright

A development status evaluation is presented for the theoretical understanding and design conceptualization of boundary layer control (BLC) systems applicable to supersonic transports, such as the currently envisioned NASA High Speed Civil Transport. By reducing fuel burned, supersonic BLC techniques could expand ranges to Pacific-crossing scales, while lowering sonic boom effects and upper-atmosphere pollution and even reducing skin friction temperature. The critical consideration for supersonic BLC is the presence of wave effects. AIAA

A93-41906
CONTROL OF VORTICES ON A DELTA WING BY LEADING-EDGE INJECTION
W. GU, O. ROBINSON, and D. ROCKWELL (Lehigh Univ., Bethlehem, PA) AIAA Journal (ISSN 0001-1452) vol. 31, no. 7 July 1993 p. 1177-1186. Research supported by USAF refs
Copyright

This experimental investigation addresses the control of flow past a half-delta wing at high angle of attack. Application of steady blowing, steady suction, or alternate suction-blowing in the tangential direction along the leading edge of the wing can retard substantially the onset of vortex breakdown and stall. The most effective period of the alternate suction-blowing is on the order of one convective time scale of the flow past the wing. As a result of this type of control, the vortex structure in the crossflow plane is modified from a fully stalled condition to a highly coherent leading-edge vortex. This transformation to a restabilized vortex is represented by instantaneous velocity fields, streamline patterns, and vorticity contours. Author

A93-41912
ACCURACY OF FLUX-SPLIT ALGORITHMS IN HIGH-SPEED VISCOUS FLOWS
DATTA GAITONDE and J. S. SHANG (USAF, Wright Lab., Wright-Patterson AFB, OH) AIAA Journal (ISSN 0001-1452) vol. 31, no. 7 July 1993 p. 1215-1221. refs
Copyright

The flux-vector split methods of MacCormack and Candler (MC) and of van Leer (vL) and the flux-difference split method of Roe are investigated in problems representative of complex flows under laminar conditions: the blunt-body flow at Mach 16 and the flow past a 24-deg compression corner at Mach 14. Higher order accuracy is obtained with the monotonic upwind-centered scheme for conservation laws (MUSCL) approach, viscous terms are centrally differenced, and an implicit relaxation method is employed for time integration. Emphasis is placed on evaluating the accuracy in prediction of surface quantities of engineering interest. The performance of the schemes is problem dependent. For the flow past the blunt body, the surface pressure is insensitive to the method as well as mesh resolution. Both the MC and Roe schemes predict accurate heat transfer rates whereas results with the vL method are dependent on the limiter employed. The overall distinction between the schemes is diminished for the compression corner especially on finer meshes. The extent of the separation region is notably influenced by the choice of the limiter. Several issues relating to the components of the calculation method are examined. Author

A93-41914* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DAMPING OF SURFACE PRESSURE FLUCTUATIONS IN HYPERSONIC TURBULENT FLOW PAST EXPANSION CORNERS
KUNG-MING CHUNG and FRANK K. LU (Texas Univ., Arlington) AIAA Journal (ISSN 0001-1452) vol. 31, no. 7 July 1993 p. 1229-1234. refs
(Contract NAG1-891)
Copyright

Surface pressure fluctuations of Mach 8 turbulent flow past a 2.5- and a 4.25-deg expansion corner maintained a Gaussian distribution but were severely attenuated by the expansion process. The pressure fluctuations did not recover to those of an equilibrium turbulent flow even though the mean pressures reached downstream inviscid values in four to six boundary-layer thicknesses. The fluctuations were convected with a velocity comparable to that on a flat plate, and they maintained their identities longer for the stronger expansion. The damping of pressure fluctuations at hypersonic Mach numbers, even by small corner angles, may be exploited in fatigue design. Author

A93-41915* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SPECTRAL SOLUTION OF THE VISCOUS BLUNT-BODY PROBLEM
DAVID A. KOPRIVA (Florida State Univ., Tallahassee) AIAA Journal (ISSN 0001-1452) vol. 31, no. 7 July 1993 p. 1235-1242. refs
(Contract NAG1-862; DE-FC05-85ER-25000)
Copyright

The viscous blunt-body problem is solved with a shock-fitted Chebyshev spectral method. No explicit artificial viscosity or filtering is needed to obtain smooth, converged solutions. The method is applied to two problems. First, results for the flow over a right circular cylinder in the Mach number range of 5.5-6.0 are compared with experimental data. Second, a solution for a Mach 25 flow over a hyperbolic cone is compared with a viscous shock-layer calculation. Author

A93-41916* National Aeronautics and Space Administration, Washington, DC.
ANALYSIS OF HYPERSONIC NOZZLES INCLUDING VIBRATIONAL NONEQUILIBRIUM AND INTERMOLECULAR FORCE EFFECTS
P. W. CANUPP, G. V. CANDLER, J. N. PERKINS, and W. D. ERICKSON (North Carolina State Univ., Raleigh) AIAA Journal (ISSN 0001-1452) vol. 31, no. 7 July 1993 p. 1243-1249. AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992, AIAA Paper 92-0330. Previously cited in issue 09, p. 1351, Accession no. A92-25777 Research supported by North Carolina Space Grant Consortium and DOE refs
(Contract NAGW-1331)
Copyright

A93-41930* National Aeronautics and Space Administration, Washington, DC.
SUPERSONIC JET CONTROL VIA POINT DISTURBANCES INSIDE THE NOZZLE
D. P. WISHART, A. KROTHAPALLI (Florida Agricultural and Mechanical Univ.; Florida State Univ., Tallahassee), and M. G. MUNGAL (Stanford Univ., CA) AIAA Journal (ISSN 0001-1452) vol. 31, no. 7 July 1993 p. 1340, 1341. Research supported by NASA refs
Copyright

Experiments on supersonic jet control via point disturbances inside the nozzle were conducted using a pressure-matched converging-diverging nozzle with an exit diameter of 3.11 cm and an exit Mach number of 2.1. The disturbance generators are situated on the supersonic nozzle wall between the throat and the jet exit plane; the resulting fluid-mechanical disturbances are observed at the intersection of the disturbance cone and the jet lip. It is demonstrated that a single disturbance generator leads to a polygonal jet appearance, while two symmetric disturbances lead to a symmetric rectangular jet shape and two nonsymmetric disturbances lead to a star-like appearance. Significant cusps are formed in all cases. AIAA

A93-41931
LOW-FREQUENCY FLOW OSCILLATION OVER AIRFOILS NEAR STALL
MICHAEL B. BRAGG, DOUGLAS C. HEINRICH, and ABDOLLAH KHODADOUST (Illinois Univ., Urbana) AIAA Journal (ISSN 0001-1452) vol. 31, no. 7 July 1993 p. 1341-1343. refs
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A low-frequency flow oscillation on airfoils occurring near the maximum-lift angle is examined. The frequency was measured with a hot-wire probe in the wake, and it was analyzed using a spectrum analyzer. Data of Zaman et al. (1989) on a LRN(1)-1007 airfoil up to an Re number of only 3 x 10 exp 5 is extended to over 1.3 x 10 exp 6. The frequency converts to a Strouhal number of approximately 0.02, which, from these data, appears to increase slightly with Re number and more significantly with angle of attack. AIAA

A93-41932
MACH DISK OF DUAL COAXIAL AXISYMMETRIC JETS
ANIL K. NARAYANAN and K. A. DAMODARAN (Indian Inst. of Technology, Madras, India) AIAA Journal (ISSN 0001-1452) vol. 31, no. 7 July 1993 p. 1343-1345. refs
Copyright

Experimental results indicate that it is possible to obtain a sizable Mach disk, Dm approximately equal to Di (where Dm is the diameter of the Mach disk and Di is the diameter of the inner nozzle), using a relatively low-pressure test facility by employing dual coaxial axisymmetric jets, brought about by compression of the inner flow in the near zone by the outer flow. With this arrangement the size of the Mach disk varies linearly with Pi (the inner flow blowing pressure), whereas the Dm/Di variation with Po (the outer flow blowing pressure) exhibits a maximum near Pi = Po. AIAA

A93-41934
SUBSONIC/TRANSONIC CASCADE FLUTTER USING A FULL-POTENTIAL SOLVER
MILIND A. BAKHLE, T. S. R. REDDY, and THEO G. KEITH, JR. (Toledo Univ., OH) AIAA Journal (ISSN 0001-1452) vol. 31, no. 7 July 1993 p. 1347-1349. AIAA Dynamics Specialists Conference, Dallas, TX. Apr. 16, 17, 1992, Technical Papers, p. 376-388. Previously cited in issue 14, p. 2323, Accession no. A92-35688 refs
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A93-42254
EXPERIMENTAL INVESTIGATION OF LEADING EDGE VORTICES USING LDA
A. CHATTERJEE and K. SUDHAKAR (Indian Inst. of Technology, Bombay, India) Aeronautical Society of India, Journal (ISSN 0001-9267) vol. 44, no. 4 Nov. 1992 p. 303-309. National Conference on Aerodynamics, 6th, Bangalore, India, Sept. 23-25, 1992 refs
Copyright

An experimental investigation of leading edge vortices on a delta wing of 70-deg sweep and at 30-deg angle of attack is presented. A two-component LDA system is used to measure velocity through the vortex core. Axial and transverse velocity components are measured along various stations across the chord of the wing. Velocity profiles are obtained both before and after the vortex breakdown takes place. Sudden changes in the velocity profiles of both axial and transverse components are seen. Core flow transforms from a jetlike flow to a wakelike flow. rms values of the velocity components are also obtained. An attempt is made to interpret the variations in rms values. Author (revised)

A93-42256
EFFECT OF RADIAL DISTORTION ON THE PERFORMANCE OF A CENTRIFUGAL COMPRESSOR
M. GOVARDHAN, N. SITARAM, N. VENKATRAYULU, and R. R. KUMAR (Indian Inst. of Technology, Madras, India) Aeronautical Society of India, Journal (ISSN 0001-9267) vol. 44, no. 4 Nov. 1992 p. 317-327. National Conference on Aerodynamics, 6th, Bangalore, India, Sept. 23-25, 1992 refs
Copyright

The effect of radial distortion on the performance of the centrifugal compressor was investigated in experiments, using an experimental facility whose components included the inlet nozzle, the inlet duct, the test impeller, the vaneless diffuser, the volume casing with circular section, the outlet duct with a throttle at the end, and a dc motor coupled directly with the shaft carrying the impeller. The distorted inlet conditions were simulated by means of meshes and perforated plates. Eight different configurations were studied. The results indicated that the distortion causes a reduction in performance and surge margins, thus reducing the useful flow range. The reduction in specific work was found to be more pronounced for the case of hub distortion than for tip distortion and midspan distortion. AIAA

A93-42260
COMPUTATION OF HYPERSONIC FLOW OVER A SPHERE USING KINETIC FLUX VECTOR SPLITTING SCHEME WITH EQUILIBRIUM CHEMISTRY
P. THEERTHAMALAI (Indian Inst. of Science, Bangalore; Defence Research and Development Lab., Hyderabad, India) and S. M. DESHPANDE (Indian Inst. of Science, Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267) vol. 44, no. 4 Nov. 1992 p. 347-353. National Conference on Aerodynamics, 6th, Bangalore, India, Sept. 23-25, 1992 refs
Copyright

An inviscid hypersonic flow over a sphere is computed, using a three-dimensional kinetic flux vector splitting scheme code BHEEMA (Deshphande et al., 1992), with perfect and equilibrium air models, for Mach numbers 10, 15, and 20. It was found that the temperature behind the shock wave in equilibrium air flow is much less compared to the perfect air flow (due to absorption of energy by the dissociation reactions), and that the density is much

higher. As a result, the pressure differences between the perfect gas model and the chemical equilibrium model are small (within 2 percent) and, hence, the difference in forces on the body are also small. AIAA

A93-42271
ON MODEL FOR PREDICTING BLADE FORCE DEFECT IN END WALL BOUNDARY LAYER INSIDE AXIAL COMPRESSOR CASCADE
HU WU, ZHITAO HUANG, SONGLING LIU, and FUQUN CHEN (Northwestern Polytechnical Univ., Xian, China) Northwestern Polytechnical University, Journal (ISSN 1000-2758) vol. 11, no. 2 April 1993 p. 172-177. In CHINESE refs

An earlier developed 3D model for predicting the blade force defect in the end-wall boundary layer inside an axial compressor cascade was reevaluated using a specially designed experimental cascade and a minute five-hole probe. The results of flowfield measurements indicate that the cause of the blade force defect in the end-wall boundary layer is the difference between the static pressure distribution along the boundary layer thickness near the pressure surface and that near the suction surface, and that the blade force defect D(z) is positive and varies greatly from the inlet to the outlet of the cascade. On the basis of these results, a new model is developed for predicting the blade force defect. Results obtained with the new model show that it yields results of higher precision than those of the previous models. AIAA

A93-42426
INTERNATIONAL SYMPOSIUM ON COMPUTATIONAL FLUID DYNAMICS, 4TH, UNIV. OF CALIFORNIA, DAVIS, SEPT. 9-12, 1991, SELECTED PAPERS
HARRY A. DWYER, ED. (California Univ., Davis) Computers & Fluids (ISSN 0045-7930) vol. 22, no. 2-3 Mar.-May 1993 322 p. For individual items see A93-42427 to A93-42449
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The present volume on computational fluid dynamics discusses cell vertex methods for inviscid and viscous flows, transonic aerodynamics including strong effects from heat addition, implicit multigrid techniques for compressible flows, and a multidimensional upwind scheme for the Euler equations on structured grids. Attention is given to numerical experiments with nonoscillatory schemes using Eulerian and new Lagrangian formulations, thermochemical models for hypersonic flows, modeling of the pressure-velocity correlation in turbulence diffusion, and an evaluation of an RNG-based algebraic turbulence model. Topics addressed include the computation of unsteady vortical flows, simulation of nonequilibrium hypersonic flows, enhanced numerical inviscid and viscous fluxes for cell-centered finite volume schemes, and a comparison of numerical methods in transonic aerodynamics. Also discussed are multiple sweep solutions of gas flow in arbitrary ducts, equilibrium and nonequilibrium modeling of hypersonic inviscid flows, and an analysis of implicit treatments for a centered Euler solver. AIAA

A93-42428
TRANSONIC AERODYNAMICS INCLUDING STRONG EFFECTS FROM HEAT ADDITION
GUENTER H. SCHNERR (Karlsruhe Univ., Germany) Computers & Fluids (ISSN 0045-7930) vol. 22, no. 2-3 Mar.-May 1993 p. 103-116. International Symposium on Computational Fluid Dynamics, 4th, Univ. of California, Davis, Sept. 9-12, 1991, Selected Papers. A93-42426 17-02 Research supported by Klein, Schanzlin & Becker Stiftung refs
(Contract DFG-ZI-18/31)
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Results are presented of a theoretical and experimental investigation of gasdynamic phenomena in transonic flows caused by the phase transition of the fluid components of vapor/carrier gas mixtures and pure vapors. The dominating parameters, the cooling rate of expansion and the reservoir conditions (vapor pressure) are varied to examine the coupled process of the nonequilibrium phase transition after homogeneous nucleation and the equilibrium condensation in flows near a Mach number of unity. Turbulent boundary layer calculations demonstrate viscous effects and the development of the nonequilibrium phase transition in shear layers. Computations on the basis of given heat source distributions show that homogeneous nucleation initiates heat release to the flow just in the most sensitive region over the airfoils. AIAA

A93-42429* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
IMPLICIT MULTIGRID TECHNIQUES FOR COMPRESSIBLE FLOWS
DAVID A. CAUGHEY (Cornell Univ., Ithaca, NY) Computers & Fluids (ISSN 0045-7930) vol. 22, no. 2-3 Mar.-May 1993 p. 117-124. International Symposium on Computational Fluid Dynamics, 4th, Univ. of California, Davis, Sept. 9-12, 1991, Selected Papers. A93-42426 17-02 Research supported by McDonnell Douglas Corp. and NSF refs
(Contract NAG2-665)
Copyright

Recent advances in the development of the diagonalized alternating direction implicit multigrid method for compressible aerodynamic problems are reviewed. These include the extension of the method originally developed for the Euler equations to include viscous effects, the computation of turbulent flows and the implementation on parallel computers of the scheme on multiblock rids. Author

A93-42430
A MULTI-DIMENSIONAL UPWIND SCHEME FOR THE EULER EQUATIONS ON STRUCTURED GRIDS
Y. TAMURA and K. FUJII (Inst. of Space and Astronautical Science, Sagamihara, Japan) Computers & Fluids (ISSN 0045-7930) vol. 22, no. 2-3 Mar.-May 1993 p. 125-137. International Symposium on Computational Fluid Dynamics, 4th, Univ. of California, Davis, Sept. 9-12, 1991, Selected Papers. A93-42426 17-02 refs
Copyright

A grid-independent multidimensional upwind scheme defined on a structured grid, called the 'weathercock method', is introduced. The present scheme was applied to both the scalar advection equations and the Euler equations and showed the enhanced resolutions of discontinuities. The higher-order extension of the scheme also demonstrated its robustness. Both the extension to three dimensions and the introduction of multidimensional Riemann solvers are straightforward. AIAA

A93-42431
FUM - AN EFFICIENT MMB SOLVER FOR STEADY INVISCID FLOWS
H. M. WU, M. L. YANG, C. Q. HU (Chinese Academy of Sciences, Computing Centre, Beijing, China), and K. OSHIMA (Inst. of Space and Astronautical Science, Sagamihara, Japan) Computers & Fluids (ISSN 0045-7930) vol. 22, no. 2-3 Mar.-May 1993 p. 157-162. International Symposium on Computational Fluid Dynamics, 4th, Univ. of California, Davis, Sept. 9-12, 1991, Selected Papers. A93-42426 17-02 Research supported by NNSFC and State Key Major Projection Basic Research of China refs
Copyright

Attention is given to a fully upwind MmB method for the numerical prediction of hypersonic inviscid flows around shuttlelike bodies. The method is shock-fitting free and singularity-capturing. It is MmB- and entropy-satisfying for 1D scalar conservation laws. Numerical tests show complex flow fields at high angles of attack and high Mach numbers competitive with those obtained using shock-fitting approaches. AIAA

A93-42432
NUMERICAL EXPERIMENTS WITH NONOSCILLATORY SCHEMES USING EULERIAN AND NEW LAGRANGIAN FORMULATIONS
J. Y. YANG and CHIANG-AN HSU (National Taiwan Univ., Taipei) Computers & Fluids (ISSN 0045-7930) vol. 22, no. 2-3 Mar.-May 1993 p. 163-177. International Symposium on Computational Fluid Dynamics, 4th, Univ. of California, Davis, Sept. 9-12, 1991,

Selected Papers. A93-42426 17-02 Research sponsored by NSC refs
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Numerical experiments with one- and two-step nonoscillatory Godunov-type schemes for steady two-dimensional supersonic flows using both the Eulerian and new Lagrangian formulations are presented. Computed examples including a sudden formation of a shock wave are given. It is illustrated that oblique shocks can be crisply resolved using both formulations, but the new Lagrangian method always resolve the slip lines better. For strong shocks, the new Lagrangian method achieves even better shock resolution with increasing Mach number due to its cell size self-adjusting property. Numerical tests indicate that the two-step second-order nonoscillatory scheme is more robust and efficient. Author

A93-42433
THERMO-CHEMICAL MODELS FOR HYPERSONIC FLOWS
YASUHIRO WADA, SATORU OGAWA (National Aerospace Lab., Chofu, Japan), and HIROTOSHI KUBOTA (Tokyo Univ., Japan) Computers & Fluids (ISSN 0045-7930) vol. 22, no. 2-3 Mar.-May 1993 p. 179-187. International Symposium on Computational Fluid Dynamics, 4th, Univ. of California, Davis, Sept. 9-12, 1991, Selected Papers. A93-42426 17-02 refs
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Investigations on the effects of high-temperature gas models have been performed by computing two-dimensional hypersonic flows. Thermal nonequilibrium effects are investigated by flow simulations around a vehicle of the Orbital Experiment along re-entry trajectory ranging from altitudes of 50 to 100 km, with the one-/two-temperature gas results being compared regarding the shock standoff distance, the heating rate and chemical species' concentrations. Additionally, calculations are performed for shock-tube flows in order to clarify the effects of the modelings included in the two-temperature model: the choice of chemical reaction constants, preferential dissociation and diffusive vibrational relaxation. Finally, a vibrational relaxation model for high-temperature gas without the need for information about immediately behind the shock wave is presented. Author

A93-42436
EVALUATION OF AN RNG-BASED ALGEBRAIC TURBULENCE MODEL
ANDI E. SAKYA, YOSHIAKI NAKAMURA, and MICHIRU YASUHARA (Nagoya Univ., Japan) Computers & Fluids (ISSN 0045-7930) vol. 22, no. 2-3 Mar.-May 1993 p. 207-214. International Symposium on Computational Fluid Dynamics, 4th, Univ. of California, Davis, Sept. 9-12, 1991, Selected Papers. A93-42426 17-02 refs
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A new length scale and dissipation rate for a purely mathematically based algebraic turbulence model derived from renormalization group theory is proposed. The proposed length scale is developed in conjunction with an accurate characteristic length scale and the dissipation rate pertaining to the damping action due to the viscous force. In the fundamental aspect, this model is tested by applying it to a flat-plate problem to check that a simple shear layer is modeled adequately. As an application, a typical transonic flow around an airfoil is presented together with the experimental results. Comparison with other algebraic turbulence models is discussed. Author

A93-42437
A MULTIDIMENSIONAL GENERALIZATION OF ROE'S FLUX DIFFERENCE SPLITTER FOR THE EULER EQUATIONS
H. DECONINCK (von Karman Inst. for Fluid Dynamics, Rhode-St.-Genese, Belgium), P. L. ROE (Michigan Univ., Ann Arbor), and R. STRUIJS (von Karman Inst. for Fluid Dynamics, Rhode-St.-Genese, Belgium) Computers & Fluids (ISSN 0045-7930) vol. 22, no. 2-3 Mar.-May 1993 p. 215-222. International Symposium on Computational Fluid Dynamics, 4th, Univ. of California, Davis, Sept. 9-12, 1991, Selected Papers. A93-42426 17-02 refs
(Contract CEC-AERO-0003-C)
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Upwind methods for the 1-D Euler equations, such as TVD schemes based on Roe's approximate Riemann solver, are reinterpreted as residual distribution schemes, assuming continuous piecewise linear space variation of the unknowns defined at the cell vertices. From this analysis three distinct steps are identified, each allowing for a multidimensional generalization without reference to dimensional splitting or 1-D Riemann problems. A key element is the necessity to have continuous piecewise linear variation of the unknowns, requiring linear triangles in two space dimensions and tetrahedra in three space dimensions. Flux differences naturally generalize to flux contour integrals over the triangles. Roe's flux difference splitter naturally generalizes to a multidimensional flux balance splitter if one assumes that the parameter vector variable is the primary dependent unknown having linear variation in space. Nonlinear positive and second-order scalar distribution schemes provide a true generalization of the TVD schemes in one space dimension. Although refinements and improvements are still possible for all these elements, computational examples show that these generalizations present a new framework for solving the multidimensional Euler equations. Author

A93-42441
HIGHER-ORDER-ACCURATE UPWIND SCHEMES FOR SOLVING THE COMPRESSIBLE EULER AND NAVIER-STOKES EQUATIONS
S. YAMAMOTO and H. DAIGUJI (Tohoku Univ., Sendai, Japan) Computers & Fluids (ISSN 0045-7930) vol. 22, no. 2-3 Mar.-May 1993 p. 259-270. International Symposium on Computational Fluid Dynamics, 4th, Univ. of California, Davis, Sept. 9-12, 1991, Selected Papers. A93-42426 17-02 refs
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A fifth-order compact upwind TVD scheme and a fourth-order compact MUSCL TVD scheme are proposed for solving the compressible Euler and Navier-Stokes equations. The fundamental form of the present schemes is based on the second(third)-order-accurate upwind scheme. One of the distinctive points using the present MUSCL TVD scheme is the ability to capture the discontinuities, such as slip lines or contact surfaces as well as shocks, more sharply than the existing TVD scheme with a simpler algorithm than the so-called ENO scheme. The algorithms are relatively simple and the formulas are quite compact. They can be applied easily to the existing Euler and Navier-Stokes solvers based on the second(third)-order upwind scheme. Finally, we show some numerical results of steady and unsteady flows, including shocks, weak discontinuities and vortices, and the superiority of the present scheme is confirmed by comparison with the results of the ordinary numerical scheme. Author

A93-42442
SOLUTION OF THREE-DIMENSIONAL SUPERSONIC FLOWFIELDS VIA ADAPTING UNSTRUCTURED MESHES
TODD J. MITTY, ANTONY JAMESON, and TIMOTHY J. BAKER (Princeton Univ., NJ) Computers & Fluids (ISSN 0045-7930) vol. 22, no. 2-3 Mar.-May 1993 p. 271-283. International Symposium on Computational Fluid Dynamics, 4th, Univ. of California, Davis, Sept. 9-12, 1991, Selected Papers. A93-42426 17-02 refs
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Solution adaptive mesh refinement in three-dimensions on unstructured Delaunay meshes was used to solve the Euler equations for two supersonic flows. One case was uniform flow past a wedge within a channel, producing a shock wave and its reflection off a wall of the channel. The other case incorporated a similar geometry but with an inviscid rotational boundary layer as an inlet condition. This flow was used to model a swept shock wave/boundary layer interaction. Author

A93-42443
SIMULATION OF NONEQUILIBRIUM HYPERSONIC FLOWS

U. RIEDEL, U. MAAS, and J. WARNATZ (Stuttgart Univ., Germany) Computers & Fluids (ISSN 0045-7930) vol. 22, no. 2-3 Mar.-May 1993 p. 285-294. International Symposium on Computational Fluid Dynamics, 4th, Univ. of California, Davis, Sept. 9-12, 1991, Selected Papers. A93-42426 17-02 refs
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Simulation of hypersonic reacting flows is a challenging task, due not only to the large variety of applications (e.g. reentry problems of space vehicles or supersonic combustion etc.) but also to the fact that a large amount of computational and numerical efforts have to be made in order to overcome the difficulties in the numerical solution of the governing Navier-Stokes equations. Whereas very often mathematical modelling is simplified by neglecting second-order effects like molecular transport, thus solving the Euler equations, several interesting phenomena such as gas-surface interactions require the solution of the full set of Navier-Stokes equations. The algorithm presented here is based on a fully conservative formulation of the conservation equations and uses a first-order flux-splitting scheme. The large system of ordinary differential and algebraic equations resulting from the spatial discretization is solved by a time-accurate implicit extrapolation method. In comparing two different nonequilibrium reaction schemes we show that finite rate chemistry has a strong influence on the computed flowfield, e.g. the maximum temperature in the shock wave or the species concentrations. Author

A93-42444
ENHANCED NUMERICAL INVISCID AND VISCOUS FLUXES FOR CELL CENTERED FINITE VOLUME SCHEMES
ALBRECHT EBERLE and STEFAN HEISS (MBB GmbH, Munich, Germany) Computers & Fluids (ISSN 0045-7930) vol. 22, no. 2-3 Mar.-May 1993 p. 295-309. International Symposium on Computational Fluid Dynamics, 4th, Univ. of California, Davis, Sept. 9-12, 1991, Selected Papers. A93-42426 17-02. Previously announced in STAR as N92-21704 refs
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The most attractive features of cell centered finite volume schemes seem to be the easy introduction of the solid body boundary condition and the implementation of characteristic based methods for evaluating the convective fluxes at the cell faces of the finite volumes. For the viscous parts of the fluxes, however, cell centered finite volume schemes are not as well suited as cell vertex based discretizations since in a general grid, cell centered schemes usually are not linear flow preserving concerning the viscous terms. That means that the viscous stress tensor and the heat flux vector may spuriously vary in a flow field with linear velocity and/or temperature distribution. Several enhancements of the flux formulations for cell centered finite volume schemes are described. Author

A93-42446
COMPARISON OF NUMERICAL METHODS IN TRANSONIC AERODYNAMICS
P. R. GARABEDIAN (New York Univ., NY) Computers & Fluids (ISSN 0045-7930) vol. 22, no. 2-3 Mar.-May 1993 p. 323-326. International Symposium on Computational Fluid Dynamics, 4th, Univ. of California, Davis, Sept. 9-12, 1991, Selected Papers. A93-42426 17-02 refs
(Contract AF-AFOSR-91-0042; NSF DMS-89-22805; NSF DMS-90-0024P)
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Ways in which complex characteristics may be used in the hodograph plane are considered. The advantages and disadvantages of the conservation form for the equation of potential flow are considered. Recent progress in the solution of the Euler equations is reviewed, with emphasis on vortex dynamics and on the estimation of the wave drag. It is argued that an improved estimate of the wave drag may be obtained through transformation of the entropy inequality. AIAA

A93-42448
EQUILIBRIUM AND NONEQUILIBRIUM MODELING OF HYPERSONIC INVISCID FLOWS
F. SABETTA, B. FAVINI, and M. ONOFRI (Roma I, Univ., Rome, Italy) Computers & Fluids (ISSN 0045-7930) vol. 22, no. 2-3 Mar.-May 1993 p. 369-380. International Symposium on Computational Fluid Dynamics, 4th, Univ. of California, Davis, Sept. 9-12, 1991, Selected Papers. A93-42426 17-02 refs
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Hypersonic flows about ellipses at high angles of attack are analyzed by means of nonequilibrium, equilibrium and inert gas models. It is shown that the technique proposed for the nonequilibrium model, based on a streamline integration of the chemical rate equations, provides accurate results and allows precise computation of the stagnation point conditions, where equilibrium must be attained. Compared with the nonequilibrium one, the equilibrium model underpredicts the bow shock stand-off distance and overpredicts the wall temperature, whereas the inert gas model can only be used as a crude approximation for evaluating the wall pressure. Author

A93-42449
ANALYSIS OF IMPLICIT TREATMENTS FOR A CENTRED EULER SOLVER
K. KHALFALLAH, G. LACOMBE, and A. LERAT (Ecole Nationale Superieure d'Arts et Metiers, Paris, France) Computers & Fluids (ISSN 0045-7930) vol. 22, no. 2-3 Mar.-May 1993 p. 381-406. International Symposium on Computational Fluid Dynamics, 4th, Univ. of California, Davis, Sept. 9-12, 1991, Selected Papers. A93-42426 17-02 refs
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This paper is concerned with the solution of the steady Euler equations by an implicit unsteady method of Lax-Wendroff type without artificial viscosity or upwinding. Stability and efficiency are discussed for various treatments of the implicit operator: direct solution, approximate factorization or a few iterations of a line-relaxation method. Computational tests are presented for a cylinder and an airfoil. Author

A93-42576
HYPERSONIC FLOWS FOR REENTRY PROBLEMS. VOLS. 1 & 2
JEAN-ANTOINE DESIDERI, ED. (INRIA, Valbonne, France), ROLAND GLOWINSKI, ED. (Houston Univ., TX), and JACQUES PERIAUX, ED. (Dassault Aviation, Saint-Cloud, France) Berlin and New York Springer-Verlag 1991 p. Vol. 1, 258 p.; vol. 2, 1243 p. For individual items see A93-42577 to A93-42647
(ISBN 0-387-54428-3; ISBN 0-387-53859-3) Copyright

The present conference discusses experiments for computational validation for fluid dynamic predictions, hypersonic flow stability and transition, scattering kernels for gas-surface interaction, and CFD methods for airbreathing hypersonic aircraft. Also discussed are the similitude phenomenon in hypersonic aerodynamics, gas-kinetic and Navier-Stokes simulations of reentry flows, the accuracy of models used in the Monte Carlo method for numerical simulation of Boltzmann flows of real gases, intrusive and nonintrusive flow property measurements, the experimental simulation of high-enthalpy real-gas effects, and CFD for hypersonic propulsion. AIAA

A93-42579* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HYPERSONIC STABILITY AND TRANSITION
ELI RESHOTKO (Case Western Reserve Univ., Cleveland, OH) *In* Hypersonic flows for reentry problems. Vol. 1 Berlin and New York Springer-Verlag 1991 p. 18-34. refs
(Contract NCC3-124)
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An evaluation is conducted of the development status of growing normal modes in the computation of flow fields over hypersonic vehicles, giving attention to the effects of surface cooling, pressure gradients, and suction on the growth rates of the normal modes. Also noted are the effects of bluntness on the stability properties of hypersonic vehicles, and the efficacy of the e exp N method of transition estimation at supersonic and hypersonic speeds. A survey

is made of the precautions that must be taken to ensure the effectiveness of experimental and computational studies of hypersonic flow phenomena. AIAA

A93-42581* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTATIONAL FLUID DYNAMICS FOR HYPERSONIC AIRBREATHING AIRCRAFT
JAMES L. THOMAS, DOUGLAS L. DWOYER, and AJAY KUMAR (NASA, Langley Research Center, Hampton, VA) *In* Hypersonic flows for reentry problems. Vol. 1 Berlin and New York Springer-Verlag 1991 p. 55-71. refs
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A development status evaluation is presented for CFD methods applicable to fuselage-integrated scramjet powerplant incorporating hypersonic vehicles; these methods are critically important due to the unavailability of experimental facilities for such elevated Mach number/high-enthalphy conditions. Advancements are required in algorithm robustness and speed, geometric flexibility, and the inclusion of more complete flow physics. The most serious deficiencies lie in turbulence modeling, the lack of complete transition-prediction methods, and combustion modeling. AIAA

A93-42582
GAS-KINETICAL AND NAVIER-STOKES SIMULATIONS OF REENTRY FLOWS
H. OERTEL, JR. (Braunschweig Technical Univ., Germany) *In* Hypersonic flows for reentry problems. Vol. 1 Berlin and New York Springer-Verlag 1991 p. 98-119. refs
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An account is given of recent research conducted in Germany on the aerothermodynamics of spacecraft reentry flows, which largely relies on direct gas kinetics simulation methods where the distribution function is represented directly by the gas particles in the phase space. Attention is given to Navier-Stokes simulations and chemically reacting flow models. It is proposed that a quantitative free-flight reentry experiment be conducted in order to validate both hypersonic wind tunnel results and numerical design tools for a reentry capsule design. AIAA

A93-42585* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CFD FOR HYPERSONIC PROPULSION
LOUIS A. POVINELLI (NASA, Lewis Research Center, Cleveland, OH) *In* Hypersonic flows for reentry problems. Vol. 1 Berlin and New York Springer-Verlag 1991 p. 170-186. Previously announced in STAR as N91-21447 refs
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An overview is given of research activity on the application of computational fluid dynamics (CDF) for hypersonic propulsion systems. After the initial consideration of the highly integrated nature of air-breathing hypersonic engines and airframe, attention is directed toward computations carried out for the components of the engine. A generic inlet configuration is considered in order to demonstrate the highly three dimensional viscous flow behavior occurring within rectangular inlets. Reacting flow computations for simple jet injection as well as for more complex combustion chambers are then discussed in order to show the capability of viscous finite rate chemical reaction computer simulations. Finally, the nozzle flow fields are demonstrated, showing the existence of complex shear layers and shock structure in the exhaust plume. The general issues associated with code validation as well as the specific issue associated with the use of CFD for design are discussed. A prognosis for the success of CFD in the design of future propulsion systems is offered. Author

A93-42587
COMPUTATION OF HYPERSONIC TURBULENT FLOW OVER A REARWARD FACING STEP
M. P. NETTEFIELD (Fluid Gravity Engineering, Ltd., Godalming, United Kingdom) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 63-74. refs
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The aim of this study was to calculate the turbulent hypersonic flow over a rearward facing step using the conditions upstream of the separation point as input. A boundary layer analysis on the cone forebody indicated the turbulent boundary layer thickness at separation to be approximately 5 mm. The Mach number in the 7 deg cone shock layer was approximately 7.2. A line-implicit solution of the Navier-Stokes equations was used in conjunction with a two-equation model of turbulence. Author (revised)

A93-42588* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HYPERSONIC CONE FLOW PREDICTIONS USING AN IMPLICIT UPWIND SPACE-MARCHING CODE
SCOTT L. LAWRENCE (NASA, Ames Research Center, Moffett Field, CA) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 75-91. refs
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Solutions have been computed and results are presented for Problem 1, the case of Mach 9 transitional flow past a 7 deg half-angle cone at zero incidence. The solutions were computed using a code developed for the integration of the parabolized Navier-Stokes equations. The algorithm employed in the code is based on a Roe-type flux-difference-splitting scheme applied following a finite-volume approach. The basic algorithm has been modified to make it implicit and second-order accurate in the crossflow directions. Results are presented in terms of surface pressure and heat transfer as well as boundary layer profiles of pitot pressure, Mach number, and tangential velocity. The case was recalculated several times in an effort to determine sensitivities to such parameters as grid density, wall temperature, turbulence model parameters, as well as freestream expansion. Comparisons with the experimental data are presented and discussed. Author (revised)

A93-42589
EXPERIMENTS ON SHOCK-WAVE/BOUNDARY-LAYER INTERACTIONS PRODUCED BY TWO-DIMENSIONAL RAMPS AND THREE-DIMENSIONAL OBSTACLES
J. DELERY and M.-C. COET (ONERA, Chatillon, France) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 97-128. refs
Copyright

Experiments on shock-wave/boundary-layer interactions have been executed on a two-dimensional ramp at Mach numbers 10 and 5 and on a three-dimensional obstacle at Mach number 10. Reynolds number effect has been examined for interactions at Mach 5. In order to reproduce the ratio of the wall temperature to the recovery temperature of the real flight the model could be cooled by circulation of liquid nitrogen. The flow produced has been investigated by means of schlieren photographs, surface flow visualizations, thermosensitive painting, surface heat transfer and surface pressure measurements. Author

A93-42590
AN EXPERIMENTAL CONTRIBUTION TO THE FLAT PLATE 2D COMPRESSION RAMP, SHOCK/BOUNDARY LAYER INTERACTION PROBLEM AT MACH 14 - TEST CASE 3.7
G. SIMEONIDES and J. F. WENDT (von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese, Belgium) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 129-151. refs
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Pressure and heat transfer distributions along the centerline of a flat plate/2D 15-deg ramp model tested in the Longshot heavy piston gun tunnel are presented. The test conditions are: free-stream Mach = 14.0, Re(unit) = 6.7 x 10 exp 6/m, T(infinity) = 57 K, T(wall) = 290 K. The results are supplemented by a schlieren photograph of the interaction. The test provides indications of transition in the reattachment region; two-dimensionality is confirmed by pressure measurements off the centerline and by the use of side plates. Evidence of the presence

of streamwise striations in the reattachment region is given by closely spaced heat transfer measurements in the spanwise direction. AIAA

A93-42591
VISCOUS, 2-D, LAMINAR HYPERSONIC FLOWS OVER COMPRESSION RAMPS
ZUHEYR ALSALIHI and HERMAN DECONINCK (von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese, Belgium) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 152-166. Research supported by FNRS refs
Copyright

Steady, laminar hypersonic viscous flows over semi-infinite flat plates and two-dimensional compression ramps are calculated. Surface pressure, skin friction and heat transfer distributions as well as flow structure plots (isoline contours) are presented for Mach numbers of 5, 10 and 14.1 and for unit Reynolds numbers of 3 to 6 million per meter. Author

A93-42592* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPUTATIONAL RESULTS FOR 2-D AND 3-D RAMP FLOWS WITH AN UPWIND NAVIER-STOKES SOLVER
ETHIRAJ VENKATAPATHY (Eloret Inst., Palo Alto; NASA, Ames Research Center, Moffett Field, CA) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 169-180. Previously announced in STAR as N91-15497 refs
(Contract NCC2-420)
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An implicit, finite-difference, upwind, full Navier-Stokes solver was applied to supersonic/hypersonic flows over two-dimensional ramps and three-dimensional obstacle. Some of the computed results are presented. The numerical scheme used in the study is an implicit, spatially second order accurate, upwind, LU-ADI scheme based on Roe's approximate Reimann solver with MUSCL differencing of Van Leer. An algebraic grid generation scheme based on generalized interpolation scheme was used in generating the grids for the various 2-D and 3-D problems. Author

A93-42593 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
APPLICATION OF THE GALERKIN/LEAST-SQUARES FORMULATION TO THE ANALYSIS OF HYPERSONIC FLOWS. I - FLOW OVER A TWO-DIMENSIONAL RAMP
F. CHALOT, T. J. R. HUGHES, Z. JOHAN (Stanford Univ., CA), and F. SHAKIB (NASA, Ames Research Center, Moffett Field, CA) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 181-200. Research supported by Dassault Aviation refs
(Contract NAG1-361)
Copyright

An FEM for the compressible Navier-Stokes equations is introduced. The discretization is based on entropy variables. The methodology is developed within the framework of a Galerkin/least-squares formulation to which a discontinuity-capturing operator is added. Results for three test cases selected among those of the Workshop on Hypersonic Flows for Reentry Problems are presented. Author (revised)

A93-42594
THE APPLICATION OF AN ADAPTIVE UPWIND UNSTRUCTURED GRID SOLUTION ALGORITHM TO THE SIMULATION OF COMPRESSIBLE LAMINAR VISCOUS FLOWS OVER COMPRESSION CORNERS
M. VAHDATI, K. MORGAN, and J. PERAIRE (Imperial College of Science, Technology and Medicine, London, United Kingdom) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 201-211. Research supported by British Aerospace/Military Aircraft/, Ltd refs
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The use of an adaptive unstructured grid algorithm for the solution of steady laminar compressive viscous flows over compression corners is described. General assemblies of triangular and quadrilateral cells are used for the spatial discretization, while the temporal discretization is accomplished implicitly. In the viscous simulations, a structured grid of triangular elements is used along solid surfaces, with an unstructured triangular grid employed elsewhere. When computing the solutions, the mesh can be adapted as the computation proceeds. The unstructured portion of the grid is adapted in a fully automatic manner according to the results of an error indicating procedure. AIAA

A93-42595
COMPUTATION OF FLOWS OVER 2D RAMPS
R. RADESPIEL, U. HERRMANN, and J. M. A. LONGO (DLR, Inst. fuer Entwurfsaerodynamik, Braunschweig, Germany) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 212-227. refs
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A central-difference multigrid scheme for the Navier-Stokes equations is extended for computations of hypersonic flows over 2D ramps. The modifications of the multigrid algorithm which are necessary to capture strong shocks are discussed. Finally, results for three Mach = 5 high-Reynolds-number test cases of the Antibes Workshop are given. Author (revised)

A93-42596
HYPERSONIC VISCOUS FLOW OVER TWO-DIMENSIONAL RAMPS
DACHUN JIANG and B. E. RICHARDS (Glasgow Univ., United Kingdom) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 228-243. refs
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Steady hypersonic viscous flows over two-dimensional compression ramps are computed for ramp angles of 0-35 deg, Mach numbers of 5-15, and Reynolds numbers of 3 x 10 exp 6 to 2.1 x 10 exp 7 using the MacCormack implicit scheme. In the case of turbulent flows, two turbulent models, the Baldwin-Lomax model and the modified Johnson-King model, are used as the closure condition for Reynolds-averaged Navier-Stokes equations. For laminar flows, results are presented as contours and wall parameters in the X direction. AIAA

A93-42597* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
GRID-REFINEMENT STUDY OF HYPERSONIC LAMINAR FLOW OVER A 2-D RAMP
JAMES L. THOMAS, DAVID H. RUDY, AJAY KUMAR (NASA, Langley Research Center, Hampton, VA), and BRAM VAN LEER (Michigan Univ., Ann Arbor) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 244-254. refs
Copyright

Computations were made for those test cases of Problem 3 which were designated as laminar flows, viz., test cases 3.1, 3.2, 3.4, and 3.5. These test cases corresponded to flows over a flat plate and a compression ramp at high Mach number and at high Reynolds number. The computations over the compression ramps indicate a substantial streamwise extent of separation. Based on previous experience with separated laminar flows at high Mach numbers which indicated a substantial effect with spatial grid refinement, a series of computations with different grid sizes were performed. Also, for the flat plate, comparisons of the results for two different algorithms were made. Author (revised)

A93-42599
COMPUTATIONAL RESULTS FOR FLOWS OVER COMPRESSION RAMPS
WERNER HAASE (Dornier Luftfahrt GmbH, Friedrichshafen, Germany) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 268-284. refs
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Steady, hypersonic viscous flows over two-dimensional compression ramps are computed by means of a finite volume

technique using a Runge-Kutta type time-stepping scheme. Results are presented based on laminar flow assumptions as well as for fully turbulent flows. Author

A93-42600
IMPLICIT UPWIND FINITE-DIFFERENCE SIMULATION OF LAMINAR HYPERSONIC FLOW OVER A 2D RAMP
B. MUELLER (DLR, Inst. fuer Theoretische Stroemungsmechanik, Goettingen, Germany) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 285-300. refs
Copyright

Laminar hypersonic flow of perfect gas over a semiinfinite flat plate and a 15 deg ramp is numerically simulated by solving the 2D compressible Navier-Stokes equations for the steady state using an implicit upwind finite-difference scheme based on approximate factorization and the total variation diminishing method of Harten and Yee. Author (revised)

A93-42601
A SYNTHESIS OF RESULTS ON THE CALCULATION OF FLOW OVER A 2D RAMP AND A 3D OBSTACLE - ANTIBES TEST CASES 3 AND 4
JOHN F. WENDT (von Karman Inst. for Fluid Dynamics, Rhode-St.-Genese, Belgium), M. MALLET (Dassault Aviation, Saint-Cloud, France), and BASTIAAN OSKAM (National Aerospace Lab., Amsterdam, Netherlands) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 301-311. refs
Copyright

Six Navier-Stokes computations on the hypersonic flow over a 2D ramp are compared to one another and to experiments. The importance of grid density for the prediction of separation length is shown. One computation on the flow over a 3D obstacle is compared with experiment. Difficulties in achieving well-defined experimental conditions, particularly fully laminar conditions at reattachment, are discussed. Author (revised)

A93-42602
EXPERIMENTAL STUDY OF THE LONGITUDINAL HYPERSONIC CORNER FLOW FIELD - HERMES-R&D RESEARCH PROGRAM, PROBLEM NO. 5
A. HENCKELS and F. MAURER (DLR, Hauptabteilung Windkanaele, Cologne, Germany) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 315-331. refs
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Recent project activities for reentry vehicles provided an impetus to numerical and experimental studies of hypersonic flows with inviscid-viscous interaction phenomena like separation-induced vortex flows. The kinetic surface heating, which is one of the major design problems of such vehicles, is for instance strongly influenced by the existence and intensity of vortices as well as the location and type of separation and reattachment of hypersonic boundary layers. Previous experimental investigations of longitudinal corner flows were mostly restricted to a streamwise compression corner, while in the present study a wind tunnel corner flow model has been tested for the case that at least one of the two plates forming the corner is at high incidence up to 20 degrees simulating lee-side flow situation. The free stream Mach number is 8.7. For measuring heat flux values an infrared thermovision camera system in connection with modern image processing allows thermal mapping of the surface heat load distribution. In addition to the thermographic results the flow interpretation was supported by an oil flow visualization study. The received quantitative results may be helpful to validate numerical codes. Author (revised)

A93-42603
EXPERIMENTAL STUDY OF THE FLOW AROUND A DOUBLE ELLIPSOID CONFIGURATION
D. AYMER, T. ALZIARY (Centre d'Etudes Aerodynamiques et Thermiques, Poitiers, France), L. DE LUCA, and G. CARLOMAGNO (Napoli, Univ., Naples, Italy) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 335-357. refs
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The hypersonic flow over a double ellipsoid configuration is studied at Mach number 8.15, Reynolds number 10 exp 6, and incidence angle of 30 deg. Schlieren and wall streamlines visualizations, wall pressures, and heat fluxes measurements provide data which may be helpful in order to validate numerical codes. Author (revised)

A93-42604
SOLUTION OF THE EULER EQUATIONS AROUND A DOUBLE ELLIPSOIDAL SHAPE USING UNSTRUCTURED MESHES AND INCLUDING REAL GAS EFFECTS
FRANCOIS DUBOIS and OLIVIER MICHAUX (Aerospatiale, Div. Systemes Strategiques et Spatiaux, Les Mureaux, France) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 358-373. refs
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We present the numerical solution of the Euler equations of gas dynamics around the double ellipsoidal shape proposed by the organizers of the Antibes 1990 workshop. In two of the test cases we consider a modelization of air by a polytropic perfect gas, at an upstream Mach number M(infinity) = 8.15, and under incidences alpha = 0 deg and 30 deg. The last test case is related to hypersonic regimes and the air is therefore described as a real gas at chemical equilibrium. In the first part of this paper we describe our 3D Euler computing code named CEL3GR developed at AEROSPATIALE Les Mureaux since 1987. In the second part, we present the generation of our two box mesh around the double ellipsoid and we emphasize on the approximation of the nontrivial line of intersection. The third part is devoted to the numerical results for each test case. Author (revised)

A93-42606
AN UPWIND RELAXATION METHOD FOR HYPERSONIC VISCOUS FLOWS OVER A DOUBLE-ELLIPSOIDAL BODY
R. SCHWANE and D. HAENEL (Aachen, Rheinisch-Westfaelische Technische Hochschule, Germany) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 396-413. refs
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The 3D Navier-Stokes equations were solved with an implicit finite-volume method. The method is based on flux-vector splitting with higher-order upwind-biased differences for the Euler terms and central differencing for the viscous terms. The implicit scheme is solved iteratively using Gauss-Seidel line relaxation. Several essential modifications of the flux-vector splitting and of the implicit scheme were implemented to improve robustness and accuracy of the solution for hypersonic flows. Results are presented for the laminar flow over a double-ellipsoidal body. Author (revised)

A93-42607
NAVIER-STOKES CALCULATIONS OVER A DOUBLE ELLIPSE AND A DOUBLE ELLIPSOID BY AN IMPLICIT NON-CENTERED METHOD
C. MARMIGNON (ONERA, Chatillon, France), H. HOLLANDERS (Aerospatiale, Les Mureaux, France), and F. COQUEL (ONERA, Chatillon, France) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 415-426. refs
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An approach to the computation of 2D and 3D hypersonic flows is proposed which is based on the solution of the complete time-dependent Navier-Stokes equations using an upwind implicit finite-volume method whereby the viscous fluxes are evaluated by means of a space centered scheme similar to that of Crank-Nicolson. The application of the method to the calculation of hypersonic laminar flows over a double ellipse and a double ellipsoid is described. Although the method is found to provide good agreement with experimental data, it is noted that some discrepancies, particularly in heat flux predictions, still remain.
AIAA

A93-42608 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
APPLICATION OF THE GALERKIN/LEAST-SQUARES FORMULATION TO THE ANALYSIS OF HYPERSONIC FLOWS. II - FLOW PAST A DOUBLE ELLIPSE
F. CHALOT, T. J. R. HUGHES, Z. JOHAN (Stanford Univ., CA), and F. SHAKIB (NASA, Ames Research Center, Moffett Field, CA) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 427-450. Research supported by Dassault Aviation refs
(Contract NAG1-361)
Copyright

A finite element method for the compressible Navier-Stokes equations is introduced. The discretization is based on entropy variables. The methodology is developed within the framework of a Galerkin/least-squares formulation to which a discontinuity-capturing operator is added. Results for four test cases selected among those of the Workshop on Hypersonic Flows for Reentry Problems are presented. Author

A93-42609
THE APPLICATION OF AN ADAPTIVE UNSTRUCTURED GRID METHOD TO THE SOLUTION OF HYPERSONIC FLOWS PAST DOUBLE ELLIPSE AND DOUBLE ELLIPSOID CONFIGURATIONS
O. HASSAN (Univ. College, Swansea, United Kingdom), J. PEIRO, J. PERAIRE, and K. MORGAN (Imperial College of Science, Technology and Medicine, London, United Kingdom) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 451-471. refs
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An adaptive finite element algorithm is used to solve inviscid and laminar compressible viscous flows past double ellipse and double ellipsoid configurations. To achieve spatial discretization, linear triangular elements are used in two dimensions, and linear tetrahedral elements in three dimensions, with time discretization accomplished in a fully explicit or implicit/explicit manner. The solution algorithm is combined with an adaptive approach whereby the unstructured portion of the grid is adaptively regenerated as the solution proceeds. The structured portion of the mesh is modified accordingly in the tangential direction. AIAA

A93-42610
COMPUTATION OF THE HYPERSONIC FLOW OVER A DOUBLE ELLIPSOID
R. RADESPIEL, U. HERRMANN, and J. M. A. LONGO (DLR, Inst. fuer Entwurfsaerodynamik, Braunschweig, Germany) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 472-493. refs
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The DLR code CEVCATS for the three-dimensional Euler equations is used to compute the hypersonic flow over a double ellipsoid. The results are discussed with respect to convergence and flow field resolution. Author

A93-42612
NUMERICAL SIMULATION OF LAMINAR HYPERSONIC FLOW PAST A DOUBLE-ELLIPSOID
S. RIEDELBAUCH (DLR, Inst. fuer Theoretische Stroemungsmechanik, Goettingen, Germany) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 517-534. refs
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Three-dimensional flow field solutions past the double ellipsoid are presented for two different freestream conditions assuming an ideal gas. The time-dependent thin-layer Navier-Stokes equations are solved by a finite difference method on a surface-oriented grid system. Spatial discretization is based on central differences with added nonlinear second and linear fourth-order damping terms. Good agreement is found for the pressure and heat flux distribution on the body. AIAA

A93-42613
2D HYPERSONIC VISCOUS FLOW PAST A DOUBLE ELLIPSE GEOMETRY
P. LEYLAND (Lausanne, Ecole Polytechnique Federale, Switzerland) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 553-565. refs
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An unfactored implicit scheme in time is used to perform Navier-Stokes calculations, with a centered approximation for the spatial discretization of unstructured P1 triangular finite elements. A standard TVD term is added in the shock region for the high Reynolds number test case. Steady state solutions for 2D hypersonic viscous flows are computed by an asymptotic time integration of the complete Navier-Stokes equations for compressible flow using an implicit Delta scheme with no factorization. AIAA

A93-42614
HYPERSONIC FLOWS OVER A DOUBLE OR SIMPLE ELLIPSE
F. ANGRAND, B. TESSIERAS (CEA, Centre d'Etudes de Limeil-Valenton, Villeneuve-St.-Georges, France), B. DUBROCA, and J. P. MORREEUW (CEA, Centre d'Etudes Scientifiques et Techniques d'Aquitaine, Le Barp, France) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 566-584. refs
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TVD schemes with approximated Riemann solvers are applied to nonstructured meshes, to allow for the easy use of local mesh adaptation techniques, or to structured meshes, which are well adapted to the forepart configuration and allow efficient use of computer time. Examples of calculations using triangular meshes with an Osher type Riemann solver are presented for viscous and nonviscous perfect gas problems. Quadrangular structured meshes are combined with a Roe type Riemann solver for nonequilibrium reactive flow problems. AIAA

A93-42616
VISCOUS AND INVISCID HYPERSONIC FLOW ABOUT A DOUBLE ELLIPSOID
KLAUS DORTMANN (Dornier Luftfahrt GmbH, Friedrichshafen, Germany) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 616-634. refs
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The steady hypersonic flow over a double ellipsoid is numerically investigated for two nonreacting inviscid cases at Ma = 8.15, one reacting inviscid case at Ma = 25 with the freestream conditions taken from standard atmosphere at 75 km and one nonreacting viscous case at Ma = 8.15 and Re = 1.27 x 10 exp 6. For the last two cases an error estimation is performed by means of global mesh refinement. Author (revised)

A93-42617
NUMERICAL SIMULATION OF HYPERSONIC FLOW OVER A DOUBLE ELLIPSE USING A TAYLOR-GALERKIN FINITE ELEMENT FORMULATION WITH ADAPTIVE GRIDS
E. ONATE, F. QUINTANA, and J. MIQUEL (Cataluna Univ. Politecnica, Barcelona, Spain) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 635-654. refs
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Numerical results obtained for the hypersonic flow (M(infinity) = 8.25 and M(infinity) = 25) over a double ellipse are presented. Results are obtained using a Taylor-Galerkin finite element formulation. Nonstructured grids of simple linear triangular three-node elements are used. An adaptive grid refinement technique based on a simple error estimator to improve the numerical solution near shocks is used. Author (revised)

A93-42618
HYPERSONIC VISCOUS FLOW PAST DOUBLE ELLIPSE AND PAST DOUBLE ELLIPSOID - NUMERICAL RESULTS
J. ARGYRIS, I. ST. DOLTSINIS, and H. FRIZ (Stuttgart Univ.,

Germany) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 655-672. refs
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Problems of hypersonic viscous flow past double ellipse and double ellipsoid configurations are solved using meshes that are well adapted in regions with strong gradients. For this purpose, an adaptive refinement procedure for triangular and tetrahedral meshes is applied in conjunction with the numerical algorithm. Numerical results for three test cases are presented. AIAA

A93-42619
ADAPTIVE MESH EMBEDDING FOR REENTRY FLOW PROBLEMS
F. GRASSO and M. PASSALACQUA (Roma I, Univ., Rome, Italy) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 673-688. refs
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In the present work adaptive gridding is applied to compute hypersonic reentry-type flows. The technique uses a finite volume formulation, adaptive mesh embedding and a multistage explicit Runge-Kutta algorithm. Results of flows around the double ellipse and over the 2D compression ramp are presented. Author

A93-42620
ATTEMPT TO EVALUATE THE COMPUTATIONS FOR TEST CASE 6.1 - COLD HYPERSONIC FLOW PAST ELLIPSOIDAL SHAPES
W. KORDULLA (DLR, Inst. fuer Theoretische Stroemungsmechanik, Goettingen, Germany), J. PERIAUX (Dassault Aviation, Saint-Cloud, France), and T. ALZIARY DE ROQUEFORT (Poitiers Univ., France) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 689-712.
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An evaluation is made of seventeen different computational contributions for cold hypersonic flows past ellipsoidal shapes associated with test case 6.1. All solutions are found to provide good predictions of pressure; inviscid flow simulations predict well windward pressure distributions in hypersonic flows. Appreciable scatter is obtained for boundary layer quantities, such as skin friction and Stanton number, which is ascribed to differences in grid resolution and numerical diffusion terms. Possible ways of improving the results are suggested. AIAA

A93-42624
A CONTRIBUTION TO THE PREDICTION OF HYPERSONIC NON-EQUILIBRIUM FLOWS
SALVATORE BORRELLI (Centro Italiano Ricerche Aerospaziali, Capua, Italy) and MAURIZIO PANDOLFI (Torino, Politecnico, Turin, Italy) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 765-781. refs
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Computations are presented for hypersonic flows about simple and double ellipses described by Euler equations. The real gas effects are described using the model described by Park (1985). In the calculations, the ionization is neglected, the vibrational energy is assumed at the local equilibrium level, and chemical processes are considered in nonequilibrium. Computation results are presented for this kind of nonequilibrium flows, for the inert perfect gas, and for the real gas in local chemical equilibrium. AIAA

A93-42626
INVISCID CALCULATIONS BY AN UPWIND FINITE ELEMENT METHOD OF HYPERSONIC FLOWS OVER A DOUBLE (SINGLE) ELLIPSE
V. SELMIN and L. FORMAGGIA (Aeritalia S.p.A., Turin, Italy) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 798-814. Previously announced in STAR as N91-30101 refs
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The quest for better designed reentry vehicles has caused the development of more sophisticated solution algorithms which take into account the complex chemical phenomena associated with high speed flows. As a result, the number of variables involved and the complexity of the equations has increased considerably. In this context, the optimization of the number of mesh points required for a given solution accuracy is of paramount importance. Unstructured grids are considered best suited to handle large variations of grid size, placing more points exactly where needed and allowing a straightforward implementation of adaptive strategies. An unstructured grid approach is therefore chosen. An inviscid flow solver able to operate on such grids is developed. This solver employs a hybrid finite volume/finite element algorithm and upwind concepts reformulated in the context of unstructured triangular grids. The upwind decomposition of the fluxes provides a way to obtain accurate and robust schemes, able to cope effectively with very strong shock phenomena. Author

A93-42627
CONTRIBUTION TO PROBLEM 6 USING AN UPWIND EULER SOLVER WITH UNSTRUCTURED MESHES
A. DESCAMPS, M. MALLET, J. PERIAUX, and B. STOUFFLET (Dassault Aviation, Saint-Cloud, France) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 815-831. refs
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The goal of this paper is to discuss the application on critical problems encountered during reentry of space vehicles of an Euler flow solver developed in the past using unstructured meshes to handle equilibrium and/or nonequilibrium reactive flow simulations. Results in two dimensions for three test cases selected among those proposed around a double ellipse geometry at high Mach number and high angle of attack are presented. Author

A93-42629* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPUTATION OF THERMOCHEMICAL NONEQUILIBRIUM FLOWS AROUND A SIMPLE AND A DOUBLE ELLIPSE
TAHIR GOKCEN (Eloret Inst.; NASA, Ames Research Center, Moffett Field, CA) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 848-870. Previously announced in STAR as N91-14558 refs (Contract NCC2-420)
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The nonequilibrium viscous reactive flows over a simple and a double ellipse at a 30 degree angle of attack were computed. The geometry and the free stream conditions are given by INRIA/GAMNI/SMAI workshop test cases 6.2-2 and 6.2-4. The governing Navier-Stokes equations coupled with thermochemical nonequilibrium processes are solved numerically using a fully coupled, implicit, finite volume technique with a dynamically adaptive grid. The nonequilibrium gas model and the numerical method used in the calculations are briefly described. Author

A93-42630
PROBLEM 6.4.1 - RAREFIED FLOW AROUND A DOUBLE ELLIPSE
SABURO IGARASHI and KENICHI NANBU (Tohoku Univ., Sendai, Japan) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 896-911. refs
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A hypersonic rarefied flow over a double ellipse with an angle of attack of 30 deg is calculated by use of the Monte Carlo Direct Simulation (MGDS) Method. The gas is assumed to be nitrogen with translational and rotational DOFs. The molecular model is the Maxwell molecule, and the variable hard sphere model is adopted to simplify the scattering law. The collisions are simulated by the collision-number scheme. The phenomenological Larsen-Borgnakke model is used to calculate inelastic collision. The probability of inelastic collision is taken to be 0.2. Molecules are diffusely reflected with complete accommodation to the wall temperature. Author (revised)

A93-42631* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE HYPERSONIC DOUBLE ELLIPSE IN RAREFIED FLOW
WILLIAM J. FEIEREISEN (NASA, Ames Research Center, Moffett

Field, CA) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 912-923. refs
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The problem of the hypersonic double ellipse in rarefied flow is treated by a particle method using the collision model first described by McDonald (1988). In the approach used here, the computational overhead is reduced by using simple cubic cells. The problem of the definition of complex geometries is addressed by developing an algorithm to define the relation of a body surface to the network of cells. AIAA

A93-42632
LEESIDE FLOW OVER DELTA WING AT M = 7.15 - EXPERIMENTAL RESULTS FOR TEST CASE 7.1.2
MAGNUS LINDE (Aeronautical Research Inst. of Sweden, Stockholm) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 927-932.
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The leeside flow over a delta wing at angle of attack at Mach 7.15 is investigated in terms of vortical features, shocks, and shock induced separations. Results of surface oil flow visualizations, static pressure measurements, and probe investigations are presented for a delta wing in two spanwise sections, x/s = 0.5 and x/c = 0.8, and alpha = 15, 25, and 30 deg. The qualitative flow features and some quantitative results are discussed. AIAA

A93-42633
FINITE VOLUME 3DNS AND PNS SOLUTIONS OF HYPERSONIC VISCOUS FLOW AROUND A DELTA WING USING OSHER'S FLUX DIFFERENCE SPLITTING
N. QIN and B. E. RICHARDS (Glasgow Univ., United Kingdom) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 947-959. refs
(Contract SERC-GR/E/89056)
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The Osher's flux difference splitting scheme has been applied to the finite volume formulation of the 3D Navier-Stokes equations and the parabolized Navier-Stokes equations. Results for the hypersonic laminar flow around the blunt leading edge delta wing at an angle of attack of 30 deg, i.e. Problem 7.1.2., are presented and discussed. Author (revised)

A93-42634
INVISCID HYPERSONIC FLOW OVER A DELTA WING
STEPHAN M. HITZEL (Dornier Luftfahrt GmbH, Friedrichshafen, Germany) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 960-980. refs
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Reentry-vehicles of relatively high lift/drag-ratio often feature a *blunt leading-edge delta wing configuration. The flow around such* configurations is highly complex including virtually all possible flow-structures, some of which cannot be simulated in proper experiments. In a numerical investigation the inviscid flow around a blunt leading-edge delta wing exposed to a steady hypersonic flow at Mach = 7.15 at an angle-of-attack = 30 deg was calculated by a finite-volume time-stepping method for the solution of the *compressible Euler equations.* Author (revised)

A93-42635
HYPERSONIC LEESIDE DELTA-WING-FLOW COMPUTATIONS USING CENTERED SCHEMES
PETER ELIASSON, ARTHUR RIZZI (Royal Inst. of Technology, Stockholm, Sweden), SHIVAKUMAR SRINIVASAN (Aeronautical Research Inst. of Sweden, Stockholm), and BENGT WINZELL (Saab Aircraft Co., Linkoping, Sweden) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 981-1005. refs
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The leeside flow over a thick blunt-edged delta wing of 70-deg sweep is studied at free-stream Mach 7.15 and alpha = 30 deg by *means of numerical simulations using Euler and Navier-Stokes* equations. The cell-centered finite element approach used to solve the Euler and Navier-Stokes equations is outlined. The flow predicted by the Euler equations is found to be quite different from that predicted by the Navier-Stokes equations, which is attributed primarily to the very blunt leading edge. The *Navier-Stokes results suggest that, instead of the concentrated* vortexs usually found over a delta wing in transonic peed, the flow in hypersonic speed is dominated by a shear layer that separates just past the leading edge and forms a more distributed vortical region over the wing. AIAA

A93-42636
EVALUATION OF CONTRIBUTIONS FOR TEST CASE 7.1.1 AND 7.1.2
ALAIN DERVIEUX (INRIA, Valbonne, France), MAGNUS LINDE (Aeronautical Research Inst. of Sweden, Stockholm), and ARTHUR RIZZI (Royal Inst. of Technology, Stockholm, Sweden) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 1006-1016.
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Several groups of solutions for the delta wing problem 7.1, concerning laminar flows past the blunt delta wing at Mach 7.15 and 30-deg incidence, are examined. The solutions are computed by using two models: inviscid flow modeled by the Euler equations (7.1.1) and viscous flow with Re = 39 x 10 exp 6 modeled by the Navier-Stokes equations. The emphasis is placed on the leeside flow, including separation points, vortex structure, and near-vacuum pressure. AIAA

A93-42637
EXPERIMENTAL DENSITY FLOWFIELDS OVER A DELTA WING LOCATED IN RAREFIED HYPERSONIC FLOWS
J. ALLEGRE, X. H. DUBREUILH, and M. RAFFIN (SESSIA; CNRS, Lab. d'Aerothermique, Meudon, France) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 1017-1030.
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An experimental investigation has been conducted in order to survey the density flowfields around the delta wing and also to quantify aerodynamic forces and convective heating communicated to the model. The present paper is restricted to the presentation of flowfield density data. Author

A93-42638
EXPERIMENTS ON THE HEAT TRANSFER AND ON THE AERODYNAMIC COEFFICIENTS OF A DELTA WING IN RAREFIED HYPERSONIC FLOWS
CH.-H. CHUN (DLR, Inst. fuer Experimentelle Stroemungsmechanik, Goettingen, Germany) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 1031-1050. refs
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For comparison with numerical simulation results the local heat transfer, especially on the leeward side of a delta wing, and the three-component aerodynamic coefficients are measured in rarefied hypersonic flows. Experiments are carried out in the hypersonic vacuum wind tunnel V2G in Goettingen with a free stream condition, Ma roughly 24 and Re(l) roughly 2.9 x 10 exp 4 at angles of attack alpha = 0-30 deg for the heat flux measurements and alpha = 0-40 deg for the force measurements. Oil flow pattern and gas glow discharge visualization are used to discuss an eventual flow separation on the leeward side and the shock shape at various angles of attack. Author (revised)

A93-42639
RAREFIED GAS FLOW AROUND A 3D-DELTAWING
F. GROPENGIESSER, H. NEUNZERT, J. STRUCKMEIER, and B. WIESEN (Kaiserslautern Univ., Germany) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 1067-1078. refs
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This paper presents numerical results for hypersonic flows around a 3D-deltawing at a low Knudsen number. The underlying body geometry as well as the physical parameters correspond to test case 7.2.1. of the workshop. The numerical method used for

the calculations is the Finite-Pointset-Method (FPM) developed at the University of Kaiserslautern since 1987. The paper gives a short introduction to the method and then follows the required output formats of the workshop. Author (revised)

A93-42640
APPRAISAL OF THE RAREFIED FLOW COMPUTATIONS (PROBLEMS 6.4.1 AND 7.2.1)
J. K. HARVEY (Imperial College of Science, Technology, and Medicine, London, United Kingdom) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 1079-1086. refs
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Solutions to two rarefied flow problems, submitted by groups from Germany, Japan, and the United States are evaluated. The problems are the 2D double ellipse and the delta wing at 30 deg incidence in a rarefied hypersonic flow. It is demonstrated that the direct simulation Monte-Carlo method and FPS methods are capable of predicting complex flows in which molecular nonequilibrium effects are present. AIAA

A93-42644* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF PROGRAM LAURA TO THERMOCHEMICAL NONEQUILIBRIUM FLOW THROUGH A NOZZLE
PETER A. GNOFFO (NASA, Langley Research Center, Hampton, VA) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 1145-1158. refs
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Program LAURA (Langley Aerothermodynamic Upwind Relaxation Algorithm) is an upwind-biased, point-implicit relaxation algorithm for obtaining the numerical solution to the governing equations for 3D viscous hypersonic flows in chemical and thermal nonequilibrium. The algorithm is derived using a finite-volume formulation in which the inviscid components of flux across cell walls are described with a modified Roe's averaging and with second-order corrections based on Yee's Symmetric Total Variation Diminishing scheme. The code has been applied to Problem 8.2 of this workshop for the case of thermochemical nonequilibrium flow through a nozzle. Chemical reaction rates are defined with the model of Park (1987). Thermal nonequilibrium is modeled using a two-temperature approximation in which the vibrational energies of all molecules are assumed to be in equilibrium at a single temperature which is generally different from the translational-rotational temperature. Two grids were used to define the flow for the original problem, with a stagnation temperature of 6500 K. A third case with a stagnation temperature of 10,000 K is also presented. The solution domain includes the converging nozzle, subsonic flow domain in which the gas is substantially in thermochemical equilibrium and the diverging nozzle, hypersonic flow domain in which the gas is substantially in thermochemical nonequilibrium. Author (revised)

A93-42656
REDUCTION OF AERODYNAMIC SKIN-FRICTION DRAG [LA REDUCTION DE TRAINEE DE FROTTEMENT AERODYNAMIQUE]
JEAN COUSTEIX (Ecole Nationale Superieure d'Aeronautique et de l'Espace; ONERA, Centre d'Etudes et de Recherches de Toulouse, France), DANIEL ARNAL, and ERIC COUSTOLS (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) Nouvelle Revue d'Aeronautique et d'Astronautique no. 1 April 1993 p. 23-31. In FRENCH refs
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Drag reduction for the next-generation of transport aircraft is one of the main areas of aerodynamic research activity in various countries. An overview is given of the current status of techniques that are being studied in connection with producing significant reductions in drag. Two types of techniques are considered in particular: (1) utilization of laminar-turbulent transition and (2) manipulation of turbulent boundary layers. The principles behind these techniques are described, and their efficiency is illustrated by wind-tunnel and flight-test results. AIAA

A93-42869
ON THE ACCURACY AND EFFICIENCY OF CFD METHODS IN REAL GAS HYPERSONICS
D. DRIKAKIS (Erlangen-Nuernberg, Univ., Erlangen, Germany) and S. TSANGARIS (Athens, National Technical Univ., Greece) International Journal for Numerical Methods in Fluids (ISSN 0271-2091) vol. 16, no. 9 May 15, 1993 p. 759-775. refs
Copyright

A study of viscous and inviscid hypersonic flows using generalized upwind methods is presented. A new family of hybrid flux-splitting methods is examined for hypersonic flows. The hybrid method is constructed by the superposition of the flux-vector-splitting (FVS) method and second-order artificial dissipation in the regions of strong shock waves. The conservative variables on the cell faces are calculated by an upwind extrapolation scheme to third-order accuracy. A second-order-accurate scheme is used for the discretization of the viscous terms. The solution of the system of equations is achieved by an implicit unfactored method. In order to reduce the computational time, a local adaptive mesh solution (LAMS) method is proposed. The LAMS method combines the mesh-sequencing technique and local solution of the equations. The local solution of either the Euler or the Navier-Stokes equations is applied for the region of the flow field where numerical disturbances die out slowly. Validation of the Euler and Navier-Stokes codes is obtained for hypersonic flows around blunt bodies. Real gas effects are introduced via a generalized equation of state. Author

A93-42870
TREATMENT OF VORTEX SHEETS FOR THE TRANSONIC FULL-POTENTIAL EQUATION
T. Q. DANG (Syracuse Univ., NY) International Journal for Numerical Methods in Fluids (ISSN 0271-2091) vol. 16, no. 9 May 15, 1993 p. 777-791. Research supported by McDonnell Douglas Corp refs
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This paper summarizes a combined analytical-computational technique which models vortex sheets in transonic potential-flow methods. In this approach, the inviscid nature of discontinuities across vortex sheets is preserved by employing the step function to remove singularities at these surfaces. The location and strength of the vortex sheets are determined by satisfying the flow-tangency boundary condition and the vorticity transport equation. The theory is formulated for the general three-dimensional case, but its application is confined to the problem of computing slipstreams behind propellers with free-vortex blading in axisymmetric flows. Author

A93-42873
NUMERICAL SIMULATION OF VORTEX SHEDDING PAST TRIANGULAR CYLINDERS AT HIGH REYNOLDS NUMBER USING A K-EPSILON TURBULENCE MODEL
STEFAN H. JOHANSSON, LARS DAVIDSON, and ERIK OLSSON (Chalmers Univ. of Technology, Goteborg, Sweden) International Journal for Numerical Methods in Fluids (ISSN 0271-2091) vol. 16, no. 10 May 30, 1993 p. 859-878. Research supported by STU and Swedish Board of Energy Administration refs
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Calculations of unsteady turbulent flow around and behind triangular-shaped flameholders using a finite volume code with a k-epsilon model of turbulence are presented. The flow behind the flameholders is found to be unsteady (a von Karman vortex street appears) with a well defined Strouhal frequency (predicted $Sr = 0.27$ compared with an experimental value of 0.25). The predicted profiles of velocity and fluctuating kinetic energy agree well with experiments. The periodic motions in the vortex street are shown to be far more important than the turbulent stochastic motions in exchanging momentum in the transversal direction. The pressure-velocity coupling is handled with the SIMPLEC pressure correction procedure. The discretization in time is fully implicit and 90 time steps are used to resolve one time cycle. It was found that to capture the vortex street it is very important that the grid spacing is sufficiently fine (180 x 100). Author (revised)

A93-42874
THREE-DIMENSIONAL VORTEX METHOD FOR PARACHUTES
MAYER HUMI (Worcester Polytechnic Inst., MA) International Journal for Numerical Methods in Fluids (ISSN 0271-2091) vol. 16, no. 10 May 30, 1993 p. 879-889. Research supported by U.S. Army refs
Copyright

We describe the implementation of a new 3D vortex algorithm for the computation of the drag and flow field around parachutes. Among its novel features, the algorithm couples large eddy simulation methodology with the vortex method, away from the wall region. Furthermore, boundary conditions for a wall (no-slip) and compliant boundaries were implemented. The results of several simulations using this algorithm are analyzed and discussed. The spectral contents of the vortex method are also considered.
Author

A93-42888
INVISCID FINITE-VOLUME LAMBDA FORMULATION
FRANCESCO CASALINI and ANDREA DADONE (Bari, Politecnico, Italy) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 4 July-Aug. 1993 p. 597-604. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991, AIAA Paper 91-2258. Previously cited in issue 18, p. 3061, Accession no. A91-44176 Research supported by MURST refs
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A93-42889* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MULTIGRID CALCULATION OF THREE-DIMENSIONAL VISCOUS CASCADE FLOWS
A. ARNONE (Florence Univ., Italy), M.-S. LIOU, and L. A. POVINELLI (NASA, Lewis Research Center, Cleveland, OH) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 4 July-Aug. 1993 p. 605-614. AIAA Applied Aerodynamics Conference, 9th, Baltimore, MD, Sept. 23-25, 1991, Technical Papers. Vol. 1, p. 297-311. Previously cited in issue 23, p. 4000, Accession no. A91-53754 refs
Copyright

A93-42891
MODELING SUPERSONIC INLET BOUNDARY-LAYER BLEED ROUGHNESS
GERALD C. PAYNTER, DAVID A. TREIBER, and W. D. KNEELING (Boeing Co., Seattle, WA) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 4 July-Aug. 1993 p. 622-627. AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992, AIAA Paper 92-0269. Previously cited in issue 09, p. 1347, Accession no. A92-25725 refs
Copyright

A93-42899* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
REVIEW OF CHEMICAL-KINETIC PROBLEMS OF FUTURE NASA MISSIONS. I - EARTH ENTRIES
CHUL PARK (NASA, Ames Research Center, Moffett Field, CA) Journal of Thermophysics and Heat Transfer (ISSN 0887-8722) vol. 7, no. 3 July-Sept. 1993 p. 385-398. refs
Copyright

A number of chemical-kinetic problems related to phenomena occurring behind a shock wave surrounding an object flying in the earth atmosphere are discussed, including the nonequilibrium thermochemical relaxation phenomena occurring behind a shock wave surrounding the flying object, problems related to aerobraking maneuver, the radiation phenomena for shock velocities of up to 12 km/sec, and the determination of rate coefficients for ionization reactions and associated electron-impact ionization reactions. Results of experiments are presented in form of graphs and tables, giving data on the reaction rate coefficients for air, the ionization distances, thermodynamic properties behind a shock wave, radiative heat flux calculations, Damkoehler numbers for the ablation-product layer, together with conclusions. AIAA

A93-42931
NEWTONIAN AND HYPERSONIC FLOWS OVER OSCILLATING BODIES OF REVOLUTION. II - PARABOLIC BODIES
HAMDI T. HEMDAN (King Saud Univ., Riyadh, Saudi Arabia) Acta Astronautica (ISSN 0094-5765) vol. 29, no. 5 May 1993 p. 363-369. refs
Copyright

Recently developed unsteady hypersonic and Newtonian perturbation theories for flow past slender pointed-nose bodies of revolution pitching about any pivot position are further studied in this paper. In Part I, circular cones were considered; here we consider bodies described by second degree equations. It is found that the circumferential speed is singular at body surface for both circular cones and second degree polynomials for pivot positions other than the vertex and is regular for pitching oscillations about the vertex. Also it is found that the in-phase component of the unsteady shock wave does not satisfy the shock attachment condition, but both the in-phase and the out-of-phase components of the stability derivative are regular for all pivot positions. The surface(convex)curvature is found to decrease the out-of-phase component of the stability derivative, but the oscillations remain dynamically stable. Author

A93-43013
EVOLUTION OF A THREE-DIMENSIONAL NONEQUILIBRIUM BOUNDARY LAYER IN A DIHEDRAL ANGLE BEHIND A PERTURBATION SOURCE [RAZVITIE PROSTRANSTVENNOGO NERAVNOVESNOGO POGRANICHNOGO SLOYA V DVUGRANNOM UGLE ZA ISTOCHNIKOM VOZMUSHCHENIJ]
V. I. KORNILOV (RAN, Inst. Teoreticheskoj i Prikladnoj Mekhaniki, Novosibirsk, Russia) Sibirskij Fiziko-Tekhnicheskij Zhurnal (ISSN 0869-1339) no. 1 Jan.-Feb. 1993 p. 39-49. In RUSSIAN refs
Copyright

Experiments were carried out in a low-turbulence subsonic wind tunnel in order to obtain quantitative information on the evolution of a three-dimensional turbulent shear flow behind a two-dimensional perturbation source. It is found that the relaxation rate of shear flow in a dihedral angle and its properties in the nonequilibrium region are largely determined by two dominant mechanisms: (1) a natural process due to the presence of a perturbation source and (2) a process involving attenuation or breakdown and subsequent repeat formation of secondary flows of the second kind representing stationary vortex structures and contributing to an increase in the memory of the shear flow.
AIAA

A93-43027
STABILITY CONDITIONS FOR A TRANSONIC DECELERATING FLOW IN A DUCT [USLOVIYA USTOJCHIVOSTI TRANSZVUKOVOGO TECHENIYA TORMOZHENIYA V KANALE]
A. G. KUZ'MIN Zhurnal Vychislitel'noj Matematiki i Matematicheskoj Fiziki (ISSN 0044-4669) vol. 32, no. 10 Oct. 1992 p. 1628-1640. In RUSSIAN refs
Copyright

The problem considered here concerns isentropic deceleration of a supersonic gas flow to subsonic velocities in a duct of variable cross section. The velocity perturbation field is investigated numerically for different perturbation distributions over the inlet cross section of the duct and different porosities of the upper wall. The effect of perturbation cumulation at the point of sonic line intersection with the upper wall is analyzed. The generation of compression and rarefaction waves at the sonic line near its point of origin is discussed. AIAA

A93-43540
RESULTS FROM A SET OF LOW SPEED BLADE-VORTEX INTERACTION EXPERIMENTS
M. B. HORNER, E. SALIVEROS, A. KOKKALIS, and R. A. MCD. GALBRAITH (Glasgow Univ., United Kingdom) Experiments in Fluids (ISSN 0723-4864) vol. 14, no. 5 April 1993 p.

341-352. Research supported by Ministry of Defence and Defence Research Agency refs
Copyright

Results of blade-vortex interaction experiments (BVI) which are the second series of tests carried out at Glasgow University to improve the facility are reported. Data obtained reveal that the BVI phenomena is dominated by the growth and collapse of the leading edge suction peak, and by the corresponding increase and subsequent reversal of lift. High temporal resolution of the pressure data provides a clearer representation of the vortex convection effects, and their relationship to perturbations in the force and moment coefficient histories. AIAA

A93-43541
AN EXPERIMENTAL STUDY OF A TURBULENT WING-BODY JUNCTION AND WAKE FLOW
J. L. FLEMING, R. L. SIMPSON, J. E. COWLING, and W. J. DEVENPORT (Virginia Polytechnic Inst. and State Univ., Blacksburg) Experiments in Fluids (ISSN 0723-4864) vol. 14, no. 5 April 1993 p. 366-378. Research supported by DARPA refs
(Contract N00014-89-J-1275; N00014-90-J-1909)
Copyright

An incompressible turbulent flow around the wing-body junction formed by a 3:2 semi-elliptic nose/NACA 0020 tail section and a flat plate is considered. Mean and fluctuating velocity measurements are performed adjacent to the wing and up to 11.56 chord length downstream. Results indicate that the characteristic horseshoe vortex flow structure is elliptically shaped, forming the primary component of the streamwise vorticity. The streamwise development of the flow distortions and vorticity distributions is strongly dependent on the geometry-induced pressure gradients and resulting flow skewing directions. It is also found that the trailing vortex leg flow structure scales on the maximum thickness of appendage. A momentum deficit factor correlates the observed trends in mean flow distortion magnitudes and vorticity distribution. AIAA

A93-43628
VORTEX-INDUCED DISTURBANCE FIELD IN A COMPRESSIBLE SHEAR LAYER
DIMITRI PAPAMOSCHOU (California Univ., Irvine) and SANJIVA K. LELE (Stanford Univ., CA) Physics of Fluids A (ISSN 0899-8213) vol. 5, no. 6 June 1993 p. 1412-1419. Research supported by Stanford Univ., USAF, U.S. Navy, and NSF refs
Copyright

The disturbance field induced by a small isolated vortex in a compressible shear layer is studied using direct simulation in a convected frame. The convective Mach number, Mc, is varied from 0.1 to 1.25. The vorticity perturbation is rapidly sheared by the mean velocity gradient. The resulting disturbance pressure field is observed to decrease both in magnitude and extent with increasing Mc, becoming a narrow transverse zone for Mc greater than 0.8. A similar trend is seen for the perturbation velocity magnitude and for the Reynolds shear stress. By varying the vortex size, it was verified that the decrease in perturbation levels is due to the mean-flow Mach number and not the Mach number across the vortex. At high Mc, the vortex still communicates with the edges of the shear layer, although communication in the mean-flow direction is strongly inhibited. The growth rate of perturbation kinetic energy declines with Mc, primarily due to the reduction in shear stress. Author (revised)

A93-43629* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A NUMERICAL STUDY OF WAVE PROPAGATION IN A CONFINED MIXING LAYER BY EIGENFUNCTION EXPANSIONS
FANG Q. HU (Old Dominion Univ., Norfolk, VA) Physics of Fluids A (ISSN 0899-8213) vol. 5, no. 6 June 1993 p. 1420-1426. refs
(Contract NAS1-19480)
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It is well known that the growth rate of instability waves of a two-dimensional free shear layer is reduced greatly at supersonic convective Mach numbers. In previous works, it has been shown that new wave modes exist when the shear layers are bounded by a channel due to the coupling effect between the acoustic wave modes and the motion of the mixing layer. The present work studies the simultaneous propagation of multiple stability waves using numerical simulation. It is shown here that the coexistence of two wave modes in the flow field can lead to an oscillatory growth of disturbance energy with each individual wave mode propagating linearly. This is particularly important when the growth rates of the unstable waves are small. It is also shown here that the propagation of two neutrally stable wave modes can lead to a stationary periodic structure of rms fluctuations. In the numerical simulations presented here the forced wave modes are propagating at same frequency, but with different phase velocities. In order to track the growth of each wave mode as it propagates downstream, a numerical method that can effectively detect and separate the contribution of the individual wave is given. It is demonstrated that by a least square fitting of the disturbance field with eigenfunctions the amplitude of each wave mode can be found. Satisfactory results as compared to linear theory are obtained. Author

A93-43685
THE DEVELOPMENT OF AN EFFICIENT ORNITHOPTER WING
J. D. DELAURIER (Toronto Univ., Downsview, Canada) Aeronautical Journal (ISSN 0001-9240) vol. 97, no. 965 May 1993 p. 153-162. Research supported by NSERC refs
Copyright

Analysis and testing have been used to develop a flapping wing which can efficiently produce lift and thrust for ornithopter flight. With the assumption that the only imposed motion is dihedral flapping at its root, the wing's spanwise distribution of pitching and bending is due to its aeroelastic response. Numerical studies revealed criteria for efficient designs, which then guided the development and construction of an example wing tested in a wind tunnel. The experimental results for average thrust and lift compared very favorably with the theoretical predictions, confirming that such aeroelastically tailored designs provide a means for achieving mechanical flapping-wing flight. Author

A93-43686
TRANSONIC SHOCKWAVE/TURBULENT BOUNDARY LAYER INTERACTIONS ON A POROUS SURFACE
N. CHOKANI and L. C. SQUIRE (Cambridge Univ., United Kingdom) Aeronautical Journal (ISSN 0001-9240) vol. 97, no. 965 May 1993 p. 163-170. refs
Copyright

Transonic shock wave/turbulent boundary layer interactions on a porous surface above a closed plenum chamber have been studied experimentally in the choked flow of a wind tunnel test-section. The equivalent freestream Mach number is 0.76 and results were obtained for three shock strengths. Without the porous surface the Mach numbers ahead of the shock were 1.13, 1.18 and 1.26. The respective shock Mach numbers with the porous surface were 1.10, 1.11 and 1.19. Laser holographic interferometry results are used to measure the density flowfield and examine the nature of the interaction. These results show that the interaction on the porous surface is modified by a thin shear layer adjacent to the surface and the weakening of the shock wave is attributed to this. The interaction was also studied by solving the two-dimensional Reynolds-averaged Navier-Stokes equations together with the two-layer algebraic eddy-viscosity model of Baldwin-Lomax modified with appropriate corrections for surface transpiration. The computed results show excellent agreement with the experimental data. The examination of these numerical results shows that the surface transpiration occurs at a low subsonic velocity and suggests that the effect of the transpiration through the porous surface on the interaction may be optimized. Author

A93-43687
FURTHER STUDY OF HIGH SPEED SINGLE FREE JETS

G. H. MOUSTAFA (Menoufia Univ., Shebeen El-Koam, Egypt) Aeronautical Journal (ISSN 0001-9240) vol. 97, no. 965 May 1993 p. 171-176. refs
Copyright

Experiments to study the behavior of a compressible free jet issuing from an axisymmetric convergent nozzle are reported. Detailed measurements of the mean flow field for subsonic, sonic and underexpanded sonic jets was made within the pressure ratio range of 1.13 to 4. The results show that the spread and decay rates of the jet vary significantly with pressure ratio. The results further indicate the radial velocity/total pressure collapse within the two-dimensional shear layer data. The underexpanded jet propagates to a greater distance downstream than the low speed jets; this leads to enhancement of the far field mixing. Author

A93-43688
SOME CONTRIBUTIONS TO PROPULSION THEORY - NON-ISENTROPIC DUCT FLOW AND THE GENERAL DRAG WAKE TRAVERSE
C. L. BORE (British Aerospace, Kingston, United Kingdom) Aeronautical Journal (ISSN 0001-9240) vol. 97, no. 965 May 1993 p. 177, 178. refs
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One-dimensional duct-flow equations were extended to flows in which total pressure is lost from one station to another. The use of a pitot state traverse at a general station for measuring the drag developed upstream of the station is shown. AIAA

A93-43780* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EFFICIENT FREE WAKE CALCULATIONS USING ANALYTICAL/NUMERICAL MATCHING
DONALD B. BLISS (Duke Univ., Durham, NC) and WAYNE O. MILLER (NASA, Ames Research Center, Moffett Field, CA) American Helicopter Society, Journal (ISSN 0002-8711) vol. 38, no. 2 April 1993 p. 43-52. AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings, p. 253-263. Previously cited in issue 11, p. 1601, Accession no. A90-28171 Research sponsored by U.S. Army refs
Copyright

A93-43781* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DIRECT PERIODIC SOLUTIONS OF ROTOR FREE WAKE CALCULATIONS
WAYNE O. MILLER (NASA, Ames Research Center, Moffett Field, CA) and DONALD B. BLISS (Duke Univ., Durham, NC) American Helicopter Society, Journal (ISSN 0002-8711) vol. 38, no. 2 April 1993 p. 53-60. AHS, Annual Forum, 46th, Washington, May 21-23, 1990, Proceedings. Vol. 2, p. 757-769. Previously cited in issue 05, p. 641, Accession no. A91-17259 Research sponsored by U.S. Army refs
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A93-43782* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A FINITE-VOLUME EULER SOLVER FOR COMPUTING ROTARY-WING AERODYNAMICS ON UNSTRUCTURED MESHES
ROGER C. STRAWN (U.S. Army, Aeroflightdynamics Directorate; NASA, Ames Research Center, Moffett Field, CA) and TIMOTHY J. BARTH (NASA, Ames Research Center, Moffett Field, CA) American Helicopter Society, Journal (ISSN 0002-8711) vol. 38, no. 2 April 1993 p. 61-67. AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 1, p. 419-428. Previously cited in issue 14, p. 2466, Accession no. A93-35935 refs
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N93-29124 Virginia Polytechnic Inst. and State Univ., Blacksburg.
AN EXPERIMENTAL STUDY OF FLOW OVER A 6 TO 1 PROLATE SPHEROID AT INCIDENCE Ph.D. Thesis
SEUNGKI AHN 1992 307 p
Avail: Univ. Microfilms Order No. DA9306841

In two-dimensional flow, the point of flow separation from the surface coincides with the point at which the skin friction vanishes. However, in three-dimensional flow, the situation is much more complex and the flow separation is rarely associated with the vanishing of the wall shear stress except in a few special cases. Though the effects of cross-plane separation are substantial and have been recognized for some time, the phenomenon of flow separation over three-dimensional bodies is still far from being completely understood. The flow is so complex that no completely satisfactory analytical tools are available at the moment. In an attempt to logically identify the various effects and parametric dependence while simultaneously minimizing configuration dependent issue, the flow over a 6 to 1 prolate spheroid, which is a generic three dimensional body, is investigated. For the identification of the general flow pattern and better understanding of the flow field, surface-oil-flow visualization tests and force and moment tests were performed. The angle of attack effect and Reynolds number effect on the separation location are studied with natural transition. Forces and moments tests, surface pressure distribution measurements as well as the surface pressure fluctuations, and mini-tuft flow visualization tests were made to document the flow characteristics on the surface of the body with an artificial boundary layer trip. It was found that there exists a critical Reynolds number at which the flow characteristics of the after body changes. This critical Reynolds number was also confirmed by the force and moment tests. Above this Reynolds number, as the Reynolds number increases, the separation lines do not change their circumferential location but stretch to the upstream of the body. For the low super critical Reynolds number range, the angle of attack effect on the location of the primary separation is not as prominent as in the higher Reynolds number range where the crossflow component effect becomes dominant. Surface pressure fluctuation data and surface pressure spectra were measured and documented for the first time for this type of three-dimensional flow. For the extension of the study to unsteady transient motion effects, a new Dynamic-Plunge-Pitch-Roll (DyPPiR) model mount was designed and developed to generate required transient motions. The measurements carried out are to be used as reference data to identify the unsteady transient effect of the flow field undergoing unsteady transient maneuvers.
Dissert. Abstr.

N93-29160*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PERFORMANCE CHARACTERISTICS OF TWO MULTIAXIS THRUST-VECTORING NOZZLES AT MACH NUMBERS UP TO 1.28
DAVID J. WING and FRANCIS J. CAPONE Washington May 1993 111 p
(Contract RTOP 505-62-30-01)
(NASA-TP-3313; L-17151; NAS 1.60:3313) Avail: CASI HC A06/MF A02

The thrust-vectoring axisymmetric (VA) nozzle and a spherical convergent flap (SCF) thrust-vectoring nozzle were tested along with a baseline nonvectoring axisymmetric (NVA) nozzle in the Langley 16-Foot Transonic Tunnel at Mach numbers from 0 to 1.28 and nozzle pressure ratios from 1 to 8. Test parameters included geometric yaw vector angle and unvectored divergent flap length. No pitch vectoring was studied. Nozzle drag, thrust minus drag, yaw thrust vector angle, discharge coefficient, and static thrust performance were measured and analyzed, as well as external static pressure distributions. The NVA nozzle and the VA nozzle displayed higher static thrust performance than the SCF nozzle throughout the nozzle pressure ratio (NPR) range tested. The NVA nozzle had higher overall thrust minus drag than the other nozzles throughout the NPR and Mach number ranges tested. The SCF nozzle had the lowest jet-on nozzle drag of the three nozzles throughout the test conditions. The SCF nozzle provided yaw thrust angles that were equal to the geometric angle and constant with NPR. The VA nozzle achieved yaw thrust vector

angles that were significantly higher than the geometric angle but not constant with NPR. Nozzle drag generally increased with increases in thrust vectoring for all the nozzles tested.
Author (revised)

N93-29165*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EVALUATION OF FOUR ADVANCED NOZZLE CONCEPTS FOR SHORT TAKEOFF AND LANDING PERFORMANCE
P. FRANK QUINTO, GUY T. KEMMERLY, and JOHN W. PAULSON, JR. Jun. 1993 98 p Sponsored by NASA, Washington
(Contract RTOP 505-59-30-02)
(NASA-TP-3314; L-16998; NAS 1.60:3314) Avail: CASI HC A05/MF A02

Four advanced nozzle concepts were tested on a canard-wing fighter in the Langley 14- by 22-Foot Subsonic Tunnel. The four vectoring-nozzle concepts were as follows: (1) an axisymmetric nozzle (AXI); (2) an asymmetric, load balanced exhaust nozzle (ALBEN); (3) a low aspect ratio, single expansion ramp nozzle (LASERN); and (4) a high aspect ratio, single expansion ramp nozzle (HASERN). The investigation was conducted to determine the most suitable nozzle concept for short takeoff and landing (STOL) performance. The criterion for the best STOL performance was a takeoff ground roll of less than 1000 ft. At approach, the criteria were high lift and sufficient drag to maintain a glide slope of -3 to -6 deg with enough pitching-moment control from the canards. The test was performed at a dynamic pressure of 45 lb/sq ft and an angle-of-attack range of 0 to 20 deg. The nozzle pressure ratio was varied from 1.0 to 4.3 at both dry power and after burning nozzle configurations with nozzle vectoring to 60 deg. In addition, the model was tested in and out of ground effects. The ALBEN concept was the best of the four nozzle concepts tested for STOL performance. Author (revised)

N93-29166*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HYPERSONIC LATERAL AND DIRECTIONAL STABILITY CHARACTERISTICS OF AEROASSIST FLIGHT EXPERIMENT CONFIGURATION IN AIR AND CF4
JOHN R. MICOL and WILLIAM L. WELLS Washington Jun. 1993 42 p
(Contract RTOP 506-40-41-01)
(NASA-TM-4435; L-17154; NAS 1.15:4435) Avail: CASI HC A03/MF A01

Hypersonic lateral and directional stability characteristics measured on a 60 deg half-angle elliptical cone, which was raked at an angle of 73 deg from the cone centerline and with an ellipsoid nose (ellipticity equal to 2.0 in the symmetry plane), are presented for angles of attack from -10 to 10 deg. The high normal-shock density ratio of a real gas was simulated by tests at a Mach number of 6 in air and CF4 (density ratio equal to 5.25 and 12.0, respectively). Tests were conducted in air at Mach 6 and 10 and in CF4 at Mach 6 to examine the effects of Mach number, Reynolds number, and normal-shock density ratio. Changes in Mach number from 6 to 10 in air or in Reynolds number by a factor of 4 at Mach 6 had a negligible effect on lateral and directional stability characteristics. Variations in normal-shock density ratio had a measurable effect on lateral and directional aerodynamic coefficients, but no significant effect on lateral and directional stability characteristics. Tests in air and CF4 indicated that the configuration was laterally and directionally stable through the test range of angle of attack. Author (revised)

N93-29284# SRI International Corp., Menlo Park, CA. Molecular Physics Center.
KINETICS AND ENERGY TRANSFER IN NONEQUILIBRIUM FLUID FLOWS Final Report, 17 Jun. 1990 - 16 Sep. 1992
DAVID R. CROSLEY 3 Feb. 1993 70 p
(Contract DAAL03-90-K-0001)
(AD-A263612; ARO-27864.3-EG-SDI) Avail: CASI HC A04/MF A01

Chemical kinetics and energy transfer have been investigated for nonequilibrium fluid flow. The particular process of interest is ultraviolet emission from the A2 sigma + excited electronic state of NO, which is generated under nonequilibrium conditions in the bow shock waves of ascending missiles at 50 to 100 km altitude. A literature survey of the pertinent rate constants and mechanism for use in computer models of the process has been undertaken. Emission from NO has been studied in shock tubes, using shock heated air and other gas mixtures. Collisional quenching of the A2 sigma + state is the reverse of heavy particle excitation of the emission. Its temperature dependence has been studied in a heated cell and a shock tube. An attempt was made to determine the final vibrational state distribution in the ground electronic state, concluding that the NO is transferred into high vibrational levels.
DTIC

N93-29410 Wright Lab., Wright-Patterson AFB, OH.
MODAL SURVEY OF A FULL-SCALE F-18 WIND TUNNEL MODEL *Interim Report, Mar. 1991 - Jul. 1992*
VINCENT J. LEVRAEA, DOUGLAS A. HENDERSON, ARNEL P. PACIA, and MICHAEL P. BANFORD Sep. 1992 63 p . Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A262482; WL-TM-92-350-FIBG) Avail: CASI HC A04

The purpose of this investigation was to perform a ground vibration test (GVT) to determine the resonant frequencies, damping, and mode shapes for the F-18 vertical tail structure. This effort represents a subtask of the twin tail buffet work currently studying the buffet response of the F-18 vertical tails to forebody vortices generated at high angles of attack. The GVT was conducted on a full-scale F-18 airframe which had been significantly modified to enable it for use as a full-scale wind tunnel model in the NASA Ames 80 ft x 120 ft wind tunnel facility. Because the major emphasis of the test was to obtain the dynamic characteristics of the vertical tails under tunnel mounting conditions, the GVT was performed with the full-scale model mounted on the tunnel pedestals in the same configuration as would be used for the wind tunnel tests. The primary excitation frequencies of the vortical wake were expected to be below 100 hertz, thus the GVT only measured tail response frequencies below this value. The results give dynamic response information for the first bending, second bending, and first torsional modes of the vertical tails.
DTIC

N93-29449*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HIGH-REYNOLDS-NUMBER TEST OF A 5-PERCENT-THICK LOW-ASPECT-RATIO SEMISPAN WING IN THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL: WING PRESSURE DISTRIBUTIONS
JULIO CHU and PIERCE L. LAWING Dec. 1990 201 p
(Contract RTOP 505-61-01-01)
(NASA-TM-4227; L-16704; NAS 1.15:4227) Avail: CASI HC A10/MF A03

A high Reynolds number test of a 5 percent thick low aspect ratio semispan wing was conducted in the adaptive wall test section of the Langley 0.3 m Transonic Cryogenic Tunnel. The model tested had a planform and a NACA 64A-105 airfoil section that is similar to that of the pressure instrumented canard on the X-29 experimental aircraft. Chordwise pressure data for Mach numbers of 0.3, 0.7, and 0.9 were measured for an angle-of-attack range of -4 to 15 deg. The associated Reynolds numbers, based on the geometric mean chord, encompass most of the flight regime of the canard. This test was a free transition investigation. A summary of the wing pressures are presented without analysis as well as adapted test section top and bottom wall pressure signatures. However, the presented graphical data indicate Reynolds number dependent complex leading edge separation phenomena. This data set supplements the existing high Reynolds number database and are useful for computational codes comparison. Author

N93-29450*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AERODYNAMIC CHARACTERISTICS OF A ROTORCRAFT AIRFOIL DESIGNED FOR THE TIP REGION OF A MAIN ROTOR BLADE
KEVIN W. NOONAN May 1991 79 p
(Contract DA PROJ. 1L1-62211-A-47-AA; RTOP 505-61-59-76)
(NASA-TM-4264; L-16855; NAS 1.15:4264;
AVSCOM-TR-91-B-003; AD-B156202L) Avail: CASI HC A05/MF A01

A wind tunnel investigation was conducted to determine the 2-D aerodynamic characteristics of a new rotorcraft airfoil designed for application to the tip region (stations outboard of 85 pct. radius) of a helicopter main rotor blade. The new airfoil, the RC(6)-08, and a baseline airfoil, the RC(3)-08, were investigated in the Langley 6- by 28-inch transonic tunnel at Mach numbers from 0.37 to 0.90. The Reynolds number varied from 5.2 x 10(exp 6) at the lowest Mach number to 9.6 x 10(exp 6) at the highest Mach number. Some comparisons were made of the experimental data for the new airfoil and the predictions of a transonic, viscous analysis code. The results of the investigation indicate that the RC(6)-08 airfoil met the design goals of attaining higher maximum lift coefficients than the baseline airfoil while maintaining drag divergence characteristics at low lift and pitching moment characteristics nearly the same as those of the baseline airfoil. The maximum lift coefficients of the RC(6)-08 varied from 1.07 at M=0.37 to 0.94 at M=0.52 while those of the RC(3)-08 varied from 0.91 to 0.85 over the same Mach number range. At lift coefficients of -0.1 and 0, the drag divergence Mach number of both the RC(6)-08 and the RC(3)-08 was 0.86. The pitching moment coefficients of the RC(6)-08 were less negative than those of the RC(3)-08 for Mach numbers and lift coefficients typical of those that would occur on a main rotor blade tip at high forward speeds on the advancing side of the rotor disk. Author

N93-29778*# Kansas Univ. Center for Research, Inc., Lawrence.
CONSTRUCTION, WIND TUNNEL TESTING AND DATA ANALYSIS FOR A 1/5 SCALE ULTRA-LIGHT WING MODEL
MICHAEL D. JAMES and HOWARD W. SMITH *In its* The Ultra Light Aircraft Testing 41 p 1993
(Contract NAG1-345)
Avail: CASI HC A03/MF A02

This report documents the construction, wind tunnel testing, and data analysis of a 1/5 scale ultra-light wing section. Wind tunnel testing provided accurate and meaningful lift, drag, and pitching moment data. This data was processed and graphically presented as follows: C(sub L) vs. gamma; C(sub D) vs. gamma; C(sub M) vs. gamma; and C(sub L) vs. C(sub D). The wing fabric flexure was found to be significant and its possible effects on aerodynamic data was discussed. The fabric flexure is directly related to wing angle of attack and airspeed. Different wing section shapes created by fabric flexure are presented with explanations of the types of pressures that act upon the wing surface. This report provides conclusive aerodynamic data for ultra-light wings. Author (revised)

N93-29862# Air Force Inst. of Tech., Wright-Patterson AFB, OH. Foreign Aerospace Science and Technology Center.
SOLUTION OF EULER EQUATIONS FOR FOREBODY-INLET ENSEMBLE OF AIRCRAFT AT HIGH ANGLE OF ATTACK
ZHENG XIAOQING and SHEN HUILI 27 Apr. 1993 19 p Transl. into ENGLISH from unidentified Chinese language document p 161-168
(AD-A263905; FASTC-ID(RS)T-0870-92) Avail: CASI HC A03/MF A01

A computational procedure was developed to simulate inviscid flows over integrated forebody-inlet ensemble of an aircraft model. The analysis, which includes the effect of Mach number, angle of attack, and engine mass flow is based on the solution of three-dimensional Euler equations. A finite-volume spatial discretization and a Runge-Kutta time stepping scheme are employed in solving the equations. To achieve the required geometric flexibility, a multizone mesh is used. The entire computational domain is divided into three zones. The mesh of each zone is generated by interpolating the fluxes across the interface between adjacent zones during iterations. A new type of treatment of inlet exit boundary conditions was developed and tested. The procedure was applied to forebody-inlet analysis for a range of flight conditions including subsonic, transonic, and supersonic flight with various engine mass flows and angles of attack. In addition, the steady states of supersonic flight up to 15 degrees of angle of attack for the subcritical engine regime were obtained. The results are in good agreement with the experimental data. DTIC

N93-29891# Naval Surface Warfare Center, Bethesda, MD. Propulsion and Auxiliary Systems Dept.
UNSTEADY VORTEX LOOP/DIPOLE THEORY APPLIED TO THE WORK AND ACOUSTICS OF AN IDEAL LOW SPEED PROPELLER Progress Report
EARL QUANDT Mar. 1993 28 p
(AD-A264057; CDNSWC/PAS-92/52) Avail: CASI HC A03/MF A01

The vortex loop/dipole singularities used to simulate blade lift and thickness in potential flow models of turbomachines are examined in an unsteady form. The three-dimensional potential fields created as these singularities rotate in the absolute frame are shown to provide the input forces, ideal work and wake energy for an incompressible fluid, as well as the tonal acoustics for slight compressibility. For typical low Mach number propellers, the sound field is dominated by the lift force and exhibits large cancellation effects with multiple blades. It is concluded that the unsteady formulation illustrates well the physics of a turbomachine, and in addition, highlights some basic principles of potential flow. DTIC

N93-29919# Air Force Inst. of Tech., Wright-Patterson AFB, OH. Foreign Aerospace Science and Technology Center.
THE APPLICATION OF CONCENTRIC VORTEX SIMULATION TO CALCULATING THE AERODYNAMIC CHARACTERISTICS OF BODIES OF REVOLUTION AT HIGH ANGLES OF ATTACK
BAN XIANLIN and TU XING 27 Apr. 1993 16 p Transl. into ENGLISH from Kongqidonglixue Xuebao (China), v. 8, no. 2, 1990 p 161-167
(AD-A263879; FASTC-ID(RS)T-0869-92) Avail: CASI HC A03/MF A01

The aerodynamic characteristic of sharp nosed bodies of revolution is calculated by using concentric vortex simulation in this paper. Based on the experimental results, an appropriate set of free integration parameters is selected and an empirical relation between initial separation angle and the Reynolds number is established. Thus, the effect of the Reynolds number is reasonably considered in the calculation. The effect of the Mach number is corrected by using Gothert's rule. The differential equations of vortex motion are solved by using the fourth order Runge Kutta method with varying step size. Three different initial step sizes are used in different integration positions in order to increase the speed of calculation. Two models (F3AI6 and F3.5A7) were calculated in this paper. DTIC

N93-30020# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
SONIC BOOM PROBLEM FOR FUTURE HIGHSPEED AIRCRAFT [LE PROBLEME DU BANG SONIQUE POUR DE FUTURS AVIONS DE TRANSPORT A HAUTE VITESSE]
ANDRE AURIOL, CLAUDE LECOMTE, and CHRISTIAN THERY 1990 52 p In FRENCH
(ISSN 0078-3781)
(ONERA-NT-1990-3; ETN-93-93723) Avail: CASI HC A04/MF A01

The various physical characteristics of sonic booms are recalled: origin, atmospheric propagation, and circumstances under which focusing takes place. The main effects on structures and living creatures are outlined. The only noticeable nuisance from the sonic boom is due to the fact that it startles people. This

reaction increases in intensity with the severity of the boom and the steepness of the shock fronts. No acceptance threshold has been defined so far, but startle reactions become scarce for boom intensities less than 50 pascals, or for those booms having a shock front of weak intensity followed by a gradual compression. This milder reaction could, therefore, be attained by changing the aerodynamic geometry of the aircraft appropriately. It is, therefore, recommended that work continues, with the following: studies on startle reactions, to define bearable booms of unconventional shapes; and studies of the aerodynamic shapes of planes able to generate such booms. Ways also have to be found to reduce the effects of the unavoidable strengthening of the boom due to the transonic acceleration of the plane. ESA

N93-30119# Army Natick Labs., MA.
A COMPUTATIONAL MODEL THAT COUPLES AERODYNAMIC AND STRUCTURAL DYNAMIC BEHAVIOR OF PARACHUTES DURING THE OPENING PROCESS Final Report, Oct. 1991 - Jan. 1993
KEITH R. STEIN, RICHARD J. BENNEY, and EARL C. STEEVES Apr. 1993 31 p
(AD-A264115; NATICK/TR-93/029) Avail: CASI HC A03/MF A01

In parachute research, the canopy inflation process is the least understood and most complex to model. Unfortunately, it is during the opening process that the canopy often experiences the largest deformations and loadings. The complexity of modelling the opening process stems from the coupling between the structural dynamics of the canopy, lines and payload with the aerodynamics of the surrounding fluid medium. The addition of a computational capability to model the coupled opening behavior would greatly assist in the understanding of the canopy inflation process. Ongoing research at the U.S. Army Natick Research, Development and Engineering Center (Natick) focuses on this coupled problem. The solution to the coupled problem is expected to assist in the development of future U.S. Army airdrop systems which include the capability of deploying at low altitudes and high speeds. A computational fluid dynamics (CFD) code and structural dynamic mass spring damper (MSD) code are coupled with an explicit marching method. The CFD flow solver provides the differential pressure values at node points along a radial which are used as input in the MSD model. The MSD code integrates the equations of motion for the canopy and returns current nodal positions and velocities to the CFD code. The node points on the MSD model coincide with a unique set of adjacent CFD grid points for all time. This coupled model predicts behavior for a quarter-scale C-9 parachute which compares favorably with experimentally determined behavior. DTIC

N93-30151# Phillips Lab., Kirtland AFB, NM.
VORTEX SHEDDING BY BLUNT/BLUFF BODIES AT HIGH REYNOLDS NUMBERS. VOLUME 4: RECTANGLES Final Report, 17 Jun. 1991 - 31 Jul. 1992
B. R. MERRILL Mar. 1993 204 p
(AD-A264154; PL-TR-92-1053-VOL-4) Avail: CASI HC A10/MF A03

This report documents the analysis of vortex shedding data collected by the Phillips Laboratory at the U.S. Air Force Academy Subsonic Wind Tunnel facility. The analysis is primarily of the power spectrum of the vortex shedding as seen in the force and moment coefficient power spectra. The shedding frequencies as seen in the power spectra are used to analyze for the Strouhal number. The analysis suggests that shape and orientation in the wind field have an effect on the shedding of vortices. DTIC

N93-30171# Phillips Lab., Kirtland AFB, NM.
VORTEX SHEDDING BY BLUNT/BLUFF BODIES AT HIGH REYNOLDS NUMBERS. VOLUME 1: DATA ANALYSIS Final Report, 17 Jun. 1991 - 31 Jul. 1992
B. R. MERRILL Mar. 1993 52 p
(AD-A264151; PL-TR-92-1053-VOL-1) Avail: CASI HC A04/MF A01

This report documents the analysis of vortex shedding data collected by the Phillips Laboratory at the U.S. Air Force Academy Subsonic Wind Tunnel facility. The analysis is primarily of the power spectrum of the vortex shedding as seen in the force and moment coefficient power spectra. The shedding frequencies as seen in the power spectra are used to analyze for the Strouhal number. The analysis suggests that shape and orientation in the wind field have an effect on the shedding of vortices. DTIC

N93-30172# Phillips Lab., Kirtland AFB, NM.
VORTEX SHEDDING BY BLUNT/BLUFF BODIES AT HIGH REYNOLDS NUMBERS. VOLUME 2: CYLINDERS, OCTAGON, HEXAGON Final Report, 17 Jun. 1991 - 31 Jul. 1992
B. R. MERRILL Mar. 1993 182 p
(AD-A264152; PL-TR-92-1053-VOL-2) Avail: CASI HC A09/MF A02

This report documents the analysis of vortex shedding data collected by the Phillips Laboratory at the U.S. Air Force Academy Subsonic Wind Tunnel facility. The analysis is primarily of the power spectrum of the vortex shedding as seen in the force and moment coefficient power spectra. The shedding frequencies as seen in the power spectra are used to analyze for the Strouhal number. The analysis suggests that shape and orientation in the wind field have an effect on the shedding of vortices. DTIC

N93-30173# Phillips Lab., Kirtland AFB, NM.
VORTEX SHEDDING BY BLUNT/BLUFF BODIES AT HIGH REYNOLDS NUMBERS. VOLUME 3. CUBES Final Report, 17 Jun. 1991 - 31 Jul. 1992
B. R. MERRILL Mar. 1993 243 p
(AD-A264153; PL-TR-92-1053-VOL-3) Avail: CASI HC A11/MF A03

This report documents the analysis of vortex shedding data collected by the Phillips Laboratory at the U.S. Air Force Academy Subsonic Wind Tunnel facility. The analysis is primarily of the power spectrum of the vortex shedding as seen in the force and moment coefficient power spectra. The shedding frequencies as seen in the power spectra are used to analyze for the Strouhal number. The analysis suggests that shape and orientation in the wind field have an effect on the shedding of vortices. DTIC

N93-30373*# Purdue Univ., West Lafayette, IN. School of Mechanical Engineering.
TURBULENCE CHARACTERISTICS OF AN AXISYMMETRIC REACTING FLOW Final Report
RICHARD D. GOULD, WARREN H. STEVENSON, and H. DOYLE THOMPSON Washington Feb. 1988 213 p
(Contract NAG3-502; RTOP 505-90-11)
(NASA-CR-4110; E-3813; NAS 1.26:4110) Avail: CASI HC A10/MF A03

Simultaneous two-componet laser velocimeter measurements were made in the turbulent flow field following an axisymmetric sudden expansion with and without combustion. The fuel (propane) and air were fully premixed to give a constant fuel-air ratio of 0.032 at the inlet (corresponding to an equivalence ratio of 0.5) for the combusting flow measurements. Reynolds number based on step height was 5.57 x 10 exp 4. The primary objective of the study was to obtain detailed measurements which would be of use to modelers. Quantities measured included mean axial and radial velocities, Reynolds stresses, and turbulent triple products. In addition, simultaneous time resolved temperature measurements were made in the reacting flow using high speed thermocouples. This permitted the computation of velocity-temperature correlations. Experimental results were compared to predictions from a widely used numerical code based on the k-epsilon turbulence model and the combustion model of Magnussen and Hjertager. Relatively good agreement was found for the cold flow case as in previous studies, but predicted values of temperature in the reacting flow case deviated substantially from the measurements. Sizable errors in the predictions for the velocity field also were found. Possible sources for the observed differences and suggestions for future model development are suggested. Author (revised)

N93-30387# National Oceanic and Atmospheric Administration, Silver Spring, MD. Air Resources Lab.
VORTEX WAKE CHARACTERISTICS OF B757-200 AND B767-200 AIRCRAFT USING THE TOWER FLY-BY TECHNIQUE
L. J. GARODZ and K. L. CLAWSON Jan. 1993 138 p See *also PB92-114586 and Volume 2, PB93-180263*
(PB93-180255; NOAA-TM-ERL-ARL-199-VOL-1) Avail: CASI HC A07/MF A02

The body of the report is a compilation of the reports and the conference proceedings cited above. It draws most heavily from the report by L.J. Garodz and K.L. Clawson, issued to NOAA in 1992. However, it also contains new evaluation methods, conclusions, and recommendations not previous reported in any form, most of which originated with K.L. Clawson. It is divided into two volumes: the first contains the body of the report, while the second contains the appendices. The document is Volume 1. NTIS

N93-30388# National Oceanic and Atmospheric Administration, Silver Spring, MD. Air Resources Lab.
VORTEX WAKE CHARACTERISTICS OF B757-200 AND B767-200 AIRCRAFT USING THE TOWER FLY-BY TECHNIQUE
L. J. GARODZ and K. L. CLAWSON Jan. 1993 570 p See also Volume 1, PB93-180255
(PB93-180263; NOAA-TM-ERL-ARL-199-VOL-2) Avail: CASI HC A24/MF A04

The body of the report is a compilation of the reports and the conference proceedings cited above. It draws most heavily from the report by L.J. Garodz and K.L. Clawson, issued to NOAA in 1992. However, it also contains new evaluation methods, conclusions, and recommendations not previous reported in any form, most of which originated with K.L. Clawson. It is divided into two volumes: the first contains the body of the report, while the second contains the appendices. The document is Volume 2. NTIS

N93-30583 Virginia Polytechnic Inst. and State Univ., Blacksburg.
COMPRESSIBLE TURBULENCE IN A HIGH-SPEED HIGH REYNOLDS NUMBER MIXING LAYER Ph.D. Thesis
RODNEY DALE WELCH BOWERSOX 1992 257 p
Avail: Univ. Microfilms Order No. DA9302663

Compressible turbulence in a high-speed, high Reynolds number, supersonic free shear layer was studied. A two-dimensional free mixing layer was chosen to study turbulence rather than a wall bounded flow due to the experimental fact that the effects of compressibility become significant at lower Mach numbers. The overall flow structure was documented with the shadowgraph and conventional mean flow probes. Image processing techniques were developed in order to determine root-mean-square index of refraction (density) fluctuation levels from the shadowgraph plates. The research concentrated on the Reynolds averaged form of the Navier-Stokes equations, where the effects of compressibility are manifested through 'apparent mass' terms (i.e. p'u'(sub i)). These terms appear in all of the Reynolds averaged Navier-Stokes equations (continuity, momentum, and energy). A new turbulence transformation, coupled with innovative experimental methods, allowed the full compressible Reynolds shear stress to be directly measured. The full compressible heat flux and apparent mass terms were also estimated from cross-wire results. Profiles were obtained at four downstream stations which were strategically located to map different levels of development of the shear flow. It was found, experimentally, that the effects of compressibility on turbulence were more than significant accounting for about 75 percent of the total level of the Reynolds shear stress formulation. For the present mean adiabatic flow, the compressible turbulence accounted for 100 percent of the turbulent heat flux. The apparent mass in the continuity equation was, by definition, only due to compressibility. These results led to the development of a new Compressible Apparent Mass Mixing Length Extension (CAMMLE) model that accounts for compressible turbulence in all of the governing equations. A total of seven turbulence models were experimentally evaluated: the CAMMLE model, the Prandtl incompressible and the Situ-Schetz compressible mixing length models, the Prandtl and Bradshaw turbulent kinetic energy (TKE) formulations, and two compressible TKE extensions that are based upon a newly defined compressible TKE formulation. The measured turbulence data was used to assess the various models, where the measured mean flow profiles were used in the model formulations. The incompressible formulations were generally successful in representing the measured incompressible part of the Reynolds shear stress. However, this term only accounted for about 25 percent of the total shear stress level. All of the compressible extensions provided accurate estimates of the full compressible Reynolds shear stress. Author (revised)

N93-30645 Stanford Univ., CA.
TURBULENT DRAG REDUCTION: STUDIES OF FEEDBACK CONTROL AND FLOW OVER RIBLETS Ph.D. Thesis
HAECHEON CHOI 1993 293 p
Avail: Univ. Microfilms Order No. DA9309581

The objective is to explore concepts for control of turbulent boundary layers leading to skin-friction reduction using the direct numerical simulation technique. Three different control methods are investigated; a passive control by longitudinal riblets, an active control by sensing and perturbing structures near the wall, and a feedback control procedure guided by control theory. In Part 1 significant drag reduction is achieved when the surface boundary condition is modified to suppress the dynamically significant coherent structures present in the wall region. The drag reduction is accompanied with significant reduction in the intensity of the wall layer structures and reductions in the magnitude of Reynolds shear stress throughout the flow. Two essential drag reduction mechanisms are presented. In Part 2 mathematical methods of control theory are applied to the problem of control of fluid flow. The procedure of how to cast the problem of controlling turbulence into a problem in optimal control theory is presented through the formalism and language of control theory. Then a suboptimal control and feedback procedure are presented using methods of calculus of variations through the adjoint state and gradient algorithms. This suboptimal feedback control procedure is applied to the distributed and boundary controls of the stochastic Burgers equation. Most cases considered show significant reductions of the costs. In Part 3 direct numerical simulation is performed to analyze turbulent flow over longitudinal riblets, and to reduce the mechanism of drag reduction by riblets. The computed drags on the riblet surfaces are in good agreement with the existing experimental data. Differences in the mean-velocity profile and turbulence quantities are found to be limited to the inner region of the boundary layer. Velocity and vorticity fluctuations as well as the Reynolds shear stresses above the riblets are reduced in drag-reducing configurations. Instantaneous flow fields near the riblets are investigated in detail and a physical explanation for the observed drag reduction is proposed. Dissert. Abstr.

N93-30892 California Inst. of Tech., Pasadena.
A THEORETICAL AND COMPUTATIONAL STUDY ON ACTIVE WAKE CONTROL Ph.D. Thesis
LUCA CORTELEZZI 1993 165 p
Avail: Univ. Microfilms Order No. DA9307031

A two-dimensional unsteady separated flow past a semi-infinite plate with transverse motion is considered. The flow is assumed incompressible and at high Reynolds number. The rolling-up of the separated shear-layer is modeled by a point vortex whose time dependent circulation is predicted by an unsteady Kutta condition. A power-law starting flow is assumed along with a power-law for the transverse motion. The effects of the motion of the plate on the starting vortex circulation and trajectory are presented. A suitable vortex shedding mechanism is introduced and a class of flows involving several vortices is presented. Subsequently, a control strategy able to maintain constant circulation when a vortex is present is derived. An exact solution for the non-linear controller is then obtained. Dynamical system analysis is used to explore the performance of the controlled system. Finally, the control strategy is applied to a class of flows and the results are discussed. The previous results are extended

to the case of a two dimensional unsteady separated flow past a plate of variable length. Again the rolling-up of the separated shear layer is modeled by a vortex pair whose time dependent circulation is predicted by an unsteady Kutta condition. A power-law starting flow is assumed while the plate length is kept constant. The results of the simulations are presented and the model validated. A time dependent scaling which unveils the universality of the phenomenon is discussed. The previous vortex shedding mechanism is implemented and a vortex merging scheme is tested in a class of flows involving several vortices and is shown to be highly accurate. Subsequently, a control strategy able to maintain constant circulation when a vortex pair is present is derived. An exact solution for the non-linear controller is obtained in the form of an ordinary differential equation. Dynamical system analysis is used to explore the performance of the controlled system and the existence of a controllability region is discussed. Finally, the control strategy is applied to two classes of flows and the results are presented. Dissert. Abstr.

N93-30947 Stanford Univ., CA.
THE NUMERICAL SIMULATION OF CIRCULATION CONTROLLED AIRFOIL FLOWFIELDS Ph.D. Thesis
SAMUEL WITHERSPOON LINTON 1993 173 p
Avail: Univ. Microfilms Order No. DA9309631

A Circulation Controlled Airfoil has a rounded trailing edge, so that the rearward stagnation point is not fixed, but is free to move along the surface. In addition, it uses upper surface blowing near the trailing edge to energize the boundary layer, thus increasing its resistance to separation. Since the jet flow rate is controlled, there is direct control of the separation point location, and thus of the circulation and lift of the airfoil. The delayed separation of the boundary layer near the trailing edge can result in a very high maximum lift coefficient. The present research is the numerical simulation of two- and three-dimensional flows over a Circulation Controlled geometry using a fully implicit Navier-Stokes code, and the comparison to experimental results. Mach numbers of 0.3 and 0.5 and jet total to freestream pressure ratios of 1.4 and 1.8 are investigated. The Baldwin-Lomax and k-epsilon turbulence models are used, each modified to include the effect of strong streamline curvature. A new numerical technique is presented for the implicit treatment of the nonlinear source terms in the k-epsilon equations. In addition to the steady-state unstalled solutions, the first known numerical solutions of jet stalled Circulation Controlled Airfoil fields are computed. In two-dimensions, the alternation between adverse pressure gradient and shock induced separation of the boundary layer on the airfoil trailing edge results in a highly repeatable periodic flow field. The first known three-dimensional computations about a Circulation Controlled Wing are also performed. The steady state solutions on the aspect ratio 4 semispan wing show locally two-dimensional behavior inboard of about the 70 percent span station, but strong roll up of the jet sheet into the tip vortex outboard. The post-stall three-dimensional computations show the same mechanism of stall as the corresponding two-dimensional results, but the oscillations are somewhat less regular. The outboard flow field is strongly influenced by the unsteady tip vortex, and the stream-lines there are highly three-dimensional. In some cases, three-dimensionality is important inboard as well, since the oscillations in lift are not in phase over the wing, but seem to travel inboard along it. Dissert. Abstr.

N93-30979*# Battelle Pacific Northwest Labs., Richland, WA.
CONSTRUCTION AND TESTING OF SIMPLE AIRFOILS TO DEMONSTRATE STRUCTURAL DESIGN, MATERIALS CHOICE, AND COMPOSITE CONCEPTS
L. ROY BUNNELL and STEVEN W. PIIPPO (Richland School District, WA.) *In* NASA. Langley Research Center, National Educators' Workshop. Update 92: Standard Experiments in Engineering Materials Science and Technology p 449-459 Jun. 1993
Avail: CASI HC A02/MF A04

The objective of this educational exercise is to have students build and evaluate simple wing structures, and in doing so, learn about materials choices and lightweight construction methods. A list of equipment and supplies and the procedure for the experiment are presented. Derived from text

N93-31037*# Colorado Univ., Boulder.
THE HSCT MISSION ANALYSIS OF WAVERIDER DESIGNS Final Report, 15 May 1991 - 14 May 1993
1993 10 p
(Contract NAG1-1295)
(NASA-CR-193467; NAS 1.26:193467) Avail: CASI HC A02/MF A01

The grant provided partial support for an investigation of wave rider design and analysis with application to High-Speed Civil Transport (HSCT) vehicles. Proposed was the development of the necessary computational fluid dynamics (CFD) tools for the direct simulation of the waverider vehicles, the development of two new wave rider design methods that would provide computational speeds and design flexibilities never before achieved in wave rider design studies, and finally the selection of a candidate waverider-based vehicle and the evaluation of the chosen vehicle for a canonical HSCT mission scenario. This, the final report, reiterates the proposed project objectives in moderate detail, and it outlines the state of completion of each portion of the study, providing references to current and forthcoming publications that resulted from this work. Author (revised)

03

AIR TRANSPORTATION AND SAFETY

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

A93-40432
MECHANICAL DAMAGE TO AIRCRAFT STRUCTURES FROM LIGHTNING STRIKES
G. W. REID (AEA Technology, Culham Lab., Abingdon, United Kingdom) Institution of Mechanical Engineers, Proceedings, Part G - Journal of Aerospace Engineering (ISSN 0954-4100) vol. 207, no. G1 1993 p. 1-14. Research supported by Ministry of Defence Procurement Executive refs
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The various types of current waveforms associated with lightning discharges are discussed together with their relevance to different areas of the aircraft structures. The physical damage that could be sustained by aircraft material due to lightning strikes, in particular the damage to composite material especially carbon fiber, is described. This damage is primarily due to the very fast heating and impulsive forces which lightning currents can produce. Minimum cross-sectional areas required to carry these currents safely are discussed as well as the effect of moisture content and loading the samples during test for the case of carbon fiber composite material. Details of the effects of arc attachment to various composite materials and also metal with the degree and type of damage that can be produced are reviewed. Author

A93-42654
PROGRESS AND TABOOS IN FLIGHT SAFETY - HUMAN-FACTORS RESEARCH IN AIR TRANSPORTATION [PROGRES ET TABOUS EN SECURITE DES VOLS - RECHERCHES SUR LES 'FACTEURS HUMAINS' DANS LE TRANSPORT AERIEN]
JEAN PINET Nouvelle Revue d'Aeronautique et d'Astronautique no. 1 April 1993 p. 7-12. In FRENCH
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It is pointed out that objective measurement methods should be applied to the study of human behavior in connection with flight safety. A quantitative approach should be adopted to complement the improvement in behavior achieved by various cockpit resource management programs. It is further noted that

training centers can play a useful role in educating airline personnel, but their impact is limited in scope and education remains a long-term issue. It is concluded that all the players in air transportation must join in a concerted effort to establish world standards and reduce the risk of aircraft accidents. AIAA

N93-29152*# Massachusetts Inst. of Tech., Cambridge. Aeronautical Systems Lab.
A PASSIVE INFRARED ICE DETECTION TECHNIQUE FOR HELICOPTER APPLICATIONS
ADAM L. DERSHOWITZ and R. JOHN HANSMAN, JR. 20 Aug. 1991 54 p
(Contract NAG3-927)
(NASA-CR-193187; NAS 1.26:193187; ASL-91-4) Avail: CASI HC A04/MF A01

A technique has been developed, and successfully tested, to detect icing remotely on helicopter rotor blades. Using passive infrared (IR) thermometry it is possible to detect the warming caused by latent heat released as supercooled water freezes. During icing, the ice accretion region on the leading edge of the blade is found to be warmer than the uniced trailing edge resulting in a chordwise temperature profile characteristic of icing. Preliminary tests, using an IR Thermal video system, were conducted on a static model in the NASA Icing Research Tunnel (IRT) for a variety of wet (glaze) and dry (rime) ice conditions. A prototype detector system was built consisting of a single point IR pyrometer, and experiments were run on a small scale rotor model. Using this prototype detector, the characteristic chordwise temperature profiles were again observed for a range of icing conditions. Several signal processing methods were investigated, to allow automatic recognition of the icing signature. Additionally, several implementation issues were considered. Based on both the static and subscale rotor tests, where ice was successfully detected, the passive IR technique appears to be promising for rotor ice detection. Author (revised)

N93-29211 Virginia Polytechnic Inst. and State Univ., Blacksburg.
GENERATION OF CARBON MONOXIDE IN COMPARTMENT FIRES Ph.D. Thesis
DANIEL T. GOTTUK Dec. 1992 266 p
(Contract NANB-1-D1176)
(PB93-146702; NIST/GCR-92/619) Avail: Issuing Activity

A test compartment was used to investigate the burning of four fuels (hexane, PMMA, spruce, and flexible polyurethane foam) in compartment fires. Empirical correlations between the upper-layer yield of major species and the plume equivalence ratio were shown to exist. The results reveal that the production of CO is primarily dependent on the compartment flow dynamics and upper layer temperature. A chemical kinetic analysis indicated that increased compartment temperature affects upper-layer species yields in two ways: (1) the generation of species in the plume is changed, and (2) oxidation of post-flame gases in the layer is affected. The correlations developed in the compartment fires were qualitatively similar to those developed by Beyler for simplified upper-layer environments. The species yields downstream of hexane compartment fires were investigated and compared to upper-layer yields. Results showed that downstream CO yields can be correlated to the plume equivalence ratio when taking into account the occurrence of external burning. NTIS

N93-29286# Federal Aviation Administration, Washington, DC. Flight Standards Service.
FAA INTERNATIONAL CONFERENCE ON AIRPLANE GROUND DEICING
29 May 1992 317 p Conference held in Reston, VA, 28-29 May 1992
(AD-A263617) Avail: CASI HC A14/MF A03

On March 22, 1992 US Air Flight 405, departing from New York's La Guardia Airport, crashed on takeoff. The Federal Aviation Administration (FAA) is proceeding on the assumption that this tragedy was due to icing. In response, the FAA initiated a 6-month effort to improve the safety of winter flight operations. This effort will result in safety improvements that will be implemented before next winter. A better understanding of airplane ground deicing and anti-icing issues is a crucial prerequisite to the implementation of feasible and effective safety improvements. To achieve this goal, the FAA sponsored a conference at which the international aviation community could exchange thoughts and offer recommendation on a variety of issues concerning safe winter operations. On May 28 and 29, 1992, the FAA held the International Conference on Airplane Ground Deicing to develop a better understanding of airplane deicing and anti-icing issues. More than 750 participants discussed the problems posed by aircraft deicing and examined possible solutions. The conference produced suggestions for corrective actions the should be taken before this winter and possible long-term improvements to existing systems. The focus of the conference was carrier operated turbine-powered airplanes with more than 30 passenger seats. DTIC

N93-30194# Army War Coll., Carlisle Barracks, PA.
AIR PIRACY AND TERRORISM DIRECTED AGAINST U.S. AIR CARRIERS Study Project
CHARLES E. MARTIN 5 Apr. 1993 32 p
(AD-A264120) Avail: CASI HC A03/MF A01

Air piracy and terrorism have presented an increasing challenge to the air carriers of the United States and to the air carriers of the rest of the world. The air carriers of the United States represent a particularly lucrative target because airlines are symbols of nations. Airliners, which may be carrying as many as 350 hostages or victims, can be pirated and controlled by a small force. Or they can be blown up by a small explosive device placed in baggage or cargo. Terrorist groups and air pirates differ significantly in their goals, aims, means, capabilities as well as many other characteristics. They represent causes and ideals which cover the ideological spectrum. No matter their cause or ideal they cause confusion and fear in the government and population of their target country. This study will examine air piracy and terrorism historically and provide a survey of more recent highly publicized and political acts against U.S. air carriers. DTIC

N93-30274 Senstar Corp., Kanata (Ontario).
FUTURE DIRECTIONS IN AVIATION SECURITY
M. C. MAKI *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 4 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

Advances in airport security technology based on the guided radar principle are reviewed. Such technology utilizes very high frequency radio waves, optimal for detection of human intruders in terms of radar cross-section. The Rapidly Extendible Perimeter Line Sensor uses a discrete wave coupling device as the sensing element. The system incorporates a pair of externally attached transmit/receive inductive couplers at opposite ends of a single conductor. For installation, the cable is unwound and clipped to support poles, with transmit and receive couplers at either end of the desired detection zone. A dual magnetically coupled slow propagation attenuating cable has been designed to provide its own attenuation of external modes of propagation, and both the transmit and receive coaxial components are contained within the same jacket. The cable can be used either in buried or surface (relocatable) modes. The Area Illuminated Leaky Cable Sensor is a variant of the leaky cable technology intended to secure a number of individual resources located in a cluster arrangement. The Tactical VHF/Volumetric Surveillance Radar provides volumetric (surface and overhead) coverage using send and receive antennas which can be configured according to the zone needing protection. The antennas can be mounted on buildings or aircraft, or can be portable types for fast temporary setup of a security perimeter. Author (CISTI)

N93-30275 American Science and Engineering, Inc., Cambridge, MA.
AUTOMATIC DETECTION OF EXPLOSIVES USING X RAY IMAGING

DAVID SCHAFER and MARTIN ANNIS *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 4 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

Backscatter imaging has been developed as a new technique for the x-ray imaging of checked baggage. In the scatter image, the contrast for explosives in an image is dramatically increased and the image confusion is decreased. An explosive detection system is being developed based on measuring the bulk x-ray characteristics of scatter images of checked baggage. In the simplified version of this system, it is proposed that normal checked baggage as a group has rather similar scatter characteristics. To test this hypothesis, bags from a lost-baggage agency were obtained and measurements were made of their scattering characteristics. Several simulated bombs were added to some of the bags and the changes in the characteristics were used to develop an automatic detection algorithm. Preliminary results show that the system was able to detect 2.3-pound bombs 100% of the time with only a 2% false alarm rate, and to detect 80% of 0.7-pound bombs at a similar false alarm rate. Author (CISTI)

N93-30276 Scintrex Ltd., Concord (Ontario).
EXPLOSIVES DETECTION SYSTEMS FOR AIRPORT SECURITY GAS CHROMATOGRAPHIC BASED DEVICES
S. NACSON, C. CASTLEDINE, T. SIU, T. LU, and O. LEGRADY *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 3 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

A high-speed explosive vapors monitoring system has been developed which is suitable for use at an airport security gate for detecting the presence of explosives on passengers and in baggage. The system consists of a rapid vapor concentration manifold, an explosive vapor preconcentrator, and a fast gas chromatograph/electron capture detection system. Different configurations of vapor concentration manifolds are used for examination of passengers and of baggage. The system was tested in two months of full-scale trials at a throughput of 7 passengers or bags per minute. An alarm rate of about one in a thousand for the walk-through unit and two in a thousand for the baggage unit were recorded. The system has shown exceptional sensitivity to explosive vapors, being capable of detecting less than 5 parts per trillion of ethylene glycol dinitrate at a low rate of false alarms. Author (CISTI)

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A93-40332
CORROBORATION OF A MOMENT-METHOD CALCULATION OF THE MAXIMUM MUTUAL COUPLING BETWEEN TWO HF ANTENNAS MOUNTED ON A HELICOPTER
J. W. R. COX (Defence Research Agency, Communications Dept., Farnborough, United Kingdom) IEE Proceedings, Part H - Microwaves, Antennas and Propagation (ISSN 0950-107X) vol. 140, no. 2 April 1993 p. 113-120. refs
Copyright

A wire-mesh mathematical model of a helicopter is used to produce estimates of the required near-field dependent parameters and to calculate the maximum mutual coupling between two HF loop antennas with acceptable accuracy. The mathematical model does not incorporate any empirically derived information, and the calculation has been performed prior to the availability of the aircraft. It is shown that predictions made using the wire-mesh model are generally consistent with the corresponding results obtained using the simplified circuit model for supplementary calculations. AIAA

A93-40359
NEW ALGORITHMS FOR HYPERBOLIC RADIONAVIGATION
A. J. FISHER (York Univ., United Kingdom) IEE Proceedings, Part F: Radar and Signal Processing (ISSN 0956-375X) vol. 140, no. 2 April 1993 p. 145-152. refs
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Hardware and software aspects of the design of a microprocessor-based radionavigation receiver are discussed. The receiver uses the orange channel of the Decca Navigator transmissions, and is based on a design published by Last (1980). Unlike Last's design, it computes a position fix by directly measuring the phase of the signal, using phase-locked-loop techniques, with software correction for interrupt latency. A phase-determination algorithm is presented which compensates for local oscillator drift and for skew error due to movement of the vehicle during the measurement cycle, and which appears to be particularly resistant to errors due to skywave propagation effects. A further algorithm, based on number-theoretic techniques, is presented for performing zone identification by phase comparison using the master (6f) and orange (8.2f) transmissions only. Author (revised)

A93-40436
THE USE OF SATELLITES FOR AERONAUTICAL COMMUNICATIONS, NAVIGATION AND SURVEILLANCE
I. C. FEREBEE (Racal Research, Ltd., Walton-on-Thames, United Kingdom) Institution of Mechanical Engineers, Proceedings, Part G - Journal of Aerospace Engineering (ISSN 0954-4100) vol. 207, no. G1 1993 p. 37-39. Aerotech '92, Birmingham, United Kingdom, Jan. 14-17, 1992 refs
Copyright

Aeronautical communication and navigation using satellite systems are becoming viable alternatives to conventional VHF (very high frequency) and HF (high frequency) operation. These newer satellite-based systems result in enhanced coverage for oceanic regions. A history of the development of these satellite-based systems is presented. The combination of these systems into a global system to enhance air traffic control functions is proposed. Author

A93-41600
EFFECTS OF EQUIPMENT CALIBRATION, TEST FLIGHT PROCEDURES AND ANALYSING METHODS ON THE ACCURACY OF ILS GLIDE PATH MEASUREMENTS
PEKKA ESKELINEN (Planning Commission for Investigation of Major Accidents, Finland) Espoo, Finland Helsinki University of Technology 1992 57 p. refs

The effects of the measuring-equipment performance and calibration, the applied test flight procedures, and the analyzing methods on the accuracy of the instrumental landing system (ILS) glide path measurements were investigated. It is shown that, if normal metrology practice is followed in tracking equipment and ILS-receiver calibration, the internationally required accuracy can not be obtained. Improved methods were considered for the analysis of glide path signal structure, and the validation results are presented on several installations. AIAA

A93-42798
AUGMENTATION OF A NAVIGATION REFERENCE SYSTEM WITH DIFFERENTIAL GLOBAL POSITIONING SYSTEM PSEUDORANGE MEASUREMENTS
WILLIAM J. NEGAST and RANDALL N. PASCHALL (USAF, Inst. of Technology, Wright-Patterson AFB, OH) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 1 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 342-348. refs

To quantify the performance of navigation systems, the US Air Force has used a baseline navigation system, the Completely Integrated Reference Instrumentation System (CIRIS), which

obtains an accurate navigation solution by combining information from three major subsystems. Although the navigation solution produced by CIRIS is accurate, it will soon be inadequate as the standard against which future navigation systems can be tested. The authors propose an alternative to CIRIS, a hybrid Enhanced Navigation Reference System (ENRS) which takes advantage of a newer ring laser gyro strapdown inertial navigation system (INS), certain features of the current CIRIS, and certain features of differential Global Positioning System (DGPS) measurements. Analysis conducted using a Kalman filter development package known as the Multimode Simulation for Optimal Filter Evaluation (MSOFE) is presented. Both a large order baseline truth model for the ENRS and full- and reduced-order Kalman filters are developed. a.

A93-42816
A CONSTRAINED FLIGHT ROUTE MONITOR SYSTEM IN TERMINAL CONTROL AREA FOR AIR TRAFFIC CONTROL
C. E. LIN, K. L. CHEN, and J. L. CHEN (National Cheng Kung Univ., Tainan, Taiwan) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 517-522. refs
(Contract NSC-CS79-0210-D006-21; NSC-CS81-0210-D006-02)
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A flight route monitor for terminal control area (TCA) application in air traffic control (ATC) including constraints is presented. To increase flight security, some restricted areas in the TCA are specified to limit flight activities in terms of simple equations. The aircraft are monitored with those created constrained boundaries. ATC controllers will be alerted to any constraint violation. The constrained flight route monitor assists the ATC controller for additional functions. A knowledge-based system is introduced to handle all routine procedures in ATC. This system is implemented into PC-AT using Turbo-Prolog. It demonstrates some useful functions for ATC automation. A prototype expert system has been implemented and demonstrated for TCA operation using the example of the Hua-Lien TCA in the Taipei Flight Information Region. a.

A93-43108
A CONTROL ALGORITHM FOR A NAVIGATION-LANDING SYSTEM IN THE CASE OF A PRIORI INDETERMINACY OF FAILURE DATA [ALGORITM UPRAVLENIYA PRIMENENIEM NAVIGATSIONNO-POSADOCHNOJ SISTEMY V USLOVIYAKH APRIORNOJ NEOPREDELENNOSTI INFORMATSII OB OTKAZAKH]
M. V. KOGINOV, M. G. NIKOLAEVA, and B. G. TSYBAEV *In* Methods and equipment for data processing and acquisition in information management systems Leningrad Leningradskij Institut Aviatsionnogo Priborostroeniya 1990 p. 59-63. In RUSSIAN refs
Copyright

An approach to the synthesis of a control algorithm for navigation-landing systems at the different stages of the system design is described. It involves the use of a parametric model of the system at the technical specification stage which states the basic rules for the development of control algorithms for multilevel, multimode, and multiparametric navigation-landing systems. At the conceptual design stage, a logical model is formulated which describes the relationships between the system parameters, and groups of parameters are selected for different functioning modes. It is shown that the development of efficient control methods at the early stages of radio equipment design makes it possible to achieve maximum utilization of the navigation-landing system capabilities at the system functioning stage. AIAA

A93-43110
INCREASING THE RELIABILITY OF AN AIR TRAFFIC CONTROL RADIO SYSTEM [POVYSHENIE NADEZHNOSTI RADIOSISTEMY UPRAVLENIYA VOZDUSHNYM DVIZHENIEM]
A. N. YAKIMOV *In* Methods and equipment for data processing and acquisition in information management systems Leningrad Leningradskij Institut Aviatsionnogo Priborostroeniya 1990 p. 70-75. In RUSSIAN refs
Copyright

A method for increasing the reliability of radio equipment used in air traffic control is discussed which is based on the use of quasi-sector antenna radiation patterns. A procedure for calculating these radiation patterns is described. It is shown that the use of quasi-sector radiation patterns instead of the traditional Gaussian radiation patterns makes it possible to achieve a significant improvement in the reliability of air traffic control systems. AIAA

A93-43111
CALCULATION OF THE PASSIVE NOISE POWER FOR ONBOARD SINGLE-PULSE AUTOMATIC DIRECTION TRACKING SYSTEMS [RASCHET MOSHCHNOSTI PASSIVNYKH POMEKH BORTOVYM MONOIMPUL'SNYM SISTEMAM ASN]
YU. P. DANILOV, YU. N. PRAZDNICHNOV, and A. P. SHEPETA *In* Methods and equipment for data processing and acquisition in information management systems Leningrad Leningradskij Institut Aviatsionnogo Priborostroeniya 1990 p. 75-80. In RUSSIAN
Copyright

A method is proposed for calculating the power of the underlying surface echo signal present at the input of the receiver of single-pulse automatic direction tracking systems of the sum-difference type. Such systems commonly employ four-support antennas with a narrow radiation pattern. The approximation of the radiation patterns by Gaussian curves for low partial widths of the radiation pattern in terms of half-power makes it possible to use the asymptotic Laplace method for calculating the signal power. AIAA

A93-43112
HALF-SCALE MODELING EXPERIENCE IN THE TESTING OF RADIO NAVIGATION AND LANDING SYSTEMS [OPYT POLUNATURNOGO MODELIROVANIYA DLYA OTRABOTKI SISTEM RADIONAVIGATSII I POSADKI]
R. V. DROZDOV, V. V. LUK'YANOV, and V. I. SPIVAK *In* Methods and equipment for data processing and acquisition in information management systems Leningrad Leningradskij Institut Aviatsionnogo Priborostroeniya 1990 p. 80-84. In RUSSIAN refs
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A simulation system for the half-scale testing of onboard radio navigation and landing equipment and its application are described. The principal components of the simulation system include a computer-based control system; a controller; a dynamic simulator of the actual radio signals of radio beacons, noise, and various radio systems; and software and metrological support. The principal stages of the testing procedure are discussed, and the efficiency of the simulation system is demonstrated. AIAA

A93-43369
EVOLUTION OF EUROPEAN AIR SPACE TOWARD PRECISION NAVIGATION (P/RNAV) [L'EVOLUTION DE L'ESPACE AERIEN EUROPEEN VERS LA NAVIGATION DE PRECISION (P/RNAV)]
CLAUDE CASTELBOU (Air France, Paris) Navigation (Paris) (ISSN 0028-1530) vol. 41, no. 162 April 1993 p. 177-187. In FRENCH I.F.N., Colloque sur la Navigation de Precision, Ouistreham, France, Oct. 21, 22, 1992
Copyright

Eurocontrol, the agency in charge of the organization and control of air traffic in Europe, has issued on behalf of ECAC a traffic flow improvement plan for 1993 to 2000. The implementation of this plan implies the use of direct routes and reduced separations between aircraft flying in the upper air space. The plan includes two phases. The first one, beginning in 1993, requires a navigation accuracy compatible with the most recent aircraft performance. The second phase, due to begin in 1998, assumes an increment in navigation accuracy demanding new aircraft equipment and improved ground aids. The purpose of this presentation is to

describe different ways of achieving the required accuracy levels in order to make possible the implementation of this program.
Author

A93-43370
THE AIRBORNE COLLISION AVOIDANCE SYSTEM (ACAS) [LE SYSTEME ANTICOLLISION EMBARQUE /ACAS/]
BERNARD MIAILLIER Navigation (Paris) (ISSN 0028-1530) vol. 41, no. 162 April 1993 p. 225-236. In FRENCH refs
Copyright

The concepts, principles of operation, and current status of ACAS are examined. ACAS is not considered part of the ATC surveillance system; it is rather considered to be only an additional safety net. It is pointed out that it is important to fully evaluate its algorithms, to confirm how far it really contributes to improved safety, and to define procedures for dealing with interaction with ATC. That is the purpose of planned experiments before actual implementation. AIAA

A93-43401
A DUAL POLARISED ACTIVE PHASED ARRAY ANTENNA WITH LOW CROSS POLARISATION FOR A POLARIMETRIC AIRBORNE SAR
MAURICE H. PAQUAY, PETER J. KOOMEN, PETER HOOGEBOOM (TNO, Delft, Netherlands), PAUL SNOEIJ (Delft Univ. of Technology, Netherlands), and HENK POUWELS (National Aerospace Lab., Amsterdam, Netherlands) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 114-117. refs
Copyright

The use of a high degree of MMIC integration, the active components of a phased-array radar can be miniaturized; an entire modular system setup is then obtained by also integrating the microstrip patch antenna. Each module is replaceable in case of malfunction. The single patch antenna is dual-polarized through the use of symmetrical feeding. AIAA

A93-43406
AN SSR/IFF ENVIRONMENT MODEL
RALPH PANTELIDES (National Air Traffic Services, London, United Kingdom) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 134-136.
Copyright

The SSR/IFF Environment Model (SIEM) encompasses a suite of programs which may be used to estimate the distribution of interrogations, replies, and interference at 1030 and 1090 MHz. The programs composing SIEM use statistical analysis methods to estimate the levels of mutual interference produced by combinations of the SSR and IFF interrogators. SIEM will in the future be used to investigate the effects of various ways of operating Mode S ground stations, predicting the impact of data link loads on the secondary radar environment. AIAA

A93-43407
MEASUREMENTS OF SSR BEARING ERRORS DUE TO SITE OBSTRUCTIONS
I. D. MACEY (National Air Traffic Services, London, United Kingdom) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 137-142.
Copyright

The 'MURATREC' multiradar track reconstruction analysis method presented which has proven useful in visualizing the effect of nearby obstructions on the angular accuracy of a secondary surveillance radar throughout its 360 deg of operation. The most common such obstructions are communications masts and other radar installations. The aircraft positional errors which these obstructions give rise to are characterized. AIAA

A93-43408
IMPROVEMENTS IN CODE VALIDATION ALGORITHMS FOR SECONDARY SURVEILLANCE RADAR
P. GIUSTINIANI, R. MENNA, and S. GALLONE (Alenia Defence Systems, Rome, Italy) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 143-146.
Copyright

SSR performance depends on the choice of code-validation algorithm. A statistical model is presented which shows that a double-confidence algorithm is in most cases suitable for SSR systems; in the case of more stringent requirements, an adaptive threshold should be used which takes into account the number of high-confidence replies received for each interrogation code. A value for the probability that the single reply has an incorrectly high confidence code is computed on the basis of the total number of received replies. AIAA

A93-43409
A MODE S IMPLEMENTATION - EXPERIMENTS ABOUT DATA-LINK AND INTERCONNECTED MODE S SENSORS
N. MOUSSINE-POUCHKINE and E. POTIER (Thomson-CSF, Paris, France) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 147-150.
Copyright

A development status evaluation is made of aircraft-interrogating Mode S ('selective') secondary surveillance radar data links. Attention is given to overlapped-coverage sensor-network applications. AIAA

A93-43410
AIRPORT SURVEILLANCE RADAR DESIGN FOR INCREASED AIR TRAFFIC
A. K. KAMAL (Mitre Corp., Bedford, MA) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 151-154. Research supported by USAF refs
Copyright

A candidate airport surveillance radar (ASR) design is presented which incorporates advanced technology concepts for phased-array antennas with active elements and data-processing capabilities. The high ASR beam agility thus achieved allows the radar's energy resources to be used much more efficiently; it may therefore be possible to perform multiple sensor functions with a single radar. A cylindrical phased-array antenna is used. Attention is given to weather monitoring and airport clutter scenarios. AIAA

A93-43411
ADAPTIVE CLUTTER SUPPRESSION FOR AIRBORNE ARRAY RADARS USING CLUTTER SUBSPACE APPROXIMATION
J. SU and Y. Q. ZHOU (Beijing Univ. of Aeronautics and Astronautics, China) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 155-158. refs
Copyright

Theoretical analyses and simulations have indicated that the degree-of-freedom of clutter in the output of a Doppler filter is small, and the clutter subspace may be well approximated by the hybrid Doppler-eigenbeams in which a Doppler filter is followed by a spatial eigenbeam. Such eigenbeams can achieve near-optimum clutter suppression at much lower computational cost than that of the optimum processor. Attention is given to anticipated behavior in cases of strong clutter fluctuation, sensor errors, and interference. AIAA

A93-43412
ADAPTIVE ARRAY PROCESSING FOR AIRBORNE RADAR
MICHAEL WICKS, HONG WANG, and LUJING CAI (Syracuse Univ.,

NY) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 159-162. refs
Copyright

The detection performance of an adaptive array radar employing an angle-Doppler Joint Domain Localized-Generalized Likelihood Radio (JDL-GLR) test is compared to that of a Displaced Phase Center Aperture (DPCA) radar. Results are presented for targets in a highly nonhomogeneous clutter and jamming environment, where conventional array processing is not feasible. In such an environment, the adaptive array radar employing the JDL-GLR test outperforms any conventional adaptive array as well as the DPCA canceler based radar. AIAA

A93-43428
NODE-AIR TRAFFIC MANAGEMENT SYSTEMS
PETER R. WEST (Siemens Plessey Systems, Ltd., Christchurch, United Kingdom) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 234-237.
Copyright

The operational requirements and significant technical details of the NODE (NATS Operational Display Equipments) air traffic management systems are examined. Technical innovations in the system architecture, display system, short-term conflict alert, radar recording, and human-computer interface are described. The NODE system benefits from the use of modular design, commercially available hardware, and rapid prototyping software tools. AIAA

A93-43432
THE DEVELOPMENT OF A PROTOTYPE AIRCRAFT HEIGHT MONITORING UNIT UTILISING AN SSR-BASED DIFFERENCE IN TIME OF ARRIVAL TECHNIQUE
D. C. RICKARD, D. J. SHERRY (Roke Manor Research, Ltd., Romsey, United Kingdom), and S. J. TAYLOR (National Air Traffic Services, London, United Kingdom) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 250-253. refs
Copyright

An SSR-based radar technique for monitoring the geometric height of an aircraft is described. This difference in time of arrival (TOA) technique is based on a multistatic receiver geometry in which each receiver measures the relative TOA of selected aircraft reply. Individual measurements are time-synchronized and communicated to a control site for processing and computation of aircraft height. The SSR signal synchronization, system architecture, initial system development, and system demonstration are addressed. AIAA

A93-43440
ANTENNA DESIGN FOR ADAPTIVE AIRBORNE MTI
R. KLEMM (Forschungsgesellschaft fuer Angewandte Naturwissenschaften, Wachtberg-Werthhoven, Germany) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 296-299. refs
Copyright

New results on space-time cluster rejection filters for moving parts are briefly discussed. Suboptimum receiver structures that promise detection of slow targets in real time and at low cost, power consumption, and weight are described. Such characteristics are especially applicable to spaceborne applications and to small unmanned aircraft. AIAA

A93-43444
SPACE-TIME PROCESSING FOR AEW RADAR
A. FARINA and L. TIMMONERI (Alenia S.p.A., Rome, Italy) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 312-315. refs
Copyright

The paper deals with the target detection by means of an airborne early warning (AEW) radar. The focus is on the space-time processing techniques adopted to cancel the interferences. In particular, an algorithm based on the QR decomposition is described together with the corresponding parallel processing architecture which is a triangular systolic array of processing elements. A comparison is made with respect to a more conventional adaptive algorithm (e.g., the one based on the direct inversion of interference covariance matrix), and the optimum algorithm based on the a-priori knowledge of the interference. Simulated as well as recorded live data are considered for processing. Finally, a first appraisal of the processing speed-up, related to the parallel nature of the algorithm and the systolic architecture, has been obtained by means of a benchmark done with a hypercube general purpose computer. Author

A93-43454
THE PHARUS PROJECT, FIRST RESULTS OF THE REALIZATION PHASE
PETER J. KOOMEN (TNO, Delft, Netherlands), PAUL SNOEIJ (Delft Univ. of Technology, Netherlands), PETER HOOGEBOOM (TNO, Delft, Netherlands), and HENK POUWELS (National Aerospace Lab., Amsterdam, Netherlands) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 355-358. refs
Copyright

The Phased Array Universal SAR (PHARUS) project aims for a polarimetric C-band aircraft SAR, that will be finalized in 1994. The system will make use of a phased array antenna with solid state amplifiers. The definition phase of the project builds up basic knowledge of airborne SAR systems develops the critical technology that will be used in the final system. The subsequent realization phase will profit from this experience and lead to a straightforward development of a polarimetric SAR system for PHARUS. In the definition phase, a study was conducted on antenna technology and calibration for an active phased array antenna, while another gave attention to motion compensation and the actual realization of a SAR testbed. An overview is given of the results of the definition phase, including the results obtained from the first test flights of the SAR testbed. Author (revised)

A93-43455
GRAZING ANGLE DEPENDENCY OF SAR IMAGERY
C. J. BAKER, A. M. HORNE, and R. G. WHITE (Defence Research Agency, Malvern, United Kingdom) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 359-362. refs
Copyright

The effects of grazing angle variations on SAR imagery and on the ability to detect automatically changes between SAR images are investigated. Measurements demonstrate that, although there are obvious differences between the different grazing angles, the effect of these are such that the performance of the change detection technique is not degraded to a point that renders it ineffective. The performance is still very commendable, making change detection an extremely valuable aid to interpreting SAR imagery. AIAA

A93-43464
REAL TIME PRF CONTROL SYSTEM FOR SAR
JOAO R. MOREIRA (DLR, Cologne, Germany) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 395-398. refs
Copyright

A real time solution is presented to link the pulse repetition frequency (PRF) of an SAR to the aircraft forward velocity without using an INS. This allows the SAR system to operate with a constant spatial PRF. The aircraft forward velocity is extracted

using the reflectivity displacement method (RDM), which extracts the motions of the aircraft from the radar backscatter signal by evaluating its azimuth spectra. The control system used to couple the RDM with the variable PDF unit is a nonlinear and adaptive one and is based on an ideal on-off relay. AIAA

A93-43466
MOTION COMPENSATION IN A TIME DOMAIN SAR PROCESSOR
MATERN P. G. OTTEN (TNO, Delft, Netherlands) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 403-406. refs
Copyright

An SAR processing scheme has been developed that is particularly suitable for a short-range SAR which is subject to large motion errors. The variable centroid processing technique and radiometric correction involved in the scheme are described. The approach was qualitatively validated using simulations and the results are reported. AIAA

A93-43475
RADAR SIGNALS ANALYSIS ORIENTED TO TARGET CHARACTERIZATION APPLIED TO CIVILIAN ATC RADAR
P. F. PELLEGRINI, S. CUOMO (Firenze, Univ., Florence, Italy), and S. PARDINI (Alenia S.p.A., Rome, Italy) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 438-445. refs
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A radar signals analysis is presented that correlates radar echo signals with characteristics typical of aircraft and their positions. Emphasis is given to typical limitative aspects of ATC systems, in particular the intrinsic undersampling due to low sweep frequency. The strategies developed to overcome these problems are discussed. Statistical results are given for particular types of aircraft in various geometric and dynamic conditions. AIAA

A93-43476
ANALYSIS OF THE EFFECTS OF BLADE PITCH ON THE RADAR RETURN SIGNAL FROM ROTATING AIRCRAFT BLADES
J. MARTIN (GEC Ferranti Defence Systems, Ltd., United Kingdom) and B. MULGREW (Edinburgh Univ., United Kingdom) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 446-449. Research supported by SERC and Ferranti Defence Systems, Ltd refs
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An analysis is presented of the effects of blade pitch on the return signal from rotating aircraft blades. It is shown that any blade pitch tends to cause a periodic variation of the return signal which causes amplitude modulation (AM) of the signal. This may affect the magnitudes of the blade flashes and the upper or lower sidebands depending on whether Theta, the angle between the plane of rotation and the line of sight from the radar to the center of rotation, is positive or negative. It is also shown that if there is any AM of the return signal due to blade pitch, this may affect the performance of any feature extract or aircraft classification algorithm. AIAA

A93-43550
INCREASING AIRPORT SAFETY AND CAPACITY USING AUTOMATED MANEUVERING AREA CONTROL [EIN BEITRAG ZUR ERHOEHUNG DER SICHERHEIT UND KAPAZITAET AUF FLUGPLAETZEN DURCH AUTOMATISIERTE ROLLFELDFUEHRUNG]
K. MOEHLENKAMP Ortung und Navigation (ISSN 0474-7550) no. 1 1993 p. 76-84. In GERMAN
Copyright

A solution to the problem of airport congestion is described that uses automated maneuvering area control for aircraft and ground vehicles. Three versions of the concept, which uses a combination of satellite navigation receivers and inertial sensors, are described. An experimental test of the approach is briefly reported. AIAA

A93-43784* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TECHNOLOGIES FOR AUTOMATING ROTORCRAFT NAP-OF-THE-EARTH FLIGHT
VICTOR H. L. CHENG and BANAVAR SRIDHAR (NASA, Ames Research Center, Moffett Field, CA) American Helicopter Society, Journal (ISSN 0002-8711) vol. 38, no. 2 April 1993 p. 78-87. AHS, Annual Forum, 48th, Washington, June 3-5, 1992, Proceedings. Vol. 2, p. 1539-1554. Previously cited in issue 14, p. 2469, Accession no. A93-36013 refs
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N93-29468# Trimble Navigation, Sunnyvale, CA.
SYSTEM ANALYSIS FOR A KINEMATIC POSITIONING SYSTEM BASED ON THE GLOBAL POSITIONING SYSTEM Final Report
G. J. GEIER, PETER V. LOOMIS, and ALFRED KLEUSBERG Dec. 1992 136 p
(Contract DACW72-89-C-0025)
(AD-A262830; TEC-DRP-92-8) Avail: CASI HC A07/MF A02

This report documents the findings of a study to design a kinematic positioning system to support U.S. Army Corps of Engineers dredging and hydrographic survey operations. Survey quality GPS receivers are considered, due to the accuracy constraints (10 cm vertical positioning). Use of auxiliary sensors (i.e., INS and high quality clocks) is considered to improve navigation performance when GPS is unavailable. Predicted navigation performance indicates that the accuracy requirements can be met, except at the extremes of the expected separation distances from the reference station. The integer ambiguities associated with the carrier phase measurements can generally be resolved within 7 minutes by processing all available satellites. Measurement gaps of roughly 60 seconds can be tolerated without losing the integers when using a high quality INS. DTIC

N93-29588*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE EFFECT OF CLOCK, MEDIA, AND STATION LOCATION ERRORS ON DOPPLER MEASUREMENT ACCURACY
J. K. MILLER *In its* The Telecommunications and Data Acquisition Report p 7-21 15 May 1993
(Contract RTOP 310-10-63-84-02)
Avail: CASI HC A03/MF A03

Doppler tracking by the Deep Space Network (DSN) is the primary radio metric data type used by navigation to determine the orbit of a spacecraft. The accuracy normally attributed to orbits determined exclusively with Doppler data is about 0.5 microradians in geocentric angle. Recently, the Doppler measurement system has evolved to a high degree of precision primarily because of tracking at X-band frequencies (7.2 to 8.5 GHz). However, the orbit determination system has not been able to fully utilize this improved measurement accuracy because of calibration errors associated with transmission media, the location of tracking stations on the Earth's surface, the orientation of the Earth as an observing platform, and timekeeping. With the introduction of Global Positioning System (GPS) data, it may be possible to remove a significant error associated with the troposphere. In this article, the effect of various calibration errors associated with transmission media, Earth platform parameters, and clocks are examined. With the introduction of GPS calibrations, it is predicted that a Doppler tracking accuracy of 0.05 microradians is achievable.
Author (revised)

N93-29653*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NEURAL NETWORKS APPLICATION TO DIVERGENCE-BASED PASSIVE RANGING
YAIR BARNIV Dec. 1992 26 p

(Contract RTOP 505-64-52)
(NASA-TM-103981; A-92198; NAS 1.15:103981) Avail: CASI HC A03/MF A01

The purpose of this report is to summarize the state of knowledge and outline the planned work in divergence-based/neural networks approach to the problem of passive ranging derived from optical flow. Work in this and closely related areas is reviewed in order to provide the necessary background for further developments. New ideas about devising a monocular passive-ranging system are then introduced. It is shown that image-plan divergence is independent of image-plan location with respect to the focus of expansion and of camera maneuvers because it directly measures the object's expansion which, in turn, is related to the time-to-collision. Thus, a divergence-based method has the potential of providing a reliable range complementing other monocular passive-ranging methods which encounter difficulties in image areas close to the focus of expansion. Image-plan divergence can be thought of as some spatial/temporal pattern. A neural network realization was chosen for this task because neural networks have generally performed well in various other pattern recognition applications. The main goal of this work is to teach a neural network to derive the divergence from the imagery.
Author (revised)

N93-30299 McMaster Univ., Hamilton (Ontario). Communications Research Lab.
CLASSIFICATION OF RADAR CLUTTER IN AN AIR TRAFFIC CONTROL ENVIRONMENT
SIMON HAYKIN, WOLFGANG STEHWIEN (Litton Systems, Canada Ltd., Etobicoke, Ontario.), CONG DENG, PETER WEBER, and RICHARD MANN *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 3 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

Highlights are presented from an experimental study aimed at the classification of radar clutter as experienced in an air traffic control environment. The results are based on recorded radar data obtained from two operational radar sites. The Burg algorithm for computing reflection coefficients is the basic mathematical tool used for extraction of radar features based on second-order statistics. Two methods for the classification are described: a parametric Bayes procedure and a neural network approach based on the backpropagation algorithm. The classification accuracies of the two methods were found to be about 82% and 90% respectively. The reasons for the superiority of the latter are discussed.
Author (CISTI)

N93-30323 Hughes Aircraft Co., Goleta, CA. Systems Div.
THE CANADIAN AUTOMATED AIR TRAFFIC SYSTEM
DON E. LUDWIG *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 4 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

The Canadian Automated Air Traffic System (CAATS) provides a model for future air traffic systems operating in the year 2000 and beyond. The design has configuration flexibility and extensibility provisions which will enable the system currently being implemented to adapt to the requirements of the 2000s. Key elements of this design are described. These are: an architecture which uses an open system interconnect for inter- and intra-system interfacing of distributed data processing and display elements; use of commercial off-the-shelf components and software with provision for substitution of evolving technology; use of Ada software and a partitioning which will facilitate maintenance and adaptation to future operational needs; introduction of a computer human interface design and state of the art workstations which facilitate efficient controller interaction and have flexibility for adaptation to a changing environment; and incorporation of automated on-line maintenance reporting and system configuration control from a centralized position.
Author (CISTI)

N93-30324 Sony Corp. of America, San Diego, CA.
COMPUTER-CONTROLLED ALIGNMENT FOR A 2000-LINE COLOR MONITOR
DAVID A. ECCLES, MANABU SUZUKI (Sony Corp., Tokyo, Japan.), HIROSHI NAKANO (Sony Corp., Tokyo, Japan.), YUKI OKAMOTO (Sony Corp., Tokyo, Japan.), and KAZUO KII (Sony Corp., Tokyo, Japan.) *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 4 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

Field alignment of a new 2048 line, 20-by-20 inch color monitor used for air traffic control is made easier by means of a new remote digital alignment system. The system includes a video processor, a digital processor for alignment data, and deflection and correction circuits. A personal computer running the alignment software is used to perform adjustments on the production line. A remote controller similar to that used with a television is provided to support field maintenance. The alignment system allows menu-driven convergence, color purity, focus, and distortion adjustment via a digital interface. Automatic setup functions for white balance and color purity have also been developed. Touchup alignment by unskilled customers can be done in about 15 minutes.
Author (CISTI)

N93-30325 Centre d'Etudes de la Navigation Aerienne, Toulouse (France).
EVOLUTION OF RADAR DATA PROCESSING IN THE FRENCH AIR TRAFFIC CONTROL SYSTEM
D. FIGAROL and B. KRINER *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 4 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

A research study called HADAMARD is described which is aimed at providing a new multiradar multiplot tracking system for air traffic control in France. The system is based on state of the art and advanced tracking technology to take full advantage of monopulse radar coverage that will be implemented at the present time. This system will help to reduce minimal radar separations between aircraft without a loss in safety. After an overview of the more general context of radar data processing evolution in France, functional characteristics of HADAMARD are described in the areas of system design, input management, track initiation, data association, track update and maneuver detection, and estimation of radar bias. The HADAMARD prototype has been developed in Ada software, and its evaluation phase was completed in the summer of 1990. HADAMARD is on its way to integration into the CAUTRA 4.1 software which will be rehosted on new Data General MV computers.
Author (CISTI)

N93-30330 Canadian Marconi Co. Ltd., Kanata (Ontario).
EMBEDDED GPS: THE CANADIAN MARCONI APPROACH
JAMES M. BROWN and R. K. TIEDEMANN *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 4 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

A new, embeddable global positioning system (GPS) card set uses the same software algorithms and very similar hardware architecture as the Canadian Marconi CMA-786 GPS navigation receiver. Three circuit cards totalling 50 square inches and typically consuming only 7.5 watts implement a complete 2-channel GPS sensor suitable for embedding in other avionics navigation equipment, land vehicle navigation equipment, or time transfer devices. A high speed 8-bit parallel interface and an RS-232 interface are provided to facilitate this integration. A separate power supply, mechanical housing and integrated microstrip antenna / preamplifier are required. Satellite acquisition and tracking algorithms, Kalman filter and navigation software, and hardware implementation are described.
Author (CISTI)

N93-30338 Transport Canada, Ottawa (Ontario).
ADAPTING SYSTEM ENGINEERING PRINCIPLES TO THE CANADIAN AIRSPACE SYSTEM
T. E. THOMPSON and R. G. LEWIS (Martin Marietta Canada Ltd., Ottawa, Ontario.) *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 4 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

Adaptations have been made to published textbook methodologies for system engineering to allow practical application to the Canadian Airspace System (CAS) redesign. The CAS is the collection of equipment and facilities which, together with skilled personel, processes, and procedures, makes up the Canadian air navigation and traffic control system. The CAS design process must put into place a complete design for the year 2000 CAS as well as a process for making controlled design changes in the future. The application of systems engineering principles in this design process is absolutely necessary to avoid expensive duplication or incompatibilities. The following six steps that are being used in the CAS redesign are described: preparing operational requirements for the systems; developing the operational and support concepts for the system; specifying system requirements; specifying system design at four different levels; developing a transition plan; and developing an integration strategy to control and manage system implementation. Support tools used in the redesign are briefly discussed, including computer aided design tools and an engineering data base. Author (CISTI)

N93-30339 MacDonald, Dettwiler and Associates Ltd., Ottawa (Ontario).
APPLICATION AND INTEGRATION OF DIVERSE TECHNOLOGY IN AN AVIATION SYSTEM: THE NATIONAL AERONAUTICAL INFORMATION PROCESSING SYSTEM
KARL SNIDER and TIM DANIEL *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 4 p 1990 Prepared in cooperation with MacDonald, Dettwiler Proprietary Ltd., New South Wales, Australia
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

The National Aeronautical Information Processing System is under development for the Australian civil aviation authorities. It will be an advanced automated aeronautical information service for providing flight briefing and flight plan filing in a flexible manner. The system development involves the combination and integration of diverse technologies including voice synthesis, aircraft flight calculations, image processing, facsimile data transmission, optical scanner inputs, geographical information systems, airspace and aircraft databases, fault tolerant computer hardware and software, telephone call distribution, geographic projections developed for satellite image correction systems, and special algorithms which permit pilots to plan flights along geographic features. The system architecture is described along with typical usage scenarios and human-machine interface design. Author (CISTI)

N93-30350 CompEngServ Ltd., Ottawa (Ontario).
ISSUES OF ATC CONFLICT RESOLUTION UNDER REAL-TIME CONSTRAINTS
I. G. SMITH and C. A. CRABB *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 4 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

The CORES 2 (COnflict REsolution System) project has the goal to produce a developmental system that provides conflict detection, prediction, and resolution advice to air traffic controllers in an enroute radar controlled airspace. Unlike several other developmental efforts, the project attempts to address many of the real-time and other temporal issues involved in this area. Some of the issues which are currently under investigation as part of the implementation of the system are described. These issues include prediction mechanisms, priorities for resolving concurrent conflicts, time allowed for presentation of solutions, validity intervals of solutions, interactions between conflicts and solutions, and presentation of conflicts and solutions. An object oriented rule-based system was chosen as a suitable development environment for the CORES system, which also includes an air traffic simulator. Author (CISTI)

N93-30351 Mitre Corp., McLean, VA.
NATIONAL AIRSPACE SYSTEM PERFORMANCE ANALYSIS CAPABILITY (NASPAC) SIMULATION MODEL
LYNNE FELLMAN *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 4 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

The National Airspace System Performance Analysis Capability (NASPAC) simulation model was developed to assist in analyzing the performance of the US National Airspace System and to estimate the effects of proposed changes in the system. An early version of the model was used to identify entities such as airports and airspace that limit system performance and to evaluate the impacts of changes to some of these entities. Subsequently, the NASPAC simulation model was enhanced and has been used to analyze the impact of planned and proposed improvements to major airports, potential changes to airspace structures, anticipated future growth in air traffic demand, and changes in airline scheduling practices. Principal inputs to the model include air traffic demand, airport and airspace network structures and capacities, and flight or aircraft characteristics. Principal outputs include operations per hour, instantaneous aircraft counts, and aircraft delays. Three recent applications of the NASPAC model are described: analysis of national impacts of the Dallas-Fort Worth Metroplex plan; analysis of impacts of a new air carrier hub at Philadelphia; and a national airspace saturation analysis. Author (CISTI)

N93-30352 Mitre Corp., McLean, VA.
PROCEDURAL DEVELOPMENT PROTOTYPE IN AUTOMATED EN ROUTE AIR TRAFFIC CONTROL
C. VANESSA FONG *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 3 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

A key element in the US Federal Aviation Administration's plan to modernize the air traffic control system is the Advanced Automation System which incorporates the collection of automation capabilities known as Automated En Route Air Traffic Control (AERA). AERA has three components: AERA 1, with the capabilities of aircraft trajectory estimation, automated problem detection, and trial planning; AERA 2, summarized below; and AERA 3, currently in the concept development phase. In order to support the evaluation of AERA 2 capabilities, a procedural development prototype is being developed for use in defining, evaluating, and revising air traffic control operational and training materials for AERA 2. The prototype is implemented on a VAX 8700/VMS system in PL/1. The AERA 2 traffic simulation and other capabilities are displayed on color monitors with graphics controllers. Capabilities of the prototype include automated problem resolution, computer human interfacing, automated controller aids, air traffic control scenario generation, data collection, and other graphics image capture and replay tools. The overall characteristics of this prototype are discussed. Author (CISTI)

N93-30353 Mitre Corp., McLean, VA.
ENHANCING AVAILABILITY, PERFORMANCE, AND FLEXIBILITY OF AIR TRAFFIC CONTROL AIR-GROUND SERVICES
GIAN P. JAIN, DOUGLAS L. BAMFORD, and LEONE C. MONTICONE *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 5 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

The air-ground (A/G) communications service for the air traffic control (ATC) community must be designed to provide end-to-end communications that meets high availability and performance requirements. These service requirements, such as voice quality, can be satisfied by the proper selection of network elements and design of the A/G network. The terrestrial portion of the A/G voice service is discussed along with the radio frequency link portion of this service. The evolution of the A/G network operations from a manual to an automated process for restoration and management is demonstrated, such evolution leading to new configurations with the potential for better availability, performance, and flexibility in an ATC environment. In addition, preliminary work is presented on a procedure that can be used to take into account the dependencies that may occur between failures (such as dependencies between circuit failures in the terrestrial environment) in any availability analysis. Author (CISTI)

N93-30354 Mitre Corp., McLean, VA.
CHANGING ROLE OF TELECOMMUNICATIONS MANAGEMENT IN AIR TRAFFIC CONTROL IN THE FAA
KIKRAM PRABHU *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 4 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

The mission of the US Federal Aviation Administration (FAA) is air traffic control (ATC). As the ATC function has evolved over the years from being primarily manual to one supported by many interconnected automated systems, the associated telecommunications requirements have become more specialized. Consequently, the FAA telecommunications network has changed over time and consists of a number of subnetworks and subsystems, some of which are interconnected in a complex manner. More subsystems are planned and will be added over the next few years. Since there is a combination of FAA-owned and leased subsystems, management of the overall network and its evolution is becoming very important. The rapidly changing telecommunications market environment in the USA has increased available equipment and service offerings; it has also made it necessary to deal with multiple carriers and vendors. The telecommunications management infrastructure for Operations, Administration, and Maintenance (OA&M) in the FAA is described along with the undergoing changes in its role. As the overall network is becoming very complex, the telecommunications management structure has to emphasize the end-to-end service perspective rather than that of individual subsystems to ensure responsiveness to ATC users. Author (CISTI)

N93-30356 Mitre Corp., McLean, VA.
DEVELOPING AUTOMATION FOR TERMINAL AIR TRAFFIC CONTROL: CASE STUDY OF THE IMAGING AID
ANAND D. MUNDRA and KERRY M. LEVIN *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 4 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

A passive automation aid called the imaging aid or ghosting aid has recently been developed for the US Federal Aviation Administration to help air traffic controllers stagger aircraft to converging runways in instrument flight rule conditions. This aid has been prototyped in a real-time simulation facility with the help of full performance level controllers, has been approved for operational evaluation at Lambert St. Louis International Airport during 1990, and is expected to be deployed nationally in the USA starting in 1992. The prototyping process used in the development of the imaging aid is described as a case study in developing air traffic control (ATC) automation. In this process, the imaging aid was designed to solve the difficulty of precise staggering on a sustained basis by converting the converging approaches geometry to simulate a single runway approach geometry. A methodology is proposed for the development of automation for terminal ATC based on the lessons learned from this prototype. Author (CISTI)

N93-30357 Transport Canada, Ottawa (Ontario).
AIRSPACE DESIGN EXPERT SYSTEM (ADES), A 2D/3D MAPPING AND MODELLING TOOL INCORPORATING AN EXPERT SYSTEM FOR USE IN INSTRUMENT APPROACH DESIGN
J. C. AINSWORTH, L. LAM (Virtual Prototypes, Inc., Montreal, Quebec.), B. SCHOOR (Virtual Prototypes, Inc., Montreal, Quebec.), and M. MCQUEEN (Virtual Prototypes, Inc., Montreal, Quebec.) *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 4 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

ADES (Airspace Design Expert System) provides Transport Canada with a two and three dimensional graphic environment for the design of flight procedures. ADES brings together data for the air navigation facilities and obstacles, criteria for the flight procedure design, and information of the physical world to provide an integrated computer environment that replaces the existing manual environment. A carefully designed graphical user interface provides a uniform and simple medium with which the design specialist can communicate. The expert knowledge used in ADES can be modified to adapt the system to different requirements in the present or future. A flexible data management strategy is also used to provide a centralized information data base that can be easily maintained and expanded. There are three distinct parts to the ADES system: the Interactive Design Environment, with software modules for flight procedure design, utilities, data, and graphics; the Design Support Environment, consisting of the Nexpert Object Expert system tools, the INFORMIX Relational Database Management System, and a graphics environment provided by the workstation and proprietary graphics tools; and the external knowledge bases and data bases. A computer aided learning component is also provided to train users and to serve as a refresher for infrequent users. Author (CISTI)

N93-30358 MiTech, Inc., Washington, DC.
EVALUATION OF CATEGORY 3 MLS DESIGNS
RICK CASSELL, KELLY R. MARKIN (Mitre Corp., McLean, VA.), and ALEX E. SMITH *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 4 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

A key aspect of the implementation of microwave landing systems (MLS) is their compliance with US Federal Aviation Administration and International Civil Aviation Organization requirements for Category 3 landing operations, the lowest visibility operation. Since the landing system is used in such operations as the sole means of guidance, safety is the primary consideration. The safety of the landing system is related to two different items, continuity of service (COS) and integrity. The COS quantifies the probability of maintaining guidance throughout the critical phase of the landing operation. Integrity quantifies the probability of not transmitting potentially hazardous guidance to the aircraft. Three MLS ground equipment design architectures are evaluated for compliance with Category 3 COS and integrity requirements. These designs include a basic design consisting of redundant transmitters and monitors; a second design, the same as the first but with periodic switchover between two transmitters and executive monitors; and a third design, the same as the first except for the addition of a redundant shutdown capability. In addition, tradeoffs between the designs and several alternatives are analyzed. It is shown that relatively small changes in design architecture and implementation can result in large differences in the calculated integrity and COS. Author (CISTI)

N93-30605 Stanford Univ., CA.
ATTITUDE DETERMINATION USING GPS: DEVELOPMENT OF AN ALL SOLID-STATE GUIDANCE, NAVIGATION, AND CONTROL SENSOR FOR AIR AND SPACE VEHICLES BASED ON THE GLOBAL POSITIONING SYSTEM Ph.D. Thesis
CLARK EMERSON COHEN 1993 203 p
Avail: Univ. Microfilms Order No. DA9309582

The Global Positioning System (GPS) is poised to revolutionize aerospace Guidance, Navigation, and Control. While traditionally thought of as a navigation system, GPS is demonstrated to be a formidable sensor for attitude determination as well. In fact, GPS may now be considered a 10 state sensor, providing continuous real-time Position, Velocity, Time, and Attitude (PVTA) for all axes. Attitude determination is derived from precise (5mm, 1sigma) differential range measurements among multiple GPS antennas mounted on a flight vehicle. Experimental testing on 3m baselines is demonstrated pointing accuracies below 0.1 deg (1sigma) with a usable bandwidth of several tens of Hz. The design and development of a new and unique GPS receiver with full PVTA capability is described. It chronicles the key innovations which made this technology possible and addresses the fundamentals and performance of GPS-based attitude determination. A prototype receiver base on antenna multiplexing is presented which offers prospects of significantly reducing the size, weight, power, and cost of the hardware. Other conceptual designs are presented for achieving the highest possible performance. Methods of resolving the cycle ambiguities of the GPS carrier based on motion are developed and tested in an effort to derive the robustness of attitude determination toward perfection. Maiden space flights of the new receiver are scheduled for launch into low Earth orbit. Test data is presented from extensive flights on a single-engine Piper Dakota to explore aircraft applications of attitude determination. Among these, attitude and precise position sensing using GPS can be applied to the estimation of the aircraft dynamic model in flight. The wealth of dynamic response data obtained through GPS can be used to estimate aircraft stability derivatives and, surprisingly, aeroelastic effects with millimeter-level clarity. This new capability is likely to enhance the overall safety and efficiency of aviation. Dissert. Abstr.

N93-30671# Technische Univ., Berlin (Germany). Fachgebiet Ortung und Navigation.
DESIGN AND IMPLEMENTATION OF A GLOBAL POSITIONING SYSTEM (GPS) SUPPORTED AREA NAVIGATION SYSTEM WITH ELECTRONIC AIRCRAFT [ENTWURF UND IMPLEMENTIERUNG EINES GPS-GESTUETZTEN FLAECHENNAVIGATIONSSYSTEMS MIT ELEKTRONISCHER LUFTFAHRTKARTE]
DETLEF STOLZE 14 Sep. 1992 192 p In GERMAN (ILR-MITT-275(1992); ETN-93-94175) Avail: CASI HC A09/MF A02

The development of an area navigation system with GPS (Global Positioning System) based position acquisition is described, with focus on low cost concepts and real time operation. A modular software solution was chosen which can be used on computers with Intel processors. An electronic aircharт with a moving map display was selected as man machine interface. A course line computer was used for trajectory points management and for calculation of characteristic magnitudes of area navigation. A modified horizontal situation indicator was used for result representation. ESA

N93-31005 Princeton Univ., NJ.
AIRCRAFT GUIDANCE FOR WIND SHEAR AVOIDANCE: DECISION-MAKING UNDER UNCERTAINTY Ph.D. Thesis
DONALD ALEXANDER STRATTON 1992 220 p
Avail: Univ. Microfilms Order No. DA9306544

Severe low-altitude wind shear poses a significant threat to air transportation safety. Concepts for assisting critical decision making under uncertainty are advanced to promote the avoidance of hazardous weather, particularly microburst wind shear. Computational strategies founded on probability and optimal estimation theories enable flight deck integration of diverse forecasting and detection systems, from airport weather information services to airborne forward-looking wind sensors. A decision-making policy for wind shear is developed from a comprehensive investigation of microburst phenomenology, its observed characteristics, and its effects on aircraft flight. Existing avoidance guidelines for wind shear are extended to exploit the latest available technology, such as Doppler weather radar and lidar. Theories for probability based decision making facilitate real-time computer reasoning with dynamic, conflicting data from a wide array of sources. Bayesian neural networks fused with multivariable estimators account for the limited precision, reliability, and timeliness of correlated sensor measurements. Monte Carlo analyses are conducted to refine a disturbance prediction Kalman filter for forward-looking sensors, with statistical results completing their incorporation into Bayesian reasoning. Symbolic and numerical processes for a Wind Shear Safety Advisor are implemented and evaluated. A risk assessment model based on empirical and analytical results is used to compare the relevance of available wind shear information sources. Simulations of the risk assessment model show its insensitivity to parameter variations. Validations of overall Wind Shear Safety Advisor logic illustrate how it conveys beneficial advance warnings in rapidly developing microburst encounter situations. These results prove that intelligently-integrated detection systems can warn pilots of threatening wind shear sooner, more frequently, and more effectively than isolated systems can. Dissert. Abstr.

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A93-40438
V-22 NACELLE CONVERSION ACTUATOR
G. WHITE (Lucas Western, Inc., City of Industry, CA) Institution of Mechanical Engineers, Proceedings, Part G - Journal of Aerospace Engineering (ISSN 0954-4100) vol. 207, no. G1 1993 p. 61-72.
Copyright

A design outline is given of the actuator that rotates the engine and rotor nacelles on the V-22 aircraft. The actuator comprises a two-stage telescopic ballscrew that is driven either hydraulically from one end or electrically from the other. Requirements for structural redundancy, least weight, operation after any single failure and performance at low temperatures are shown to influence the choice of actuator configuration and the design of assemblies. Author

A93-40473
OPTIMISATION OF CONSTANT ALTITUDE-CONSTANT AIRSPEED FLIGHT FOR PISTON-PROP AIRCRAFT
S. K. OJHA (Indian Inst. of Technology, Bombay, India) Aeronautical Journal (ISSN 0001-9240) vol. 97, no. 964 April 1993 p. 145-148. refs
Copyright

An analytical method is developed to obtain the optimum range and associated flight parameters for a piston-prop aircraft. The airspeed, lift coefficient, aerodynamic efficiency, power required, range, and endurance to achieve optimum range are obtained. AIAA

A93-40493
PARAMETER SELECTION OF ELECTRO-IMPULSE DE-ICING SYSTEMS
XIEGANG QIU and XIANMIN GUO (Nanjing Aeronautical Inst., China) Nanjing Aeronautical Institute, Journal (ISSN 1000-1956) vol. 25, no. 2 April 1993 p. 211-218. In CHINESE refs

The basic principle of the electro-impulse de-icing system is described. The effects of electric parameters, coil geometrical parameters, and skin material on the de-icing performance are analyzed. According to theoretical analysis and laboratory data, icing tunnel and flight tests, a selected parameter area for effective de-icing is recommended. The measure to improve performance is also presented. Author (revised)

A93-41038
TOWARD THE SECOND-GENERATION SUPERSONIC TRANSPORT [VERS L'AVION DE TRANSPORT SUPERSONIQUE FUTUR]
J.-P. MAREC, PHILIPPE POISSON-QUINTON (ONERA, Chatillon, France), CLAUDE LENSEIGNE (Aerospatiale, Paris, France), ISABELLE DUBOIS (SNECMA, Paris, France), CHRISTIANE MICHAUT, JEAN-JACQUES THIBERT, and FRANCIS HIRSINGER (ONERA, Chatillon, France) ONERA, TP no. 1993-26 1993 37 p. In FRENCH ONERA, Colloque, Chatillon, France, Apr. 16, 1992 refs
(ONERA, TP NO. 1993-26) Copyright
Papers given at the 1992 ONERA colloquium on the second-generation supersonic transport are presented. Attention is given to the role of ONERA in the Concorde program, the choice of configuration for the Alliance project, the turbojet for the second-generation supersonic transport, supersonic-transport research underway at ONERA, the aerodynamics of the supersonic transport, and ONERA studies on the modeling of pollutant emissions. AIAA

A93-41361
RECONNAISSANCE CAPABLE F/A-18D OPTICAL AND INFRARED WINDOW ANTIFOG SYSTEMS
RANDAL C. KNOBLAUCH and LASZLO I. BUDA (McDonnell Aircraft Co., Saint Louis, MO) Jul. 1992 14 p. SAE, International Conference on Environmental Systems, 22nd, Seattle, WA, July 13-16, 1992 Research supported by U.S. Navy refs
(SAE PAPER 921182) Copyright
Aircraft modifications have been developed to make F/A-18D Hornets capable of being converted to a reconnaissance configuration which includes both optical and infrared sensors. A major design challenge was to prevent fog formation on the two exterior moldline windows used for viewing by these sensors. Antifogging was required during a rapid 7620 m/min (25,000 ft/min) descent into humid atmospheric conditions following a sustained cold soak at altitude. This paper describes the design development and laboratory verification testing of the two unique antifog systems selected to meet this requirement. Author

A93-41399
TESTING OF AN ENERGY EFFICIENT ENVIRONMENTAL CONTROL SYSTEM FOR A PATROL-TYPE AIRCRAFT
TIMOTHY A. SPRINGER, JAMES E. MCNAMARA (U.S. Navy, Naval Air Warfare Center, Warminster, PA), JOHN C. LENTZ, and DAVID B. WIGMORE (Sundstrand Power Systems, San Diego, CA) Jul. 1992 11 p. SAE, International Conference on Environmental Systems, 22nd, Seattle, WA, July 13-16, 1992 refs
(SAE PAPER 921225) Copyright
A P-3C patrol-type aircraft Energy-Efficient Environmental Control System (EEECS) has been developed, and found upon testing to yield not only significant fuel savings, but also enhancements of avionics reliability through reductions in the electronics-cooling air temperatures. The EEECS is a vapor-cycle system that uses an electrically driven, variable-speed centrifugal compressor operating at 30,000 to 70,000 rpm. Energy savings are achieved by continuously monitoring aircraft cooling requirements at the evaporator heat exchanger. AIAA

A93-41778* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LAMINAR FLOW FLIGHT EXPERIMENTS - A REVIEW
R. D. WAGNER, D. V. MADDALON, D. W. BARTLETT, F. S. COLLIER, JR. (NASA, Langley Research Center, Hampton, VA), and A. L. BRASLOW (Analytical Services and Materials, Inc., Hampton, VA) *In* Natural laminar flow and laminar flow control New York Springer-Verlag 1992 p. 23-71. refs
Copyright
A development history is presented for flight tests of flow-laminarizing technologies, from the wooden-structure wing glove used with the B-18 of about 1940 to the X-21 of 1963-1965 and the wing incidence-varying tests conducted with gloved-wing F-111 and F-14 variable-sweep aircraft in more recent years. Natural laminar flight control testing has also been conducted with a B 757 airliner. Over the years, increasing attention has been given to the treatment of the leading edge of laminar flow wings in order to prevent flow instabilities that precipitate flow transition to turbulence farther aft. AIAA

A93-41779* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FLIGHT RESEARCH ON NATURAL LAMINAR FLOW APPLICATIONS
BRUCE J. HOLMES (NASA, Langley Research Center, Hampton, VA) and CLIFFORD J. OBARA (Lockheed Engineering and Sciences Co., Hampton, VA) *In* Natural laminar flow and laminar flow control New York Springer-Verlag 1992 p. 73-142. refs
Copyright
Natural laminar flow (NLF) is clearly one of the most potentially attractive drag reduction technologies by virtue of its relative simplicity. NLF is achieved passively, that is, by design of surface shapes to produce favorable pressure gradients. However, it is not without its challenges and limitations. This chapter describes the significant challenges to achieving and maintaining NLF and documents certain of the limitations for practical applications. A brief review of the history and of more recent NLF flight experiments is given, followed by a summary of lessons learned which are pertinent to future applications. The chapter also summarizes important progress in test techniques, particularly in flow visualization and hot-film techniques for boundary-layer measurements in flight. Author

A93-41903
PERIODIC MAXIMUM RANGE CRUISE WITH SINGULAR CONTROL
GOTTFRIED SACHS and KLAUS LESCH (Muenchen, Technische Univ., Munich, Germany) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 4 July-Aug. 1993 p. 790-793. refs
Copyright
It has been shown recently that the classical aircraft cruise consisting of a steady-state flight at constant speed or altitude with a rectilinear flight path is not generally optimal and that optimal aircraft cruises exist that show a periodic behavior. This paper shows that singular arcs exist in optimal periodic cruise problems for minimizing fuel consumption per range, with a hypothetical propeller-driven aircraft used as an example. The mathematics and the flight-mechanics aspects concerning the existence of singular arcs are considered. AIAA

A93-41904
PERFORMANCE OF HIGHER HARMONIC CONTROL ALGORITHMS FOR HELICOPTER VIBRATION REDUCTION
STEVEN R. HALL and NORMAN M. WERELEY (MIT, Cambridge, MA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 4 July-Aug. 1993 p. 793-797. Research supported by Boeing Helicopters refs
Copyright
A framework is proposed for the performance evaluation in terms of classical control theory of the higher harmonic control (HHC) algorithms for helicopter vibration reduction. It is shown that HHC is fundamentally similar to the sinusoidal disturbance rejection techniques of classical control and that the performance of different HHC algorithms can be compared quantitatively by treating the periodic disturbance as a stochastic rather than a deterministic phenomenon. This framework makes it possible to make direct comparison of the discrete-time algorithms of Shaw and others to continuous-time algorithms such as those of Gupta and Du Val. Moreover, this framework allows the investigation of the effects of model uncertainty due to parameter uncertainty and changing flight conditions. AIAA

A93-42369
CURRENT METHODS OF SELECTING THE CONFIGURATIONS AND PARAMETERS OF FLIGHT VEHICLES [SOVREMENNYE METODY VYBORA SKHEM I PARAMETROV LA]
A. M. MATVEENKO, ED. Moscow Moskovskij Aviatsionnyj Institut 1990 87 p. In RUSSIAN For individual items see A93-42370 to A93-42381
Copyright

The papers presented in this volume are concerned with the methodological aspects of the design and development of aircraft. Topics discussed include optimization of equipment layout in the fuselage of maneuverable aircraft, selection of the primary aircraft structure at the preliminary design stage, and the structure of a knowledge base used in the computerized synthesis of aircraft layout. The discussion also covers formalization of problems in the preliminary design of aircraft, determination of the takeoff characteristics of jet engines during the preliminary design of aircraft, and selection of the turbofan engine size. AIAA

A93-42370
OPTIMIZATION OF EQUIPMENT LAYOUT IN THE FUSELAGE OF MANEUVERABLE AIRCRAFT [OPTIMIZATSIYA RAZMESHCHENIYA OBORUDOVANIYA V FYUZELYAZHE MANEVRENNOGO SAMOLETA]
O. B. PASHCHENKO *In* Current methods of selecting the configurations and parameters of flight vehicles Moscow Moskovskij Aviatsionnyj Institut 1990 p. 4-11. In RUSSIAN refs
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A heuristic approach to the optimization of equipment layout in the fuselage of high-speed maneuverable aircraft is proposed which is based on formalized methods and techniques used in the design procedure. Based on a systematic analysis of the designer's activities, a semantic-information model of the design process is developed in the form of a generalized algorithm. The principal design constraints and criteria are discussed. AIAA

A93-42371
SELECTION OF THE PRIMARY AIRCRAFT STRUCTURE AT THE PRELIMINARY DESIGN STAGE [VYBOR KONSTRUKTIVNO-SILOVOJ SKHEMY SAMOLETA NA EHTAPE PREDVARITEL'NOGO PROEKTIROVANIYA]
G. T. ZAKARYAN *In* Current methods of selecting the configurations and parameters of flight vehicles Moscow Moskovskij Aviatsionnyj Institut 1990 p. 11-15. In RUSSIAN refs
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An approach to the formalization of the problem of automatic selection of the primary aircraft structure in computer-aided design is proposed. In accordance with the proposed approach, the primary load-bearing structure is selected in conjunction with the volume/weight layout, with the non-load-bearing structures also taken into account. A flow chart of the procedure for the synthesis of the primary load-bearing structure is presented. AIAA

A93-42373
STRUCTURE OF A KNOWLEDGE BASE USED IN THE COMPUTERIZED SYNTHESIS OF AIRCRAFT LAYOUT [STRUKTURA BAZY ZNANIJ, ISPOL'ZUEMOJ V PROTSESSE AVTOMATIZIROVANNOGO SINTEZA SKHEMY SAMOLETA]
V. V. MAL'CHEVSKIJ *In* Current methods of selecting the configurations and parameters of flight vehicles Moscow Moskovskij Aviatsionnyj Institut 1990 p. 21-28. In RUSSIAN refs
Copyright

The integration of a knowledge base into the CAD system for aircraft design is examined. One of possible knowledge base structures is considered, with attention given only to the procedural part of the knowledge base, containing the rules, methods, and heuristics for the generation of novel design decisions. The principal components of the knowledge base deal with the design of the powerplant, aerodynamic design, and structural design. Some specific techniques for generating new design solutions are discussed. AIAA

A93-42374
SOME ASPECTS OF THE DESIGN OF COMBINATION LANDING GEAR [OSOBENNOSTI PROEKTIROVANIYA KOMBINIROVANNOGO SHASSI]
T. M. AVDYUKHINA and A. N. STEPANOV *In* Current methods of selecting the configurations and parameters of flight vehicles Moscow Moskovskij Aviatsionnyj Institut 1990 p. 28-32. In RUSSIAN refs
Copyright

Some problems associated with the use of air-cushion landing gear are examined, and the use of combination landing gear, consisting of air-cushion landing gear and auxiliary conventional wheel-type landing gear, is proposed as a possible method of solving some of these problems. In particular, it is shown that the use of auxiliary wheel-type landing gear solves the problem of stable aircraft motion on the runway. Criteria for the efficient selection of the auxiliary landing gear design are developed which yield quantitative estimates for specific design solutions. AIAA

A93-42375
FORMALIZATION OF THE PROBLEM OF PRELIMINARY AIRCRAFT DESIGN [FORMALIZATSIYA ZADACH PREDVARITEL'NOGO PROEKTIROVANIYA SAMOLETA]
N. K. LISEJTSEV *In* Current methods of selecting the configurations and parameters of flight vehicles Moscow Moskovskij Aviatsionnyj Institut 1990 p. 33-40. In RUSSIAN refs
Copyright

The development of formalized procedures that implement the aircraft design process within the CAD system is examined. In particular, attention is given to the tasks of formulating the principal design problems in a systematic manner, analyzing solution algorithms, indentifying the invariant fragments, and evaluating the possibility of using specific mathematical formalisms. Another important task is estimating the fraction of heuristic procedures and the possibility of reducing this fraction by combining some of the heuristic procedures with the formal ones. These tasks are examined with particular reference to the stage of technical proposal development. AIAA

A93-42376
COMPUTERIZED SYNTHESIS OF THREE-DIMENSIONAL KINEMATIC LANDING GEAR SCHEMES WITH A SINGLE TURNING AXIS [AVTOMATIZIROVANNYJ SINTEZ PROSTRANSTVENNYKH KINEMATICHESKIKH SKHEM SHASSI S ODNOJ OS'YU POVOROTA]
S. A. CHURSANOV *In* Current methods of selecting the configurations and parameters of flight vehicles Moscow Moskovskij Aviatsionnyj Institut 1990 p. 40-49. In RUSSIAN
Copyright

A set of software has been developed for the synthesis of kinematic landing gear designs with a single turning axis of the strut. The software includes the capability of analyzing the position of the landing gear wheels and rotation axis from the standpoint of the required volume, structural design efficiency, lateral nose-over angle, and other parameters and constraints. The general software structure, the principal modules, and specific synthesis problems are examined. AIAA

A93-42377
DEPENDENCE OF THE SERVICE LIFE OF A WING ON ITS STRENGTH UNIFORMITY AND LANDING GEAR LOCATION [ZAVISIMOST' RESURSA KRYLA OT USLOVIJ EGO RAVNOPROCHNOSTI I RASPOLOZHENIYA SHASSI]
G. D. ARALOV and S. YU. VINOGRADOV *In* Current methods of selecting the configurations and parameters of flight vehicles Moscow Moskovskij Aviatsionnyj Institut 1990 p. 49-58. In RUSSIAN
Copyright

The load dynamics under typical flight conditions is analyzed

for different cross sections of a wing. Based on the analysis, expressions are obtained which make it possible to analyze the fatigue life of a wing as a function of strength uniformity over different cross sections of the wing and landing gear location. Ways of increasing the fatigue life of a wing are discussed. It is shown, in particular, that in aircraft with landing gear located on the fuselage, the wing service life is generally less than that in aircraft with landing gear attached to the wing. AIAA

A93-42378
DETERMINATION OF THE TAKEOFF CHARACTERISTICS OF JET ENGINES DURING THE PRELIMINARY DESIGN OF AIRCRAFT [OPREDELENIE STARTOVYKH KHARAKTERISTIK VRD V PERIOD PREDVARITEL'NOGO PROEKTIROVANIYA SAMOLETA]
V. F. MISHIN *In* Current methods of selecting the configurations and parameters of flight vehicles Moscow Moskovskij Aviatsionnyj Institut 1990 p. 58-68. In RUSSIAN refs
Copyright

A method is proposed for estimating the thrust and fuel efficiency characteristics of a jet engine without resorting to complex gasdynamic calculations. The method considers the dependence of the engine thrust and fuel consumption characteristics on the principal parameters only, with the effect of secondary parameters taken into account through the use of specific coefficients derived from statistical data. Thrust and specific fuel consumptions calculations for bypass engines with and without an afterburner are presented as an example. AIAA

A93-42381
CHARACTERISTICS OF DATA PROCESSING DURING THE DEVELOPMENT OF A DATA BASE FOR A CAD SYSTEM FOR AIRCRAFT DESIGN [OSOBENNOSTI OBRABOTKI INFORMATSII PRI FORMIROVANII BAZY DANNYKH SAPR SAMOLETOV]
A. M. IVANOV *In* Current methods of selecting the configurations and parameters of flight vehicles Moscow Moskovskij Aviatsionnyj Institut 1990 p. 78-83. In RUSSIAN
Copyright

The principal types of information that must be included into the data base of any CAD system for aircraft design are defined. The information that must be included covers technical contradictions and competing technical factors, technical solutions and technical solution rating in terms of cost factors, practical implementations of technical solutions, and criteria for selecting optimal technical solutions among various alternatives. As an example, swept wings with fixed and adjustable sweep angle are analyzed as two alternative technical solutions for several different types of aircraft. AIAA

A93-42778
INTEGRATING CONTROLS AND AVIONICS ON COMMERCIAL AIRCRAFT
JOHN R. TODD (Douglas Aircraft Co., Long Beach, CA) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 1 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 46-62.
Copyright

The technologies, functions, and innovations which are likely to be incorporated into late 1990s commercial aircraft are reported, together with possible integration approaches. The author discusses integrated modular avionics within the context of controls and data transfer, power distribution and management, and cockpit navigation and sensing equipment. The optical propulsion management system (OPMIS) is described, as is the autonomous operations optical integration concept. a.

A93-42794
SELECTING LOCATIONS FOR AVIONICS ANTENNAS - A STRUCTURED APPROACH
DAVID P. CARROLL (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 1 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 297-303. refs

A methodology that analytically estimates an avionics system's performance when its antennas are installed at various compromised locations is described. The methodology begins with a computer-aided design analysis to determine what aircraft structure lies in the antenna's free-space field of view from a given installed location. This first step allows candidate locations to be eliminated if the aircraft blocks too much of the antenna's field of interest. Once a location that provides a sufficiently unobstructed field of view is identified, the geometric theory of diffraction or other appropriate electromagnetic scattering code is used to obtain a more detailed prediction of the installed antenna's performance. An analysis of the avionics system performance is made to determine whether the installed device can meet avionics system requirements. When antenna locations that simultaneously satisfy avionics system requirements and meet other constraints are found, prototype testing can be accomplished to verify that predicted antenna patterns. a.

A93-42995
BIG TIME DOORSTEP DELIVERY
HARRY HOPKINS Flight International (ISSN 0015-3710) vol. 143, no. 4370 May 19, 1993 p. 31-35.
Copyright

A flight test evaluation is conducted of the performance of the C-17 strategic airlift aircraft, whose design attempts to combine the long range/high speed cruise efficiency of turbofan aircraft with the short-field takeoff and landing performance of turboprops such as the C-130. The key to such short-field performance is the 'blowing' of the large trailing edge flaps by the efflux of the four turbofan engines; this furnishes direct downthrust for lift augmentation. A cutaway drawing of the C-17 is included. AIAA

A93-43570
SIMPLIFIED FINITE ELEMENT REPRESENTATION OF FUSELAGE FRAMES WITH FLEXIBLE CASTELLATIONS
M. E. HEERSCHAP (Delft Univ. of Technology, Netherlands) Computers & Structures (ISSN 0045-7949) vol. 47, no. 1 April 3, 1993 p. 19-32. Research supported by Fokker Aircraft refs
Copyright

The frames in an aircraft fuselage are commonly attached to the skin by flexible castellations, to reduce the stresses in the frames when the fuselage is pressurized. This results in a complex deformation of the frames and castellations. Nevertheless it is impractical to model these in detail in a finite element model of the fuselage as a whole, because of the number of frames and castellations present in the fuselage and the many elements which would be needed to model a single frame and castellation. A suitable, highly simplified representation of the frame with castellations is developed here. It is shown that the errors, with regard to stresses in the skin, can be reduced to an acceptable level. Author

A93-43776
A MULTIBODY FORMULATION FOR HELICOPTER STRUCTURAL DYNAMIC ANALYSIS
O. A. BAUCHAU and N. K. KANG (Rensselaer Polytechnic Inst., Troy, NY) American Helicopter Society, Journal (ISSN 0002-8711) vol. 38, no. 2 April 1993 p. 3-14. refs
(Contract DAAL03-88-C-0004)
Copyright

This paper presents a multibody formulation for helicopter nonlinear dynamic analysis. Cartesian coordinates are used to represent the configuration of each body. This approach involves more unknown coordinates than are strictly necessary to define the configuration of the system; hence, constraint equations linking the redundant coordinates are an integral part of the formulation. In classical rotorcraft methodologies, elastic bodies are represented in a local, rotating frame of reference which amounts to separating

rigid body and elastic motions. The approach followed in this work departs radically from this classical approach: the total motion of all elastic bodies is directly referred to a single inertial frame. This approach readily allows the development of computer models to deal with arbitrarily complex multibody configurations. In this work, finite rotations are represented using the components of the conformal rotation vector, and the constraint equations are enforced via an augmented Lagrangian formulation. Simple numerical examples are presented to validate the formulation, and the classical ground resonance problem is treated here as a multibody problem. Good correlation is found between analytical solutions and multibody formulations. Author

A93-43777
INVESTIGATION OF HELICOPTER AIR RESONANCE IN HOVER BY COMPLEX COORDINATES AND MUTUAL EXCITATION ANALYSIS
XIAOGU ZHANG (Nanjing Aeronautical Inst., China) American Helicopter Society, Journal (ISSN 0002-8711) vol. 38, no. 2 April 1993 p. 15-24. refs
Copyright

Helicopter air resonance is investigated through the analysis of mutual excitation of different degrees of freedom (d.o.f.) based on the complex coordinates used to express the motions. The expressions of excitation are derived and typical cases are calculated. The source of instability is that two d.o.f. mutually interact to do positive work on each other. Through the analysis of the approximate expressions of the mutual excitation and the analysis of mode shapes, the physical explanation and the influence of important design parameters on the instability are studied. For the case of zero collective pitch, the source of instability is the positive mutual excitation between rotor regressive lead-lag motion and forward body whirling motion due to inertial coupling. In the case of nonzero collective pitch, aerodynamic and inertial coupling between rotor lead-lag motion and flapping motion also influences the instability. Author

A93-43779* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TIP VORTEX GEOMETRY OF A HOVERING HELICOPTER ROTOR IN GROUND EFFECT
JEFFREY S. LIGHT (NASA, Ames Research Center, Moffett Field, CA) American Helicopter Society, Journal (ISSN 0002-8711) vol. 38, no. 2 April 1993 p. 34-42. AHS, Annual Forum, 45th, Boston, MA, May 22-24, 1989, Proceedings, p. 551-562. Previously cited in issue 11, p. 1611, Accession no. A90-28196 refs
Copyright

A93-43831
FUNDAMENTALS OF FLIGHT VEHICLE DESIGN [OSNOVY USTROJSTVA I KONSTRUIROVANIYA LETATEL'NYKH APPARATOV]
VLADIMIR N. NOVIKOV, BORIS M. AVKHIMOVICH, and VALERIJ E. VEJTIN Moscow Izdatel'stvo Mashinostroenie 1991 368 p. In RUSSIAN refs
(ISBN 5-217-01299-4) Copyright

The fundamentals of the design of flight vehicles are presented from the standpoint of systems design whereby the flight vehicle is treated as part of a large engineering system. The discussion covers the principles of controlled flight, types and characteristics of onboard equipment, control systems, and powerplants. Particular attention is given to the characteristics of a design that unifies all the subsystems into one whole. Consideration is also given to the design of flight vehicle components and units, algorithms for the selection of the parameters of individual units and parts with allowance for the compex interaction with the environment, and solving problems arising the computer-aided design of flight vehicles. AIAA

N93-29153*# Arizona State Univ., Tempe.
AN INTEGRATED OPTIMUM DESIGN APPROACH FOR HIGH SPEED PROP-ROTORS INCLUDING ACOUSTIC CONSTRAINTS Semiannual Progress Report, 1 Jan. - 30 Jun. 1993
ADITI CHATTOPADHYAY, VALANA WELLS, THOMAS MCCARTHY, and ARRIS HAN 30 Jun. 1993 11 p
(Contract NCC2-795)
(NASA-CR-193222; NAS 1.26:193222) Avail: CASI HC A03/MF A01

The objective of this research is to develop optimization procedures to provide design trends in high speed prop-rotors. The necessary disciplinary couplings are all considered within a closed loop multilevel decomposition optimization process. The procedures involve the consideration of blade-aeroelastic aerodynamic performance, structural-dynamic design requirements, and acoustics. Further, since the design involves consideration of several different objective functions, multiobjective function formulation techniques are developed. Derived from text

N93-29268# Technische Univ., Eindhoven (Netherlands).
QUIET BY DESIGN: NUMERICAL ACOUSTO-ELASTIC ANALYSIS OF AIRCRAFT STRUCTURES Ph.D. Thesis
NICOLAAS BERNARDUS ROOZEN 1992 158 p Sponsored by Fokker B.V. Original contains color illustrations
(ISBN-90-386-0042-9; ETN-93-93578) Avail: CASI HC A08/MF A02

The development of feasible analysis methods and models to calculate the dynamic behavior of fuselage and the so called acousto-elastic interaction with its enclosed acoustic cavity, is reported. These methods are to be used in the design optimization of aircraft resulting in considerable noise reduction. The so called structural detuning concept, in which the fuselage structure and propulsion system are designed in such a way that the aircraft resistant frequencies and the propulsion system excitation frequencies are well separated, was applied. The two analysis methods investigated were the continuous analysis (analytical) models and discrete analysis (finite element method) models. ESA

N93-29409# Wright Lab., Wright-Patterson AFB, OH.
A REAL-TIME, HARDWARE-IN-THE-LOOP SIMULATION OF AN UNMANNED AERIAL RESEARCH VEHICLE Final Report, 1 May 1991 - 28 Aug. 1992
SCOTT D. ROBERTSON Aug. 1992 65 p
(Contract AF PROJ. 2403)
(AD-A262477; WL-TR-93-3005) Avail: CASI HC A04/MF A01

Simulation is a valuable tool for rapidly and cost effectively developing and verifying new systems. This report describes the design and development of a system which simulates an unmanned aircraft and verifies the proper operation of its flight computer. Flight computers, being time critical devices, must execute at a certain rate in order to safely and accurately control an aircraft. In order to verify the proper operation of the flight computer, the simulation must execute in 'real-time', which is a rate of 100 Hz for this flight computer. The flight computer's inputs and outputs are connected to the simulation so that the flight computer thinks it is flying. The simulation architecture is a VME-based computer system, consisting of an input board (designed for this project) which demodulates 13 channels of pulse-width modulated signals, a processor board which executes the simulation software, and a digital-to-analog output board. The existing simulation software was ported to the C language and re-hosted on a 68030 processor board. Additional software was written to handle all the I/O and data conversions. The system accurately simulates the unmanned aircraft, runs in real-time, and verifies the proper operation of the flight computer. DTIC

N93-29464# European Space Agency, Paris (France).
FLIGHT MECHANICAL MODEL FOR PERFORMANCE CALCULATIONS AND INTERACTIONS BETWEEN FLIGHT VEHICLE AND RAMJET IN REGARD TO THE FLIGHT ORBIT
FRANS G. J. KREMER (Deutsche Forschungsanstalt fuer Luft-

und Raumfahrt, Cologne, Germany.) Oct. 1992 93 p Transl. into ENGLISH of Flugmechanikmodel fuer Leistungsrechnungen und Wechselwirkungen zwischen Flugkoerper und Staustrahltriebwerk mit Unterschallverbrennung in bezung zur Flugbahn (Cologne, Germany, DLR), Feb. 1991 p 1-95 Original language document was announced as N91-32131
(ESA-TT-1267; DLR-FB-91-03; ETN-93-93714) Avail: CASI HC A05/MF A02; Original German version available from DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany, HC

A flight mechanics model for performance calculations and relationships between flight vehicle and ramjet engine with subsonic combustion relative to the flight path is described. Performance calculation for a ramjet engine initially required determination of the burst demand throughout the flight path. This is the objective of a flight mechanics computer model. The computer model described is based on the assumption of equilibrium of forces at the center of gravity of the flight vehicle. A further input is an aerodynamic model of the flight vehicle. The flight path is input with a statement of the flight profile, acceleration on flight direction and turning acceleration. The interaction between flight vehicles and ramjet engines in conjunction with the flight path is considered. The influencing variables in the consumption relating to mission phases are described. The role of the angle of incidence and the significance of the design are explained. Interactions are described on the basis of modification of parameters for flight path data (ram pressure, acceleration in flight direction and turning acceleration). ESA

N93-29498*# Boeing Commercial Airplane Co., Seattle, WA. Technology and Product Development Div.
ADVANCED TECHNOLOGY COMPOSITE AIRCRAFT STRUCTURES Monthly Technical Progress Report No. 25, 1-31 May 1991
LARRY B. ILCEWICZ and THOMAS H. WALKER 14 Jun. 1991 133 p
(Contract NAS1-18889)
(NASA-CR-190420; NAS 1.26:190420) Avail: CASI HC A07/MF A02

Work performed during the 25th month on NAS1-18889, Advanced Technology Composite Aircraft Structures, is summarized. The main objective of this program is to develop an integrated technology and demonstrate a confidence level that permits the cost- and weight-effective use of advanced composite materials in primary structures of future aircraft with the emphasis on pressurized fuselages. The period from 1-31 May 1991 is covered. Author

N93-29713*# California State Polytechnic Univ., Pomona.
HIGH-ALTITUDE RECONNAISSANCE AIRCRAFT
RENEE ANNA YAZDI *In* Universities Space Research Association, Houston, Proceedings of the Seventh Annual Summer Conference. NASA/USRA: University Advanced Design Program p 11-18 1991 Previously announced in IAA as A91-54045
Avail: CASI HC A02/MF A03

At the equator the ozone layer ranges from 65,000 to 130,000+ ft, which is beyond the capabilities of the ER-2, NASA's current high-altitude reconnaissance aircraft. This project is geared to designing an aircraft that can study the ozone layer. The aircraft must be able to satisfy four mission profiles. The first is a polar mission that ranges from Chile to the South Pole and back to Chile, a total range of 6000 n.m. at 100,000 ft with a 2500-lb payload. The second mission is also a polar mission with a decreased altitude and an increased payload. For the third mission, the aircraft will take off at NASA Ames, cruise at 100,000 ft, and land in Chile. The final mission requires the aircraft to make an excursion to 120,000 ft. All four missions require that a subsonic Mach number be maintained because of constraints imposed by the air sampling equipment. Three aircraft configurations were determined to be the most suitable for meeting the requirements. The performance of each is analyzed to investigate the feasibility of the mission requirements. Author (revised)

N93-29715*# California State Univ., Northridge.
PROJECT ARES 2: HIGH-ALTITUDE BATTERY-POWERED AIRCRAFT
In Universities Space Research Association, Houston, Proceedings of the Seventh Annual Summer Conference. NASA/USRA: University Advanced Design Program p 29-33 1991
Avail: CASI HC A01/MF A03

A high-altitude, battery-powered, propeller-driven aircraft was designed and is being built by undergraduate students at California State University, Northridge. The aircraft will fly at an altitude of 104,000 ft at Mach 0.2 (190 ft/sec) and will be instrumented to record flight performance data, including low Reynolds number propeller and airfoil information. This project will demonstrate the feasibility of electric-powered flight in a low-density, low-temperature Earth environment that models the atmosphere of Mars. Data collected will be used to design a Mars aircraft to investigate the surface of Mars prior to manned missions. The instrumented payload and the mission profile for the high-altitude Earth flight were determined. Detailed aerodynamic and structural analyses were performed. Control, tracking, and data recording subsystems were developed. Materials were obtained and fabrication begun. The aircraft has a 32-ft wing span, a wing area of 105 sq ft, is 17.5 ft long, has a 12-in payload bay, and weighs 42 lb. It is composed primarily of lightweight materials, including Mylar, and composite materials, including graphite/epoxy and aramid core honeycomb sandwich. Low-altitude flight testing to check guidance and control systems and to calibrate data-gathering instruments will take place this summer, followed shortly by the 104,000-ft flight. Author

N93-29717*# Kansas Univ., Lawrence.
PRELIMINARY DESIGN STUDIES OF AN ADVANCED GENERAL AVIATION AIRCRAFT
In Universities Space Research Association, Houston, Proceedings of the Seventh Annual Summer Conference. NASA/USRA: University Advanced Design Program p 45-56 1991
Avail: CASI HC A03/MF A03

Preliminary design studies are presented for an advanced general aviation aircraft. Advanced guidance and display concepts, laminar flow, smart structures, fuselage and wing structural design and manufacturing, and preliminary configuration design are discussed. This project was conducted as a graduate level design class under the auspices of the KU/NASA/USRA Advanced Design Program in Aeronautics. The results obtained during the fall semester of 1990 (Phase 1) and the spring semester of 1991 (Phase 2) are presented. Author (revised)

N93-29718*# Notre Dame Univ., IN.
DESIGN STUDY TO SIMULATE THE DEVELOPMENT OF A COMMERCIAL TRANSPORTATION SYSTEM
In Universities Space Research Association, Houston, Proceedings of the Seventh Annual Summer Conference. NASA/USRA: University Advanced Design Program p 57-64 1991
Avail: CASI HC A02/MF A03

Seven teams of senior-level Aerospace Engineering undergraduates were given a Request for Proposals (RFP) for a design concept of a remotely piloted vehicle (RPV). The RPV designs were intended to simulate commercial transport aircraft within the model of 'Aeroworld.' The Aeroworld model was developed so that the RPV designs would be subject to many of the engineering problems and tradeoffs that dominate real-world commercial air transport designs, such as profitability, fuel efficiency, range vs. payload capabilities, and ease of production and maintenance. As part of the proposal, each team was required to construct a prototype and validate its design with a flight demonstration. Author (revised)

N93-29721*# Purdue Univ., West Lafayette, IN.
DESIGN OF A TURBOFAN POWERED REGIONAL TRANSPORT AIRCRAFT
In Universities Space Research Association, Houston, Proceedings of the Seventh Annual Summer Conference. NASA/USRA:

University Advanced Design Program p 83-88 1991 Previously announced as N92-20280
Avail: CASI HC A02/MF A03

The majority of the market for small commercial transport aircraft is dominated by high-efficiency, propeller-driven aircraft of non-U.S. manufacture. During the past year senior student design teams at Purdue developed and then responded to a Request For Proposal (RFP) for a regional transport aircraft. The RFP development identified promising world markets and their needs. The students responded by designing aircraft with ranges of up to 1500 n.m. and passenger loads of 50 to 90. During the design project, special emphasis was placed upon keeping acquisition cost and direct operating costs at a low level while providing passengers with quality comfort levels. Twelve student teams worked for one semester developing their designs. Several of the more successful designs and those that placed a high premium on innovation are described. The depth of detail and analysis in these student efforts are also illustrated. Author (revised)

N93-29722*# Worcester Polytechnic Inst., MA.
SOLAR POWERED MULTIPURPOSE REMOTELY POWERED AIRCRAFT
In Universities Space Research Association, Houston, Proceedings of the Seventh Annual Summer Conference. NASA/USRA: University Advanced Design Program p 89-94 1991
Avail: CASI HC A02/MF A03

Environmental problems such as the depletion of the ozone layer and air pollution demand a change in traditional means of propulsion that is sensitive to the ecology. Solar-powered propulsion is a favorable alternative that is both ecologically harmless as well as cost effective. Integration of solar energy into designs ranging from futuristic vehicles to heating is, therefore, beneficial to society. The design and construction of a Multipurpose Remotely Piloted Vehicle (MPRPV) seeks to verify the feasibility of using solar propulsion as a primary fuel source. This task has been a year-long effort by a group of eight students, divided into four teams, each dealing with different aspects of the design. The aircraft was designed to take off, climb to the design altitude, fly in a sustained figure-eight flight path, and cruise for approximately one hour. This mission requires flight at Reynolds numbers between 150,000 and 200,000 and demands special considerations in the aerodynamic design to achieve flight in this regime. Optimal performance requires a lightweight configuration with both structural integrity and maximum power availability. The structural design and choice of solar cells for the propulsion were governed by weight, efficiency, and cost considerations. The final design is an MPRPV weighing 35 N that cruises at 7 m/s at the design altitude of 50 m. The configuration includes a wing composed of balsa and foam NACA 6409 airfoil sections and carbon fiber spars, a tail of similar construction, and a truss structure fuselage. The propulsion system consists of 98 12.5 percent-efficient solar cells donated by Mobil Solar, a NiCad battery for energy storage, and a folding propeller regulated by a lightweight and efficient control system. The airfoils and propeller chosen for the design were researched and tested during the design process.
Author (revised)

N93-29774*# Kansas Univ. Center for Research, Inc., Lawrence. Dept. of Aerospace Engineering.
THE ULTRA LIGHT AIRCRAFT TESTING Final Report
HOWARD W. SMITH 1993 172 p
(Contract NAG1-345)
(NASA-CR-193043; NAS 1.26:193043) Avail: CASI HC A08/MF A02

The final report for grant NAG1-345 is presented. Recently, the bulk of the work that the grant has supported has been in the areas of ride quality and the structural analysis and testing of ultralight aircraft. The ride quality work ended in May 1989. Hence, the papers presented in this final report are concerned with ultralight aircraft.

N93-29775*# Kansas Univ. Center for Research, Inc., Lawrence. Dept. of Aerospace Engineering.
REPORT ON THE TEST SET-UP FOR THE STRUCTURAL TESTING OF THE AIRMASS SUNBURST ULTRALIGHT AIRCRAFT
WILLIAM ZIMMERMAN and HOWARD W. SMITH *In its* The Ultra Light Aircraft Testing 5 p 1993
(Contract NAG1-345)
Avail: CASI HC A01/MF A02

This report reviews the test set-up and procedure for the structural testing of the Airmass Sunburst Ultralight Aircraft. In general aviation today, there is a growing need for more stringent design criteria for ultralight aircraft. Unlike most general aviation aircraft, the ultralight lacks sufficient design criteria and more importantly it lacks sufficient certification enforcement. The Airmass Sunburst ultralight that is currently being tested is responsible for over a dozen deaths. It is believed that had there been a more stringent criteria and certification process, this might have been prevented. Our attempt is to show that the failing loads of the aircraft in question are so far below that of the current design criteria, that the laws need to be changed. Author (revised)

N93-29776*# Kansas Univ. Center for Research, Inc., Lawrence. Dept. of Aerospace Engineering.
LOAD TEST SET-UP FOR THE AIRMASS SUNBURST ULTRA-LIGHT AIRCRAFT
DANIEL W. KRUG and HOWARD W. SMITH *In its* The Ultra Light Aircraft Testing 41 p 1993
(Contract NAG1-345)
Avail: CASI HC A03/MF A02

The purpose of this project was to set up, instrument, and test a Sunburst Ultra-Light aircraft. The intentions of the project were that the aircraft would need to be suspended from the test stand, leveled in the stand, the strain gauges tested and wired to the test equipment, and finally, the aircraft would be destroyed to obtain the failing loads. All jobs were completed, except for the destruction of the aircraft. This notebook shows the group's progress as these tasks were completed, and the following section attempts to explain the photographs in the notebook.
Author (revised)

N93-29885*# University of South Florida, Tampa. Dept. of Civil Engineering and Mechanics.
EFFECT OF DESIGN SELECTION ON RESPONSE SURFACE PERFORMANCE
WILLIAM C. CARPENTER Washington Jun. 1993 181 p
(Contract NAG1-1378; RTOP 505-63-50)
(NASA-CR-4520; NAS 1.26:4520) Avail: CASI HC A09/MF A02

Artificial neural nets and polynomial approximations were used to develop response surfaces for several test problems. Based on the number of functional evaluations required to build the approximations and the number of undetermined parameters associated with the approximations, the performance of the two types of approximations was found to be comparable. A rule of thumb is developed for determining the number of nodes to be used on a hidden layer of an artificial neural net and the number of designs needed to train an approximation is discussed.
Author (revised)

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A93-41318* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ENGINEERING A VISUAL SYSTEM FOR SEEING THROUGH FOG
J. LARIMER (NASA, Ames Research Center, Moffett Field, CA),

M. PAVEL (New York Univ., NY), A. AHUMADA, and B. SWEET (NASA, Ames Research Center, Moffett Field, CA) Jul. 1992 7 p. SAE, International Conference on Environmental Systems, 22nd, Seattle, WA, July 13-16, 1992 refs
(SAE PAPER 921130) Copyright

We examine the requirements for on-board aircraft sensor systems that would allow pilots to 'see through' poor weather, especially fog, and land and rollout aircraft under conditions that currently cause flight cancellations and airport closures. Three visual aspects of landing and rollout are distinguished: guidance, hazard detection and hazard recognition. The visual features which support the tasks are discussed. Three broad categories of sensor technology are examined: passive millimeter wave (PMMW), imaging radar, and passive infrared (IR). PMMW and imaging radar exhibit good weather penetration, but poor spatial and temporal resolution. Imaging radar exhibits good weather penetration, but typically relies on a flat-earth assumption which can lead to interpretive errors. PMMW systems have a narrow field of view. IR has poorer weather penetration but good spatial resolution. We recommend using both millimeter-wave and infrared sensor systems, blending the images using multiresolution digital-image pyramid-processing technology, and fusing the resulting real-time images with stored database imagery of the same scene. Author

A93-42777
INTEGRATED MODULAR AVIONICS
PAUL J. PRISAZNUK (Aeronautical Radio, Inc., Annapolis, MD) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 1 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 39-45.
Copyright

Advancements in technology have enabled the avionics industry to develop design concepts which result in highly integrated digital avionics under software control. This approach, collectively referred to as integrated modular avionics (IMA), introduces methods which will result in substantial cost savings compared to earlier avionics implementations. The IMA concept is described together with the benefits that airlines can expect as a result of this avionics architecture. The author reports on IMA design goals, line replaceable modules (LRMs), maintenance and support strategies for IMA-equipped aircraft, modularity goals, packaging goals, and interchangeability goals. a.

A93-42780
APPLICATION OF MODULAR AVIONICS TO THE EF-111A SYSTEMS IMPROVEMENT PROGRAM
DENNIS REISIGER (IBM Corp., Owego, NY) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 1 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 182-186.
Copyright

IBM has been selected by Grumman to supply embedded processor sets (EPSs) for the EF-111A system improvement program. These EPSs utilize modular avionics technology to provide data processing and MIL-STD-1553 I/O for several avionics units in the system. Existing modules developed under the F-15 VHSIC central computer program are reused for EF-111A, thereby maximizing logistics benefits and reducing development cost and risk. The modules are implemented in the SEM-E form factor, and implement the PI bus, TM-bus, and MIL-STD-1750 instruction set architecture. A bus translator module interfaces the 1750 module architecture to the existing host native buses of the line replaceable units in which they are embedded. This same concept may be used in other applications that require a substantial processing performance upgrade at low risk and low cost. a.

A93-42784
THE PAVE PACE INTEGRATED RF ARCHITECTURE FOR NEXT GENERATION AVIONICS
R. B. MARCUM, RICK V. KURTZ, THOMAS G. LITTLE, and ARNO E. PETTAI (TRW Avionics & Surveillance Group, San Diego, CA) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 1 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 226-232.
Copyright

The authors discuss requirements for the PAVE PACE integrated radio frequency (IRF) system and present a description of the IRF conceptual architecture, including receive process, transmit process, and integrated maintenance approach. A comparison is made between the PAVE PACE system and a Pave Pillar/JIAWG system (assuming advanced technology insertion), to determine improvements in cost, volume, weight, power, and reliability. a.

A93-42786
TOPOGRAPHIC MAPPING USING A KU-BAND AIRBORNE ELEVATION INTERFEROMETER
JAMES D. O'BRIEN and DANIEL N. HELD (Norden Systems, Inc., Norwalk, CT) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 1 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 244-249. refs
Copyright

An experimental topographic mapping capability is investigated using data obtained with a multiaperture radar collection system. The authors discuss the signal and image processing aspects that have been implemented in order to produce 3D terrain maps which depict elevation angle and signal strength as functions of range and cross-range. The radar antenna contains both elevation and azimuth multiport interferometers. Horizontal and vertical polarizations can be achieved. The data collection system permits real-time mapping, and data recording for subsequent ground processing. Ground data processing is performed with a mainframe computer. Autofocus and elevation tracking are implemented, multiple looks are overlaid, and the resulting database is image transformed for interpretation. Topographic maps generated from overland flights are presented. a.

A93-42855
ENVIRONMENTAL DEFINITION OF A MULTI-PLATFORM AVIONICS SYSTEM
LEO M. ROSENSTEIN (Control Data Corp., Electronic Mission Systems Div., Minneapolis, MN) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 788-794. refs
Copyright

The author discusses the process of developing a general life cycle history for a multiplatform avionics system using the mission profiles and mission mixes of the different aircraft. In addition, a method of specifying the proper overall composite operating environment is offered. It is shown that quality and integrity can be designed into avionics/electronics equipment when the environmental criteria are evaluated and understood. These criteria can be implemented into the design, and the design developed from a known set of conditions. In the case of multiple platforms, a method of comparison and further tailoring of environments to take into account extremes and the special conditions of each platform is required. The overall composite environment is the result of defining an envelope that contains the extremes of all the platforms and incorporates the levels and durations for these extremes. These environments can then be incorporated into the test and evaluation program to assure that the equipment will perform properly in its intended environment. a.

A93-43624
FIRST MOVES TOWARDS AN 'INTELLIGENT' GPWS
BERNARD FITZSIMONS Interavia/Aerospace World (ISSN 0983-1592) vol. 48 May 1993 p. 55-57.
Copyright

Ground proximity warning system (GPWS) enhancements intended to reduce the incidence of controlled flight into terrain accidents are addressed. It is noted that even the latest GPWSs

suffer from two basic drawbacks, namely, nuisance alerts, which can occur when an aircraft passes over terrain that intrudes into the sensor's warning envelope, and its inability to predict vertical obstacles ahead. Improvements to existing GPWS equipment include the addition of a sloped terrain clearance floor near the runaway, a flight monitoring program for a forward-looking capability, and contour shading on a digital map display to highlight terrain above the aircraft's current height. AIAA

N93-29971# Naval Postgraduate School, Monterey, CA.
A CONCLUDING STUDY OF THE ALTITUDE DETERMINATION DEFICIENCIES OF THE SERVICE AIRCRAFT INSTRUMENTATION PACKAGE (SAIP) M.S. Thesis
DANIEL G. SERGENT 25 Mar. 1993 64 p
(AD-A263515) Avail: CASI HC A04/MF A01

Previous research at the Naval Postgraduate School addressed the aerodynamic effects that caused the altitude determination errors in the Service Aircraft Instrumentation Package (SAIP). This thesis builds on the previous work and focused on establishing a correction for the SAIP using both aerodynamic and atmospheric corrections to the Extended Area Test System (EATS) system evaluator program. By using a quadratic function of Mach number to estimate the Cp, the aerodynamic errors can be reduced to enable the SAIP to measure altitude correctly to within 100 ft for velocities up to Mach 0.8. This correction is used to modify the static pressure read by the SAIP. Further flight tests will have to be accomplished to determine the correction for a range of altitudes and aircrafts. The atmospheric errors can be corrected by analyzing the sounding data generated by the Geophysics Department at Pt. Mugu and substituting actual lapse rate information into the standard altitude equation. This model is shown to predict altitudes to within 200 feet up through 60,000 feet. DTIC

N93-30416*# National Aeronautics and Space Administration. Pasadena Office, CA.
VIRTUAL REALITY FLIGHT CONTROL DISPLAY WITH SIX-DEGREE-OF-FREEDOM CONTROLLER AND SPHERICAL ORIENTATION OVERLAY Patent Application
BRIAN C. BECKMAN, inventor (to NASA) (Jet Propulsion Lab., California Inst. of Tech., Pasadena.) 23 Apr. 1993 31 p
(Contract NAS7-918)
(NASA-CASE-NPO-18733-1-CU; NAS 1.71:NPO-18733-1-CU; US-PATENT-APPL-SN-056503) Avail: CASI HC A03/MF A01

A virtual reality flight control system displays to the pilot the image of a scene surrounding a vehicle or pod having six degrees of freedom of acceleration or velocity control by the pilot and traveling through inertial space, the image itself including a superimposed figure providing the pilot an instant reference of orientation consisting of superimposed sets of geometric figures whose relative orientations provide the pilot an instantaneous feel or sense of orientation changes with respect to some fixed coordinate system. They include a first set of geometric figures whose orientations are fixed to the pilot's vehicle and a second set of geometric figures whose orientations are fixed with respect to a fixed or interstellar coordinate system. The first set of figures is a first set of orthogonal great circles about the three orthogonal axes of the flight vehicle or pod and centered at and surrounding the pilot's head, while the second set of figures is a second set of orthogonal great circles about the three orthogonal axes of a fixed or interstellar coordinate system, also centered at and surrounding the pilot's head. NASA

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.

A93-40435
SURGE RECOVERY AND COMPRESSOR WORKING LINE CONTROL USING COMPRESSOR EXIT MACH NUMBER MEASUREMENT
G. J. DADD and M. J. PORTER (Defence Research Agency, Aerospace Div., Farnborough, United Kingdom) Institution of Mechanical Engineers, Proceedings, Part G - Journal of Aerospace Engineering (ISSN 0954-4100) vol. 207, no. G1 1993 p. 27-35. Aerotech 1992, Birmingham, United Kingdom, Jan. 14-17, 1992 *refs*
Copyright

Closed-loop compressor working line controls that act preferentially to suppress surge events offer improvements in both engine performance and simplification of engine fuel systems. This paper outlines aspects of a control strategy, applied to a military turbofan engine, to support these objectives. Compressor exit Mach number feedback was used to maintain steady running lines or limit working points during transients. The control laws used for this are described and engine test results for both low-pressure and high-pressure compression systems are presented which demonstrate effective working point control together with rapid surge detection and recovery. Author

A93-40437* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HYPERSONIC PROPULSION - BREAKING THE THERMAL BARRIER
J. P. WEIDNER (NASA, Langley Research Center, Hampton, VA) Institution of Mechanical Engineers, Proceedings, Part G - Journal of Aerospace Engineering (ISSN 0954-4100) vol. 207, no. G1 1993 p. 47-59. Seminar on 21st, Century Aero Engine Design, Oxford, United Kingdom, May 7, 8, 1992 refs
Copyright

The challenges of hypersonic propulsion impose unique features on the hypersonic vehicle - from large volume requirements to contain cryogenic fuel to airframe-integrated propulsion required to process sufficient quantities of air. Additional challenges exist in the design of the propulsion module that must be capable of efficiently processing air at very high enthalpies, adding and mixing fuel at supersonic speeds and expanding the exhaust products to generate thrust greater than drag. The paper explores the unique challenges of the integrated hypersonic propulsion system, addresses propulsion cycle selection to cope with the severe thermal environment and reviews the direction of propulsion research at hypervelocity speeds. Author

A93-40475
DESIGN DEVELOPMENT FOR ADVANCED GENERAL AVIATION AIRCRAFT. II
Aerospace Engineering (ISSN 0736-2536) vol. 13, no. 5 May 1993 p. 7-11.
Copyright

An account is given of the propulsion system integration-related configurational design optimization for a small, pusher-prop general-aviation aircraft. Attention is given to the design of an engine mounting/support truss structure which is intended to maximize access for maintenance, as well as to various flight-control system arrangements. AIAA

A93-40803
LIFE ANALYSIS OF A GAS TURBINE FAN DISC
TARUN GOSWAMI (Wollongong Univ., Australia) *In* Mechanical behaviour of materials - VI; *Proceedings of the 6th International*

Conference, Kyoto, Japan, July 29-Aug. 2, 1991. Vol. 2 Oxford and Elmsford, NY Pergamon Press 1992 p. 59-65. refs
Copyright

A fan disc was analyzed for life from various laboratory data. A laboratory testing program was planned to generate material data at the representative working conditions of a fan disc. The life analysis was made within the framework of a safe life design, that determines the life prior to the onset of a crack. A safe crack propagation life was also analyzed by carrying out a number of crack growth studies over a set of material conditions. A safe life, that includes initiation and a propagation phases of a crack, has been derived to be 4100 flying hours, based on this analysis and the limiting conditions. Author

A93-41045*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL INVESTIGATION OF SPHERICAL-CONVERGENT-FLAP THRUST-VECTORING TWO-DIMENSIONAL PLUG NOZZLES
DANIEL L. CLER, MARY L. MASON (NASA, Langley Research Center, Hampton, VA), and ANN R. GUTHRIE (Pratt and Whitney Group, West Palm Beach, FL) Jun. 1993 18 p. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 29th, Monterey, CA, June 28-30, 1993 refs
(AIAA PAPER 93-2431) Copyright

An experimental investigation of multiaxis thrust vectoring nozzles with spherical convergent flaps (SCF) and a convertible (in-flight deployable) centerline plug were tested in the NASA-Langley 16-Foot Transonic Tunnel Static Test Facility. Parameters tested during the static test included plug length, external shroud length, shroud internal angle, and yaw vector angle. Results indicated that the SCF convertible-plug nozzle flow is highly three dimensional and characterized by internal flow separation and shock effects. The resultant thrust and discharge coefficient levels were lower than previous wedge nozzle results. In addition, increasing shroud internal angle increased resultant thrust ratio but decreased discharge coefficient. Increasing shroud length increased resultant thrust ratio performance for NPR's greater than 6.0 but for NPR's less than 6.0, resultant thrust ratio decreased as shroud length increased. Increasing plug length caused an increase in resultant thrust ratio and an increase in discharge coefficient. Increasing geometric yaw vector angle had no effect on resultant thrust ratio and little effect on discharge coefficient. Author

A93-41046*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INTERNAL PERFORMANCE CHARACTERISTICS OF VECTORED AXISYMMETRIC EJECTOR NOZZLES
MILTON LAMB (NASA, Langley Research Center, Hampton, VA) Jun. 1993 14 p. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 29th, Monterey, CA, June 28-30, 1993 refs
(AIAA PAPER 93-2432)

A series of vectoring axisymmetric ejector nozzles were designed and experimentally tested for internal performance and pumping characteristics at NASA-Langley Research Center. These ejector nozzles used convergent-divergent nozzles as the primary nozzles. The model geometric variables investigated were primary nozzle throat area, primary nozzle expansion ratio, effective ejector expansion ratio (ratio of shroud exit area to primary nozzle throat area), ratio of minimum ejector area to primary nozzle throat area, ratio of ejector upper slot height to lower slot height (measured on the vertical centerline), and thrust vector angle. The primary nozzle pressure ratio was varied from 2.0 to 10.0 depending upon primary nozzle throat area. The corrected ejector-to-primary nozzle weight-flow ratio was varied from 0 (no secondary flow) to approximately 0.21 (21 percent of primary weight-flow rate) depending on ejector nozzle configuration. In addition to the internal performance and pumping characteristics, static pressures were obtained on the shroud walls. Author

A93-41047*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PREDICTION OF STATIC PERFORMANCE FOR SINGLE EXPANSION RAMP NOZZLES
JOHN R. CARLSON (NASA, Langley Research Center, Hampton, VA) and KHALED S. ABDOL-HAMID (Analytical Services and Materials, Inc., Hampton, VA) Jun. 1993 9 p. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 29th, Monterey, CA, June 28-30, 1993 refs
(AIAA PAPER 93-2571) Copyright

A multiblock three-dimensional Navier-Stokes method was utilized in a two-dimensional fully implicit mode to calculate the flowfield of a single expansion ramp nozzle configuration. The code has been shown previously to be fairly accurate in predicting three-dimensional nozzle flowfields and internal performance for several axisymmetric and nonaxisymmetric geometries. A two-dimensional implementation of the method was used to reduce the resources required to obtain preliminary performance parameters of nozzle concepts. A two-dimensional description of a single-expansion ramp nozzle configuration was analyzed to verify the applicability of the Navier-Stokes code and nozzle performance package to this class of nozzles. Internal static pressure distributions, discharge coefficient and thrust ratio quantities were calculated for a range of operating conditions. Comparisons of predicted performance parameters with experimental data were within 0.5 percent for mass flow, and typically within 1.5 percent for thrust ratio. Author

A93-41400* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THERMAL ANALYSIS OF A SHOWER-HEAD BURNER
MARCO A. EGOAVIL (NASA, Langley Research Center, Hampton, VA) Jul. 1992 13 p. SAE, International Conference on Environmental Systems, 22nd, Seattle, WA, July 13-16, 1992 refs
(SAE PAPER 921226) Copyright

The heat transfer coefficients and convective temperatures around the spray bar of the shower-head burner in the NASA Langley Research Center High Temperature Tunnel are determined. The use of the FLUENT computer code and empirical equations in this effort is described. It is concluded that using the FLUENT code allows higher convective temperatures to be predicted than using experimental data at shutdown conditions. Empirical equations are acceptable for calculation heat-transfer coefficients. AIAA

A93-41740
EXPERIMENTAL INVESTIGATION ON STARTING OF A TURBOJET ENGINE IN FLIGHT
QING ZHU (31st Research Inst., China) and YIHE JIANG (Shenyang Aeroengine Research Inst., China) Journal of Propulsion Technology (ISSN 1001-4055) no. 2 April 1993 p. 28-33. In CHINESE

If an aircraft engine dies out during flight a reliable restarting ability must be provided. In this paper, an experimental technique for restarting a turbojet engine in flight is described. Based on experimental results and measurement data under the windmill conditions, the transient curves of the dynamic parameters and temperature at the restarting process are presented. The experimental results are of practical use in increasing ignition altitude and solving restarting testing problems in flight. Author (revised)

A93-41742
THE EXPERIMENTAL INVESTIGATION OF COMBINATION EFFECT BY USING INJECTION EFFECT OF AEROENGINE JET EXHAUST
DEZHANG LIU, YONG LIU, SUOFANG WANG, and JINGSONG YANG (Nanjing Aeronautical Inst., China) Journal of Propulsion Technology (ISSN 1001-4055) no. 2 April 1993 p. 40-46. In CHINESE

In this paper, the cooling back fuselage structure is investigated by a model experiment in which outside cool air is sucked into

the airplane cabin by the ejection effect of aeroengine jet exhaust. The ejected air will mix with the jet exhaust aft the aircraft tail cup, and the resulting effect on the infrared radiation, noise, and propulsive force of the exhaust is investigated. Author (revised)

A93-41918
INFLUENCE OF STATOR-ROTOR GAP ON AXIAL-TURBINE UNSTEADY FORCING FUNCTIONS
THEODOSIOS KORAKIANITIS (Washington Univ., Saint Louis, MO) AIAA Journal (ISSN 0001-1452) vol. 31, no. 7 July 1993 p. 1256-1264. refs
Copyright

This paper investigates the effects of stator-to-rotor axial gap on the two-dimensional propagation of pressure disturbances due to potential-flow interaction between the blade rows and viscous-wake effects from upstream blade rows in axial-turbine-blade rotor cascades. Results are obtained by modeling the effects of the upstream stator viscous wake and potential flowfield on the downstream rotor flowfield, and computing the unsteady flowfields in the rotor frame. The potential-flowfield is modeled as a sinusoidal pressure disturbance of amplitude 4 percent of the local pressure across the stator trailing edges that decays downstream. The axial gap between rotor and stator is varied to show how the two disturbances propagating in different directions reinforce or counteract each other at different stator-rotor gaps. The corresponding forces on rotor blades are computed for typical values of reduced frequency. Analyses of this type will enable turbomachinery designers to predict (and with geometric design modifications to reduce) the unsteady stresses acting on turbomachinery blades. Author

A93-42372
EFFECT OF GASDYNAMIC PARAMETERS ON THE SPECIFIC WEIGHT OF GAS-TURBINE AIRCRAFT ENGINES [VLIYANIE GAZODINAMICHESKIKH PARAMETROV NA UDEL'NYJ VES AVIATSIONNYKH GAZOTURBINNYKH DVIGATELEJ]
V. F. MISHIN and V. I. CHERNYKH *In* Current methods of selecting the configurations and parameters of flight vehicles Moscow Moskovskij Aviatsionnyj Institut 1990 p. 15-21. In RUSSIAN refs
Copyright

The characteristics of modern turbojet engines of various types are examined. In particular, the effect of the gasdynamic powerplant parameters on the specific weight of the powerplant is analyzed, and expressions are obtained for the specific weight of gas turbine engines as a function of the gasdynamic parameters. These functional dependences can be used for calculating the weight characteristics of powerplants at the preliminary design stage. AIAA

A93-42379
SELECTION OF THE TURBOFAN ENGINE SIZE [VYBOR RAZMERNOSTI TURBOVENTILYATORNOGO DVIGATELYA]
D. V. ZAKHAROV *In* Current methods of selecting the configurations and parameters of flight vehicles Moscow Moskovskij Aviatsionnyj Institut 1990 p. 68-71. In RUSSIAN
Copyright

The use of turbofan engines in subsonic transport aircraft (STA) makes it possible to reduce the specific fuel consumption by about 20 percent, with an increase of 30-35 percent in fuel efficiency. The use of turbofans does not call for any significant changes in STA design, but the transition from bypass engines to turbofans may affect the selection of the engine size and its operating regimes due to the differences in the altitude/velocity and throttle characteristics of the two types of engines. In particular, it is shown that, when designing STA with turbofan engines, the installation of an oversized (in terms of thrust) powerplant may increase the fuel efficiency of the aircraft and improve its takeoff and landing characteristics. AIAA

A93-42380
SELECTION OF THE POWERPLANT FOR A THERMOPLANE [VYBOR TIPA EHNERGETICHESKOJ SILOVOJ USTANOVKI DLYA TERMOPLANA]
YA. B. BYZOV *In* Current methods of selecting the configurations and parameters of flight vehicles Moscow Moskovskij Aviatsionnyj Institut 1990 p. 71-77. In RUSSIAN refs
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The paper is concerned with the problem of selecting the type of powerplant for a 'thermoplane'-type airship, which uses hot air as the ballast gas. In a thermoplane, the power plant provides for the horizontal flight thrust as well as for the heating of air in the ballast volume for vertical maneuvers. An expression is obtained for estimating the mass of the powerplant as a function of the powerplant type, airship volume, and flight velocity and duration. It is shown, in particular that a gas-turbine powerplant is preferred to a piston engine for flights lasting less than 7-8 hr at velocities exceeding a certain boundary velocity. AIAA

A93-42877
RESEARCH ON SUPERSONIC COMBUSTION
F. S. BILLIG (Johns Hopkins Univ., Laurel, MD) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 4 July-Aug. 1993 p. 499-514. AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992, AIAA Paper 92-0001. Previously cited in issue 07, p. 1014, Accession no. A92-22126 refs
Copyright

A93-42878
DEMONSTRATION OF MODE TRANSITION IN A SCRAMJET COMBUSTOR
G. A. SULLINS (Johns Hopkins Univ., Laurel, MD) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 4 July-Aug. 1993 p. 515-520. refs
Copyright

Direct-connect combustor hardware has been assembled to investigate a hydrogen-fueled scramjet combustor. The test hardware was designed to perform tests at simulated Mach 5 to 8 flight conditions. This is done using a combustion heater with H2 fuel and makeup O2. The air, H2 and O2 flow rates are all supplied through computer-controlled digital valves. This system allows rapid changes in conditions, and very steady flow rates can be maintained throughout the test. Tests were performed in which the flow rates were systematically varied in each case to simulate an acceleration from M of 5.9 to 6.2. During this acceleration, the fuel-air equivalence ratio was held constant and the combustor transitioned from a dual mode ramjet with a precombustion shock system creating subsonic flow at the injection plane, to a scramjet with no precombustion shock system. The results of these tests are presented, along with descriptions of the hardware and control systems. Author (revised)

A93-42879
SCRAMJET NOZZLE EXPERIMENT WITH HYPERSONIC EXTERNAL FLOW
SHIGEYA WATANABE (National Aerospace Lab., Chofu, Japan) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 4 July-Aug. 1993 p. 521-528. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference and Exhibit, 28th, Nashville, TN, July 6-8, 1992, AIAA Paper 92-3289. Previously cited in issue 20, p. 3480, Accession no. A92-48878 refs
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A93-42884
SUPERSONIC TURBOMACHINE ROTOR FLUTTER CONTROL BY AERODYNAMIC DETUNING
KAREN M. SPARA and SANFORD FLEETER (Purdue Univ., West Lafayette, IN) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 4 July-Aug. 1993 p. 561-568. AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 25th, Monterey, CA, July 10-13, 1989, AIAA Paper 89-2685. Previously

cited in issue 20, p. 3093, Accession no. A89-47015 refs
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A93-42885
BLADE ROW INTERACTION EFFECTS ON COMPRESSOR MEASUREMENTS
T. SHANG, A. H. EPSTEIN, M. B. GILES (MIT, Cambridge, MA), and A. K. SEHRA (Textron Lycoming, Stratford, CT) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 4 July-Aug. 1993 p. 569-578. Previously announced in STAR as N90-18419 Research supported by Textron Lycoming refs
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The influence of a downstream stator row on the measurement of compressor rotor performance was examined using a computational fluid dynamic code backed by laser anemometry data on a transonic fan stage. The upstream potential influence of the stator causes unsteady circulation about the rotor blades which is a function of the rotor circumferential position. This, in turn, results in a nonuniform circumferential pattern of time averaged temperature and pressure in the stationary frame. An analytical theory relating the temperature and pressure variations to circulation perturbation is presented and shown to give good agreement with the numerical calculations. The results of a parametric study show that the magnitude of this effect is a strong function of rotor-stator blade row spacing and relative blade counts. The effects range from negligible for large spacings typical of high bypass ratio fans to several percent of the stage pressure and temperature rise for closely spaced blade rows typical of high compressors. Because the temperature and pressure perturbations are in spatial phase, the net effect on measured rotor efficiency is negligible so long as the pressure and temperature measurements are made in the same location relative to the stators. If they are not, errors of + or - 1.5 percent can result. The effects of axial position and stator loading are shown to be relatively small. Author

N93-29065*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EFFECTS OF FLOW-PATH VARIATIONS ON INTERNAL REVERSING FLOW IN A TAILPIPE OFFTAKE CONFIGURATION FOR ASTOVL AIRCRAFT
JACK G. MCARDLE and BARBARA S. ESKER Jun. 1993 23 p Presented at the 29th Joint Propulsion Conference and Exhibit, Monterey, CA, 28-30 Jun. 1993; cosponsored by AIAA, SAE, ASME, and ASEE
(Contract RTOP 505-68-32)
(NASA-TM-106149; E-7643; NAS 1.15:106149; AIAA PAPER 93-2438) Avail: CASI HC A03/MF A01

A one-third-scale model of a generic tailpipe offtake system for an advanced short takeoff, vertical landing (ASTOVL) aircraft was tested at the NASA Lewis Research Center Powered Lift Facility. The basic model consisted of a tailpipe with a center body to form an annulus simulating turbine outflow with no swirl; twin offtake ducts with elbows at the ends to turn the flow to a downward direction; flow control nozzles at the ends of the elbows; and a blind flange at the end of the tailpipe to simulate a closed cruise nozzle. The offtake duct-to-tailpipe diameter ratio was 0.74. Modifications of a generic nature were then made to this basic configuration to measure the effects of flow-path changes on the flow and pressure-loss characteristics. The modifications included adding rounded entrances at the forward edges of the offtake openings, blocking the tailpipe just aft the openings instead of at the cruise nozzle, changing the location of the openings along the tailpipe, removing the center body, and varying the Mach number (flow rate) over a wide range in the tailpipe ahead of the openings by changing the size of the flow control nozzles. The tests were made with unheated air at tailpipe-to-ambient pressure ratios from 1.4 to 5. Results are presented and compared with performance graphs, total-pressure contour plots, paint streak flow visualization photographs, and a flow-angle probe traverse at the offtake entrance. Derived from text

N93-29072*# Ohio Aerospace Inst., Brook Park.
THREE-DIMENSIONAL NUMERICAL SIMULATION OF GRADUAL OPENING IN A WAVE ROTOR PASSAGE
LOUIS M. LAROSILIERE Jun. 1993 23 p Presented at the 29th Joint Propulsion Conference and Exhibit, Monterey, CA, 28-30 Jun. 1993; sponsored by AIAA, SAE, ASME, and ASEE Original contains color illustrations
(Contract NCC3-208; RTOP 505-62-10)
(NASA-CR-191157; E-7957; NAS 1.26:191157; AIAA PAPER 93-2526) Avail: CASI HC A03/MF A01; 10 functional color pages

The evolution of the contact interface and the propagation of compression waves inside a single wave rotor passage gradually opening to and traversing an inlet port is studied numerically using an inviscid formulation of the governing equations. Insights into the response of the interface and kinematics of the flow field to various opening times are given. Since the opening time is inversely proportional to the rotational speed of the rotor, the effects of passage rotation such as centripetal and Coriolis accelerations are intrinsically coupled to the gradual opening process. Certain three-dimensional features associated with the gradual opening process as a result of centripetal and Coriolis accelerations are illustrated. For the range of opening times or rotational speeds considered, a portion of the interface behaves like a vortex sheet that can degenerate into a complex interfacial structure. The vortices produced along the interface can serve as a stirring mechanism to promote local mixing. Coriolis and centripetal accelerations can introduce three dimensional effects such as interfacial distortions in meridional planes and spanwise migration of fluid elements. Author

N93-29162*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE 3-D VISCOUS FLOW CFD ANALYSIS OF THE PROPELLER EFFECT ON AN ADVANCED DUCTED PROPELLER SUBSONIC INLET
CHANTHY IEK, DONALD R. BOLDMAN, and MOUNIR IBRAHIM (Cleveland State Univ., OH.) Jun. 1993 41 p Presented at the 29th Joint Propulsion Conference and Exhibit, Monterey, CA, 28-30 Jun. 1993; sponsored by AIAA, SAE, ASME, and ASEE Original contains color illustrations
(Contract RTOP 505-03-10)
(NASA-TM-106240; E-7958; NAS 1.15:106240; AIAA PAPER 93-1847) Avail: CASI HC A03/MF A01; 14 functional color pages

A time marching Navier-Stokes code called PARC3D was used to study the 3-D viscous flow associated with an advanced ducted propeller (ADP) subsonic inlet at take-off operating conditions. At a free stream Mach number of 0.2, experimental data for the inlet-with-propeller test model indicated that the airflow was attached on the cowl windward lip at an angle of attack of 25 degrees became unstable at 29 degrees, and separated at 30 degrees. An experimental study with a similar inlet and with no propeller (through-flow) indicated that flow separation occurred at an angle of attack a few degrees below the value observed when the inlet was tested with the propeller. This tends to indicate that the propeller exerts a favorable effect on the inlet performance. During the through-flow experiment a stationary blockage device was used to successfully simulate the propeller effect on the inlet flow field at angles of attack. In the present numerical study, this flow blockage was modeled via a PARC3D computational boundary condition (BC) called the screen BC. The principle formulation of this BC was based on the one-and-half dimension actuator disk theory. This screen BC was applied at the inlet propeller face station of the computational grid. Numerical results were obtained with and without the screen BC. The application of the screen BC in this numerical study provided results which are similar to the results of past experimental efforts in which either the blockage device or the propeller was used. Author (revised)

N93-29926# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Propulsion and Energetics Panel.

HEAT TRANSFER AND COOLING IN GAS TURBINES [LE TRANSFERT THERMIQUE ET LE REFROIDISSEMENT DANS LES TURBINES A GAZ]

Feb. 1993 492 p 80th Symposium held in Antalya, Turkey, 12-16 Oct. 1992

(AGARD-CP-527; ISBN-92-835-0701-0) Copyright Avail: CASI HC A21/MF A04

The symposium was arranged in the following sessions: turbine blades--external heat transfer; turbine blades--internal heat transfer; measurement techniques; rotating disks, labyrinth seals, and shafts; combustors; design, interactions; and prediction methods. Heat transfer and cooling in gas turbines are still key factors for achieving high performance, increased life, and improved reliability. Any progress in this field will lead to a reduction of maintenance cost and fuel consumption. The purpose of the symposium was to bring together experts from industry, research establishments, and universities to discuss fundamental and applied heat transfer problems relevant to gas turbines, to exchange practical experience gained, and to review the state of the art.

N93-29927# Rensselaer Polytechnic Inst., Troy, NY.

KEYNOTE ADDRESS: UNSTEADY, MULTIMODE TRANSITION IN GAS TURBINE ENGINES

ROBERT E. MAYLE *In* AGARD, Heat Transfer and Cooling in Gas Turbines 7 p Feb. 1993

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A theory for unsteady, multimode transition on gas turbine airfoils is presented. The theory, which provides a correction to the Mayle-Dullenkopf multimode model, considers a more physically correct viewpoint by taking into account the periodic disturbance caused by both the wake-induced turbulent strips and the 'becalmed' flow following them. In addition, a comparison of the theory with data is provided, which shows excellent agreement, and results illustrating the effects of transition onset distance and wake-passing Strouhal number on multimode transition are presented. Derived from text

N93-29928# Defence Research Agency, Farnborough (England). Aerodynamics and Propulsion Dept.

HEAT TRANSFER AND AERODYNAMICS OF A 3D DESIGN NOZZLE GUIDE VANE TESTED IN THE PYESTOCK ISENTROPIC LIGHT PISTON FACILITY

K. S. CHANA *In* AGARD, Heat Transfer and Cooling in Gas Turbines 11 p Feb. 1993

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In HP turbines, predictions of the heat transfer to the blade and endwalls is particularly important for an accurate assessment of turbine component life. On the endwalls, there are often complex 3D (secondary) flows present which make predictions of heat transfer particularly difficult. A detailed investigation of this area has been carried out on a fully annular cascade of highly 3D nozzle guide vanes. Measurements were made on the vane and endwalls to determine heat transfer and aerodynamic characteristics. Testing was conducted in a short duration Isentropic Light Piston Test Facility, at engine representative Reynolds number, Mach number, and gas-to-wall temperature ratio. Interpreted test data are compared with computations obtained at test conditions. Author (revised)

N93-29929# Minnesota Univ., Minneapolis. Dept. of Mechanical Engineering.

VORTEX STRUCTURE AND MASS TRANSFER NEAR THE BASE OF A CYLINDER AND A TURBINE BLADE

M. Y. JABBARI and R. J. GOLDSTEIN *In* AGARD, Heat Transfer and Cooling in Gas Turbines 14 p Feb. 1993 Sponsored in part by AFOSR

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Results of naphthalene sublimation measurements and flow visualization studies near the base of round and a square cylinder mounted on a flat plate are compared with similar measurements in the endwall region of a turbine blade. Differences and similarities of the flow and mass transfer are discussed. Samples of mass transfer distribution and visualization results in the region are provided. Supported by the sublimation and the flow visualization results models for the vortex structure in the flow are suggested. Derived from text

N93-29930# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).

THERMAL EFFECTS OF A COOLANT FILM ALONG THE SUCTION SIDE OF A HIGH PRESSURE TURBINE NOZZLE GUIDE VANE

T. ARTS and I. LAPIDUS (Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Villaroche, France.) *In* AGARD, Heat Transfer and Cooling in Gas Turbines 8 p Feb. 1993 Sponsored in part by SNECMA

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The purpose is to try to describe some of the influences on external convective heat transfer of a coolant film whose position varies along the suction side of a high pressure turbine nozzle guide vane. The measurements were performed in the short duration Isentropic Light Piston Compression Tube Facility CT-2 of the von Karman Institute. The effects of external and internal flow are considered in terms of Mach number, Reynolds number, freestream turbulence intensity, blowing rate, and coolant to freestream temperature ratio. The way to evaluate those results in terms of heat transfer coefficient is finally discussed. Author (revised)

N93-29931# Poitiers Univ. (France). Lab. d'Etudes Aerodynamiques.

EXPERIMENTAL STUDY OF HEAT TRANSFER CLOSE TO A PLANE WALL HEATED IN THE PRESENCE OF MULTIPLE INJECTIONS (SUBSONIC FLOW) [ETUDE EXPERIMENTALE DU TRANSFERT DE CHALEUR PRES D'UNE PAROI PLANE CHAUFFEE EN PRESENCE D'INJECTIONS MULTIPLES (ECOULEMENT SUBSONIQUE)]

E. FOUCAULT, P. DENIBOIRE, J.-L. BOUSGARBIES, J.-J. VULLIERME, and E. DORIGNAC *In* AGARD, Heat Transfer and Cooling in Gas Turbines 10 p Feb. 1993 In FRENCH

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The results of a detailed experimental study of the aerodynamic and thermic fields within the boundary layer of a plane wall heated in the presence of localized injections of hot air are presented. For two values of the ratio of jet speed/main flow (0.6 and 1.6) the three components of the flight path vector and the local temperature of the flow are measured in many positions, respectively by Doppler laser anemometry using a cold probe wire. A map of the temperature of the plane wall is obtained by means of an infrared camera. The results show the strongly 3D aspect of the flow downstream from the jet which is dominated by the presence of swirling structures. These last areas generate strong rates of turbulence and have a great influence on the temperature field in the wake of the jets. For the largest of the two speed ratios considered, the cross-flow penetrates under the jets downstream from the injection openings and thus, is in opposition to the heat transfer. Author (revised)

N93-29932# Massachusetts Inst. of Tech., Cambridge. Gas Turbine Lab.

THE INFLUENCE OF NON-UNIFORM SPANWISE INLET TEMPERATURE ON TURBINE ROTOR HEAT TRANSFER

G. R. GUENETTE, G. PAPPAS, and A. H. EPSTEIN *In* AGARD, Heat Transfer and Cooling in Gas Turbines 10 p Feb. 1993 Sponsored in part by Rolls-Royce, Inc.

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The influence of a spanwise varying, circumferentially uniform inlet total temperature distortion was measured on a transonic turbine stage in a short duration turbine test facility. Large levels of distortion were found to increase rotor blade heat transfer, especially on the pressure surface. A three-dimensional, steady, multi-blade row, Euler code and a streamline curvature calculation

were used to interpret the data but did not account for all of the heat transfer increase observed. Author (revised)

N93-29933# Naval Air Warfare Center, Trenton, NJ. Aircraft Div.

DETERMINATION OF SURFACE HEAT TRANSFER AND FILM COOLING EFFECTIVENESS IN UNSTEADY WAKE FLOW CONDITIONS

M. SAUTNER, S. CLOUSER, and J. C. HAN (Texas A&M Univ., College Station.) *In* AGARD, Heat Transfer and Cooling in Gas Turbines 12 p Feb. 1993

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The effect of unsteady wake flows on blade heat transfer and film cooling effectiveness was experimentally determined by using a spoked-wheel type wake generator. The experiments were performed with a five airfoil linear cascade at the Texas A&M University low speed wind tunnel facility. The mainstream Reynolds number based on airfoil chord length was about 3 x 10 exp 5. The wake Strouhal number was varied between 0 and 0.4 by changing the rotating wake passing frequency. A hot wire anemometer system was located at the cascade inlet to detect the instantaneous velocity, phase-averaged mean velocity, and turbulence intensity induced by the passing wake. A pressure tap instrumented blade was used to measure the surface static pressure distributions and compared well with predicted velocity distributions in the cascade. An instrumented blade without film holes equipped with a thin foil thermocouple was used to determine the surface heat transfer coefficient distributions. The results show that the periodically passing wake promotes earlier boundary layer transition, causing much higher heat transfer on the suction surface. The passing wake also significantly enhances the heat transfer on the pressure surface. The other thin foil thermocouple instrumented blade contained several rows of film cooling holes at the stagnation region and on both the suction and pressure surfaces, and was employed to determine the film cooling effectiveness distributions. The results show that the strong passing wake interacts with the film layer and causes a relatively lower film effectiveness on both the suction and pressure surfaces for all three blowing ratios studied (M = 0.4, 0.8, and 1.2).

Derived from text

N93-29934# Oxford Univ. (England). Dept. of Engineering Science.

MEASUREMENT OF TURBULENT SPOTS AND INTERMITTENCY MODELLING AT GAS-TURBINE CONDITIONS

J. P. CLARK, J. E. LAGRAFF (Syracuse Univ., NY.), P. J. MAGARI, and T. V. JONES *In* AGARD, Heat Transfer and Cooling in Gas Turbines 14 p Feb. 1993

(Contract F49620-92-J-0079; AF-AFOSR-0427-89)

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Measurements have been made of instantaneous heat-transfer rates to a flat-plate surface under a transitional boundary layer. The thin-film surface instrumentation used in the study was capable of time-resolving the effects of changes in the heat-transfer rate within an accuracy of 10 microseconds. The tests were conducted in the Oxford University 6 inch Isentropic Light-Piston Tunnel (ILPT) under simulated gas turbine Reynolds numbers, Mach numbers, gas-to-wall temperature ratios, and pressure gradients. The ability to observe and track the end stage of the transition process (i.e., turbulent spots) in a laminar boundary layer undergoing transition allowed turbulent-spot convection speeds and spreading angles to be estimated. In these tests, the important fluid-dynamic parameters of Mach number, Reynolds number, and streamwise pressure gradient were varied independently over a wide range of values characteristic of those encountered in the turbine environment. Using quantitative values of the measured turbulent-spot characteristics, a simple time-marching code was developed based on Emmons' turbulent-spot theory to estimate the intermittency. Derived from text

N93-29938# Manchester Coll. of Science and Technology (England).

TURBULENT FLOW AND HEAT TRANSFER IN IDEALIZED BLADE COOLING PASSAGES

T. BO and B. E. LAUNDER *In* AGARD, Heat Transfer and Cooling in Gas Turbines 16 p Feb. 1993 Sponsored in part by Ministry of Defence and Rolls-Royce Ltd.

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The paper brings together recent research at UMIST directed at the prediction of flow through tight, square sectioned U-bends rotating in orthogonal mode. The cases of flow through rotating straight ducts and stationary U-bends are considered first to allow comparison with experimental data; finally, having demonstrated the level of accord achieved with experiment, predictions for the rotating U-bend are provided. A fairly simple turbulence model was adopted with the usual high Reynolds number k-epsilon model being interfaced with a 1-equation near-wall model. To achieve, in the case of the U-bend, grid independent behavior with the available computer core, a bounded third-order discretization of convective transport had to be applied to all dependent variables. The agreement with the available experimental data is broadly satisfactory in the case of the rotating straight duct (the substantial modifications to the Nusselt number on the pressure and suction faces of the duct due to Coriolis and buoyant forces being well reproduced. Agreement is less complete in the case of the U-bend but even so, the predicted levels of Nusselt number and the distribution of velocity downstream of the bend are broadly in line with experiment. The results point to the desirability of incorporating second-moment closure into the bend-flow calculations as models of this type have a track record of capturing the sensitivity of the turbulent stresses to complex strains better than the eddy viscosity model adopted here. Author (revised)

N93-29939# Fiat Aviazione S.p.A., Turin (Italy).

COOLING GEOMETRY OPTIMIZATION USING LIQUID CRYSTAL TECHNIQUE

G. LODIGIANI, A. TROVATI, L. PACI, and P. PIRRELLI (Elasis S.C.p.A., Brindisi, Italy.) *In* AGARD, Heat Transfer and Cooling in Gas Turbines 12 p Feb. 1993

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Experimental results concerning the cooling performance of jet engine blading internal passages are presented. Use was made of the Liquid Crystal Transient Technique in order to obtain detailed information about heat transfer coefficients on the internal blade surfaces in presence of turbulence promoters. A peculiar behavior of the cooling channels with turbulators was detected, which reduces the expected heat transfer effectiveness. Heat transfer experimental results, reproducing actual engine operating conditions, were employed to predict the blade metal temperature: cooling flow parameters and internal channel characteristics were therefore tuned in order to attain a suitable metal temperature distribution, and to optimize the cooling effectiveness. The outcome of experimental and calculation work was then compared to the engine test blade surface temperature distribution, obtained by means of thermal paints. The comparison showed fairly good agreement, demonstrating once more the usefulness of the Liquid Crystal Transient Technique in allowing designers to improve present blade cooling devices. Author (revised)

N93-29943*# Arizona State Univ., Tempe. Dept. of Mechanical and Aerospace Engineering.

LOCAL HEAT TRANSFER MEASUREMENT WITH LIQUID CRYSTALS ON ROTATING SURFACES INCLUDING NON-AXISYMMETRIC CASES

D. E. METZGER and Y. K. KIM *In* AGARD, Heat Transfer and Cooling in Gas Turbines 11 p Feb. 1993 Sponsored by NASA. Marshall Space Flight Center and Rockwell International Corp.

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An overview and summary of test methods and results are given for the problem of measuring local heat transfer on rotating surfaces that model gas turbine engine disks. Disk cavity situations generically similar to those encountered in the high pressure stage

disk cooling are considered, with cooling air supplied both at or near the wheel centerline as well as through single or multiple jets impinging outboard on the wheel near the blade attachment region. In some situations provision has been made for ingestion into the disk-cavity from the gas path region radially outboard of the disk. Local heat transfer rates in all cases are determined from the color display from a thin coating of encapsulated liquid crystals sprayed onto the disk, in conjunction with use of a video camera and computer vision system. For cases with axisymmetric disk surfaces, the coated surfaces are illuminated and viewed continuously, and detailed radial distributions of local Nusselt number are obtained. For non-axisymmetric disk surfaces, such as encountered in the vicinity of bolt heads, the disk is illuminated with stroboscopic light, and a method has been developed and used to synchronize the computer frame grabber with the illumination. Author (revised)

N93-29946# Motoren- und Turbinen-Union Muenchen G.m.b.H. (Germany).
TRANSIENT THERMAL BEHAVIOUR OF A COMPRESSOR ROTOR WITH AXIAL COOLING AIR FLOW AND CO-ROTATING OR CONTRA-ROTATING SHAFT
C. BURKHARDT, A. MAYER, and E. REILE *In* AGARD, Heat Transfer and Cooling in Gas Turbines 9 p Feb. 1993
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Heat transfer measurements were made in a five-cavity compressor drum rig, in which cooling air passed axially through the center of the discs. The rig also contained a central drive shaft which could be either co- or contrarotated. Tests were conducted for different mass flow rates, rotational speeds and air temperatures. Typical engine conditions for steady state and transient operating conditions were simulated. Local Nusselt numbers were obtained for the discs of one cavity and compared with other published results. Furthermore an investigation into the effect of co- and contrarotating shaft on the surface temperatures of the discs and on the Nusselt number distribution was also carried out. It was found that the direction of rotation and speed of the shaft influenced the disc temperatures as well as the Nusselt numbers. Author

N93-29947# Office National d'Etudes et de Recherches Aerospatiales, Bagneux (France). Direction de l'Energetique.
AEROTHERMIC CALCULATIONS OF FLOWS IN INTERDISC CAVITIES OF TURBINES [CALCULS AEROTHERMIQUES D'ECOULEMENTS DANS DES CAVITES INTERDISQUES DE TURBINES]
D. DUTOYA and P. PONCELINDERAUCOURT (Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Moissy-Cramayel, France.) *In* AGARD, Heat Transfer and Cooling in Gas Turbines 9 p Feb. 1993 In FRENCH
Copyright Avail: CASI HC A02/MF A04

The operating temperatures of turboshaft engines oblige the manufacturers to cool the parts of the engine located downstream from the combustion chamber and in particular the turbines. Knowledge of the air flow in the air ventilation paths is essential to optimize the cooling of the engines. In order to precisely determine the phenomena of heat exchanges and the aerodynamic forces on the walls of complex cavities, SNECMA uses the MATHILDA code developed with ONERA. The MATHILDA code solves the three dimensional Navier-Stokes equations for flows of compressible fluid. The equations are treated using a finite volume method accomplished on a mesh structure. The resolution scheme is decentered by the order of 2. An implicit method of the ADI type makes it possible to stabilize and accelerate the calculation. This article presents the work of the validation of the MATHILDA code for applications to the flows in interdisc cavities. The cases presented were studied by the implementation of the axisymmetric two-dimensional version. Two types of experimental cavities served as the validations, rotor/stator cavities and rotor/rotor cavities. The solutions obtained, compared with the experimental measurements, are satisfactory, from an aerodynamic point of view and a thermal point of view. The last calculation, on a real configuration of the internal cavity of the engine, makes it possible to apprehend the difficulties encountered in the implementation of this type of modeling, and to measure the contribution of the code solving the Navier-Stokes equations to the description of the cooling flows. Transl. by FLS

N93-29949# Rolls-Royce Ltd., Derby (England).
MODELLING THERMAL BEHAVIOUR OF TURBOMACHINERY DISCS AND CASINGS
R. D. MONICO and J. W. CHEW *In* AGARD, Heat Transfer and Cooling in Gas Turbines 10 p Feb. 1993
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The thermal behavior of discs and casings in gas turbine engines has important effects on engine performance and integrity and theoretical or computer modelling of these effects is an essential part of the design process. In this paper the current status of thermal modelling is reviewed, problem areas are identified, examples of where application of the latest numerical and modelling techniques have led to improvements are given, and prospects for further developments are discussed. It is concluded that, although recent research and computing advances are improving the predictive capability, considerable scope for further improvement remains. Author

N93-29950# Bath Univ. (England). School of Mechanical Engineering.
FLOW AND HEAT TRANSFER BETWEEN GAS-TURBINE DISCS
X. GAN, M. KILIC, and J. M. OWEN *In* AGARD, Heat Transfer and Cooling in Gas Turbines 11 p Feb. 1993 Sponsored in part by Ministry of Defence and Science Research Council
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The paper provides both a brief review of some recent research into the flow and heat transfer associated with the turbine and compressor discs of gas turbine engines and some new results for flow between contra-rotating turbine discs. Elliptic solvers, parabolic solvers and integral methods have all been applied successfully to some important axisymmetric boundary-layer-dominated flows, and multigrid elliptic solvers used in conjunction with parallel computers offer great promise for the future computation of nonaxisymmetric flows. LDA velocity measurements and computations have given fresh insight into the flow between contra-rotating turbine discs. Batchelor-type flow, in which there are boundary layers on the discs and a shear layer in the midplane, has been computed for laminar flow but has not been observed in practice, even at local rotational Reynolds numbers as low as 2.2 x 10(exp 4). The actual flow structure comprised radial outflow in boundary layers on the discs and a central core of radial inflow in which rotational effects were weak. Although the flow in the core was always turbulent, the flow in the boundary layers was laminar for rotational Reynolds numbers up to at least 1.2 x 10(exp 5). Agreement between the computed turbulent velocities and the measured values was good for Reynolds numbers above 4.5 x 10(exp 5). Author (revised)

N93-29951# Karlsruhe Univ. (Germany). Lehrstuhl und Inst. fuer Thermische Stroemungsmaschinen.
HEAT TRANSFER AND LEAKAGE IN HIGH-SPEED ROTATING STEPPED LABYRINTH SEALS
W. WASCHKA, S. WITTIG, S. KIM, and T. SCHERER *In* AGARD, Heat Transfer and Cooling in Gas Turbines 10 p Feb. 1993
Copyright Avail: CASI HC A02/MF A04

A new experimental and numerical research program was conducted to determine the effects of rotation on the leakage loss and the heat transfer coefficients of compressible flows in modern high performance labyrinth seals. In this study, the interest is focused on divergent shaped stepped labyrinth seals. That type of labyrinth seal is the last one within a row of different labyrinth seals, investigated at the University of Karlsruhe: straight-through, staggered labyrinth seals and convergent shaped stepped labyrinth seals have been the other geometries. For heat transfer and leakage loss measurements our high temperature test facility was used, providing realistic conditions of gas temperatures, pressure ratios as well as a wide range of axial and peripheral Reynolds

numbers. In addition, numerical codes have been verified by experimentally obtained data. Heat transfer coefficients for the stator and the rotor are derived utilizing the well-known standard k-epsilon model and the Stanton-analogy. This report discusses some new rotational effects, which are significant for the divergent shaped seal. In addition, these results are compared with those obtained from our other seal geometries studied.
Author (revised)

N93-29957# Alfa Romeo S.p.A., Naples (Italy). Research and Development.
AERO-THERMAL DESIGN OF A COOLED TRANSONIC NGV AND COMPARISON WITH EXPERIMENTAL RESULTS
S. COLANTUONI, A. COLELLA, L. DINOLA, D. CARBONE, and D. MAROTTA *In* AGARD, Heat Transfer and Cooling in Gas Turbines 25 p Feb. 1993
Copyright Avail: CASI HC A03/MF A04

The aerothermal design process applied to a Nozzle Guide Vane of a gas-generator axial-flow turbine for a compact advanced technology core engine is described. The principal characteristics of the NGV are: Overall Tip Radius, 108.8 mm; Blade height, 19.7 mm; Blade aspect ratio, 0.53; Solidity, 1.37; Mean Exit isentropic Mach Number, 0.95; Inlet Temperature, 1450K. The NGV is cooled by a combination of different solutions, like impingement cooling and film-cooling on the front side, and forced convection on the rear side, followed by a cooling ejection at pressure side near the trailing edge. Representative results of the computational fluid-dynamics and of the thermal analysis of the NGV blade, together with some experimental data obtained from component test rig and engine demonstrator are presented and discussed.
Author (revised)

N93-29958# *ABB Power Generation, Inc., Baden (Switzerland).*
THE AERODYNAMIC EFFECT OF COOLANT EJECTION IN THE LEADING EDGE REGION OF A FILM-COOLED TURBINE BLADE
A. BEECK, L. FOTTNER (Munich FAF Univ., Neubiberg, Germany.), E. BENZ (Karlsruhe Univ., Germany.), and S. WITTIG (Karlsruhe Univ., Germany.) *In* AGARD, Heat Transfer and Cooling in Gas Turbines 10 p Feb. 1993 Sponsored in part by Bundesministerium der Verteidigung
Copyright Avail: CASI HC A02/MF A04

Air ejection for film-cooling affects the aerodynamic behavior of the blading by the mixing of the coolant with the mainstream as well as by the interaction between the jet and the boundary layer. The main objective is to receive more information on the flow field in the leading edge region. The focus is the aerodynamic behavior of ejection in the stagnation region. A Navier-Stokes code was used to evaluate the flow field considering the ejection. The calculated results are compared with experimental investigations. Cold gas experiments were conducted in a cascade wind tunnel on three large scaled turbine blades with slotted leading edges. The mass flux ratio was varied from 0.0 to 2.5 to simulate film cooling effects. A high resolution of the flow field especially close to the wall (nearest distance: 50 microns) was achieved by Laser-2-Focus measurements. The pressure distributions on the blade surface and in the wake were measured in order to determine the overall behavior of the blades quantitatively while oil flow patterns and Schlieren pictures provide qualitative results. The experimental results show that the strong pressure gradient near the stagnation point affects the velocity distribution of the jets. This non-uniformity produces additional aerodynamic losses. To take these effects into account for the Navier-Stokes calculation a multi-block grid was used to model the flow field in the ejection holes and in the mainstream. Thus, the experimental and numerical results show a good agreement. Author (revised)

N93-29960# Centre National de la Recherche Scientifique, Ecully (France). Lab. de Mecanique des Fluides et d'Acoustique.
MODELING OF A TURBULENT FLOW IN THE PRESENCE OF DISCRETE PARIETAL COOLING JETS [MODELISATION D'UN ECOULEMENT TURBULENT EN PRESENCE DE JETS PARIETAUX DISCRETS DE REFROIDISSEMENT]
J. M. MAURICE, F. LEBOEUF, and P. KULISA *In* AGARD, Heat Transfer and Cooling in Gas Turbines 13 p Feb. 1993 In FRENCH
Copyright Avail: CASI HC A03/MF A04

The high temperature level reached in the first turbine stages requires efficient blade cooling. Film cooling has proved its ability to protect the wall from the hot upstream flow. However, the jets strongly disturb the aerodynamic flow characteristics. As a consequence, the main objective of the designers is to get the best compromise between thermal strains and aerodynamic losses. A two-dimensional viscous flow model, with discrete jets and based on a boundary layer concept, was developed at Ecole Centrale de Lyon. The turbulence closure was first performed by a mixing length model. A low Reynolds number version of a k-epsilon model is presented. A space averaging method in the transverse direction is used; thereby the two-dimensional character of the computation is preserved, while the specific effects of the discrete jets are taking into account in the model. Comparisons with experimental results are given in the case of a row of jets, as injected through a turbulent boundary layer on a flat plate, near the injection orifice. Author (revised)

N93-29961# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Cologne (Germany). Inst. fuer Antriebstechnik.
COUPLING OF 3D-NAVIER-STOKES EXTERNAL FLOW CALCULATIONS AND INTERNAL 3D-HEAT CONDUCTION CALCULATIONS FOR COOLED TURBINE BLADES
A. HESELHAUS, D. T. VOGEL, and H. KRAIN *In* AGARD, Heat Transfer and Cooling in Gas Turbines 9 p Feb. 1993
Copyright Avail: CASI HC A02/MF A04

The problem of cooled gas turbine blades is theoretically investigated. The presented code solves the 3D-Reynolds *averaged-Navier-Stokes equations for the external passage flow* and the 3D-heat conduction equation for the interior of the blade. Both calculation schemes are coupled without any modeling of the heat transfer boundary conditions at the blade surface. Calculations are presented for a thin hollow flat plate and a typical guide vane blade with a simple cooling channel configuration. Both geometries are cooled by prescribing fixed heat transfer boundary conditions at the inner boundaries. Additionally numerical results are compared to analytical data. The agreement is quite satisfactory. Author (revised)

N93-29962# Politecnico di Milano (Italy). Dipt. di Energetica.
A NAVIER-STOKES SOLVER WITH DIFFERENT TURBULENCE MODELS APPLIED TO FILM-COOLED TURBINE CASCADES
F. BASSI, S. REBAY, M. SAVINI (National Center for Energetics and Propulsion, Peschiera Borromeo, Italy.), S. COLANTUONI (Alfa Romeo S.p.A., Naples, Italy.), and G. SANTORIELLO (Alfa Romeo S.p.A., Naples, Italy.) *In* AGARD, Heat Transfer and Cooling in Gas Turbines 16 p Feb. 1993
Copyright Avail: CASI HC A03/MF A04

The numerical simulation of transonic flows through film-cooled turbine cascades is described. The modelization of coolant injection was implemented in a computational code which solves either the laminar or the Reynolds-averaged Navier-Stokes equations in cascades. Turbulence effects are accounted for by means of the eddy viscosity concept. Two turbulence models were implemented in the code. The first is the Baldwin-Lomax algebraic model and the second is the two-equation k-omega model proposed by Wilcox. Both models were coupled with a Navier-Stokes solver in a simple, robust, and efficient way. The numerical solution of both the flow and the turbulence model equations is based on a cell centered finite volume scheme and on an explicit Runge-Kutta method for time integration. The code was applied to compute the transonic flow in a cascade of nozzle guide vanes (NGV's) developed by Alfa Romeo Avio S.p.A. The computations were performed both for a cascade of 'solid' vane profiles and for a cascade of 'cutted' vane profiles that allow coolant flow ejection through a slot on the pressure side near the trailing edge. The NGV cascade is still under testing and at present only the experimental data for the 'solid' NGV cascade are available for code validation. The computational results presented show that the proposed coupling

of the k-omega model with the explicit Navier-Stokes solver does not seem to suffer from the stiffness problems often characterizing other two-equation turbulence models. Author (revised)

N93-29963*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NAVIER-STOKES ANALYSIS OF THREE-DIMENSIONAL FLOW AND HEAT TRANSFER INSIDE TURBINE BLADE ROWS
C. HAH *In* AGARD, Heat Transfer and Cooling in Gas Turbines 11 p Feb. 1993
Copyright Avail: CASI HC A03/MF A04

A numerical method for solving the three-dimensional, Navier-Stokes equations for unsteady, viscous flow and heat transfer through multiple turbomachinery blade rows is presented. The method solves the fully three-dimensional Navier-Stokes equations with an implicit scheme which is based on a control volume approach. A two-equation turbulence model with a low Reynolds number modification is employed. A third-order accurate upwinding scheme is used to approximate convection terms while a second order accurate central difference scheme is used for the discretization of viscous terms. A second-order accurate scheme is employed for the temporal discretization. The numerical method is applied to study the unsteady flow and heat transfer field of the High Pressure Fuel side Turbo-Pump (HPFTP) of the Space Shuttle Main Engine (SSME). The stage calculation is performed by coupling the stator and the rotor flow fields at each time step through an over-laid grid. Numerical results for the complete geometry with the vane trailing edge cutback are presented and compared with the available experimental data. Author (revised)

N93-29964# Sener Ingenieria y Sistemas S.A., Madrid (Spain).
COOLING PREDICTIONS IN TURBOFAN ENGINE COMPONENTS
A. MATESANZ, R. REBOLO, A. VIEDMA (Universidad Politecnica de Madrid, Spain.), and M. RODRIGUEZ (Universidad Politecnica de Madrid, Spain.) *In* AGARD, Heat Transfer and Cooling in Gas Turbines 7 p Feb. 1993
Copyright Avail: CASI HC A02/MF A04

How the metal temperature measured in a convergent divergent nozzle and in a turbine exhaust diffuser of a turbofan engine can be predicted with reasonable approximation using the data available in the open literature is shown. It is shown how the simplified fluid dynamic equations with the appropriate experimental correlation allow the prediction of these results in other flight conditions than those tested. Author (revised)

N93-29999# ABB Kraftwerke A.G., Manheim (Germany). Abt. Gasturbinenentwicklung.
OPTICAL BLADE VIBRATION MEASUREMENT Final Report [OPTISCHE SCHAUFELSCHWINGUNGSMESSUNG. SCHLUSSBERICHT]
CHRISTIAN WUETHRICH, ERNST-MICHAEL ZUEFLE, and LARS HILLSTROEM Jun. 1992 85 p In GERMAN
(Contract BMFT-0326800D)
(ETN-93-93454) Avail: CASI HC A05/MF A01

A theoretical analysis of the optical method for blade vibration measurements with special emphasis on multiprobe systems (more than two probes) was performed. On the basis of a theoretical model, guidelines for the optimization of the experimental setup and for the analysis of experimental errors are given. Test calculations show that the blade vibrations can be reliably detected even in the presence of disturbances. In multiprobe systems, equidistant arrangements of the probes on the circumference of the rotor are preferred. For this case, robust evaluation algorithms are presented. It is shown that blade vibrations can be analyzed not only for static but also for fast transient excitations using the optical system. ESA

N93-30168# Oak Ridge National Lab., TN.
CHARACTERIZATION OF CERAMIC COMPOSITE MATERIALS FOR GAS TURBINE APPLICATIONS
K. REIFSNIDER (Virginia Polytechnic Inst. and State Univ., Blacksburg.), W. STINCHCOMB (Virginia Polytechnic Inst. and State Univ., Blacksburg.), K. LIAO (Virginia Polytechnic Inst. and State Univ., Blacksburg.), L. OLEKSUK (Virginia Polytechnic Inst. and State Univ., Blacksburg.), and D. STINTON 1993 7 p Presented at the 38th ASME International Gas Turbine and Aeroengine Congress and Exhibition, Cincinnati, OH, 24-27 May 1993
(Contract DE-AC05-84OR-21400)
(DE93-009719; CONF-930502-6) Avail: CASI HC A02/MF A01

Ceramic composite materials have the capability to sustain high stress in the presence of high temperatures and aggressive atmospheres. Such materials are being considered for application as combustors, burner cubes, heat exchangers, headers. hot-gas filters, and even rotors of stationary gas turbine engines. In the present program, Nicalon preforms of tubular geometry were fabricated with different fiber architectures (filament winding, 3D braiding, or cloth winding) to tailor the mechanical properties for specific applications. However, these applications require that candidate materials be carefully characterized. Mechanical characterization must establish the properties and performance that are essential for structural design of the turbine components. For this purpose, a full complement of properties is needed, i.e., the stiffness and strengths of the composite material at a range of temperatures, and the fatigue and creep behavior of the materials under the stress states anticipated by the user. This mechanical characterization requires specialized equipment and methodologies, which are now under development by the authors. This paper will present a description of the methodologies required for ceramic composite characterization, and will describe initial results for ceramic composite tubes, a representative geometry for gas turbine components. Future needs and opportunities will also be discussed. DOE

N93-30877# M-DOT, Inc., Phoenix, AZ.
THRUST AUGMENTATION SYSTEM FOR LOW-COST-EXPENDABLE TURBOJET ENGINE Final Report, 26 Jun. 1992 - 31 Mar. 1993
BRYAN J. SEEGERS and DAVID G. SHREINER 31 Mar. 1993 65 p
(Contract DAAH01-92-C-R359)
(AD-A263727) Avail: CASI HC A04/MF A01

During the performance period, a dump-combustor afterburner and water/methanol injection system were designed, fabricated, and tested on a Sundstrand TJ-90 expendable-turbojet engine. Maximum thrust measured was 150 lbs. This yields an augmentation ratio of 1.57. Also evaluated were silicone based and alumina based lining materials for the afterburner combustion tube and coated-graphite and alumina based materials for the exit nozzle. Water/methanol injection was tested at four engine stations: 8 inches upstream of the compressor face, directly upstream of the compressor deswirl vanes, directly into the combustor dilution region and downstream of the turbine exit. Maximum predicted water/methanol flow rates could not be achieved due to combustor flame out. Performance was measured in the following ways: dry, with water/methanol only, with afterburner only, and with afterburner and water/methanol injection. DTIC

08

AIRCRAFT STABILITY AND CONTROL

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

A93-40328
EXPERIMENTAL INVESTIGATION ON AIRCRAFT DYNAMIC STABILITY PARAMETERS
FRANCESCO FUSCO (Centro Italiano Ricerche Aerospaziali, Capua, Italy) and GIORGIO GUGLIERI (CNR, Centro di Studio per la Dinamica dei Fluidi, Turin, Italy) Meccanica (ISSN

0025-6455) vol. 28, no. 1 1993 p. 61-68. refs
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In this paper, the design requirements of an experimental apparatus for the measurement of the direct derivatives on an oscillating aircraft model in a wind tunnel are discussed. The elaboration of the signal output of the force transducer is analyzed, according to the direct forced oscillation technique. The distorsions of the primary oscillatory motion were previously evaluated and corrected, adopting an open loop control technique. This algorithm is presented and its reliability is verified. Finally, the behavior of the experimental stability parameters, adopting different oscillation amplitudes and frequencies, is discussed. Author

A93-41889
ROBUST SAMPLED DATA EIGENSTRUCTURE ASSIGNMENT USING THE DELTA OPERATOR
JEAN E. PIOU and KENNETH M. SOBEL (City College, New York) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 4 July-Aug. 1993 p. 702-711. AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 1, p. 486-496. Previously cited in issue 23, p. 4064, Accession no. A92-55200 refs
(Contract F49620-88-C-0053)
Copyright

A93-41890
ANALYTICAL DEVELOPMENT OF AN EQUIVALENT SYSTEM MISMATCH FUNCTION
MARK R. ANDERSON (Virginia Polytechnic Inst. and State Univ., Blacksburg) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 4 July-Aug. 1993 p. 712-716. refs
Copyright

A mismatch function is used to check the validity of a low-order equivalent system model that has been derived from a high-order system representation. If the difference between the low- and high-order models is greater than allowed by the mismatch function, the flying qualities predictions obtained from parameters of the low-order equivalent system may not be representative of the ratings a pilot would give the actual aircraft. A methodology is developed in this paper to derive equivalent system mismatch functions analytically. The methodology is used to analytically determine a mismatch function for the longitudinal axis of a class IV fighter aircraft in the category A, nonterminal flight phase. Author

A93-41893
INVERSE SIMULATION OF LARGE-AMPLITUDE AIRCRAFT MANEUVERS
C. GAO and R. A. HESS (California Univ., Davis) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 4 July-Aug. 1993 p. 733-737. AIAA Atmospheric Flight Mechanics Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers, p. 140-149. Previously cited in issue 20, p. 3414, Accession no. A91-47165 refs
Copyright

A93-41894* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NEUROCONTROL DESIGN AND ANALYSIS FOR A MULTIVARIABLE AIRCRAFT CONTROL PROBLEM
TERRY TROUDET (Sverdrup Technology, Inc., Brook Park, OH), SANJAY GARG, and WALTER MERRILL (NASA, Lewis Research Center, Clevelend, OH) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 4 July-Aug. 1993 p. 738-747. AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 2, p. 993-1009. Previously cited in issue 21, p. 3600, Accession no. A91-49676 refs
Copyright

A93-41895* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
QUANTITATIVE FEEDBACK THEORY APPLIED TO THE DESIGN OF A ROTORCRAFT FLIGHT CONTROL SYSTEM
R. A. HESS and P. J. GORDER (California Univ., Davis) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 4 July-Aug. 1993 p. 748-753. AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992, AIAA Paper 92-0044. Previously cited in issue 07, p. 1015, Accession no. A92-22161 refs
(Contract NCC2-624)
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A93-41896
LINEAR QUADRATIC GAUSSIAN/LOOP TRANSFER RECOVERY DESIGN FOR A HELICOPTER IN LOW-SPEED FLIGHT
JEREMY J. GRIBBLE (Glasgow Univ., United Kingdom) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 4 July-Aug. 1993 p. 754-761. refs
Copyright

A control law for a helicopter in low-speed flight is designed using the linear quadratic Gaussian/loop transfer recovery method. The specifications are adapted from a subset of the U.S. Army helicopter handling qualities requirements. The design model consists of the rigid-body dynamics linearized about the 30 kt forward flight condition, together with a simplified, low-order representation of actuator and rotor dynamics. Evaluation is performed using higher-order models, obtained by linearization about several different points in the flight envelope, covering the speed range from 10 to 50 kt. These models contain more accurate representations of the high-frequency actuator and rotor modes. The final selection of the numerical values of the linear quadratic parameters is made by numerical optimization of the loop shape. It is found that the specifications considered can be satisfied for all of the evaluation models without gain scheduling. Author

A93-41897* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
VALIDATION OF ENGINEERING METHODS FOR PREDICTING HYPERSONIC VEHICLE CONTROL FORCES AND MOMENTS
M. MAUGHMER, L. OZOROSKI, D. STRAUSSFOGEL, and L. LONG (Pennsylvania State Univ., University Park) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 4 July-Aug. 1993 p. 762-769. AIAA Atmospheric Flight Mechanics Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers, p. 1-16. Previously cited in issue 20, p. 3407, Accession no. A91-47152 refs
(Contract NAG1-849)
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A93-41919* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AEROELASTIC RESPONSE, LOADS, AND STABILITY OF A COMPOSITE ROTOR IN FORWARD FLIGHT
EDWARD C. SMITH and INDERJIT CHOPRA (Maryland Univ., College Park) AIAA Journal (ISSN 0001-1452) vol. 31, no. 7 July 1993 p. 1265-1273. AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 33rd, Dallas, TX, Apr. 13-15, 1992, Technical Papers. Pt. 4, p. 1996-2014. Previously cited in issue 13, p. 2100, Accession no. A92-34480 refs
(Contract NAG1-1253; DAAL03-88-C-0002)
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A93-42259
LIFT AND PITCHING MOMENT MEASUREMENTS IN VERTICAL GUSTS
MANAS K. LAHA and AMIT K. GHOSH (Indian Inst. of Technology, Kharagpur, India) Aeronautical Society of India, Journal (ISSN 0001-9267) vol. 44, no. 4 Nov. 1992 p. 341-345. National Conference on Aerodynamics, 6th, Bangalore, India, Sept. 23-25,

1992 Research supported by Ministry of Defence refs
Copyright

Measurements of lift and pitching moment were conducted in a gust tunnel facility of the Aerospace Engineering Department at IIT Kharagpur (India) on three wing planforms, using various gust frequencies and freestream speeds. The paper describes the development of appropriate instrumentation and sensors, the development data reduction software for unsteady lift and moment, the calibration of the wind tunnel for unsteady measurements, and the procedure used for measuring lift and pitching moment of the three wing planforms. Preliminary results showed fair agreement with existing data. AIAA

A93-42559
HELICOPTER CONTROL LAW BASED ON SLIDING MODE WITH MODEL FOLLOWING

A. J. FOSSARD (Ecole Nationale Superieure d'Aeronautique et de l'Espace; ONERA, Centre d'Etudes et de Recherches de Toulouse, France) International Journal of Control (ISSN 0020-7179) vol. 57, no. 5 May 1993 p. 1221-1235. refs
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A variable structure methodology and approximate model following are used to examine the design of a control law adapted to a process characterized by great parametric variations and strong couplings. It is shown that, even in the case of partial state availability, this approach leads to much better robustness than model control while allowing more versatility with respect to control objectives (a modification of the reference model does not imply a modification of the switching). These increased performances do not require a higher level of control activity than in modal-based schemes. In the present illustration, it is shown to be possible to shift from a purely decoupled model at low speeds to one providing coordinated turns at higher speeds. AIAA

A93-42804
RELIABILITY ASSESSMENT FOR SELF-REPAIRING FLIGHT CONTROL SYSTEMS

N. E. WU and TIJIAN CHEN (New York State Univ., Binghamton) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 423-427. Research supported by General Electric Co refs
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It is pointed out that by using aerodynamically redundant control surfaces a flight control system can be reconfigured in the event of actuator failure and/or surface damage. This feature is usually implemented through the use of an impairment detection, isolation, and accommodation (IDIA) scheme. The authors report two aspects of new development in reliability assessment for such self-repairing flight control systems. The first is the incorporation of the IDIA performance through coverage into the system reliability computation. The second is the establishment of a simple theory for obtaining accurate reliability predictions without having to use Markov chain models. As a result of applying these methods to an aircraft model, one can recommend how much improvement is needed in designing its reconfigurable control system, and where its hardware reduction can be further made. a.

A93-42806
MULTIPLE MODEL ADAPTIVE ESTIMATION APPLIED TO THE VISTA F-16 FLIGHT CONTROL SYSTEM WITH ACTUATOR AND SENSOR FAILURES

TIMOTHY E. MENKE and PETER S. MAYBECK (USAF, Inst. of Technology, Wright-Patterson AFB, OH) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 441-448. refs

Multiple model adaptive estimation is applied to the Variable In-flight Stability Test Aircraft (VISTA) F-16 flight control system. Single actuator and hard sensor failures are introduced and system performance is evaluated. A modified Bayesian approach allows for a blending of state estimates and provides lower bounds to enhance algorithm convergence properties. Scalar residual monitoring aids in resolving ambiguities by demonstrating residual characteristics consistent with a true failure. The algorithm demonstrates good convergence characteristics during purposeful commands and dither signals. Optimizing the dither to improve algorithm performance is effective. a.

A93-42807
DESIGN OF A RULE-BASED FUZZY CONTROLLER FOR THE PITCH AXIS OF AN UNMANNED RESEARCH VEHICLE

DEEPAK SABHARWAL and KULDIP S. RATTAN (Wright State Univ., Dayton, OH) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 449-455. refs
Copyright

A control scheme based on fuzzy logic is proposed. The objective is to design a fuzzy controller for the pitch axis of an unmanned research vehicle. The inputs to the controller are the error and the change in error. A set of fuzzy rules that makes the controller look like a proportional-plus-derivative controller is obtained and simulated on Matrixx, a software package for the analysis and design of control systems. The fuzzy controller was found to give better results than those obtained from the existing analog controller. a.

A93-42808
DIRECT OPTICAL CONTROL - A LIGHTWEIGHT BACKUP CONSIDERATION

JOHN R. TODD (Douglas Aircraft Co., Long Beach, CA) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 456-463.
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The author addresses the benefits and issues associated with direct optical flight control and discusses the status of work to bring it to reality. It is noted that the approach considered is compatible with existing and future fly-by-wire and fly-by-light actuation approaches, can be used as a dedicated backup or integrated with primary fly-by-light systems over common command paths, and can be implemented as a minimal or extensive backup with very little weight penalty. In addition, it can be effectively retrofitted to existing fly-by-wire systems, provides enhanced survivability and mission capability in severe EMI (electromagnetic interference) environments, and provides a simple, reliable, and inexpensive backup capability. Direct optical control can be implemented as analog, pulsewidth modulated, etc. and is well adapted for harsh aircraft environments. It does not require new technologies to be developed for effective implementation, is extremely well adapted for power-by-wire actuation systems, and if implemented properly it can substantially reduce aircraft wiring and associated shielding maintenance. a.

A93-42810
DESIGN OF ROBUST DIGITAL MODEL-FOLLOWING FLIGHT CONTROL SYSTEMS

B. PORTER (Salford Univ., United Kingdom) and XIN-GUO ZHANG (Chinese Aeronautical Establishment, Flight Automatic Control Research Inst., Xian, China) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 468-474. refs
Copyright

The robustness characteristics of digital model-following systems incorporating fast-sampling PID (proportional plus integral plus derivative) controllers are elucidated in the case of both regular and completely irregular linear multivariable plants. It is shown that the plant-parameter variations tolerable by such digital model-following systems 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 digital model-following systems for the F4-E aircraft. This example demonstrates the ease with which the methodology of B. Porter et al. (1988) can be used to design robust digital model-following flight control systems. a.

A93-42811
DESIGN OF RECONFIGURABLE DIGITAL MULTIPLE MODEL-FOLLOWING FLIGHT CONTROL SYSTEMS
B. PORTER (Salford Univ., United Kingdom) and XIN-GUO ZHANG (Chinese Aeronautical Establishment, Flight Automatic Control Research Inst., Xian, China) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 475-481. refs
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It is demonstrated that reconfigurable digital multiple model-following flight control systems incorporating fast-sampling error-actuated digital PID (proportional plus integral plus derivative) controllers can be easily designed using directly measurable input/output data. Thus, for example, it is shown in the case of the F-16 aircraft that desired flying qualities with respect to both pitch-rate and angle-of-attack response characteristics can be simultaneously achieved in the absence of sensor failures. In addition, in the case of failure of the angle-of-attack sensor, it is shown that desired flying qualities with respect to pitch-rate response chararacteristics and satisfactory flying qualities with respect to angle-of-attack response characteristics can still be achieved by reconfiguring the digital controller. a.

A93-42812* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PILOT-IN-THE-LOOP ANALYSIS OF PROPULSIVE-ONLY FLIGHT CONTROL SYSTEMS
HWEI-LAN CHOU and DANIEL J. BIEZAD (California Polytechnic State Univ., San Luis Obispo) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 482-488. refs
(Contract NCC2-711)
Copyright

Longitudinal control system architectures which directly couple flight stick motions to throttle commands for a multi-engine aircraft are presented. This coupling enables positive attitude control with complete failure of the flight control system. The architectures chosen vary from simple feedback gains to classical lead-lag compensators with and without prefilters. Each architecture is reviewed for its appropriateness for piloted flight. The control systems are then analyzed with pilot-in-the-loop metrics related to bandwidth required for landing. Results indicate that current and proposed bandwidth requirements should be modified for throttles-only flight control. Pilot ratings consistently showed better ratings than predicted by analysis. Recommendations are made for more robust design and implementation. The use of quantitative feedback theory for compensator design is discussed. Although simple and effective augmented control can be achieved in a wide variety of failed configurations, a few configuration characteristics are dominant for pilot-in-the-loop control. a.

A93-42813
THE UTA AUTONOMOUS AERIAL VEHICLE - AUTOMATIC CONTROL AND NAVIGATION
KLIFFTON M. BLACK, JEFFREY O. SMITH (Texas Univ., Arlington), and RICHARD A. ROBERTS (LTV Missiles and Electronics Group, Grand Prairie, TX) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 489-496. Research sponsored by Sky Technology, Microtech Research, Polaroid Corp., et al. refs
(Contract F49620-86-C-0127)
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Some preliminary results on the design and implementation of robust automatic controls for the University of Texas at Arlington autonomous VTOL (vertical takeoff and landing) prototype are presented. Both stability augmentation and navigational issues are addressed. Since the use of inexpensive sensors and actuators has resulted in a relatively large degree of uncertainty about the system model, a robust controller is required. The authors demonstrate the mixed H2/H(infinity)-optimal design methodology used to obtain the automatic controllers for this aircraft. The technique used is a loop transfer recovery procedure which has been generalized by the removal of an assumption constraining a design variable. a.

A93-42815
FLIGHT MANAGEMENT SYSTEM ON THE F-117A
S. R. COMBS, R. C. LOSCHKE, and G. J. TAUKE (Lockheed Advanced Development Co., Burbank, CA) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 510-516. Research supported by USAF refs
Copyright

The authors describe the F-117A night attack aircraft flight management system (FMS). The need for and purpose of the system are described, and the design goals are identified. The various modes and their important features are presented. The pitch and speed control laws are shown. a.

A93-43079
ACTIVE ALGORITHMS FOR CONTROLLING THE ROTATIONAL MOTION OF FLIGHT VEHICLES [AKTIVNYE ALGORITMY UPRAVLENIYA VRASHCHATEL'NYMI DVIZHENIYAMI LETATEL'NYKH APPARATOV]
P. D. KRUT'KO (Moskovskij Gosudarstvennyj Tekhnicheskij Univ., Moscow, Russia) Rossijskaya Akademiya Nauk, Doklady (ISSN 0869-5652) vol. 329, no. 2 March 1993 p. 144-147. In RUSSIAN refs
Copyright

Algorithms with a unified structure are proposed for controlling the rotational motion of flight vehicles. The algorithms are synthesized by solving the problem of minimizing a functional characterizing the instantaneous value of the flight vehicle motion energy in the vicinity of a phase trajectory generated by a reference model. Algorithms synthesized in this way provide for a low system sensitivity to changes in the plant parameters. This is achieved without identification procedures, estimation of state coordinates, and self-tuning. The problem of aircraft motion control with respect to the yaw angle is considered as an example. AIAA

A93-43102
SYNTHESIS OF A DATA PROCESSING AND MEASURING SYSTEM FOR FLIGHT VEHICLE CONTROL SYSTEMS [SINTEZ INFORMATSIONNO-IZMERITEL'NOGO KOMPLEKSA DLYA SISTEM UPRAVLENIYA LETATEL'NOGO APPARATA]
M. E. VOJNOV and A. G. KASHIN *In* Methods and equipment for data processing and acquisition in information management systems Leningrad Leningradskij Institut Aviatsionnogo Priborostroeniya 1990 p. 4-8. In RUSSIAN refs
Copyright

The paper is concerned with the problem of the optimum design of a data processing and measuring package for flight vehicles. The general structure of a flight vehicle control system is treated as a closed-loop system consisting of a controlled system, a data processing and measuring system, an observing device, and a controller. The approach to the synthesis of an optimal data processing and measuring system used here employs a Riccati matrix equation, where the matrix determines the structure of the system and the accuracy characteristics of the transducers. AIAA

A93-43103
EXPERIMENTAL AND ALGORITHMIC MEANS OF IDENTIFYING MATHEMATICAL MODELS OF FLIGHT VEHICLE [EHKSPERIMENTAL'NYE I ALGORITMICHESKIE SREDSTVA IDENTIFIKATSII MATEMATICHESKOJ MODELI LETATEL'NYKH APPARATOV]
S. V. BOGOSLOVSKIJ and A. V. SEDYAKIN *In* Methods and equipment for data processing and acquisition in information management systems Leningrad Leningradskij Institut Aviatsionnogo Priborostroeniya 1990 p. 13-16. In RUSSIAN refs
Copyright
The problem of identifying a mathematical model of a flight vehicle is treated as a combination of two related problems. The first problem involves selecting a wind tunnel that would provide the required information and developing a proper experimental procedure that would provide the required efficiency. The second problem involves developing programming and algorithmic data in a format usable by the designer. Ways of solving these problems are discussed. AIAA

A93-43106
APPROXIMATION OF A FLIGHT VEHICLE TRAJECTORY USING WALSH FUNCTIONS [APPROKSIMATSIYA TRAEKTORII LETATEL'NOGO APPARATA S POMOSHCH'YU FUNKTSIJ UOLSHA]
B. L. VISHNEVSKIJ and I. F. STOLYAROV *In* Methods and equipment for data processing and acquisition in information management systems Leningrad Leningradskij Institut Aviatsionnogo Priborostroeniya 1990 p. 53-56. In RUSSIAN refs
Copyright
Methods of approximating flight vehicle trajectories are proposed which are based on the use of modified Walsh functions. This approach makes it possible to significantly reduce the computational effort with only a slight loss of estimation accuracy. By comparing this approach with the least squares method, the applicability limits of the Walsh function method are defined. Analytical expressions are obtained which make it possible to estimate the coefficients and their dispersions for any orders of approximation. AIAA

A93-43783
APPLICATION OF TWO CHAOS METHODS TO HIGHER HARMONIC CONTROL DATA
MARTI M. SARIGUL-KLIJN (U.S. Navy, Naval Aviation Depot, Alameda, CA), RAMESH KOLAR, and E. R. WOOD (U.S. Naval Postgraduate School, Monterey, CA) American Helicopter Society, Journal (ISSN 0002-8711) vol. 38, no. 2 April 1993 p. 68-77. Research supported by U.S. Navy, NPS Foundation, and McDonnell Douglas Helicopter Co refs
Copyright
This paper presents two new data analysis methods which will reduce Higher Harmonic Control (HHC) flight test requirements. HHC is an active system which suppresses helicopter vibrations. These methods, originally used in the study of chaos, are the Poincare section and the Van der Pol plane. Using flight test data from a test aircraft, these methods show the following: (1) the limits of HHC vibration reduction; (2) determination of HHC controller type; and (3) that the HHC controller transfer matrix is predictable and repeatable when defined in the 'Rotor Time Domain'. These benefits do not require an HHC-equipped helicopter, although they do require an instrumentation system installed. Finally, these methods can be implemented in real time in most instrumentation systems using only software changes and may be applicable to other vibration control and flight testing problems. Author (revised)

N93-29278 Department of the Navy, Washington, DC.
ARTICULATED FIN/WING CONTROL SYSTEM Patent
CHARLES H. BEAUCHAMP, inventor (to Navy), MANUEL CINCOTTA, JR., inventor (to Navy), ANTHONY V. RAFFA, inventor (to Navy), and BENOIT G. GAUTHIER, inventor (to Navy) 16 Feb. 1993 9 p Filed 8 Nov. 1991
(AD-D015712; US-PATENT-5,186,420; US-PATENT-APPL-SN-790607; US-PATENT-CLASS-244-219)
Avail: US Patent and Trademark Office
An articulated control surface is provided for hydrodynamic control utilizing a moldable control surface. The central surface is shaped by contracting and elongating wire bundles fabricated with shape-memory alloys located in an adjacent cooling chamber. The shape-memory alloys contract when heated via an applied electric current and elongate when cooled, i.e., the electric current is removed. A pair of wire bundles is anchored inside the cooling chamber. Each bundle is routed over several pulleys in such a manner that a lateral movement is produced at the actuator end of the wire. A pair of bundles act in opposition to maintain dynamic tension at the actuator end. Cooling flow to opposing wire bundles is controlled independently to enhance response time and reduce power requirements. The actuator is a post extending from the cooling chamber to the trailing edge structure of the control surface. DTIC

N93-29985# Michigan Technological Univ., Houghton. Dept. of Mechanical Engineering and Engineering Mechanics.
ROBUST CONTROL OF INTELLIGENT ROTOR
REZA KASHANI 22 Feb. 1993 37 p
(Contract DAAL03-92-G-0303)
(AD-A263707; ARO-30299-1-EG-II) Avail: CASI HC A03/MF A01
The performance and robustness of the intelligent rotors under feedback control depend on the fidelity of the models used in designing their controllers. This is also true for other kinds of smart structures. A computer aided robust control design program has been developed that takes the percentage of the variation on the parameters, as well as the desired number of modes to be included in the model and designs a robust controller that guarantees the stability of the system in presence of the formulated uncertainty. Moreover, the use of Terfenol-D magnetostrictive rods for actuation of an intelligent rotor is explored. The challenge in the use of these actuators in intelligent rotor applications is housing them in the structure of the rotor. The packaging of the Terfenol rod actuators, considered in this work, inside the structure of the rotor blade is based on lining the actuators inside the spar along the axis of the blade. This is possible due to the fact that most blades have a hollow D or box spar. The two ends of each actuator is sandwiched between two plates which, for flapwise actuation of the spar, are attached to the top and bottom of the spar, alternatively. This arrangement translate the actuator force to two point moments on the blade at the plate populations. DTIC

N93-30498# Wright Lab., Wright-Patterson AFB, OH.
COMPUTATION OF A DELTA-WING ROLL-AND-HOLD MANEUVER Final Report, 1 Feb. 1992 - 1 Feb. 1993
RAYMOND E. GORDNIER and MIGUEL VISBAL 12 Feb. 1993 46 p
(AD-A264704; WL-TR-93-3016) Avail: CASI HC A03/MF A01
This report presents computations of the flowfield around an 80 degree sweep delta wing undergoing a constant roll-rate maneuver from 0 to 45 degrees. The governing equations for the problem are the unsteady, three-dimensional Navier-Stokes equations. The equations are solved using the implicit, approximately-factored algorithm of Beam-Warming. Fixed roll angle results are also presented and compared with experimental measurements to demonstrate the ability of the numerical technique to accurately capture the flowfield around a rolled delta wing. The dynamic behaviors of the vortex position and strength, as well as their corresponding effect on surface pressure, lift, and roll moment are described. A simple, quasi-static explanation of these vortex behaviors based on effective angle-of-attack and sideslip angle is proposed. DTIC

N93-30550# Johns Hopkins Univ., Baltimore, MD. Dept. of Electrical and Computer Engineering.
ANALYTICAL FOUNDATIONS OF GAIN SCHEDULING Final Report, 1 Mar. 1990 - 28 Feb. 1993

WILSON J. RUGH 15 Mar. 1993 7 p
(Contract AF-AFOSR-0138-90)
(AD-A264682; AFOSR-93-0325TR) Avail: CASI HC A02/MF A01

This final report briefly describes research results on a theory of gain scheduling for flight control applications that were obtained by the Principal Investigator and his students over the three-year period of support. Results reported include development of a basic theory of gain scheduling in nonlinear systems, solution of output regulation problems based on an exogenous system assumption for the exogenous signals (including disturbance and scheduling signals), initial development of methods to alleviate performance degradation in the case of rapidly-varying scheduling signals, and an exploratory application of these results to an autopilot design example. Publications describing the results in detail are listed. DTIC

N93-30604 *Aeronautical Research Labs., Melbourne (Australia).*
OPTIMAL TRAJECTORIES FOR AIRCRAFT TERRAIN FOLLOWING AND TERRAIN AVOIDANCE: A LITERATURE REVIEW UPDATE
M. E. HALPERN Mar. 1993 23 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(AD-A264075; ARL-TR-5; DODA-AR-006-630) Avail: CASI HC A03

This is a literature review relevant to the automated design of flight paths for low-flying military aircraft in terrain following and terrain avoidance roles. Improvements in computer technology continue to widen the range of approaches which may be applied to this important problem. In particular, there is interest in the application of techniques which use elements of artificial intelligence. DTIC

N93-30764*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
FLIGHT CONTROL SYSTEM DESIGN FACTORS FOR APPLYING AUTOMATED TESTING TECHNIQUES
JOEL R. SITZ and TODD H. VERNON (Planning Research Corp., Edwards, CA.) Washington Oct. 1990 17 p Presented at the 9th Annual Digital Avionics System Conference, Virginia Beach, VA, 15-18 Oct. 1990; sponsored by IEEE Previously announced in IAA as A91-54610
(Contract RTOP 533-02-51)
(NASA-TM-4242; H-1631; NAS 1.15:4242) Avail: CASI HC A03/MF A01

Automated validation of flight-critical embedded systems is being done at ARC Dryden Flight Research Facility. The automated testing techniques are being used to perform closed-loop validation of man-rated flight control systems. The principal design features and operational experiences of the X-29 forward-swept-wing aircraft and F-18 High Alpha Research Vehicle (HARV) automated test systems are discussed. Operationally applying automated testing techniques has accentuated flight control system features that either help or hinder the application of these techniques. The paper also discusses flight control system features which foster the use of automated testing techniques. Derived from text

09

RESEARCH AND SUPPORT FACILITIES (AIR)

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

A93-41059*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AERODYNAMIC INVESTIGATION WITH FOCUSING SCHLIEREN IN A CRYOGENIC WIND TUNNEL
EHUD GARTENBERG (Old Dominion Univ., Norfolk, VA), LEONARD M. WEINSTEIN, and EDWIN E. LEE, JR. (NASA, Langley Research Center, Hampton, VA) Aug. 1993 12 p. AIAA, Applied Aerodynamics Conference, 11th, Monterey, CA, Aug. 9-11, 1993 refs
(Contract NAS1-18584)
(AIAA PAPER 93-3485) Copyright

A flow visualization study was performed using a focusing schlieren system in the 0.3m Transonic Cryogenic Tunnel at NASA Langley Research Center. The design employed proved to be a useful flow visualization tool for flows as low as M = 0.4. This study marked the first verification of the focusing schlieren technique in a major subsonic/transonic wind tunnel, and the first time that high quality, detailed pictures of high-Reynolds number flows were obtained in a cryogenic wind tunnel. This test was part of a development program to implement instrumentation techniques in cryogenic wind tunnels, with the ultimate aim to use them in the National Transonic Facility (NTF). Author

A93-41783* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE LANGLEY 8-FT TRANSONIC PRESSURE TUNNEL LAMINAR-FLOW-CONTROL EXPERIMENT
PERCY J. BOBBITT, WILLIAM D. HARVEY, CHARLES D. HARRIS, and CUYLER W. BROOKS, JR. (NASA, Langley Research Center, Hampton, VA) *In* Natural laminar flow and laminar flow control New York Springer-Verlag 1992 p. 247-411. refs
Copyright

An account is given of the considerations involved in selecting the NASA-Langley transonic pressure tunnel's design and test parameters, as well as its liner and a swept wing for laminar flow control (LFC) experimentation. Attention is given to the types and locations of the instrumentation employed. Both slotted and perforated upper surfaces were tested with partial- and full-chord suction; representative results are presented for all. AIAA

A93-42642
NON-EQUILIBRIUM FLOW IN AN ARC HEATED WIND TUNNEL
P. C. SLEZIONA, M. AUWETER-KURTZ, B. GLOCKER, T. GOGEL, T. GOELZ, E. MESSERSCHMID, and H. O. SCHRADE (Stuttgart Univ., Germany) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 1116-1130. refs
Copyright

The problem of a free jet expanding into a plenum chamber is modeled physically and numerically employing an approach used for the numerical simulation of MPD thrusters. The program systems used here reliably connect different physical fields. As a result, the problem is divided into 3 separate fields, the flow, chemical, and electron temperature fields. The coupling is achieved by applying an iteration procedure until convergence is reached. AIAA

A93-42892
DESIGN VERIFICATION OF GROUND RUN-UP NOISE SUPPRESSORS FOR AFTERBURNING ENGINES
S. A. FISHER, A. M. ABDEL-FATTAH (Defence Science and Technology Organisation, Aeronautical Research Lab., Melbourne, Australia), and L. A. CHALLIS (Challis and Associates, Pty., Ltd., Sydney, Australia) Journal of Propulsion and Power (ISSN 0748-4658) vol. 9, no. 4 July-Aug. 1993 p. 628-635. refs
Copyright

New facilities for ground running of engines in Royal Australian Air Force F/A-18 aircraft feature air-cooled exhaust augmentors for noise suppression. Aerothermodynamic aspects of the augmentor designs were appraised in some detail, making use of isothermal scale model tests, ejector theory, and available empirical data. Quantitative assessments were made of cooling flow pumping performance, and geometric features were identified which are important to the symmetry of the flow in the augmentor ducts. The final designs displayed satisfactory aerodynamic behavior, tolerant to both inlet asymmetries and reasonable levels of engine

jet misalignment. The estimated pumping performance exceeded the design requirements. Author

N93-29398# Coordinating Research Council, Inc., Atlanta, GA.
AIRCRAFT AND REFUELER BONDING AND GROUNDING STUDY
Feb. 1993 48 p
(AD-A262027; CRC-583) Avail: CASI HC A03/MF A01

The 1990 Edition of NFPA 407, Standard on Aircraft Fuel Servicing, deleted the requirement for grounding during aircraft fueling and tank truck loadings. This change has caused a great deal of concern in the industry since it impacts not only refueling operations, but also airport construction and maintenance. In order to resolve the more controversial aspects of this change, the Coordinating Research Council (CRC) Electrical Discharges Liaison Group conducted a series of tests at Denver Stapleton Airport, 30 October-8 November 1991. This test program culminated in a demonstration of a simulated aircraft refueling operation conducted with and without the use of ground wires. The demonstration was witnessed by representatives from the FAA, the airline, air cargo and aircraft fueling industries, airport design industry and the Denver Fire Department. The program did not address grounding requirements for purposes other than refueling. DTIC

N93-29436# Naval Postgraduate School, Monterey, CA.
MATHEMATICAL MODELING AND CONTROL LAW DEVELOPMENT FOR THE ATMOSPHERIC MONITORING AND CONTROL SYSTEM OF THE CONTROLLED ENVIRONMENT RESEARCH CHAMBER (CERC) AT NASA AMES RESEARCH CENTER M.S. Thesis
BRUCE H. MATHERS Dec. 1992 127 p
(AD-A261978) Avail: CASI HC A07/MF A02

The objective of this research is to develop a mathematical model and control algorithm for maintenance of the environmental system within the Controlled Environmental Research Chamber (CERC) located at the National Aeronautics and Space Administration (NASA) Ames Research Center, Moffet Field, CA. The hypobaric research chamber is currently undergoing renovation as part of the Human Exploration Development Project (HEDP), an effort on behalf of NASA for advanced life support research. A broad overview of the chamber is provided which includes a physical description, preliminary system hardware and associated performance, and potential experimental uses. A mathematical model of the chamber air mass is developed based on key energy and mass balances. Two methods of adaptive control have been implemented for the coupled control of temperature, composition, pressure and humidity within the closed environment. Simulations testing the control algorithm performance are conducted, including a sup and modified ramp response. The results of the simulations indicate the adaptive methods performed well for the model presented. Further research is required in refining the chamber model for algorithm optimization including integration of hardware dynamics. DTIC

N93-29788# Mitre Corp., McLean, VA.
THE 1991-1992 AVIATION SYSTEM CAPACITY PLAN Report, Jul. 1990 - Jul. 1991
1992 310 p
(AD-A263436; DOT/FAA/ACS-91-1) Avail: CASI HC A14/MF A03

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 problems in the future. The major areas of discussion are: (1) Airport Development, (2) Airport and Airspace Capacity, (3) Technology for Capacity Improvement, and (4) Marketplace Solutions. DTIC

N93-29815# Massachusetts Inst. of Tech., Lexington.
TWO SIMULATION STUDIES OF PRECISION RUNWAY MONITORING OF INDEPENDENT APPROACHES TO CLOSELY SPACED PARALLEL RUNWAYS
ANN MARIE T. LIND 2 Mar. 1993 129 p
(Contract DTFA01-89-Z-02033; F19628-90-C-0002)
(AD-A263433; ATC-190; DOT/FAA/NR-92/9) Avail: CASI HC A07/MF A02

This report documents the findings of two simulation studies of air traffic controller reaction to the Precision Runway Monitor (PRM). The PRM is a new system for monitoring independent approaches to closely spaced parallel runways. It consists of a radar which has higher accuracy and a faster update interval than the current system. The PRM radar is accompanied by a high-resolution color display which provides automated visual and vocal warnings to alert controllers of impending and actual penetration of a 'No Transgression Zone' between parallel runways. The studies, were conducted in order to determine the effects of key variables on controller reaction time and to determine controller opinion on system acceptability. Study 1 examined the use of the PRM when the runway separation was both 3,400 ft and 4,300 ft. Study 2 examined the use of the PRM when the runway separation was 3,000 ft. Real-time simulated approach blunders were presented to controllers, and measurements of their reaction times were recorded and analyzed. Independent variables studied included sensor update interval, runway separation, deviation angle, deviation range, flight path condition, approach blunder type, and controller experience level. In addition, controller opinions of the PRM were surveyed. Findings regarding the effects of each of the variables are reported. Survey results of controller opinion are reported. Recommendations for enhancing the realism of the simulation and recommendations of issues for future study are discussed. DTIC

N93-29869# California Univ., Berkeley. Lawrence Berkeley Lab.
X RAY MICROSCOPY RESOURCE CENTER AT THE ADVANCED LIGHT SOURCE
W. MEYER-ILSE, M. KOIKE, R. BEGUIRISTAIN, J. MASER, and D. ATTWOOD Jul. 1992 4 p Presented at the SPIE International Symposium on Optical Applied Science and Engineering, San Diego, CA, 19-24 Jul. 1992
(Contract DE-AC03-76SF-00098)
(DE93-010449; LBL-32323; CONF-920792-51) Avail: CASI HC A01/MF A01

An x-ray microscopy resource center for biological x-ray imaging will be built at the Advanced Light Source (ALS) in Berkeley. The unique high brightness of the ALS allows short exposure times and high image quality. Two microscopes, an x-ray microscope (XM) and a scanning x-ray microscope (SXM) are planned. These microscopes serve complementary needs. The XM gives images in parallel at comparable short exposure times, and the SXM is optimized for low radiation doses applied to the sample. The microscopes extend visible light microscopy towards significantly higher resolution and permit images of objects in an aqueous medium. High resolution is accomplished by the use of Fresnel zone plates. Design considerations to serve the needs of biological x-ray microscopy are given. Also, the preliminary design of the microscopes is presented. Multiple wavelength and multiple view images will provide elemental contrast and some degree of 3D information. DOE

N93-29945# Calspan Advanced Technology Center, Buffalo, NY.
THE USAF ADVANCED TURBINE AEROTHERMAL RESEARCH RIG (ATARR)
C. W. HALDEMAN, JR., M. G. DUNN, C. D. MACARTHUR (Wright Lab., Wright-Patterson AFB, OH.), and C. G. MURAWSKI (Wright Lab., Wright-Patterson AFB, OH.) *In* AGARD, Heat Transfer and Cooling in Gas Turbines 14 p Feb. 1993
Copyright Avail: CASI HC A03/MF A04

The Advanced Turbine Aerothermal Research Rig (ATARR) has been under development and construction at Wright-Patterson

Air Force Base for the past three years. Construction of the facility is now complete and demonstration experiments are underway. These demonstration experiments involve use of an instrumented turbine stage (both surface pressure and surface heat flux instrumentation) to obtain measurements for comparison with predictions, flow path measurement of total pressure, total temperature, and static pressure to determine flow path uniformity, as well as instrumentation to ascertain proper operation of all facility components. At the time of this writing, the experiments designed to obtain the data just mentioned are underway but results are not available. Therefore, the written paper will be confined to a description of: (1) the facility and its design capabilities, (2) a description of the operation of the major components with limited supporting data, e.g., main valve opening and closing times, and (3) a brief description of an uncertainty analysis that has been completed for the instrumentation and aero-performance measurements. Author

N93-29972# Human Resources Research Organization, Alexandria, VA.
DEVELOPMENT OF A CONCEPT FORMULATION PROCESS AID FOR ANALYZING TRAINING REQUIREMENTS AND DEVELOPING TRAINING DEVICES Final Report, Apr. 1991 - Jul. 1992
PAUL A. STICHA, STEPHENS GIBBONS, and MICHAEL J. SINGER Mar. 1993 39 p
(Contract DAHC35-89-D-0046; DA PROJ. 2Q2-63007-A-795)
(AD-A263579; ARI-RR-1637) Avail: CASI HC A03/MF A01

This report describes the development of a concept formulation process decision aid that addresses the tradeoff determination phase. It adapts previously developed models for use during a specific step in the development of a training device. The report identifies the source of information used and explains the rationale for the development of different aspects of the system,. A brief overview of the aiding system is presented. The goals of the aid are introduced and the steps taken to meet those goals are presented. The report describes the data elements, links between elements, and aiding functions and presents and discusses the evaluation of the system by projected users and the results of that evaluation. Difficulties discovered during development and suggestions for future research and development are presented in the conclusion. DTIC

N93-30103# Army Cold Regions Research and Engineering Lab., Hanover, NH.
MATHEMATICAL MODEL OF FROST HEAVE AND THAW SETTLEMENT IN PAVEMENTS
GARY L. GUYMON, RICHARD L. BERG, and THEODORE V. HROMADKA Apr. 1993 128 p
(Contract DTFA01-84-Z-02038)
(CRREL-REPT-93-2; DOT/FAA/RD-93/15) Avail: CASI HC A07/MF A02

Since 1975, the U.S. Army Corps of Engineers, The Federal Highway Administration, and the Federal Aviation Administration have been working cooperatively to develop a mathematical model to estimate frost heave and thaw weakening under various environmental conditions and for various pavement designs. A model has been developed. It is a 1D representation of vertical heat and moisture flux, is based on a numerical solution technique termed the nodal domain integration method, and estimates frost heave and frost penetration reasonably well for a variety of situations. The model is now ready for additional field evaluation and implementation in appropriate cases. The main objectives are the following: (1) to describe the model, FROST, including modeling uncertainties and errors; (2) to summarize recent comparisons between measured and computed values for frost heave and frost penetration; and (3) to describe parameters necessary for input into the model. Author (revised)

N93-30675*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HELICOPTER SIMULATOR STANDARDS
EDWARD M. BOOTHE *In its* NASA/FAA Helicopter Simulator Workshop p 31-33 Apr. 1992
Avail: CASI HC A01/MF A02

The initial advisory circular was produced in 1984 (AC 120-XX). It was not finalized, however, because the FAR's for pilot certification did not recognize helicopter simulators and, therefore, permitted no credit for their use. That is being rectified, and, when the new rules are published, standards must be available for qualifying simulators. Because of the lack of a data base to support specification of these standards, the FAA must rely on the knowledge of experts in the simulator/training industry. A major aim of this workshop is to form a working group of these experts to produce a set of standards for helicopter training simulators. Author

N93-30678*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SIMULATORS FOR CORPORATE PILOT TRAINING AND EVALUATION
CURT TREICHEL *In its* NASA/FAA Helicopter Simulator Workshop p 45-47 Apr. 1992
Avail: CASI HC A01/MF A02

Corporate aviation relies heavily on simulation to meet training and evaluation requirements. It appreciates the savings in fuel, money, noise, and time, and the added safety it provides. Also, simulation provides opportunities to experience many emergencies that cannot be safely practiced in the aircraft. There is a need to focus on the advantages of simulator training over aircraft training and to provide appropriate changes in the regulations to allow the community to make it possible for users to take full advantage of simulation. Author

N93-30681*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HELICOPTER SIMULATOR QUALIFICATION
BRIAN HAMPSON *In its* NASA/FAA Helicopter Simulator Workshop p 61-64 Apr. 1992
Avail: CASI HC A01/MF A02

CAE has extensive experience in building helicopter simulators and has participated in group working sessions for fixed-wing advisory circulars. Against this background, issues that should be addressed in establishing helicopter approval criteria were highlighted. Some of these issues are not immediately obvious and may, indeed, be more important than the criteria a themselves. Author (revised)

N93-30682*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HELICOPTER SIMULATION: MAKING IT WORK
BARRY PAYNE *In its* NASA/FAA Helicopter Simulator Workshop p 65-68 Apr. 1992
Avail: CASI HC A01/MF A02

The opportunities for improved training and checking by using helicopter simulators are greater than they are for airplane pilot training. Simulators permit the safe creation of training environments that are conducive to the development of pilot decision-making, situational awareness, and cockpit management. This paper defines specific attributes required in a simulator to meet a typical helicopter operator's training and checking objectives. Author

N93-30683*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HELICOPTER TRAINING SIMULATORS: KEY MARKET FACTORS
JOHN MCINTOSH *In its* NASA/FAA Helicopter Simulator Workshop p 69-76 Apr. 1992
Avail: CASI HC A02/MF A02

Simulators will gain an increasingly important role in training helicopter pilots only if the simulators are of sufficient fidelity to provide positive transfer of skills to the aircraft. This must be done within an economic model of return on investment. Although rotor pilot demand is still only a small percentage of overall pilot

requirements, it will grow in significance. This presentation described the salient factors influencing the use of helicopter training simulators. Author (revised)

N93-30685*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DETERMINING THE TRANSFERABILITY OF FLIGHT SIMULATOR DATA
DAVID GREEN *In its* NASA/FAA Helicopter Simulator Workshop p 91-108 Apr. 1992
Avail: CASI HC A03/MF A02

This paper presented a method for collecting and graphically correlating subjective ratings and objective flight test data. The method enables flight-simulation engineers to enhance the simulator characterization of rotor craft flight in order to achieve maximum transferability of simulator experience. Author (revised)

N93-30686*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PROGRESS THROUGH PRECEDENT: GOING WHERE NO HELICOPTER SIMULATOR HAS GONE BEFORE
RICHARD J. ADAMS *In its* NASA/FAA Helicopter Simulator Workshop p 109-114 Apr. 1992
Avail: CASI HC A02/MF A02

Helicopter simulators have been approved by means of special exemption; there are no FAA standards for simulators used in training or airmen Certification checking. The fixed-wing industry provides a precedent which can be used for expediting implementation of helicopter simulators. The analysis in this paper is founded on the experience with that precedent and is driven by a clear definition of helicopter user needs for (1) improved training at lower cost, (2) more comprehensive emergency training at lower risk, (3) increased fidelity of transition and instrument training compared with low-cost aircraft alternatives, and (4) certification credit for improved simulator training. Author (revised)

N93-30687*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TRANSFER OF TRAINING AND SIMULATOR QUALIFICATION OR MYTH AND FOLKLORE IN HELICOPTER SIMULATION
JACK DOHME *In its* NASA/FAA Helicopter Simulator Workshop p 115-121 Apr. 1992
Avail: CASI HC A02/MF A02

Transfer of training studies at Fort Rucker using the backward-transfer paradigm have shown that existing flight simulators are not entirely adequate for meeting training requirements. Using an ab initio training research simulator, a simulation of the UH-1, training effectiveness ratios were developed. The data demonstrate it to be a cost-effective primary trainer. A simulator qualification method was suggested in which a combination of these transfer-of-training paradigms is used to determine overall simulator fidelity and training effectiveness. Author

N93-30689*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FREQUENCY-RESPONSE TECHNIQUES FOR DOCUMENTATION AND IMPROVEMENT OF ROTORCRAFT SIMULATORS
MARK B. TISCHLER *In its* NASA/FAA Helicopter Simulator Workshop p 131-146 Apr. 1992
Avail: CASI HC A03/MF A02

Pilot-in-the-loop characterizations are most naturally formulated in terms of end-to-end frequency responses, so a frequency-response-based method is the natural approach to assessing simulator dynamic fidelity. A comprehensive frequency-response approach used heavily by Ames Research Center researchers was described, and results were presented from a number of simulator fidelity assessment studies. Those studies included UH-60 mathematical model validation and upgrade, ASTOVL linear model extraction, and documentation of the Vertical Motion Simulator (at Ames Research Center) motion and visual system characteristics. Derived from text

N93-30690*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
BANDWIDTH AND SIMDUCE AS SIMULATOR FIDELITY CRITERIA
DAVID KEY *In its* NASA/FAA Helicopter Simulator Workshop p 147-160 Apr. 1992
Avail: CASI HC A03/MF A02

The potential application of two concepts from the new Handling Qualities Specification for Military Rotorcraft was discussed. The first concept is bandwidth, a measure of the dynamic response to control. The second is a qualitative technique developed for assessing the visual cue environment the pilot has in bad weather and at night. Simulated Day Usable Cue Environment (SIMDUCE) applies this concept to assessing the day cuing fidelity in the simulator. Derived from text

N93-30691*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
METHODOLOGY DEVELOPMENT FOR EVALUATION OF SELECTIVE-FIDELITY ROTORCRAFT SIMULATION
WILLIAM D. LEWIS, D. P. SCHRAGE, J. V. R. PRASAD, and DANIEL WOLFE *In its* NASA/FAA Helicopter Simulator Workshop p 161-166 Apr. 1992
Avail: CASI HC A02/MF A02

This paper addressed the initial step toward the goal of establishing performance and handling qualities acceptance criteria for realtime rotorcraft simulators through a planned research effort to quantify the system capabilities of 'selective fidelity' simulators. Within this framework the simulator is then classified based on the required task. The simulator is evaluated by separating the various subsystems (visual, motion, etc.) and applying corresponding fidelity constants based on the specific task. This methodology not only provides an assessment technique, but also provides a technique to determine the required levels of subsystem fidelity for a specific task. Derived from text

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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.

A93-42234#
HOVER TESTING A DEMONSTRATED AND COST-EFFECTIVE RISK REDUCTION TOOL
J. PAVLINSKY (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) Jun. 1993 12 p. AIAA and SDIO, Annual Interceptor Technology Conference, 2nd, Albuquerque, NM, June 6-9, 1993 refs
(AIAA PAPER 93-2677) Copyright

Kinetic Vehicle (KV) development programs employ a variety of system test techniques to collectively assure vehicle compliance with performance requirements. Before space flight, many programs have included hardware-in-the-loop (HWIL) and hover testing as key system tests. This approach has been shown to efficiently address mission parameters and real world system hardware performance. Hover testing, in particular, has consistently identified unforeseen problems in KV site operations and in flight. Site problems identified and corrected include KV hardware and software design and checkout and test procedures. Hover flight data has identified component and system degradations due to design and propulsion system interaction. In most cases, substantial cost and schedule savings were realized given the alternative of uncovering the same problems at USAKA or WSMR. This paper identifies the merits of hover testing and substantiates the benefits relative to other ground test approaches. Hover test data, its uses,

advantages, and limitations in KV development programs are shown. A survey of the hover tests conducted to date is provided, identifying problems uncovered and program impact. In summary, the combined experience of KV contractors has shown the HWIL/hover approach to be highly cost and schedule effective.
Author

A93-42927
TAKEOFF AND LANDING ANALYSIS METHODOLOGY FOR AN AIRBREATHING SPACE BOOSTER
H. CHENG, R. V. GRANDHI, W. L. HANKEY, and P. J. BELCHER (Wright State Univ., Dayton, OH) Acta Astronautica (ISSN 0094-5765) vol. 29, no. 5 May 1993 p. 325-332. refs
(Contract F33615-87-C-1550)
Copyright

This study developed methods and a general computer model for analyzing the guidance, automatic control, and runway performance of a large horizontal takeoff and landing (HTOL) airbreathing space booster. The model treats vehicle translation and rotation during ground run, transition, climb out, descent, and flare. Guidance and automatic control equations were developed for elevator rate and throttle position commands. A commercial airplane with similar takeoff weight was analyzed and compared with the HTOL space booster takeoff and landing characteristics. The study shows that the space booster configuration analyzed in this work can potentially use the same type of runways as current airplanes use.
Author

A93-43437
BISTATIC RADAR USING SATELLITE-BORNE ILLUMINATORS OF OPPORTUNITY
H. D. GRIFFITHS, A. J. GARNETT (Univ. College, London, United Kingdom), C. J. BAKER, and S. KEAVENEY (Defence Research Agency, Malvern, United Kingdom) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 276-279. refs
Copyright

The use of satellite-borne iluminators of opportunity in various kinds of surveillance applications is examined, in particular Direct Broadcast by Satellite Television (DBS TV) transmissions. The stability of TV waveforms for radar operation is considered. It is found that, though their autocorrelation functions reveal them to be not ideal, they can give acceptable results which are potentially useful. A simple model based on the bistatic radar equation is used to predict the range performance of the radar. Comparison of model predictions with experimental SNRs suggest that the model is essentially correct. The predicted values show that a very large amount of processing gain is needed. The gain is inversely proportional to the target Doppler shift, suggesting that the radar applies more readily to large slow-moving targets.
AIAA

A93-43549
SATELLITE NAVIGATION IN TRAFFIC MANAGEMENT [SATELLITENNAVIGATION IM VERKEHRSMANAGEMENT]
HEINZ-GEORG WIPPICH and HANS-DIETER REINHARD Ortung und Navigation (ISSN 0474-7550) no. 1 1993 p. 3-9. In GERMAN
Copyright

An experimental system is described which enables management of regional airports and their airstrips and of aircraft fleets. Satellite navigation systems are integral elements of this system. They are joined by a link processor and a VHF or HF transceiver on board ship or aircraft. The system also contains a ground station.
AIAA

N93-29134# Air Force Inst. of Tech., Wright-Patterson AFB, OH. Foreign Aerospace Science and Technology Center.
THE INFRARED MEASUREMENT FOR THE REENTRY-BODY-TRANSLATION
CONGZHONG ZHAO 3 Apr. 1993 13 p Transl. into ENGLISH from Hongwai Yaniju (China), v. 7, no. 3, 1988 p 219-223
(AD-A263100; FASTC-ID(RS)T-0311-92) Avail: CASI HC A03/MF A01

The measured results of a reentry-body by a PbS radiometer are described in this paper. The standoff range of the radiometer reaches 100 km. Some features about the target are given.
DTIC

N93-29194*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
GRAVITY SENSITIVITY OF A RESISTOJET WATER VAPORIZER
W. EARL MORREN Jun. 1993 24 p Presented at the 29th Joint Propulsion Conference and Exhibit, Monterey, CA, 28-30 Jun. 1993; cosponsored by AIAA, SAE, ASME, ASEE
(Contract RTOP 506-42-31)
(NASA-TM-106220; E-7870; NAS 1.15:106220; AIAA PAPER 93-2402) Avail: CASI HC A03/MF A01

A laboratory model of a water vaporizer for resistojet applications was designed, fabricated, and steady and transient characteristics were measured. Vaporizer operation was not impacted by rotation about a horizontal axis normal to its own. The vaporizer was operated under low and high accelerations aboard a jet aircraft for periods up to 25 s at flow rates ranging from 159(10)(exp -6) to 230(10)(exp -6) kg/s. Slight changes in inlet and outlet pressures and some heat exchanger temperatures were observed during the low-gravity tests. However, the results of these tests indicated probable compatibility of the vaporizer design tested with a low-gravity environment.
Author (revised)

N93-29215*# Rockwell International Corp., Downey, CA. Space Systems Div.
STRATEGIC AVIONICS TECHNOLOGY DEFINITION STUDIES. SUBTASK 3-1A: ELECTRICAL ACTUATION (ELA) SYSTEMS
BEN T. F. LUM, CHARLES POND, and WILLIAM DERMOTT 30 Jun. 1993 154 p
(Contract NAS9-18880)
(NASA-CR-193237; NAS 1.26:193237; SSD93D0354) Avail: CASI HC A08/MF A02

This interim report presents the preliminary results of an electrical actuation (ELA) system study (subtask TA3-1A) to support the NASA strategic avionics technology definition studies. The final report of this ELA study is scheduled for September 30, 1993. The topics are presented in viewgraph form and include the following ELA technology demonstration testing; ELA system baseline; power and energy requirements for shuttle effector systems; power efficiency and losses of ELA effector systems; and power and energy requirements for ELA power sources.
Derived from text

N93-29652*# TRW, Inc., Houston, TX.
REFERENCE EQUATIONS OF MOTION FOR AUTOMATIC RENDEZVOUS AND CAPTURE
DAVID M. HENDERSON Apr. 1992 40 p
(Contract NAS9-17900)
(NASA-CR-185676; NAS 1.26:185676; TRW-91:J431.1-182)
Avail: CASI HC A03/MF A01

The analysis presented in this paper defines the reference coordinate frames, equations of motion, and control parameters necessary to model the relative motion and attitude of spacecraft in close proximity with another space system during the Automatic Rendezvous and Capture phase of an on-orbit operation. The relative docking port target position vector and the attitude control matrix are defined based upon an arbitrary spacecraft design. These translation and rotation control parameters could be used to drive the error signal input to the vehicle flight control system. Measurements for these control parameters would become the bases for an autopilot or feedback control system (FCS) design for a specific spacecraft.
Author (revised)

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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.

A93-39963
DESIGN AND COST VIABILITY OF COMPOSITES IN COMMERCIAL AIRCRAFT
J. E. MCCARTY (Composite Structures Consulting, Bellevue, WA) Composites (ISSN 0010-4361) vol. 24, no. 4 June 1993 p. 361-365.
Copyright

The design and cost aspects of a composite considered for a commercial aircraft program are discussed. It is emphasized that the vitally important safety issues (static strength, damage tolerance, and flutter margin) and economic issues (both manufacturing and in-service maintenance costs) must be fully addressed before full utilization of composites in commercial aircraft can be realized. It is suggested that economic issues currently represent the greatest concern, cost being the largest stumbling block to the expanded application of composites to commercial aircraft. AIAA

A93-40362
OXIDATION-RESISTANT HIGH-TEMPERATURE MATERIALS
ROBB W. NEWMAN (Johns Hopkins Univ., Laurel, MD) Johns Hopkins APL Technical Digest (ISSN 0270-5214) vol. 14, no. 1 Jan.-Mar. 1993 p. 24-28. refs
Copyright

A brief history of the testing and analysis of various new oxidation-resistant high-temperature materials for use in Navy missiles is presented. In particular, attention is given to silicone elastomers, graphite materials, and carbon/carbon composites. It is found that HfC-infiltrated carbon/carbon composites have the lowest recession rates and can survive exposures to a 5000 F oxidizing flow for periods exceeding 10 min. AIAA

A93-40777
MATERIALS DEVELOPMENT FOR LIGHT DESIGN - A SUPPLIERS VIEW
JEFF W. EDINGTON (Alcan International, Ltd., Montreal, Canada) *In* Mechanical behaviour of materials - VI; Proceedings of the 6th International Conference, Kyoto, Japan, July 29-Aug. 2, 1991. Vol. 1 Oxford and Elmsford, NY Pergamon Press 1992 p. 3-16. refs
Copyright

The paper discusses two major points of consideration for the material suppliers, regarding material technology development for light-weight structures. The first is represented by the example of the development of Al-Li alloys for airframes, a classical case where the key step is the alloy development. The second is represented by the example of the technology development for aluminum-structured automobile bodies, a more complex situation where the alloy development is a minor issue. The major issues are the manufacturing and cost problems and problems of vehicle performance, which must be solved by collaboration between the materials supplier and the automobile manufacturer. AIAA

A93-40787
CHARACTERIZATION OF DELAMINATION AND FIBER FRACTURES IN CARBON FIBER REINFORCED PLASTICS INDUCED FROM IMPACT
KLAS LEVIN (Aeronautical Research Inst. of Sweden, Bromma) *In* Mechanical behaviour of materials - VI; Proceedings of the 6th International Conference, Kyoto, Japan, July 29-Aug. 2, 1991. Vol. 1 Oxford and Elmsford, NY Pergamon Press 1992 p. 519-524. Research supported by Swedish Defence Material Administration refs
Copyright

This investigation addressed the damage shape and size distribution in laminated carbon fiber reinforced plastics subjected to impact. Unique shapes of delamination at each interface and fiber fracture in each ply occurred for such factors as material toughness and impactor tip diameter for a range of impact energies. However both toughness and impactor tip diameter had an effect on the size distribution especially at lower impact energies where the damages were preferably located in the lower part of the laminate. However the effect decreased at higher energies where a more symmetrical size distribution occurred. Moreover a rotation of a stacking sequence did not alter the delamination shapes and sizes. Author

A93-40802
RECENT EVOLUTION OF GAS TURBINE MATERIALS AND THE DEVELOPMENT OF MODELS FOR LIFE PREDICTION
M. MCLEAN (Imperial College of Science, Technology, and Medicine, London, United Kingdom), B. F. DYSON (National Physical Lab., Teddington, United Kingdom), and R. N. GHOSH (National Metallurgical Lab., Jamshedpur, India) *In* Mechanical behaviour of materials - VI; Proceedings of the 6th International Conference, Kyoto, Japan, July 29-Aug. 2, 1991. Vol. 2 Oxford and Elmsford, NY Pergamon Press 1992 p. 49-57. refs
Copyright

Important developments in materials for gas turbines are briefly reviewed. Effective use of such materials is often limited by incomplete understanding of the material behavior and deficiencies in representing the relevant data. An approach to describing the creep behavior of nickel-base superalloys in terms of physical models of damage generation is outlined and comparisons of model-base predictions with experimental data are made. Models for both isotropic and single-crystal superalloys are described. Author

A93-40804
EVALUATION OF METALLURGICAL DEGRADATION ON GAS TURBINE COMPONENTS
Y. YOSHIOKA, D. SAITO, K. FUKUDA, K. FUJIYAMA, N. OKABE, and Y. ABURATANI (Toshiba Corp., Yokohama, Japan) *In* Mechanical behaviour of materials - VI; Proceedings of the 6th International Conference, Kyoto, Japan, July 29-Aug. 2, 1991. Vol. 2 Oxford and Elmsford, NY Pergamon Press 1992 p. 67-72. refs
Copyright

To extend the life economically and reliably, the life exhaustion and recovery concepts in each hot gas path component of gas turbines were established. In the natural gas fired base-load operation, creep and oxidation life are primary factors for the first-stage buckets. Coating life should also be taken into consideration to determine the oxidation life and recovery time. In the transition region, creep is important especially in the case of Hastelloy X. Metallurgical methods to estimate the mechanical properties were developed. Author (revised)

A93-40805
CRACK SIMULATION AND LIFE ASSESSMENT OF GAS TURBINE NOZZLES
K. FUJIYAMA, Y. YOSHIOKA, N. OKABE, and K. KIMURA (Toshiba Corp., Yokohama, Japan) *In* Mechanical behaviour of materials - VI; Proceedings of the 6th International Conference, Kyoto, Japan, July 29-Aug. 2, 1991. Vol. 2 Oxford and Elmsford, NY Pergamon Press 1992 p. 73-78. refs
Copyright

For the purpose of presuming damage and degradation of used gas turbine nozzles, hardness tests, low cycle fatigue tests and fatigue crack propagation tests are conducted on Co-base nozzle superalloy FSX414 thermal aged up to 10,000 hours. Although hardening occurs due to thermal aging, there is no significant change in fatigue properties. The fatigue crack behavior is attributable to crack propagation morphology and is simulated by fractal geometry model of dendrite structure and random distribution of initial cracks. The multiple crack simulation is proved to be a

promising technique for life assessment of nozzles which are used in the crack existing state after inspection and repairment.
Author

A93-40807
LIFE PREDICTION - THERMAL FATIGUE FROM ISOTHERMAL DATA
W. J. PLUMBRIDGE and T. GOSWAMI (Wollongong Univ., Australia) *In* Mechanical behaviour of materials - VI; Proceedings of the 6th International Conference, Kyoto, Japan, July 29-Aug. 2, 1991. Vol. 2 Oxford and Elmsford, NY Pergamon Press 1992 p. 85-92. refs
Copyright

Isothermal fatigue (IF) behavior was generated in a separate paper for a gas turbine blade material MarM002, and the life prediction was made phenomenologically in terms of generic models. The isothermal damage mechanisms were studied to develop a thermomechanical life prediction model. The empirical modelling of thermo-mechanical fatigue (TMF) was made in terms of cyclic stress-strain in a product and hysteretic energy in time-dependent form. The TMF lives were assumed to be that of isothermal, at the maximum temperature of the TMF cycle. The prediction of in phase life was more than the out of phase ones and was not expected. The spanning function, Taira's empirical model, and strain range partitioned components of a hysteresis loop were studied. TMF life was overpredicted by all the above models, however; Taira's empirical model was too conservative.
Author (revised)

A93-40808
CREEP CRACK GROWTH AND TAIL PART BEHAVIOR OF LOW ALLOY STEELS AND NI BASED SUPER ALLOY
A. FUJI and M. KITAGAWA (Ishikawajima-Harima Heavy Industries Co., Ltd., Structural Materials Dept., Tokyo, Japan) *In* Mechanical behaviour of materials - VI; Proceedings of the 6th International Conference, Kyoto, Japan, July 29-Aug. 2, 1991. Vol. 2 Oxford and Elmsford, NY Pergamon Press 1992 p. 93-98. Research sponsored by Science and Technology Agency of Japan refs
Copyright

The creep crack growth behavior for low alloy steels and Ni-based superalloy is characterized by the relation between crack growth rate and displacement rate. The crack growth life is represented by a Monkman-Grant type formula in the relation with minimum displacement rate. Author (revised)

A93-40811
NEW CORROSION RESISTANT NICKEL-BASE SUPER-ALLOYS AND TECHNOLOGICAL PROCESSES OF CASTING GAS TURBINES PARTS WITH DIRECTIONAL SINGLE CRYSTAL AND REGULABLE EQUIAXIAL MINIMIZED MICROPOROSITY STRUCTURE
Y. I. ZVEZDIN, E. L. KATS, YU. V. KOTOV, V. P. LUBENETS, E. V. SPIRIDONOV, and M. L. KONTER (NPO TsNII Tyazhelogo Mashinostroeniya, Moscow, Russia) *In* Mechanical behaviour of materials - VI; Proceedings of the 6th International Conference, Kyoto, Japan, July 29-Aug. 2, 1991. Vol. 2 Oxford and Elmsford, NY Pergamon Press 1992 p. 111-116.
Copyright

A research program intended to develop new high corrosion resistance Ni-based superalloys and technological methods of casting different large-scale parts with minimized microporosity and controlled structure is presented. It is concluded that the superalloys in conjunction with advanced casting technologies make it possible to improve efficiency of the operational characteristics and to reduce production costs of a variety of working and leading blades, combustion chambers, and high temperature components of gas turbines. AIAA

A93-40814
CONCURRENT FIELD SERVICE AND LABORATORY TESTING AS A MEANS OF IMPROVING RELIABILITY IN CREEP-RUPTURE APPLICATIONS
S. S. MANSON and JONGHWA PARK (Case Western Reserve Univ., Cleveland, OH) *In* Mechanical behaviour of materials - VI; Proceedings of the 6th International Conference, Kyoto, Japan, July 29-Aug. 2, 1991. Vol. 2 Oxford and Elmsford, NY Pergamon Press 1992 p. 227-232. refs
Copyright

A method is presented whereby long-time creep rupture data on several heats of one material are used to extrapolate the long-time behavior for a new heat of the same material. Use is made of short-time data on the new heat, which can be obtained during early design or concurrent with the service of the component. Author

A93-41023
EFFECT OF ENVIRONMENT ON CREEP-FATIGUE CRACK PROPAGATION IN TURBINE DISC SUPERALLOYS
J. MENDEZ, P. VIOLAN, M. QUINTARD (Ecole Nationale Superieure de Mecanique et d'Aerotechnique, Poitiers, France), G. MARCON, M. MARTY, P. THEVENIN, and A. WALDER (ONERA, Chatillon, France) ONERA, TP no. 1993-5 1993 18 p. International Conference on Corrosion-Deformation Interactions, Fontainebleau, France, Oct. 5-7, 1992 refs
(ONERA, TP NO. 1993-5)

The effect of environment on the type of crack and the rate of crack growth during creep fatigue in a PM Astroloy with the wt pct composition Ni-16.42 Co-14.69 Cr-3.86 Al-3.46 Ti-5.01 Mo-0.03 C-0.021 B-0.032 Zr was investigated using data obtained in crack propagation tests in creep-fatigue conditions, conducted at 650 and 750 C in air and in high vacuum. It is shown that the intergranular damage observed at 650 C in the air-tested specimens (vs. the transgranular crack growth observed in vacuum tested specimens) is associated with oxidation effects. The change in the crack growth mechanism in air-tested specimens was accompanied by a significant acceleraltion in crack propagation rates, as compared with vacuum tested specimens. AIAA

A93-41031
INFRARED THERMOGRAPHY OF PLASTIC INSTABILITIES IN A SINGLE CRYSTAL SUPERALLOY
P. LEVESQUE (ONERA, Chatillon, France), B. LISIECKI, L. KUBIN, P. CARON (Lab. d'Etude des Microstructures, Chatillon, France), A. DEOM, and D. BALAGEAS (ONERA, Chatillon, France) ONERA, TP no. 1993-18 1993 8 p. Quantitative infrared thermography, Paris, Editions Europeennes Thermique et Industrie, 1992, p. 135-140 refs
(ONERA, TP NO. 1993-18) Copyright

A tensile test of a AM3 single crystal superalloy is analysed with the help of the thermographic technique. During the plastic flow with a moderate strain rate at room temperature, the *deformation is very localized and large slip bands occur on the* surface of the specimen, and the stress-strain curve exhibits yielding serrations. The IR thermography is used to measure local heatings. The heating associated with the deformation band occurrence, during the instability, is evaluated by a time-resolved analysis of the thermograms delivered by the IR camera, using a very simple thermal model. A value of about 140 is found and compared to the upper possible limit of this parameter, given by theoretical calculations and analysis of the tensile curve. Author

A93-43616
STRUCTURE OF MARTENSITE IN TITANIUM ALLOY TI-6AL-1.6ZR-3.3MO-0.3SI
A. K. SINGH, C. RAMACHANDRA, M. TAVAFOGHI, and V. SINGH (Banaras Hindu Univ., Varanasi, India) Journal of Materials Science Letters (ISSN 0261-8028) vol. 12, no. 10 May 15, 1993 p. 697-699. refs
Copyright

The creep-resistant, alpha + beta-type Ti alloy designated VT9 develops a wide range of microstructures depending on solution-treatment temperature and subsequent cooling rate. The crystal structure of the martensite due to beta treatment and water quenching is found to be orthorhombic; a small amount of Si appears to stabilize the orthorhombic martensite. AIAA

N93-29125 California Univ., San Diego.
STUDIES OF HYDROGEN-AIR DIFFUSION FLAMES AND OF COMPRESSIBILITY EFFECTS RELATED TO HIGH-SPEED PROPULSION Ph.D. Thesis
GANESHAN BALAKRISHNAN 1992 144 p
Avail. Univ. Microfilms Order No. DA9307178

The structure and the extinction phenomena of hydrogen-air diffusion flames in the counterflow configuration with full and reduced chemical-kinetic mechanisms are investigated. The main reduced mechanism considered is a two-step mechanism. Numerical calculations are performed for strain rates on the air side of 10(exp -4)/s to extinction. The effect of nitrogen chemistry and the uncertainties in elementary rate parameters on flame structure as well as on extinction is investigated. Based on the two-step scheme and on results from numerical integrations, an asymptotic analysis is then performed to derive analytical expressions for predicting extinction strain rates. The flame structure consists of three regions: a thin radical production zone in which H atoms are generated by the global step 3H2 + O2 yields 2H2O + 2H whose rate is largely determined by a high-activation-energy chain-branching elementary reaction, flanked by two thick radical-consumption layers in which the H is consumed by the overall step H + H + M yields H2 + M, the rate of which is controlled by different elementary reactions on the lean and rich sides. The predicted extinction conditions appear to be in reasonable agreement with experiments, although additional work is needed in specific areas that are indicated. Supersonic combustion in turbulent mixing layers locally involve counterflowing streams in which compressibility is important, with the viscous and chemical effects restricted to a narrow layer at the stagnation plane. A theoretical analysis of the inviscid flow is performed for small values of the ratio of the plate separation distance to the lateral extent of the plates, for both planar and axisymmetric geometries. The problem of computing the flow field is reduced to the solution of a single integral equation, which is achieved numerically. The flow exhibits choking at a critical value of the lateral extent of the plate, in the vicinity of which the Mach number approaches unity. The results provide the external boundary-layer conditions needed for studying the flame structure in the viscous region between the two counterflowing streams when compressibility is important. With pressure dependent mass addition along the porous walls, the choking condition is made relevant to the operation of solid-propellant rocket motors. Dissert. Abstr.

N93-29402# Wright Lab., Wright-Patterson AFB, OH.
ADVANCED THERMALLY-STABLE, COAL-DERIVED, JET FUELS PROGRAM: EXPERIMENT SYSTEM AND MODEL DEVELOPMENT Annual Report, Jul. 1991 - Sep. 1992
ELMER KLAVETTER, STEVE MARTIN, WAYNE TROTT, TIM OHERN, and GERALD NELSON Feb. 1993 93 p
(Contract MIPR-FY1455-91N-0638; AF PROJ. 3048)
(AD-A262747; WL-TR-92-2105) Avail: CASI HC A05/MF A01

A program entitled 'Thermally-Stable Jet Fuels Development' was initiated in FY89 by the U.S. Air Force, Aero Propulsion and Power Directorate, working jointly with the Department of Energy, Pittsburgh Energy Technology Center. Thermal stability of aviation fuels is of concern because of the potential operation problems arising from fuel degradation under thermal stress conditions. Sandia National Laboratories has been conducting efforts to develop instrumentation for monitoring characteristics of jet fuel degradation and solids deposition and develop models of those mechanisms from the data acquired using that instrumentation. This report describes the instrumentation development, data acquisition, and model parameter determination. Analysis of solid deposits is also described. DTIC

N93-29451*# Allied-Signal Aerospace Co., Torrance, CA. Garrett Ceramic Components.
IMPROVED SILICON NITRIDE FOR ADVANCED HEAT ENGINES Final Report
HARRY C. YEH and HO T. FANG Apr. 1991 291 p
(Contract NAS3-24385; RTOP 533-05-01)
(NASA-CR-182193; REPT-88-61608; NAS 1.26:182193) Avail: CASI HC A13/MF A03

The results of a four year program to improve the strength and reliability of injection-molded silicon nitride are summarized. Statistically designed processing experiments were performed to identify and optimize critical processing parameters and compositions. Process improvements were monitored by strength testing at room and elevated temperatures, and microstructural characterization by optical, scanning electron microscopes, and scanning transmission electron microscope. Processing modifications resulted in a 20 percent strength and 72 percent Weibull slope improvement of the baseline material. Additional sintering aids screening and optimization experiments succeeded in developing a new composition (GN-10) capable of 581.2 MPa at 1399 C. A SiC whisker toughened composite using this material as a matrix achieved a room temperature toughness of 6.9 MPa m(exp .5) by the Chevron notched bar technique. Exploratory experiments were conducted on injection molding of turbocharger rotors. Author

N93-29767# Oak Ridge National Lab., TN.
MICROWAVE PROCESSING OF SILICON NITRIDE FOR ADVANCED GAS TURBINE APPLICATIONS
T. N. TIEGS and J. O. KIGGANS 1993 6 p Presented at the 38th ASME International Gas Turbine and Aeroengine Congress and Exhibition, Cincinnati, OH, 24-27 May 1993
(Contract DE-AC05-84OR-21400)
(DE93-007910; CONF-930502-4) Avail: CASI HC A02/MF A01

Results from previous studies on microwave processing of silicon nitride-based ceramics are reviewed to ascertain the application of this technology to advanced gas turbine (AGT) materials. Areas of microwave processing that have been examined in the past are (1) sintering of powder compacts; (2) heat treatment of dense materials; and (3) nitridation of Si for reaction bonded silicon nitride. The sintering of Si3N4 powder compacts showed improved densification and enhanced grain growth. However, the high additive levels required to produce crack-free parts generally limit these materials to low temperature applications. Improved high-temperature creep resistance was observed for microwave heat-treated materials and therefore has application to materials used in highly demanding service conditions. In contrast to Si3N4, Si couples well in the microwave and sintered reaction-bonded silicon nitride materials were fabricated in a one-step process with cost-effective raw materials. However, these materials are also limited to lower temperature applications, under about 1000 C. DOE

N93-29981# Pittsburgh Univ., PA. Dept. of Materials Science and Engineering.
PLATINUM-MODIFIED DIFFUSION ALUMINIDE COATINGS ON NICKEL-BASE SUPERALLOYS Final Report, Jun. 1985 - Jun. 1988
G. M. KIM, G. H. MEIER, and F. S. PETTIT Mar. 1993 32 p
(Contract DAAG46-85-K-0008)
(AD-A263597; ARL-CR-50) Avail: CASI HC A03/MF A01

Conventional and platinum modified diffusion aluminide coatings on some state-of-the-art single crystal and polycrystalline nickel-base superalloys have been compared in tests designed to establish conditions representative of those existing in gas turbines operating over a range of applications. Resistance of these coatings to oxidation, high temperature hot corrosion, and low temperature hot corrosion have been compared. Platinum has been found to significantly improve the resistance of diffusion aluminides to all of these forms of degradation but the improvement with regard to low temperature hot corrosion is not as great as in the case of the other two forms of attack. Substrate composition has been found to exert a very significant effect on the lives of coatings in the high temperature tests. In the case of high temperature oxidation elements such as Hf are important in that they extend coating lives whereas for high temperature hot corrosion the type and concentration of refractory elements are significant factors affecting coating lives. A limited number of experiments have

indicated intermittent hot corrosion exposures degrade the subsequent cyclic oxidation resistance of Pt-aluminide coatings.
DTIC

N93-30203# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
CONTRIBUTION TO THE STUDY OF THE INTERACTION BETWEEN ACOUSTIC WAVES AND COHERENT STRUCTURES INDUCED BY A PRISMATIC CYLINDER IN A RECTANGULAR CAVITY Ph.D. Thesis - Paris VI Univ. [CONTRIBUTION A L'ETUDE DE L'INTERACTION ENTRE DES ONDES ACOUSTIQUES ET DES STRUCTURES TOURBILLONNAIRES EMISES PAR UN OBSTACLE PRIMASTIQUE DANS UNE CAVIT RECTANGULAIRE]
FRANCOIS GARNIER Sep. 1990 159 p *In* FRENCH
(ISSN 0078-3781)
(ONERA-NT-1990-10; ETN-93-93728) Avail: CASI HC A08/MF A02

Due to the complexity of the problem of the association of large scale vortices to combustion instabilities, the interaction of coherent structures and acoustics are considered in the simplified case of a nonreactive flow. Experimental works were developed on an aerodynamic experiment and in the energetics department. Strouhal number values, associated to coherent structure emission, are similar for the two experiments. A resonance mechanism is observed, and flow visualizations show that vortices are quite symmetric when vortex shedding frequency and that of an acoustic mode are closed. An analytical modeling is developed from the Lighthill theory. Coupling between different modes, observed in experiments, is qualitatively confirmed. The numerical simulation of the interaction between acoustics and coherent structures is made with the help of KIVA code. In the initial version, this code does not describe inflow and outflow. Tests for these boundary conditions have been made with success. This allows a simulation of the aerodynamic experiment. The Strouhal number values, associated to vortex shedding, are in good agreement with the experiments. The transition between a various wake and a vortex street is made easy by an acoustic excitation. The results obtained must give, at term, an efficient action on combustion instabilities.
ESA

N93-30429*# Boeing Commercial Airplane Co., Seattle, WA.
COMPOSITES: A VIABLE OPTION
JOHN E. MCCARTY *In* NASA. Langley Research Center, The First NASA Advanced Composites Technology Conference, Part 1 p 3-37 Jan. 1991
Avail: CASI HC A03/MF A04

While it sounded great to be asked to talk about composites, I found it difficult to select subject areas that would be of real interest. My choice is based on saying some things about where the maturity of the composite aircraft structures is today and what that means in terms of future criteria for application. This focus was the basis for my title selection. The other issue that will be addressed was requested by NASA and focuses on composites structures cost. This fits well with the state-of-the-art interpretations I will discuss first, since the cost issue must be viewed from both the current status and future points of view. The difficulty in presenting something in these areas is not in the subjects themselves but in trying to present a real world viewpoint to an audience of composite experts. So, with recognition of the expertise of the audience, I hope you will see something in this presentation about how to view composite aircraft structure.
Author

N93-30430*# Lockheed Aeronautical Systems Co., Burbank, CA.
ADVANCED COMPOSITE STRUCTURAL CONCEPTS AND MATERIAL TECHNOLOGIES FOR PRIMARY AIRCRAFT STRUCTURES
ANTHONY JACKSON *In* NASA. Langley Research Center, The First NASA Advanced Composites Technology Conference, Part 1 p 39-69 Jan. 1991
Avail: CASI HC A03/MF A04

Structural weight savings using advanced composites have been demonstrated for many years. Most military aircraft today use these materials extensively and Europe has taken the lead in their use in commercial aircraft primary structures. A major inhibiter to the use of advanced composites in the United States is cost. Material costs are high and will remain high relative to aluminum. The key therefore lies in the significant reduction in fabrication and assembly costs. The largest cost in most structures today is assembly. As part of the NASA Advanced Composite Technology Program, Lockheed Aeronautical Systems Company has a contract to explore and develop advanced structural and manufacturing concepts using advanced composites for transport aircraft. Wing and fuselage concepts and related trade studies are discussed. These concepts are intended to lower cost and weight through the use of innovative material forms, processes, structural configurations and minimization of parts. The approach to the trade studies and the downselect to the primary wing and fuselage concepts is detailed. The expectations for the development of these concepts is reviewed.
Author

N93-30431*# Douglas Aircraft Co., Inc., Long Beach, CA.
COMPOSITES TECHNOLOGY FOR TRANSPORT PRIMARY STRUCTURE
VICTOR CHEN, ARTHUR HAWLEY, MAX KLOTZSCHE, ALAN MARKUS, and RAY PALMER *In* NASA. Langley Research Center, The First NASA Advanced Composites Technology Conference, Part 1 p 71-126 Jan. 1991
Avail: CASI HC A04/MF A04

The ACT contract activity being performed by the McDonnell Douglas Corporation is divided into two separate activities: one effort by Douglas Aircraft in Long Beach, California with a focus on Transport Primary Wing and Fuselage Structure, and the other effort by McDonnell Aircraft in St. Louis, Missouri with a focus on Advanced Combat Aircraft Center Wing-Fuselage Structure. This presentation is on the Douglas Aircraft Transport Structure portion of the ACT program called ICAPS - Innovative Composite Aircraft Primary Structure.
Author

N93-30432*# Boeing Commercial Airplane Co., Seattle, WA.
ADVANCED TECHNOLOGY COMMERCIAL FUSELAGE STRUCTURE
L. B. ILCEWICZ, P. J. SMITH, T. H. WALKER, and R. W. JOHNSON *In* NASA. Langley Research Center, The First NASA Advanced Composites Technology Conference, Part 1 p 127-155 Jan. 1991
(Contract NAS1-18889)
Avail: CASI HC A03/MF A04

Boeing's program for Advanced Technology Composite Aircraft Structure (ATCAS) has focused on the manufacturing and performance issues associated with a wide body commercial transport fuselage. The primary goal of ATCAS is to demonstrate cost and weight savings over a 1995 aluminum benchmark. A 31 foot section of fuselage directly behind the wing to body intersection was selected for study purposes. This paper summarizes ATCAS contract plans and review progress to date. The six year ATCAS program will study technical issues for crown, side, and keel areas of the fuselage. All structural details in these areas will be included in design studies that incorporate a design build team (DBT) approach. Manufacturing technologies will be developed for concepts deemed by the DBT to have the greatest potential for cost and weight savings. Assembly issues for large, stiff, quadrant panels will receive special attention. Supporting technologies and mechanical tests will concentrate on the major issues identified for fuselage. These include damage tolerance, pressure containment, splices, load redistribution, post-buckled structure, and durability/life. Progress to date includes DBT selection of baseline fuselage concepts; cost and weight comparisons for crown panel designs; initial panel fabrication for manufacturing and structural mechanics research; and toughened material studies related to keel panels. Initial ATCAS studies have shown that NASA's Advanced Composite Technology program goals for cost and weight savings are attainable for composite fuselage.
Author (revised)

N93-30433*# Lockheed Aeronautical Systems Co., Burbank, CA.

DESIGN, ANALYSIS, AND FABRICATION OF THE TECHNOLOGY INTEGRATION BOX BEAM

C. F. GRIFFIN and L. E. MEADE *In* NASA. Langley Research Center, The First NASA Advanced Composites Technology Conference, Part 1 p 157-178 Jan. 1991 Sponsored in part by Lockheed Aeronautical Systems Company

(Contract NAS1-17699; NAS1-18888)

Avail: CASI HC A03/MF A04

Numerous design concepts, materials, and manufacturing methods were investigated analytically and empirically for the covers and spars of a transport wing box. This information was applied to the design, analysis, and fabrication of a full-scale section of a transport wing box. A blade-stiffened design was selected for the upper and lower covers of the box. These covers have been constructed using three styles of AS4/974 prepreg fabrics. The front and rear T-stiffened channel spars were filament wound using AS4/1806 towpreg. Covers, ribs, and spars were assembled using mechanical fasteners. When they are completed later this year, the tests on the technology integration box beam will demonstrate the structural integrity of an advanced composite wing design which is 25 percent lighter than the metal baseline. Author (revised)

N93-30434*# McDonnell Aircraft Co., Saint Louis, MO.

DESIGN AND MANUFACTURING CONCEPTS FOR THERMOPLASTIC STRUCTURES

MICHAEL P. RENIERI, STEVEN J. BURPO, and LANCE M. ROUNDY *In* NASA. Langley Research Center, The First NASA Advanced Composites Technology Conference, Part 1 179-206 Jan. 1991

Avail: CASI HC A03/MF A04

Results to date on the application of two manufacturing techniques, fiber placement and single diaphragm/coconsolidation, to produce cost-effective, thermoplastic composite (TPC), primary fuselage structure are presented. Applications relative to fuselage upper cover structure indicate potential cost savings relative to conventional approaches. Progress is also presented on efforts concerned with other design details which take advantage of thermoplastic composites such as fastener less stiffener/frame attachments. In addition, results are presented on the development and verification testing of a composite lug analysis program which incorporates through-the-thickness effects. Author (revised)

N93-30435*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

STRUCTURAL EVALUATION OF CURVED STIFFENED COMPOSITE PANELS FABRICATED USING A THERM-XSM PROCESS

CHRISTOS KASSAPOGLOU (Sikorsky Aircraft, Stratford, CT.), ALBERT J. DINICOLA (Sikorsky Aircraft, Stratford, CT.), JACK C. CHOU (Sikorsky Aircraft, Stratford, CT.), and JERRY W. DEATON *In its* First NASA Advanced Composites Technology Conference, Part 1 p 207-232 Jan. 1991

(Contract NAS1-18799)

Avail: CASI HC A03/MF A04

The use of composites in aircraft structures is often limited by material and manufacturing costs which, for some designs and applications, are prohibitively high. To increase the frequency of application of composites in primary airframe components alternative manufacturing processes are sought that reduce cost and/or enhance structural efficiency. One alternative process involves the use of THERM-Xsm as the pressure transfer medium during autoclave curing. THERM-Xsm, a silicon-based flow able polymer which behaves like a liquid under autoclave presssure, transmits quasi-hydrostatic pressure to all contacting surfaces of the part to be cured. Once the autoclave pressure is relieved, THERM-Xsm reverts back to the powdery solid state and can be reused many times. The THERM-Xsm process to be evaluated is depicted and consists of (1) enclosing the tool and part to be cured by a set of frames that create a box, (2) pouring THERM-Xsm powder onto the part and filling the box, and (3) placing a vacuum bag over the box assembly. In this program, a separating non-porous film (Teflon) was placed between the part to be cured and THERM-Xsm powder to avoid any contamination. The use of THERM-Xsm has two significant advantages over conventional manufacturing procedures. First, it eliminates complicated hard tooling since it guarantees uniform pressure transfer and thus, good compaction at complex structural details (such as frame-stiffener intersections and corners). Second, it greatly simplifies vacuum bagging, since once the part to be cured is covered by THERM-Xsm powder, the vacuum bag need only conform to a relatively flat shape reducing significantly the number of pleats required. A program is on-going at Sikorsky Aircraft to evaluate the structural performance of complex composite fuselage structures made with this THERM-Xsm process and to quantify the impact of THERM-Xsm on manufacturing labor hours and cost. The program involves fuselage panel optimization analysis, a building block test program where structural details representative of the full-scale article are analyzed and tested, and static and fatigue test/analysis of the full-scale test articles. The main results of this program are reported. Author (revised)

N93-30436*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

NOISE TRANSMISSION PROPERTIES AND CONTROL STRATEGIES FOR COMPOSITE STRUCTURES

RICHARD J. SILCOX, TODD B. BEYER, and HAROLD C. LESTER *In its* First NASA Advanced Composites Technology Conference, Part 1 p 233-246 Jan. 1991

Avail: CASI HC A03/MF A04

A study of several component technologies required to apply active control techniques to reduce interior noise in composite aircraft structures is described. The mechanisms of noise transmission in an all composite, large-scale, fuselage model are studied in an experimental program and found similar to mechanisms found in conventional aircraft construction. Two primary conditions of structural acoustic response are found to account for the dominant interior acoustic response. A preliminary study of active noise control in cylinders used piezoceramic actuators as force inputs for a simple aluminum fuselage model. These actuators provided effective control for the same two conditions of noise transmission found in the composite fuselage structure. The use of piezoceramic actuators to apply force inputs overcomes the weight and structural requirements of conventional shaker actuators. Finally, in order to accurately simulate these types of actuators in a cylindrical shell, two analytical models are investigated that apply either in-plane forces or bending moments along the boundaries of a finite patch. It is shown that the bending model may not be as effective as the force model for exciting the low order azimuthal modes that typically dominate the structural acoustic response in these systems. This result will affect the arrangement and distribution of actuators required for effective active control systems. Author (revised)

N93-30438*# *Douglas Aircraft Co., Inc., Long Beach, CA.*

RESIN TRANSFER MOLDING FOR ADVANCED COMPOSITE PRIMARY AIRCRAFT STRUCTURES

ALAN MARKUS and RAY PALMER *In* NASA. Langley Research Center, The First NASA Advanced Composites Technology Conference, Part 1 p 271-292 Jan. 1991

Avail: CASI HC A03/MF A04

Resin Transfer Molding (RTM) has been identified by Douglas Aircraft Company (DAC) and industry to be one of the promising processes being developed today which can break the cost barrier of implementing composite primary structures into a commercial aircraft production environment. The RTM process developments and scale-up plans Douglas Aircrart will be conducting under the NASA ACT contract are discussed. Author (revised)

N93-30439*# Grumman Aerospace Corp., Bethpage, NY. Aircraft Systems.

CONSOLIDATION OF GRAPHITE THERMOPLASTIC TEXTILE PREFORMS FOR PRIMARY AIRCRAFT STRUCTURE

J. SUAREZ and J. MAHON *In* NASA. Langley Research Center,

The First NASA Advanced Composites Technology Conference, Part 1 p 293-338 Jan. 1991
Avail: CASI HC A03/MF A04

The use of innovative cost effective material forms and processes is being considered for fabrication of future primary aircraft structures. Processes that have been identified as meeting these goals are textile preforms that use resin transfer molding (RTM) and consolidation forming. The Novel Composites for Wing and Fuselage Applications (NCWFA) program has as its objective the integration of innovative design concepts with cost effective fabrication processes to develop damage-tolerant structures that can perform at a design ultimate strain level of 6000 micro-inch/inch. In this on-going effort, design trade studies were conducted to arrive at advanced wing designs that integrate new material forms with innovative structural concepts and cost effective fabrication methods. The focus has been on minimizing part count (mechanical fasteners, clips, number of stiffeners, etc.), by using cost effective textile reinforcement concepts that provide improved damage tolerance and out-of-plane load capability, low-cost resin transfer molding processing, and thermoplastic forming concepts. The fabrication of representative Y spars by consolidation methods will be described. The Y spars were fabricated using AS4 (6K)/PEEK 150g commingled angle interlock 0/90-degree woven preforms with +45-degree commingled plies stitched using high strength Toray carbon thread and processed by autoclave consolidation. Author

N93-30440*# Boeing Commercial Airplane Co., Seattle, WA.
COST STUDIES FOR COMMERCIAL FUSELAGE CROWN DESIGNS
T. H. WALKER, P. J. SMITH, G. TRUSLOVE, K. S. WILLDEN, S. L. METSCHAN, and C. L. PFAHL *In* NASA. Langley Research Center, *The First NASA Advanced Composites Technology* Conference, Part 1 p 339-355 Jan. 1991
(Contract NAS1-18889)
Avail: CASI HC A03/MF A04

Studies were conducted to evaluate the cost and weight potential of advanced composite design concepts in the crown region of a commercial transport. Two designs from each of three design families were developed using an integrated design-build team. A range of design concepts and manufacturing processes were included to allow isolation and comparison of cost centers. Detailed manufacturing/assembly plans were developed as the basis for cost estimates. Each of the six designs was found to have advantages over the 1995 aluminum benchmark in cost and weight trade studies. Large quadrant panels and cobonded frames were found to save significant assembly labor costs. Comparisons of high- and intermediate-performance fiber systems were made for skin and stringer applications. Advanced tow placement was found to be an efficient process for skin lay up. Further analysis revealed attractive processes for stringers and frames. Optimized designs were informally developed for each design family, combining the most attractive concepts and processes within that family. A single optimized design was selected as the most promising, and the potential for further optimization was estimated. Technical issues and barriers were identified. Author

N93-30441*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A UNIFIED APPROACH FOR COMPOSITE COST REPORTING AND PREDICTION IN THE ACT PROGRAM
W. TOM FREEMAN, LOUIS F. VOSTEEN (Analytical Services and Materials, Inc., Hampton, VA.), and SHAHID SIDDIQI (Analytical Services and Materials, Inc., Hampton, VA.) *In its* First NASA Advanced Composites Technology Conference, Part 1 p 357-369 Jan. 1991
Avail: CASI HC A03/MF A04

The Structures Technology Program Office (STPO) at NASA Langley Research Center has held two workshops with representatives from the commercial airframe companies to establish a plan for development of a standard cost reporting format and a cost prediction tool for conceptual and preliminary designers. This paper reviews the findings of the workshop representatives with a plan for implementation of their recommendations. The recommendations of the cost tracking and reporting committee will be implemented by reinstituting the collection of composite part fabrication data in a format similar to the DoD/NASA Structural Composites Fabrication Guide. The process of data collection will be automated by taking advantage of current technology with user friendly computer interfaces and electronic data transmission. Development of a conceptual and preliminary designers' cost prediction model will be initiated. The model will provide a technically sound method for evaluating the relative cost of different composite structural designs, fabrication processes, and assembly methods that can be compared to equivalent metallic parts or assemblies. The feasibility of developing cost prediction software in a modular form for interfacing with state of the art preliminary design tools and computer aided design (CAD) programs is assessed. Author (revised)

N93-30442*# Northrop Corp., Hawthorne, CA. Aircraft Div.
F-15 COMPOSITE ENGINE ACCESS DOOR
RAMASWAMY L. RAMKUMAR and JAMES C. WATSON (McDonnell Aircraft Co., Saint Louis, MO.) *In* NASA. Langley Research Center, The First NASA Advanced Composites Technology Conference, Part 1 p 371-384 Jan. 1991
(Contract F33615-87-C-5242)
Avail: CASI HC A03/MF A04

This paper presents a summary of the successfully concluded phase 1 of the two-phase Design and Manufacture of Advanced Thermoplastic Structures (DMATS) program. It addresses the design, manufacture, and validation testing of a thermoplastic F-15E forward engine access door and includes lessons learned during the concurrent product and process design development phases of the program. Author

N93-30443*# Boeing Helicopter Co., Philadelphia, PA.
FABRICATION OF THE V-22 COMPOSITE AFT FUSELAGE USING AUTOMATED FIBER PLACEMENT
ROBERT L. PINCKNEY *In* NASA. Langley Research Center, The First NASA Advanced Composites Technology Conference, Part 1 p 385-397 Jan. 1991
Avail: CASI HC A03/MF A04

Boeing Helicopters and its subcontractors are working together under an Air Force Wright Research and Development Center (WRDC)-Manufacturing-Technology Large-Composite Primary Structure Fuselage program to develop and demonstrate new manufacturing techniques for producing composite fuselage skin and frame structures. Three sets of aft fuselage skins and frames have been fabricated and assembled, and substantial reductions in fabrication and assembly costs demonstrated. Author

N93-30444*# Northrop Corp., Hawthorne, CA.
LESSONS LEARNED FOR COMPOSITE STRUCTURES
R. S. WHITEHEAD *In* NASA. Langley Research Center, The First NASA Advanced Composites Technology Conference, Part 1 p 399-415 Jan. 1991
Avail: CASI HC A03/MF A04

Lessons learned for composite structures are presented in three technology areas: materials, manufacturing, and design. In addition, future challenges for composite structures are presented. Composite materials have long gestation periods from the developmental stage to fully matured production status. Many examples exist of unsuccessful attempts to accelerate this gestation period. Experience has shown that technology transition of a new material system to fully matured production status is time consuming, involves risk, is expensive and should not be undertaken lightly. The future challenges for composite materials require an intensification of the science based approach to material development, extension of the vendor/customer interaction process to include all engineering disciplines of the end user, reduced material costs because they are a significant factor in overall part cost, and improved batch-to-batch pre-preg physical property control. Historical manufacturing lessons learned are presented using current in-service production structure as examples. Most producibility problems for these structures can be traced to their

sequential engineering design. This caused an excessive emphasis on design-to-weight and schedule at the expense of design-to-cost. This resulted in expensive performance originated designs, which required costly tooling and led to non-producible parts. Historically these problems have been allowed to persist throughout the production run. The current/future approach for the production of affordable composite structures mandates concurrent engineering design where equal emphasis is placed on product and process design. Design for simplified assembly is also emphasized, since assembly costs account for a major portion of total airframe costs. The future challenge for composite manufacturing is, therefore, to utilize concurrent engineering in conjunction with automated manufacturing techniques to build affordable composite structures. Composite design experience has shown that significant weight savings have been achieved, outstanding fatigue and corrosion resistance have been demonstrated, and in-service performance has been very successful. Currently no structural design show stoppers exist for composite structures. A major lesson learned is that the full scale static test is the key test for composites, since it is the primary structural 'hot spot' indicator. The major durability issue is supportability of thin skinned structure. Impact damage has been identified as the most significant issue for the damage tolerance control of composite structures. However, delaminations induced during assembly operations have demonstrated a significant nuisance value. The future challenges for composite structures are threefold. Firstly, composite airframe weight fraction should increase to 60 percent. At the same time, the cost of composite structures must be reduced by 50 percent to attain the goal of affordability. To support these challenges it is essential to develop lower cost materials and processes. Author (revised)

N93-30841*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FIRST NASA ADVANCED COMPOSITES TECHNOLOGY CONFERENCE, PART 2
JOHN G. DAVIS, JR., comp. and HERMAN L. BOHON, comp. (Lockheed Engineering and Sciences Co., Hampton, VA.) Jan. 1991 622 p Conference held in Seattle, WA, 29 Oct. - 1 Nov. 1990
(Contract RTOP 510-02-11)
(NASA-CP-3104-PT-2; L-16889-PT-2; NAS 1.55:3104-PT-2)
Avail: CASI HC A99/MF A06

Presented here is a compilation of papers presented at the first NASA Advanced Composites Technology (ACT) Conference held in Seattle, Washington, from 29 Oct. to 1 Nov. 1990. The ACT program is a major new multiyear research initiative to achieve a national goal of technology readiness before the end of the decade. Included are papers on materials development and processing, innovative design concepts, analysis development and validation, cost effective manufacturing methodology, and cost tracking and prediction procedures. Papers on major applications programs approved by the Department of Defense are also included.

N93-30845*# Boeing Commercial Airplane Co., Seattle, WA.
EFFECTS OF INTRA- AND INTER-LAMINAR RESIN CONTENT ON THE MECHANICAL PROPERTIES OF TOUGHENED COMPOSITE MATERIALS
DODD H. GRANDE, LARRY B. ILCEWICZ, WILLIAM B. AVERY (Boeing Co., Seattle, WA.), and WILLARD D. BASCOM (Utah Univ., Salt Lake City.) *In* NASA. Langley Research Center, First NASA Advanced Composites Technology Conference, Part 2 p 455-475 Jan. 1991
(Contract NAS1-18889)
Avail: CASI HC A03/MF A06

Composite materials having multiphase toughened matrix systems and laminate architectures characterized by resin-rich interlaminar layers (RIL) have been the subject of much recent attention. Such materials are likely to find applications in thick compressively loaded structures such as the keel area of commercial aircraft fuselages. The effects of resin content and its interlaminar and intralaminar distribution on mechanical properties were investigated with test and analysis of two carbon-epoxy systems. The RIL was found to reduce the in situ strengthening effect for matrix cracking in laminates. Mode 2 fracture toughness was found to increase with increasing RIL thickness over the range investigated, and Mode 1 interlaminar toughness was negligibly affected. Compressive failure strains were found to increase with increasing resin content for specimens having no damage, holes, and impact damage. Analytical tools for predicting matrix cracking of off-axis plies and damage tolerance in compression after impact (CAI) were successfully applied to materials with RIL.
Author (revised)

N93-30852*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DEVELOPMENT OF STITCHING REINFORCEMENT FOR TRANSPORT WING PANELS
RAYMOND J. PALMER (Douglas Aircraft Co., Inc., Huntington Beach, CA.), MARVIN B. DOW, and DONALD L. SMITH (Lockheed Engineering and Sciences Co., Hampton, VA.) *In its* First NASA Advanced Composites Technology Conference, Part 2 p 621-646 Jan. 1991
Avail: CASI HC A03/MF A06

The NASA Advanced Composites Technology (ACT) program has the objective of providing the technology required to obtain the full benefit of weight savings and performance improvements offered by composite primary aircraft structures. Achieving the objective is dependent upon developing composite materials and structures which are damage tolerant and economical to manufacture. Researchers are investigating stitching reinforcement combined with resin transfer molding to produce materials meeting the ACT program objective. Research is aimed at materials, processes, and structural concepts for application in both transport wings and fuselages, but the emphasis to date has been on wing panels. Empirical guidelines are being established for stitching reinforcement in structures designed for heavy loads. Results are presented from evaluation tests investigating stitching types, threads, and density (penetrations per square inch). Tension strength, compression strength, and compression after impact data are reported. Author

N93-30853*# Dow Chemical Co., Midland, MI.
DEVELOPMENT OF RESINS FOR COMPOSITES BY RESIN TRANSFER MOLDING
EDMUND P. WOO, PAUL M. PUCKETT, and SHAWN J. MAYNARD *In* NASA. Langley Research Center, First NASA Advanced Composites Technology Conference, Part 2 p 647-658 Jan. 1991
(Contract NAS1-18841)
Avail: CASI HC A03/MF A06

Designed to cover a wide range of resin technology and to meet the near-term and long-term needs of the aircraft industry, this research has three objectives: to produce resin transfer molding (RES) resins with improved processability, to produce prepreg systems with high toughness and service temperature, and to produce new resin systems. Progress on reaching the objectives is reported. Author

N93-30854*# BASF Structural Materials, Inc., Charlotte, NC.
ADVANCED FIBER/MATRIX MATERIAL SYSTEMS
J. TIMOTHY HARTNESS *In* NASA. Langley Research Center, First NASA Advanced Composites Technology Conference, Part 2 p 659-676 Jan. 1991
(Contract NAS1-18834)
Avail: CASI HC A03/MF A06

Work completed in Phase 1 of the NASA Advanced Composite Technology program is discussed. Two towpreg forms (commingled yarns and fused powder towpregs) are being characterized under the program. These towpregs will be used to evaluate textile fabrication technologies for advanced aircraft composite structures. The unique characteristic of both of these material forms is that both fiber and matrix resin are handled in a single operation such as weaving, braiding, or fiber placement. The evaluation of both commingled and fused powder towpreg is described. Various polymer materials are considered for both subsonic and supersonic

applications. Polymers initially being evaluated include thermoplastic polyimides such as Larc-TPI and New-TPI, thermoplastics such as PEEK and PEKEKK as well as some toughened crosslinked polyimides. Preliminary mechanical properties as well as tow handling are evaluated. Author

N93-30855*# Boeing Defense and Space Group, Philadelphia, PA.
MECHANICAL AND ANALYTICAL SCREENING OF BRAIDED COMPOSITES FOR TRANSPORT FUSELAGE APPLICATIONS
MARK J. FEDRO, CHRISTIAN GUNTHER, and FRANK K. KO (Drexel Univ., Philadelphia, PA.) *In* NASA. Langley Research Center, First NASA Advanced Composites Technology Conference, Part 2 p 677-704 Jan. 1991
(Contract NAS1-18889)
Avail: CASI HC A03/MF A06

The mechanics of materials progress in support of the goal of understanding the application of braided composites in a transport aircraft fuselage are summarized. Composites consisting of both 2-D and 3-D braid patterns are investigated. Both consolidation of commingled graphite/PEEK and resin transfer molding of graphite-epoxy braided composite processes are studied. Mechanical tests were used to examine unnotched tension, open hole tension, compression, compression after impact, in-plane shear, out-of-plane tension, bearing, and crippling. Analytical methods are also developed and applied to predict the stiffness and strengths of test specimens. A preliminary study using the test data and analytical results is performed to assess the applicability of braided composites to a commercial aircraft fuselage. Author

N93-30857*# Boeing Co., Seattle, WA.
DEVELOPMENTS IN IMPACT DAMAGE MODELING FOR LAMINATED COMPOSITE STRUCTURES
ERNEST F. DOST, WILLIAM B. AVERY, GARY D. SWANSON, and KUEN Y. LIN (Washington Univ., Seattle.) *In* NASA. Langley Research Center, First NASA Advanced Composites Technology Conference, Part 2 p 721-736 Jan. 1991
(Contract NAS1-18889)
Avail: CASI HC A03/MF A06

Damage tolerance is the most critical technical issue for composite fuselage structures studied in the Advanced Technology Composite Aircraft Structures (ATCAS) program. The objective here is to understand both the impact damage resistance and residual strength of the laminated composite fuselage structure. An understanding of the different damage mechanisms which occur during an impact event will support the selection of materials and structural configurations used in different fuselage quadrants and guide the development of analysis tools for predicting the residual strength of impacted laminates. Prediction of the damage state along with the knowledge of post-impact response to applied loads will allow for engineered stacking sequencies and structural configurations; intelligent decisions on repair requirements will also result. Author

N93-30858*# Washington Univ., Seattle.
MULTI-PARAMETER OPTIMIZATION TOOL FOR LOW-COST COMMERCIAL FUSELAGE CROWN DESIGNS
ZELDA ZABINSKY, MARK TUTTLE, DOUGLAS GRAESSER, GUN-IN KIM, DARRIN HATCHER, GARY SWANSON (Boeing Commercial Airplane Co., Seattle, WA.), and LARRY ILCEWICZ (Boeing Commercial Airplane Co., Seattle, WA.) *In* NASA. Langley Research Center, First NASA Advanced Composites Technology Conference, Part 2 p 737-748 Jan. 1991
Avail: CASI HC A03/MF A06

The work in progress for developing a methodology and software tool to aid in the optimal design of composite structures is discussed. The methodology is being developed to take advantage of the ability to tailor the composite material in conjunction with the design of the structure. The composites optimization design software UWCODA was found to be very successful in preliminary testing and early experience. UWCODA is a composites design code that uses a number of plies and fiber angles as design variables, employs maximum strain failure criteria for objective function and additional constraints, includes Boeing design tools for stiffened panels, and includes stiffener geometry in the design variables. Author

N93-30861*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DESIGN AND ANALYSIS OF GRID STIFFENED CONCEPTS FOR AIRCRAFT COMPOSITE PRIMARY STRUCTURAL APPLICATIONS
DAMODAR R. AMBUR *In its* First NASA Advanced Composites Technology Conference, Part 2 p 779-789 Jan. 1991
Avail: CASI HC A03/MF A06

An approach to buckling resistant design of general grid stiffened flat plates based on smeared stiffener theory for combined inplane loading is discussed. Some results from parametric studies performed to assess the validity of smeared stiffener for practical stiffener configurations and to illustrate the benefits of different stiffening concepts are given. Details of a design study are discussed where the present analysis method is used to design a grid stiffened panel for a fuselage application and verified using a finite element analysis results. Author

N93-30862*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
OPTIMIZATION OF COMPOSITE SANDWICH COVER PANELS SUBJECTED TO COMPRESSIVE LOADINGS
JUAN R. CRUZ *In its* First NASA Advanced Composites Technology Conference, Part 2 p 791-807 Jan. 1991
Avail: CASI HC A03/MF A06

An analysis and design method is presented for the design of composite sandwich cover panels that includes transverse shear effects and damage tolerance considerations. This method is incorporated into an optimization program called SANDOP (SANDwich OPtimization). SANDOP is used in the present study to design optimized composite sandwich cover panels for transport aircraft wing applications as a demonstration of its capabilities. The results of this design study indicate that optimized composite sandwich cover panels have approximately the same structural efficiency as stiffened composite cover panels designed to identical constraints. Results indicate that inplane stiffness requirements have a large effect on the weight of these composite sandwich cover panels at higher load levels. Increasing the maximum allowable strain and the upper percentage limit of the 0 degree and plus or minus 45 degree plies can yield significant weight savings. The results show that the structural efficiency of these optimized composite sandwich cover panels is relatively insensitive to changes in core density. Author (revised)

N93-30863*# California Univ., Davis.
A COMPARISON OF CLASSICAL MECHANICS MODELS AND FINITE ELEMENT SIMULATION OF ELASTICALLY TAILORED WING BOXES
LAWRENCE W. REHFIELD, RICHARD D. PICKINGS, STEPHEN CHANG, and MICHAEL HOLL *In* NASA. Langley Research Center, First NASA Advanced Composites Technology Conference, Part 2 p 809-815 Jan. 1991
Avail: CASI HC A02/MF A06

Structural tailoring concepts were developed to create wings with elastically produced camber for the purpose of increasing lift during takeoff conditions. Simple models based upon enhancements to the thin walled composite beam theory of Rehfield were developed to investigate prospects for elastic tailoring of the chordwise deformation of wing structures. The purpose here is to provide a comparison of the theoretical results with a finite element model for the bending method of producing camber. Finite element correlation studies were completed for two cases: a bonded unstiffened structural box, and a bolted unstiffened structural box. Results from these studies show an error of less than one percent for the bonded case and less than six percent for the bolted case in predicting camber curvature for the structural box. Examination of the results shows that the theory is very

accurate for the cases studied and will provide an excellent basis for conducting further tailoring studies. Author

N93-30864*# Hercules Aerospace Co., Magna, UT. Composite Structures Programs.
ADVANCED FIBER PLACEMENT OF COMPOSITE FUSELAGE STRUCTURES
ROBERT L. ANDERSON and CARROLL G. GRANT *In* NASA. Langley Research Center, First NASA Advanced Composites Technology Conference, Part 2 p 817-830 Jan. 1991
Avail: CASI HC A03/MF A06

The Hercules/NASA Advanced Composite Technology (ACT) program will demonstrate the low cost potential of the automated fiber placement process. The Hercules fiber placement machine was developed for cost effective production of composite aircraft structures. The process uses a low cost prepreg tow material form and achieves equivalent laminate properties to structures fabricated with prepreg tape layup. Fiber placement demonstrations planned for the Hercules/NASA program include fabrication of stiffened test panels which represent crown, keel, and window belt segments of a typical transport aircraft fuselage. Author

N93-30865*# Boeing Commercial Airplane Co., Seattle, WA.
PROCESS AND ASSEMBLY PLANS FOR LOW COST COMMERCIAL FUSELAGE STRUCTURE
KURTIS WILLDEN, STEPHEN METSCHAN, and VAL STARKEY *In* NASA. Langley Research Center, First NASA Advanced Composites Technology Conference, Part 2 p 831-842 Jan. 1991
Avail: CASI HC A03/MF A06

Cost and weight reduction for a composite structure is a result of selecting design concepts that can be built using efficient low cost manufacturing and assembly processes. Since design and manufacturing are inherently cost dependent, concurrent engineering in the form of a Design-Build Team (DBT) is essential for low cost designs. Detailed cost analysis from DBT designs and hardware verification must be performed to identify the cost drivers and relationships between design and manufacturing processes. Results from the global evaluation are used to quantitatively rank design, identify cost centers for higher ranking design concepts, define and prioritize a list of technical/economic issues and barriers, and identify parameters that control concept response. These results are then used for final design optimization. Author

N93-30867*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MULTIPLE METHODS INTEGRATION FOR STRUCTURAL MECHANICS ANALYSIS AND DESIGN
J. M. HOUSNER and M. A. AMINPOUR (Analytical Services and Materials, Inc., Hampton, VA.) *In its* First NASA Advanced Composites Technology Conference, Part 2 p 875-889 Jan. 1991
Avail: CASI HC A03/MF A06

A new research area of multiple methods integration is proposed for joining diverse methods of structural mechanics analysis which interact with one another. Three categories of multiple methods are defined: those in which a physical interface are well defined; those in which a physical interface is not well-defined, but selected; and those in which the interface is a mathematical transformation. Two fundamental integration procedures are presented that can be extended to integrate various methods (e.g., finite elements, Rayleigh Ritz, Galerkin, and integral methods) with one another. Since the finite element method will likely be the major method to be integrated, its enhanced robustness under element distortion is also examined and a new robust shell element is demonstrated. Author

N93-30869*# Northrop Corp., Hawthorne, CA. Aircraft Div.
A RAYLEIGH-RITZ ANALYSIS METHODOLOGY FOR CUTOUTS IN COMPOSITE STRUCTURES
STEVEN G. RUSSELL *In* NASA. Langley Research Center, First NASA Advanced Composites Technology Conference, Part 2 p 901-920 Jan. 1991
(Contract NAS1-18842)
Avail: CASI HC A03/MF A06

A new Rayleigh-Ritz stress analysis methodology that was developed for composite panels containing cutouts is described. The procedure, which makes use of a general assumed displacement field, accommodates circular and elliptical cutouts in biaxially loaded rectangular composite panels. Symmetric integral padups around the cutout can be included in the analysis. Benchmark results are presented to demonstrate the accuracy of the technique. Strength predictions based on the average stress criterion are generated and compared with experimental data. Finally, the stress analysis methodology is integrated into a design procedure for sizing integral padups around circular cutouts, and a sample problem is solved to illustrate its use. Author

N93-30873*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STRUCTURAL RESPONSE OF BEAD-STIFFENED THERMOPLASTIC SHEAR WEBS
MARSHALL ROUSE *In its* First NASA Advanced Composites Technology Conference, Part 2 p 969-977 Jan. 1991
Avail: CASI HC A02/MF A06

The results of an experimental and analytical study of the structural response and failure characteristics of selected bead-stiffened thermoplastic shear-webs are presented. Results are given for specimens with one stiffeneer, with two stiffeners, and different stiffener geometries. Selected analytical results that were obtained with the Computational Structural Mechanics (CSM) Testbed computer code are presented. Analytical results that describe normal and transverse shear stress are also presented. Author

N93-30875*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN OVERVIEW OF THE CRASH DYNAMICS FAILURE BEHAVIOR OF METAL AND COMPOSITE AIRCRAFT STRUCTURES
HUEY D. CARDEN, RICHARD L. BOITNOTT (Army Aerostructures Directorate, Hampton, VA.), EDWIN L. FASANELLA (Lockheed Engineering and Sciences Co., Hampton, VA.), and LISA E. JONES (Lockheed Engineering and Sciences Co., Hampton, VA.) *In its* First NASA Advanced Composites Technology Conference, Part 2 p 1005-1035 Jan. 1991
Avail: CASI HC A03/MF A06

An overview of failure behavior results is presented from some of the crash dynamics research conducted with concepts of aircraft elements and substructure not necessarily designed or optimized for energy absorption or crash loading considerations. Experimental and analytical data are presented that indicate some general trends in the failure behavior of a class of composite structures that includes fuselage panels, individual fuselage sections, fuselage frames, skeleton subfloors with stringers and floor beams without skin covering, and subfloors with skin added to the frame stringer structure. Although the behavior is complex, a strong similarity in the static/dynamic failure behavior among these structures is illustrated through photographs of the experimental results and through analytical data of generic composite structural models. Author

N93-30876*# California Univ., Davis.
TAILORED COMPOSITE WINGS WITH ELASTICALLY PRODUCED CHORDWISE CAMBER
LAWRENCE W. REHFIELD, STEPHEN CHANG, PETER J. ZISCHKA, RICHARD D. PICKINGS, and MICHAEL W. HOLL *In* NASA. Langley Research Center, First NASA Advanced Composites Technology Conference, Part 2 p 1037-1047 Jan. 1991
(Contract NAS1-18754)
Avail: CASI HC A03/MF A06

Four structural concepts were created which produce chordwise camber deformation that results in enhanced lift. A wing box can be tailored to utilize each of these with composites. In attempting

to optimize the aerodynamic benefits, researchers 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

N93-30974*# Purdue Univ., Elkhart, IN.
PERFORMANCE OF THERMAL ADHESIVES IN FORCED CONVECTION
NIKHIL K. KUNDU *In* NASA. Langley Research Center, National Educators' Workshop. Update 92: Standard Experiments in Engineering Materials Science and Technology p 393-401 Jun. 1993
Avail: CASI HC A02/MF A04

Cooling is critical for the life and performance of electronic equipment. In most cases cooling may be achieved by natural convection but forced convection may be necessary for high wattage applications. Use of conventional type heat sinks may not be feasible from the viewpoint of specific applications and the costs involved. In a heat sink, fins can be attached to the well by ultrasonic welding, by soldering, or with a number of industrially available thermal adhesives. In this paper, the author investigates the heat transfer characteristics of several adhesives and compares them with ultrasonic welding and theoretically calculated values. This experiment was conducted in an air flow chamber. Heat was generated by using heaters mounted on the well. Thermstrate foil, Uniset A401, and Aremco 571 adhesives were tested along with an ultrasonically welded sample. Ultrasonic welding performed far better than the adhesives and Thermstrate foil. This type of experiment can be adapted for a laboratory exercise in an upper level heat transfer course. It gives students an exposure to industrial applications that help them appreciate the importance of the course material. Author (revised)

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ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A93-39949
FLUID-FILM FOIL BEARINGS CONTROL ENGINE HEAT
LEO O'CONNOR Mechanical Engineering (ISSN 0025-6501) vol. 115, no. 5 May 1993 p. 72-75. refs
Copyright

The state-of-the-art of fluid-film foil bearings and their current and prospective applications are briefly reviewed. In particular, attention is given to the general design of fluid-film foil bearings, the materials used, and bearing performance. The applications discussed include launch vehicle turbopumps, turbines used to cool aircraft cabins, and turbocompressors and turboexpanders used in the processing of cryogenic fluids. Future applications may include turbochargers, textile spindles, cryocoolers, motor blowers, heat pumps, and solar chillers. AIAA

A93-40334
ELF, VLF AND LF RADIATION FROM A VERY LARGE LOOP ANTENNA WITH A MOUNTAIN CORE
R. BARR (National Inst. of Water and Atmospheric Research, Lower Hutt, New Zealand), W. IRELAND (New Zealand Inst. for Industrial Research and Development, Lower Hutt), and M. J. SMITH (National Inst. of Water and Atmospheric Research, Lower Hutt, New Zealand) IEE Proceedings, Part H - Microwaves, Antennas and Propagation (ISSN 0950-107X) vol. 140, no. 2 April 1993 p. 129-134. Research supported by Admiralty Research Establishment of the United Kingdom refs
Copyright

The establishment of an LF/VLF/ELF transmitting facility at the Homer tunnel near Milford South in the South Island of New Zealand is described. The antenna consisted of a 3.3 km-long PVC-covered aluminum conductor passing through the tunnel and over the mountain above, forming a large vertical loop antenna. Measurements of the electric field radiated from the transmitter, recorded at both Lauder and Palmerston, 133 and 225 km from the transmitter site, respectively, are presented. The antenna radiation pattern derived from observations made onboard an Orion aircraft circling the antenna at a distance of 200 km is also presented. Theoretical models are derived which enable fits to the radiated field data to be made over a wide frequency range (0.5-40 kHz). With 1 kW of input power the antenna produced peak radiated fields at frequencies near 10 kHz equivalent to those of a vertical monopole source radiating 150 mW. Author

A93-40390
VELOCITY VECTOR LDA MEASUREMENT INSIDE A PITCHED BLADE IMPELLER
MICHAL PTACNIK, JAROMIR LAMKA (Aeronautical Research and Test Inst., Prague, Czech Republic), and IVAN FORT (Czech Technical Univ., Prague, Czech Republic) Dantec Information (ISSN 0900-5579) no. 12 Feb. 1993 p. 6-9. refs
Copyright

The integral quantities of flow in a mixing system with a pitched blade impeller are generally known, but the flow pattern inside and in the close neighborhood of the impeller is not well documented. This paper describes results of pitched blade impeller synchronous measurements obtained by Laser Doppler Anemometry. Author

A93-40445
EFFECT OF STRUCTURAL UNCERTAINTIES ON FLUTTER ANALYSIS
F. POIRION (ONERA, Chatillon, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X) no. 6 1992 p. 31-41. refs
Copyright

A numerical method is developed for analyzing the sensitivity of the solutions to the flutter equation to uncertain structural parameters. The uncertainties are modelled by random variables following a given law. The problem is first solved using a first-order linearization method, and then with a Monte-Carlo simulation method. When the results are compared, we find that the former method, though widely used for the modal analysis, of uncertain dynamical systems, is not adequate for the flutter analysis of such systems. Author

A93-40472
SOME CONTRIBUTIONS TO PROPULSION THEORY - THE STREAM FORCE THEOREM AND APPLICATIONS TO PROPULSION
C. L. BORE (British Aerospace, PLC, Kingston, United Kingdom) Aeronautical Journal (ISSN 0001-9240) vol. 97, no. 964 April 1993 p. 138-144. refs
Copyright

After deriving the Stream Force Theorem, it is shown how this simplifies many problems of propulsion theory and makes the mathematics direct and concise. Applications discussed include forces upon ducting systems, intake entry losses, spill drag, mixing losses, errors in measuring intake losses by pitot traverse, and use of measured intake lip suction force in assessing entry losses and spill drag. Author

A93-40492
STUDY ON DYNAMIC CHARACTERISTICS OF HEAT EXCHANGER

WENJIANG YING (Nanjing Aeronautical Inst., China) Nanjing Aeronautical Institute, Journal (ISSN 1000-1956) vol. 25, no. 2 April 1993 p. 203-210. In CHINESE refs

Temperature regulation in aircraft air conditioning systems is considered. The structural form of a dynamic mathematical model for a heat exchanger with the form of lumped parameter model is theoretically deduced. An experimental way to obtain the model parameters is proposed and the appropriate calculation formulas are deduced. A method for calculating the dynamic characteristics of a heat exchanger is pointed out. An example is given. Author (revised)

A93-40654
PROCESSING OF HIGH TEMPERATURE CARBON FIBER REINFORCED POLYMERS

MILTON H. ANDERSON (Composites Horizons, Inc., Covina, CA) Aug. 1992 10 p. Society of Manufacturing Engineers, High Temperature Composites Clinic Conference, Los Angeles, CA, Aug. 12, 13, 1992
(SME PAPER EM92-215) Copyright

The drive to produce high-performance carbon fiber-reinforced polymer composites has resulted in the development of several new commercial materials. This paper describes some fabrication experience gained by working with these high-temperature thermosets and thermoplastics in both prototype and production modes. Tooling for these composites is also discussed. Author

A93-40656
MACHINING COST COMPARISON OF SILICON CARBIDE DISCONTINUOUSLY REINFORCED ALUMINUM, UNREINFORCED ALUMINUM, AND TITANIUM

BRETT R. BERLIN (Moog, Inc., East Aurora, NY) Sep. 1992 16 p. Society of Manufacturing Engineers, Conference on Machining Requirements for Metal Matrix Composites, Dearborn, MI, Sept. 22, 23, 1992 refs
(SME PAPER EM92-252) Copyright

An investigation into applications of discontinuously reinforced aluminum should also address concerns for machining economics. The abrasiveness created by the silicon carbide reinforcement requires the use of diamond tooling. The high cost of diamond tooling, specifically polycrystalline diamond, draws an immediate concern for tooling cost. This paper will introduce an economic model generated during test machining of 2009/SiC 115W-T6 and compare machining costs with 6061-T6 aluminum and Al6-4V titanium. This model is based on the machining procedures and techniques associated with low-volume production of high-performance aerospace hardware. Author

A93-40666
EMERGING TECHNOLOGY FOR LARGE-AREA SCANNING OF AGING AIRCRAFT

FRANK A. IDDINGS (Southwest Research Inst., San Antonio, TX) Jun. 1992 9 p. Society of Manufacturing Engineers, Maintaining and Supporting an Aircraft Fleet Conference, Dayton, OH, June 9-11, 1992 refs
(Contract F4606-89-D-0039)
(SME PAPER AD92-205) Copyright

A need exists for an NDI technique that can scan large areas of commercial or military aircraft to determine whether that aircraft can be returned to service or should be placed into maintenance. The requirements for this large-area scanning technique are speed, simple operation by a few technicians, easily interpreted and archived data, and detection of delaminations, disbond, cracks, and impact damage. Two NDI techniques that promise to satisfy the requirements are shearography and pulsed infrared thermography. Each of the two techniques is described and discussed in terms of these requirements. Author

A93-40672
A NOVEL AIRCRAFT-BASED TANDEM MASS SPECTROMETER FOR ATMOSPHERIC ION AND TRACE GAS MEASUREMENTS

O. MOEHLER, TH. REINER, and F. ARNOLD (Max-Planck-Inst. fuer Kernphysik, Heidelberg, Germany) Review of Scientific Instruments (ISSN 0034-6748) vol. 64, no. 5 May 1993 p. 1199-1207. Research supported by BMFT and EEC refs
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The general design and operation of a novel aircraft-based triple-quadrupole mass spectrometer (TQMS) developed for the improved detection and collisional analysis of atmospheric ions and trace gases are described. The instrument is also suitable for laboratory collision-induced dissociation measurements, studies of ion-molecule reactions, and analytical applications. Highly sensitive and selective trace gas detection by chemical ionization mass spectrometry is also possible using a novel ion injection technique. Result of aircraft-based measurements made with the TQMS are summarized. AIAA

A93-40775
CRACK ANALYSIS USING DISCONTINUOUS BOUNDARY ELEMENTS

A. ELZEIN and R. A. ADEY (Computational Mechanics, Southampton, United Kingdom) Institution of Mechanical Engineers, Proceedings, Part G - Journal of Aerospace Engineering (ISSN 0954-4100) vol. 207, no. G1 1993 p. 41-45. Aerotech 92, Birmingham, United Kingdom, Jan. 14-17, 1992 refs
Copyright

A simple and efficient approach is proposed for the analysis of crack problems occurring in mechanical components widely used in the aerospace industry. A linear stress analysis of the cracked components is performed using discontinuous boundary elements at the crack tip. The engineering analysis system BEASY is used to derive accurate predictions of the stress intensity factors corresponding to either of the three modes K(I), K(II) or K(III). With the proposed approach, the user has to model only the surface of the component, as opposed to its volume infinite elements. Thus, line elements in 2D and axisymmetric problems and surface quadrilaterals or triangles in 3D problems are used to mesh the components. The approach clearly results in substantial savings in mesh preparation effort. The paper will describe the application of the system to problems in the aerospace field and the convergence results that demonstrate the high accuracy and reliability of the technique. Author (revised)

A93-40823
THE FINITE ELEMENT METHOD IN THE 1990'S

E. ONATE, ED., J. PERIAUX, ED., and A. SAMUELSSON, ED. Barcelona, Spain/Berlin and Secaucus, NJ CIMNE/ Springer-Verlag 1991 638 p. No individual items are abstracted in this volume
(ISBN 0-387-54930-7) Copyright

The present volume discusses a novel boundary-type finite element for 2D and 3D elastic solids, thermomechanical coupling in elastoplastic analysis, rigid FEM in structural analysis, the selection of stresses to suppress zero-energy deformation modes in hybrid FEM, FEM for fast transient dynamics, a FEM for dynamic contact problems, and convergence of the Newton-Raphson method in elastoplastic softening structural dynamics. Also discussed the corotational approach to substructuring for flexible multibody analysis, mass lumping by spectral matching, generalized mesh and adaptivity techniques for CFD, FEM and magnetic scalar potentials, dualities in minimum surfaces, a novel feasible-directions solution approach in constrained optimization, and a new approach to stability analysis of partitioned systems. AIAA

A93-41029
INFRARED THERMOGRAPHY CHARACTERIZATION OF GOERTLER VORTEX TYPE PATTERNS IN HYPERSONIC FLOWS

D. BOSCHER, B. BAUDOUY, A. DEOM, M.-C. COET, J. DELERY, and D. BALAGEAS (ONERA, Chatillon, France) ONERA, TP no. 1993-13 1993 15 p. NATO, Advanced Research Workshop on New Trends in Instrumentation for Hypersonic Research, Toulouse, France, Apr. 27-May 1, 1992 refs
(ONERA, TP NO. 1993-13) Copyright

Results are presented on aerothermal analysis, using infrared

thermography, of the Goertler vortex type patterns observed in a wind tunnel. The parameters investigated included the relative amplitude of the heat transfer coefficient (h) modulation, the amplitude of the local recovery temperature (Tr) modulation, and the spatial frequencies of these modulations. Results indicate that the two modulations, h and Tr, are in phase opposition. AIAA

A93-41397
APPLICATIONS OF IR IMAGERY TO THERMAL EVALUATIONS
RICHARD L. BOCCHICCHIO (Grumman Corp., Aircraft Systems Div., Bethpage, NY) Jul. 1992 9 p. SAE, International Conference on Environmental Systems, 22nd, Seattle, WA, July 13-16, 1992
(SAE PAPER 921223) Copyright

Three successful applications of IR imagery to thermal measurements and analysis are presented: (1) turbo-prop engine exhaust heating measurements, (2) temperature measurements of the gun (a 20-mm cannon) port area, and (3) tailpipe bellows temperature measurements. IR measurements were made with a dual-band scanner system incorporating a shortwave scanner covering the 3- to 5.6-micron spectral band and a longwave scanner covering the 8- to 14-micron spectral band. The output of the electronics was fed to a computer that has been adapted to the imager display and analysis software. Real-time images were displayed continuously (approximately 25/sec) and were recorded on the internal hard disk every 4 to 5 sec or continuously on tape. AIAA

A93-41398 *National Aeronautics and Space Administration.* Marshall Space Flight Center, Huntsville, AL.
ENHANCED HEAT TRANSPORT IN ENVIRONMENTAL SYSTEMS USING MICROENCAPSULATED PHASE CHANGE *MATERIALS*
D. P. COLVIN (Triangle Research and Development Corp., Research Triangle Park, NC), J. C. MULLIGAN (North Carolina State Univ., Raleigh), and Y. G. BRYANT (Triangle Research and Development Corp., Research Triangle Park, NC) Jul. 1992 11 p. SAE, International Conference on Environmental Systems, 22nd, Seattle, WA, July 13-16, 1992 Research supported by SDIO refs
(Contract NAS8-35840; F33615-85-C-3420; F33615-87-C-2746; NAS9-17952)
(SAE PAPER 921224) Copyright

A methodology for enhanced heat transport and storage that uses a new two-component fluid mixture consisting of a microencapsulated phase change material (microPCM) for enhanced latent heat transport is outlined. SBIR investigations for NASA, USAF, SDIO, and NSF since 1983 have demonstrated the ability of the two-component microPCM coolants to provide enhancements in heat transport up to 40 times over that of the carrier fluid alone, enhancements of 50 to 100 percent in the heat transfer coefficient, practically isothermal operation when the coolant flow is circulated in an optimal manner, and significant reductions in pump work. AIAA

A93-41575
COMPARISON MEASUREMENTS OF CURRENTS INDUCED BY RADIATION AND INJECTION
JOHN W. ADAMS, JOSE CRUZ, and DEAN MELQUIST (NIST, Boulder, CO) IEEE Transactions on Electromagnetic Compatibility (ISSN 0018-9375) vol. 34, no. 3, pt. 2 Aug. 1992 p. 360-362. Research supported by the U.S. Army refs
Copyright

Measurements that show significant differences between currents measured in individual wires of a bundle due to equal current excitations by external radiated fields or by bulk injection are reported. This raises concern whether bulk current injection is a reliable technique for EMC work. Author

A93-41700
EXPERIMENTAL INVESTIGATION OF THE MANAGEMENT OF LARGE-SIZED DROPS AND THE ONSET OF MARANGONI-CONVECTION
M. TREUNER, A. DELGADO, H. J. RATH (Bremen Univ., Germany), U. DUDA, J. A. SZYMCZYK, and J. SIEKMANN (Essen Univ., Germany) *In* Microgravity fluid mechanics; Proceedings of the IUTAM Symposium, Bremen, Germany, Sept. 2-6, 1991 Berlin and New York Springer-Verlag 1992 p. 227-234. Research supported by BMFT refs
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This paper presents results concerning thermal Marangoni-convection in large-sized drops. The Experiments have been carried out during KC-135 parabolic flights. Generation and management of drops with diameters up to 15 mm are described. Flow and temperature distribution inside the drops were visualized by using liquid crystals. Marangoni-convection was observed under defined thermal boundary conditions. The evident flow agrees well in its basic features with theoretical calculations available. Author

A93-41714
STABILITY OF THE VAPOUR PHASE IN A ROTATING TWO-PHASE FLUID SYSTEM SUBJECTED TO DIFFERENT GRAVITATIONAL INTENSITIES
D. YEE, J. A. WADE, and C. A. WARD (Toronto Univ., Canada) *In* Microgravity fluid mechanics; Proceedings of the IUTAM Symposium, Bremen, Germany, Sept. 2-6, 1991 Berlin and New York Springer-Verlag 1992 p. 373-379. Research supported by Canadian Space Agency and NSERC refs
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An experimental study is presented of the stability of a bubble immersed in a liquid phase with both phases in an isothermal, constant volume, constant mass system that is subjected to both centrifugal and gravitational fields. The stability of the bubble was examined in both ground based studies and in an aircraft flying Keplarian parabolas. It was found that for a given gravitational intensity there is a lower limit of the rotation rate for which the bubble will remain stable. If the rotation rate becomes less than this value the bubble becomes unstable and breaks into two or more smaller bubbles. The lower limit of the rotation rates for which a bubble remains stable increases approximately linearly with increases in the gravitational intensity. Author

A93-41729
CALIBRATION OF THERMAL ANEMOMETER AT VERY LOW REYNOLDS NUMBERS UNDER MICROGRAVITY
F. R. STENGELE, A. DELGADO, and H. J. RATH (Bremen Univ., Germany) *In* Microgravity fluid mechanics; Proceedings of the IUTAM Symposium, Bremen, Germany, Sept. 2-6, 1991 Berlin and New York Springer-Verlag 1992 p. 529-538. Research supported by BMFT refs
Copyright

An experimental configuration is presented for conducting hot wire anemometer measurements at very low velocities, as demonstrated for the cases of a KC-135 aircraft in microgravity trajectory and a small drop-tower facility. It is noted that the influence of the Grashof number is more pronounced, even at relatively high velocities, than anticipated in the extant literature. AIAA

A93-41749
PROCESSING INTEGRAL IMPELLER 4-COORDINATE NUMERICALLY CONTROLLED MILLING MACHINE
XINPING HU and ZHONGQING LI (MAS, Capital Machinery Works, China) Journal of Propulsion Technology (ISSN 1001-4055) no. 2 April 1993 p. 82-86, 21. In CHINESE

A practical method for formation of envelope surface is introduced in the paper and a programmed calculation method for manufacturing integral impellers with a four-coordinate NC-miller is presented. The selection of cutters, the clamping of an impeller, and checking by interferometer are discussed. The integral impeller used in a missile turbojet engine was manufactured first in China with a four-coordinate NC-miller using the method. Its performance meets design standard. Author (revised)

A93-41751
MOI - MAGNETO-OPTIC/EDDY CURRENT IMAGING
SANDRA SIMMS (PRI International, Torrance, CA) Materials Evaluation (ISSN 0025-5327) vol. 51, no. 5 May 1993 p. 529-532, 534.
Copyright
The magnetooptic/eddy current imager (MOI) is an instrument designed for nondestructive testing of aircraft skin for cracks and corrosion. The instrument induces eddy currents in the material to be inspected, and the anomalies in the resulting magnetic field are imaged by a magnetooptic sensor of the system. The paper discusses the principles of the image formation and describes the results. It was found by the users of MOI that the instrument is easy to use; is accurate, reliable, and fast; and the results are easy to interpret. AIAA

A93-41910
HIGH-SPEED TURBULENCE MODELING OF SHOCK-WAVE/BOUNDARY-LAYER INTERACTION
F. GRASSO and D. FALCONI (Roma I, Univ., Rome, Italy) AIAA Journal (ISSN 0001-1452) vol. 31, no. 7 July 1993 p. 1199-1206. AIAA, Aerospace Sciences Meeting and Exhibit, 31st, Reno, NV, Jan. 11-14, 1993, AIAA Paper 93-0778. Previously cited in issue 08, p. 1373, Accession no. A93-24860 refs
Copyright

A93-41911
MEASUREMENTS IN A PRESSURE-DRIVEN THREE-DIMENSIONAL TURBULENT BOUNDARY LAYER DURING DEVELOPMENT AND DECAY
WALTER R. SCHWARZ and PETER BRADSHAW (Stanford Univ., CA) AIAA Journal (ISSN 0001-1452) vol. 31, no. 7 July 1993 p. 1207-1214. AIAA, Aerospace Sciences Meeting and Exhibit, 31st, Reno, NV, Jan. 11-14, 1993, AIAA Paper 93-0543. Previously cited in issue 07, p. 1149, Accession no. A93-23283 Research supported by Boeing Co. and Society of Experimental Test Pilots refs
Copyright

A93-41935
SUPERSONIC PANEL FLUTTER ANALYSIS OF SHALLOW SHELLS
MAHER N. BISMARCK-NASR (Inst. Tecnologico de Aeronautica, Sao Jose dos Campos, Brazil) AIAA Journal (ISSN 0001-1452) vol. 31, no. 7 July 1993 p. 1349-1351. Research supported by CNPq refs
Copyright
Finite element solutions of the supersonic flutter of cylindrically curved panels are presented. Reissner's two field variable variational principle is used to formulate a C super 1 continuity element that satisfies the requirements of the finite element method. This finite element formulation makes possible a direct and exact application of the in-plane end conditions for all classical boundary conditions. AIAA

A93-42405
A NUMERICAL STUDY OF THE FLUTTER OF CONICAL SHELLS [CHISLENNOE ISSLEDOVANIE FLATTERA KONICHESKIKH OBOLOCHEK]
V. V. DITKIN, B. A. ORLOV, and G. I. PSHENICHNOV Rossijskaya Akademiya Nauk, Izvestiya, Mekhanika Tverdogo Tela (ISSN 0572-3299) no. 1 Jan.-Feb. 1993 p. 185-189. In RUSSIAN refs
Copyright
The paper is concerned with the problem of the aerodynamic stability of thin shells in supersonic flow of a compressible gas. An efficient iteration method for solving problems of this kind is proposed. The problem of supersonic flow of a gas past a cantilever conical nozzle is analyzed as an example. AIAA

A93-42578
COMMENTS ON EXPERIMENTS FOR COMPUTATIONAL VALIDATION FOR FLUID DYNAMIC PREDICTIONS
SEYMOUR M. BOGDONOFF (Princeton Univ., NJ) *In* Hypersonic flows for reentry problems. Vol. 1 Berlin and New York Springer-Verlag 1991 p. 12-17. refs
Copyright
An account is given of the course of development over the last 20 years of the understanding of complex hypersonic flows, on the basis of an interactive collaboration between computational simulations and wind tunnel experimental investigations. Attention is given to the design of experiments for CFD validation and to the choosing of test parameters. For applications in which combustion takes place in the flows under study, as in propulsion systems, the incorporation of chemical effects is critically important. AIAA

A93-42625
REACTIVE AND INERT INVISCID FLOW SOLUTIONS BY QUASI-LINEAR FORMULATIONS AND SHOCK FITTING
F. SABETTA, B. FAVINI, G. MORETTI, M. ONOFRI, and M. VALORANI (Roma I, Univ., Rome, Italy) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 782-797.
Copyright
Solutions are presented for nonreactive flows on the double ellipse and for equilibrium and nonequilibrium reactive flows on the simple ellipse. For nonreactive flows, calculations are performed using both global and local time stepping. The method for solving reactive flows is based on the splitting of the governing equation system in two parts: the gasdynamic operator and the chemical operator. The successive application of the two operators constitutes one cycle of the iterative procedure which brings the solution to steady state. AIAA

A93-42646
QUASI MONODIMENSIONAL INVISCID NON EQUILIBRIUM NOZZLE FLOW COMPUTATION
LIONEL MARRAFFA (ONERA, Chatillon, France) *In* Hypersonic flows for reentry problems. Vol. 2 Berlin and New York Springer-Verlag 1991 p. 1193-1205. refs
Copyright
Nonequilibrium quasi-one-dimensional flow through a nozzle is analyzed for both nominal and high-enthalpy cases. A simple chemistry is assumed in the nominal case, and it is found that the coupling between vibration and dissociation has little influence. The high-enthalpy case exhibits more sensitivity to the physicochemical modeling, requiring the use of more sophisticated models. A more accurate determination of the flow requires complete Navier-Stokes nonequilibrium computations. AIAA

A93-42657
THE RING LASER GYRO AND ITS APPLICATIONS [LE GYROLASER ET SES APPLICATIONS]
MICHEL HUCHER (Academie Nationale de l'Air et de l'Espace, Paris, France) Nouvelle Revue d'Aeronautique et d'Astronautique no. 1 April 1993 p. 32-42. In FRENCH refs
Copyright
The development of the ring laser gyro and some of its aerospace applications are reviewed. Examples of its application in transport aircraft, the Ariane launch vehicle, military aircraft, and helicopters are discussed. Future prospects of the development of ring laser gyros are also examined. AIAA

A93-42781
PAVE PILLAR IN-HOUSE RESEARCH FINAL REPORT
JESSE L. BLAIR and PHILIP POWERS (USAF, Wright Labs., Wright-Patterson AFB, OH) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 1 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 193-199. refs
The authors report on the concepts and technologies required to develop, integrate, and test the Pave Pillar architecture in an avionics system. Hardware and software issues relating to

multiprocessing, multitasking, and real-time reconfiguration are discussed. The issues involved in developing and integrating 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 set-up called the integrated testbed (ITB) facility. The configuration and test setup for the common avionics modules were selected to provide a realistic environment and to be as close to the defined Pave Pillar architecture as possible. a.

A93-42782
CROSS CHANNEL DEPENDENCY REQUIREMENTS OF THE MULTI-PATH REDUNDANT AVIONICS SUITE
FRED MARTIN and DARRYL ADAMS (General Dynamics Corp., Space Systems Div., San Diego, CA) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 1 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 200-206. refs
(Contract F04701-88-C-0110)
Copyright

Requirements for cross channel dependencies in the multipath redundant avionics suite (MPRAS) architecture are described. MPRAS is a data synchronous avionics architecture for space launch vehicle applications. The MPRAS cross channel data link (CCDL) provides the mechanism, required by data synchronous architectures, to exchange data and maintain synchronization among redundant channels. MPRAS architectural requirements impose a variety of characteristics for cross channel dependencies which make traditional CCDL solutions unacceptable for MPRAS target applications. The MPRAS CCDL requirements have led to a CCDL design which maintains resilience to faults, does not introduce large cross channel bandwidth reductions, and meets the other established MPRAS CCDL requirements. A review of fault-tolerant system principles applicable to CCDL issues is presented as well as a top-level functional description of the MPRAS CCDL design. a.

A93-42783
RECONFIGURABLE PHOTONIC DATA NETWORKS FOR MILITARY AIRCRAFT
T. L. WEAVER, D. W. SEAL, and M. A. HOARD (McDonnell Aircraft Co., Saint Louis, MO) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 1 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 212-218. refs
Copyright

The authors propose a photonic switched network approach capable of supporting multi-gigabit-per-second data rate transmissions, independent of protocol, over a large number of simultaneous, independent paths. To form the heart of this network, a single chip, gallium arsenide (GaAs), all-optical crossbar switch *suitable for application to fighter aircraft has been developed.* This monolithic photonic crossbar requires no electrical/optical conversions; thus it provides a transparent network interface. It is capable of digital data transmission at rates from dc to at least 2 Gb/s, independently of communication protocol or format. It can connect any input to any available output without disturbing existing connections, and it is capable of broadcasting signals from one input to multiple outputs. It can reconfigure its input to output routings in less than 1.0 ns. The authors report on optical switch technology assessment, and laboratory evaluation of photonic data bus star repeaters. a.

A93-42793
ISAR MOTION COMPENSATION AND SUPERRESOLUTION IMAGING OF AIRCRAFT
ZHISHUN SHE and ZHAODA ZHU (Nanjing Aeronautical Inst., China) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 1 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 291-296. Research supported by Aeronautical Science Foundation of China refs
Copyright

High-resolution microwave imaging of moving targets can be achieved by inverse synthetic aperture radar (ISAR). Information processing of ISAR, including motion compensation and image-formation, is investigated by use of the real data of a Boeing-727 commercial aircraft. Several motion compensation schemes for ISAR are formularized and compared. A superresolution imaging method based on data extrapolation is carried out to enhance image resolution. The reconstructed images of a Boeing-727 are given. This demonstrates the correctness and effectiveness of the motion compensation and superresolution approaches which are discussed. a.

A93-42909
NUMERICAL SOLUTION OF AXISYMMETRIC HEAT CONDUCTION PROBLEMS USING FINITE CONTROL VOLUME TECHNIQUE
B. F. BLACKWELL and R. E. HOGAN (Sandia National Labs., Albuquerque, NM) Journal of Thermophysics and Heat Transfer (ISSN 0887-8722) vol. 7, no. 3 July-Sept. 1993 p. 462-471. AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991, AIAA Paper 91-1353. Previously cited in issue 18, p. 3133, Accession no. A91-43420 refs
(Contract DE-AC04-76DP-00789)
Copyright

A93-42920
MICROSENSORS FOR HIGH HEAT FLUX MEASUREMENTS
J. M. HAGER, L. W. LANGLEY (Vatell Corp., Blacksburg, VA), S. ONISHI, and T. E. DILLER (Virginia Polytechnic Inst. and State Univ., Blacksburg) Journal of Thermophysics and Heat Transfer (ISSN 0887-8722) vol. 7, no. 3 July-Sept. 1993 p. 531-534. Abridged. AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991, AIAA Paper 91-0165. Previously cited in issue 07, p. 1046, Accession no. A91-21388 refs
(Contract NSF CBT-88-14364)
Copyright

A93-43338
COMPARISON OF SOME DIRECT MULTI-POINT FORCE APPROPRIATION METHODS
K. ALEXIOU (Construcciones Aeronauticas, S.A., Div. Espacio, Madrid, Spain) and J. R. WRIGHT (Manchester, Victoria Univ., United Kingdom) Modal Analysis: The International Journal of Analytical and Experimental Modal Analysis (ISSN 1066-0763) vol. 8, no. 2 April 1993 p. 119-136. Research supported by Defence Research Agency of United Kingdom refs
Copyright

In multi-point modal testing the appropriated force distributions for identifying and isolating pure modes of vibration may be determined by Iterative or Direct methods. In this paper a number *of the Direct methods which are based on the classical Phase* Resonance criterion and operate on measured frequency response function matrix data have been investigated and compared using a simulated multi degree of freedom model. Of the methods which operate on square frequency response function matrix data a suggested variation on the Asher method was found useful for estimating the effective number of modes (and hence exciters needed) in the frequency range of interest. The Traill-Nash method provided the clearest estimate of appropriated forces but was more sensitive to noise. Of the methods which operate on rectangular frequency response function matrices the Extended Asher method was least suitable and it is shown that the original formulation of this method was fallacious. The Multivariate Mode Indicator Function method was the most promising but suffered from conditioning problems if too many exciters were used. Author

A93-43344
STUDIES OF SUPERRESOLUTION RANGE-DOPPLER IMAGING
ZHAODA ZHU, ZHENRU YE, XIAOQING WU, JUN YIN, and

ZHISHUN SHE (Nanjing Aeronautical Inst., China) Journal of Infrared and Millimeter Waves (ISSN 1001-9014) vol. 12, no. 1 Feb. 1993 p. 67-74. In CHINESE refs

This paper presents three superresolution imaging methods, including the linear prediction data extrapolation DFT (LPDEDFT), the dynamic optimization linear least squares (DOLLS), and the Hopfield neural network nonlinear least squares (HNNNLS). Live data of a metalized scale model B-52 aircraft, mounted on a rotating platform in a microwave anechoic chamber, have in this way been processed, as has a flying Boeing-727 aircraft. The imaging results indicate that, compared to the conventional Fourier method, either higher resolution for the same effective bandwidth of transmitted signals and total rotation angle in imaging, or equal-quality images from smaller bandwidth and total rotation, angle may be obtained by these superresolution approaches. Moreover, these methods are compared in respect of their resolution capability and computational complexity. Author (revised)

A93-43376
RADAR 92; PROCEEDINGS OF THE INTERNATIONAL CONFERENCE, BRIGHTON, UNITED KINGDOM, OCT. 12, 13, 1992

London and Piscataway, NJ Institution of Electrical Engineers (IEE Conference Publication, No. 365) 1992 567 p. For individual items see A93-43377 to A93-43492, A93-43394 to A93-43498
(ISBN 0-85296-533-2) Copyright

The present conference discusses topics indicative of the development status of radar simulation and modeling, sea and land clutter effects, multifunction and monopulse radar, radar propagation and target measurement, surveillance and tracking, clutter suppression, antenna designs, and air traffic control applications of radar systems. Also discussed are radar techniques for electronic warfare, antenna-related signal processing, SAR for remote sensing, multifunction signal processing, SAR and ISAR, radar target classification, bistatic radar, signal reconstruction, Doppler weather radar, and electronic warfare countermeasures. AIAA

A93-43381
GROUND CLUTTER MEASUREMENTS USING AN AEROSTAT SURVEILLANCE RADAR

L. F. MOORE, F. R. WILLIAMSON, W. L. CASSADAY (Georgia Inst. of Technology, Atlanta), H. R. WHITEHEAD (General Electric Co., Fairfield, CT), and L. SLASKI (USAF, Rome Lab., Griffiss AFB, NY) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 30-33. refs
Copyright

A radar ground clutter measurement program has been conducted using an aerostat-mounted L-band radar system; the data thus obtained can be used to develop new clutter models or validate and update existing ones. These models can then support the development of future radars aimed at the detection of low observable targets against various surface clutter backgrounds. AIAA

A93-43392
EXPERIMENTAL RESULTS ON RIAS DIGITAL BEAMFORMING RADAR

ANNE-SOPHIE LUCE, HELENE MOLINA, DANIEL MULLER, and VINCENT THIRARD (Thomson-CSF, Systemes Defense et Controle, Bagneux, France) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 74-77. Research supported by Service Technique des Telecommunications et des Equipements Aeronautiques refs
Copyright

The RIAS synthetic antenna and impulse radar's performance is presently estimated in terms of radar coverage in range and elevation, localization accuracy, and target discrimination. The results obtained indicate operability in multimode surveillance/tracking for air defense and ATC. Performance prediction models developed around RIAS concepts are already highly reliable. AIAA

A93-43405
DUAL BAND TUNED RADOMES FOR RADAR APPLICATIONS

E. C. NGAI, M. NAOR, and A. P. SMOLSKI (Electronic Space Systems Corp., Concord, MA) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 130-133. refs
Copyright

Highly effective dual-band tuning methods have been developed for sandwich panel-structure radome joints, simultaneously reducing perturbations to the joints in both the PSR and SSR bands. The new methodology, which solves the logistic problems associated with the previously used zoned tuning method, allows greater flexibility in the use of the same radome with different radars. AIAA

A93-43434
AN INTEGRATED WEATHER CHANNEL DESIGNED FOR AN UP-TO-DATE ATC RADAR SYSTEM

M. BASILE, E. D'ADDIO, M. DI LAZZARO, and L. PASQUALI (Alenia S.p.A., Rome, Italy) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 261-267.
Copyright

A new ATC radar weather channel is described which integrates aircraft detection and weather power estimates. The channel provides rain reflectivity classification performed after temporal and spatial smoothing so that the processor is unaffected by aircraft echoes as well as asynchronous and CW interference. The effects of ground clutter on the estimate of low Doppler rain are minimized by Doppler filtering and an incoherent clutter map. The results of computer simulations of the system are reported. AIAA

A93-43463
DIGITAL PULSE COMPRESSION WITH LOW RANGE SIDELOBES

J. P. LARVOR (Thomson-CSF, Systemes Defense et Controle, Bagneux, France) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 391-394.
Copyright

A definition of pulse compression performance is introduced and the pulse compression filter synthesis is explained. The evaluation of the real performance of a pulse compression system is described, taking into account the contribution and imperfections of each analog device of the transmitting and receiving channels. A realization example is given. AIAA

A93-43502
A HORIZONTAL ATMOSPHERIC TEMPERATURE SOUNDER - APPLICATIONS TO REMOTE SENSING OF ATMOSPHERIC HAZARDS

R. W. MCMILLAN (Georgia Inst. of Technology, Atlanta) International Journal of Infrared and Millimeter Waves (ISSN 0195-9271) vol. 14, no. 5 May 1993 p. 931-948. refs
Copyright

A horizontal atmospheric temperature sounder for the measurement of temperature differences associated with atmospheric hazards is described. Wind shear, clear-air turbulence, and wake vortices cause special hazards to aircraft and are characterized by a change in temperature relative to ambient. This temperature change may be detected by a millimeter wave radiometer operating on an oxygen absorption line in the atmosphere. A multi-channel radiometer operating near 60 GHz is capable of detecting atmospheric hazards and other potential dangers. It is shown that the temperature sounder should measure

the range and temperature difference of atmospheric hazards with reasonable accuracy. A design is proposed and graphs of expected performance are presented. AIAA

A93-43539 National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STRONG VORTEX/BOUNDARY LAYER INTERACTIONS. I - VORTICES HIGH
A. D. CUTLER (George Washington Univ.; NASA, Langley Research Center, Hampton, VA) and P. BRADSHAW (Stanford Univ., CA) Experiments in Fluids (ISSN 0723-4864) vol. 14, no. 5 April 1993 p. 321-332. refs
(Contract NAGW-581; NCC1-24; NAS1-18458)
Copyright

Detailed measurements with hot-wires and pressure probes are presented for the interaction between a turbulent longitudinal vortex pair with 'common flow' down, and a turbulent boundary layer. The interaction has a larger value of the vortex circulation parameter, and therefore better represents many aircraft/vortex interactions, than those studied previously. The vortices move down towards the boundary layer, but only the outer parts of the vortices actually enter it. Beneath the vortices the boundary layer is thinned by lateral divergence to the extent that it almost ceases to grow. Outboard of the vortices the boundary layer is thickened by lateral convergence. The changes in turbulence structure parameters in the boundary layer appear to be due to the effects of 'extra-rate-of-strain' produced by lateral divergence (or convergence) and by free-stream turbulence. The effect of the interaction on the vortices (other than the inviscid effect of the image vortices below the surface) is small. The flow constitutes a searching test case for prediction methods for three-dimensional turbulent flows. *Author*

A93-43778
A FREQUENCY DOMAIN THEORY FOR STRUCTURAL IDENTIFICATION
JOSHUA H. GORDIS (U.S. Naval Postgraduate School, Monterey, CA) American Helicopter Society, Journal (ISSN 0002-8711) vol. 38, no. 2 April 1993 p. 25-33. European Rotorcraft Forum, 16th, Glasgow, United Kingdom, Sept. 18-21, 1990, Paper. Previously cited in issue 14, p. 2378, Accession no. A92-35745
Research supported by U.S. Army refs
Copyright

N93-29090# Joint Publications Research Service, Arlington, VA.
JPRS REPORT: SCIENCE AND TECHNOLOGY. CENTRAL EURASIA: ENGINEERING AND EQUIPMENT
26 May 1993 19 p Transl. into ENGLISH from various Russian articles
(JPRS-UEQ-93-004) Avail: CASI HC A03/MF A01

Translated abstracts cover the following areas: optics, nuclear energy, fluid dynamics, and industrial technology. Some specific topics include internal source optimization in problem of sphere in MHD flow; on development of oblique waves in planar subsonic boundary layer; variational method of plotting subsonic airfoil profiles; and gas dynamics of pulsed jets and pressure oscillations on laser-irradiated target. CASI

N93-29141# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
FLOW PHENOMENA IN TURBOMACHINES Final Technical Report, 20 Oct. 1989 - 19 Oct. 1992
E. M. CREITZER, A. H. EPSTEIN, M. B. GILES, J. E. MCCUNE, and C. S. TAN 20 Jan. 1993 181 p
(Contract AF-AFOSR-0035-90)
(AD-A263049; AFOSR-93-0194TR) Avail: CASI HC A09/MF A02

This report describes work carried out at the Gas Turbine Laboratory at MIT during the period 10/20/89 - 10/19/92, as part of our multi-investigator effort on basic unsteady flow phenomena in turbomachines. Within the overall project four separate tasks are specified. These are, in brief: (1) The Influence of Inlet Temperature Nonuniformities on Turbine Heat Transfer and Dynamics; (2) Assessment of Unsteady Losses in Stator/Rotor Interactions; (3) Unsteady Phenomena and Flowfield instabilities in Multistage Axial Compressors; (4) Vortex Wake-Compressor Blade Interaction in Cascades - A New Rapid Method for Unsteady Separation and Vorticity Flux Calculations. DTIC

N93-29154*# *Old Dominion Univ., Norfolk, VA. Coll. of* Engineering and Technology.
NONLINEAR ANALYSES OF COMPOSITE AEROSPACE STRUCTURES IN SONIC FATIGUE Progress Report, 16 Dec. 1992 - 15 Jun. 1993
CHUH MEI Jun. 1993 21 p
(Contract NAG1-1358)
(NASA-CR-193124; NAS 1.26:193124) Avail: CASI HC A03/MF A01

This report summarizes the semiannual research progress, accomplishments, and future plans performed under the NASA Langley Research Center Grant No. NAG-1-1358. The primary research effort of this project is the development of analytical methods for the prediction of nonlinear random response of composite aerospace structures subjected to combined acoustic and thermal loads. The progress, accomplishments, and future plates on four sonic fatigue research topics are described. The sonic fatigue design and passive control of random response of shape memory alloy hybrid composites presented in section 4, which is suited especially for HSCT, is a new initiative. Derived from text

N93-29157*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HIGH REYNOLDS NUMBER AND TURBULENCE EFFECTS ON AERODYNAMICS AND HEAT TRANSFER IN A TURBINE CASCADE
FREDERICK C. YEH, STEVEN A. HIPPENSTEELE, G. JAMES VANFOSSEN, PHILIP E. POINSATTE, and ALI AMERI (Kansas Univ. Center for Research, Inc., Lawrence.) Jun. 1993 17 p Presented at the 29th Joint Propulsion Conference and Exhibit, Monterey, CA, 28-30 Jun. 1993; cosponsored by AIAA, SAE, ASME, and ASEE
(Contract RTOP 505-62-52)
(NASA-TM-106187; E-7791; NAS 1.15:106187; AIAA PAPER 93-2252) Avail: CASI HC A03/MF A01

Experimental data on pressure distribution and heat transfer on a turbine airfoil were obtained over a range of Reynolds numbers from 0.75 to 7.5 x 10 exp 6 and a range of turbulence intensities from 1.8 to about 15 percent. The purpose of this study was to obtain fundamental heat transfer and pressure distribution data over a wide range of high Reynolds numbers and to extend the heat transfer data base to include the range of Reynolds numbers encountered in the Space Shuttle main engine (SSME) turbopump turbines. Specifically, the study aimed to determine (1) the effect of Reynolds number on heat transfer, (2) the effect of upstream turbulence on heat transfer and pressure distribution, and (3) the relationship between heat transfer at high Reynolds numbers and the current data base. The results of this study indicated that Reynolds number and turbulence intensity have a large effect on both the transition from laminar to turbulent flow and the resulting heat transfer. For a given turbulence intensity, heat transfer for all Reynolds numbers at the leading edge can be correlated with the Frossling number developed for lower Reynolds numbers. For a given turbulence intensity, heat transfer for the airfoil surfaces downstream of the leading edge can be approximately correlated with a dimensionless parameter. Comparison of the experimental results were also made with a numerical solution from a two-dimensional Navier-Stokes code. Author (revised)

N93-29213*# Purdue Univ., West Lafayette, IN. School of Aeronautics and Astronautics.
DEVELOPMENT OF AN UNSTRUCTURED SOLUTION ADAPTIVE METHOD FOR THE QUASI-THREE-DIMENSIONAL EULER AND NAVIER-STOKES EQUATIONS Final Report, 2 Jan. 1990 - 31 Aug. 1993
YI-TSANN JIANG and WILLIAM J. USAB, JR. 31 Aug. 1993

269 p
(Contract NAG3-1127)
(NASA-CR-193241; NAS 1.26:193241) Avail: CASI HC A12/MF A03

A general solution adaptive scheme based on a remeshing technique is developed for solving the two-dimensional and quasi-three-dimensional Euler and Favre-averaged Navier-Stokes equations. The numerical scheme is formulated on an unstructured triangular mesh utilizing an edge-based pointer system which defines the edge connectivity of the mesh structure. Jameson's four-stage hybrid Runge-Kutta scheme is used to march the solution in time. The convergence rate is enhanced through the use of local time stepping and implicit residual averaging. As the solution evolves, the mesh is regenerated adaptively using flow field information. Mesh adaptation parameters are evaluated such that an estimated local numerical error is equally distributed over the whole domain. For inviscid flows, the present approach generates a complete unstructured triangular mesh using the advancing front method. For turbulent flows, the approach combines a local highly stretched structured triangular mesh in the boundary layer region with an unstructured mesh in the remaining regions to efficiently resolve the important flow features. One-equation and two-equation turbulence models are incorporated into the present unstructured approach. Results are presented for a wide range of flow problems including two-dimensional multi-element airfoils, two-dimensional cascades, and quasi-three-dimensional cascades. This approach is shown to gain flow resolution in the refined regions while achieving a great reduction in the computational effort and storage requirements since solution points are not wasted in regions where they are not required. Author

N93-29273# European Space Agency, Paris (France).
FLOW VISUALIZATION ON HELICOPTER BLADES USING ACENAPHTHEN
CLAAS-HINRIK ROHARDT (Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick, Germany.) Nov. 1992 41 p Transl. into ENGLISH of Stroemungssichtbarmachung an Hubschrauberrotorblaettern Mittels Acenaphthen (Brunswick, Germany, DLR) Jul. 1990 p 1-42 Original language document was announced as N91-21466
(ESA-TT-1255; DLR-FB-90-37; ETN-93-93712) Avail: CASI HC A03/MF A01; Original German version available from DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany, HC

Results of visualization of boundary layer characteristics on a helicopter blade under practical conditions are described. The acenaphthene visualization method was used. It was found to be effective in ascertaining the laminar turbulent transition point. The results confirm the design philosophy of generating the longest possible laminar paths in order to minimize skin friction drag. Despite some inadequacy of surface quality (especially in the front area of the blade), there are prolonged laminar boundary layer paths in the hover. It is nonetheless found that aerofoil disturbances, such as those arising due to the anti-erosion strip, should be avoided. Likewise, regular cleaning of the rotor blades to remove insect residues is important in order to maintain high aerofoil performance levels. Calculations with a two dimensional method tended to indicate satisfactory consistency with transition points obtained by experimental means. ESA

N93-29388# Wisconsin Univ. Hospital, Madison. Engine Research Center.
MODELING THE EFFECTS OF DROP DRAG AND BREAKUP ON FUEL SPRAYS
ALEX B. LIU, DANIEL MATHER, and ROLF D. REITZ Mar. 1993 17 p
(Contract DAAL03-86-K-0174)
(AD-A263650; TP-930072; ARO-24623.126-EG-UIR) Avail: CASI HC A03/MF A01

Spray models were evaluated using experimentally measured trajectories and drop sizes of single drops injected into a high relative velocity gas flow. The computations were made using a modified version of the KIVA-2 code. It was found that the drop drag coefficient and the drop breakup time model constant had to be adjusted in order to match the measurements. Based on these findings, a new drop drag submodel is proposed in which the drop drag coefficient changes dynamically with the flow conditions. The model accounts for the effects of drop distortion and oscillation due to the relative motion between the drop and the gas. The value of the drag coefficient varies between the two limits of that of a rigid sphere (no distortion) and that of a disk (maximum distortion). The modified model was also applied to diesel sprays. The results show that the spray tip penetration is relatively insensitive to the value used for the drop drag coefficient. However, the distribution of drop sizes within sprays is influenced by drop drag. This is due to the fact that changes in drop drag produce changes in the drop-gas relative velocity. This, in turn, causes changes in the spray drop size through the drop breakup and coalescence processes. The changes occur in such a way that the net effect on the spray penetration is small over the tested ranges of conditions. These results emphasize that measurements of spray penetration are not sufficient to test and produce improved spray models. Instead, local measurements of drop size and velocity are needed to develop accurate spray models. DTIC

N93-29777*# Kansas Univ. Center for Research, Inc., Lawrence. Dept. of Aerospace Engineering.
NASTRAN ANALYSIS FOR THE AIRMASS SUNBURST MODEL 'C' ULTRALIGHT AIRCRAFT
JOHN VERBESTEL and HOWARD W. SMITH *In its* The Ultra Light Aircraft Testing 32 p 1993
(Contract NAG1-345)
Avail: CASI HC A03/MF A02

The purpose of this project was to create a three dimensional NASTRAN model of the Airmass Sunburst Ultralight comparable to one made for finite element analysis. A two dimensional sample problem will be calculated by hand and by NASTRAN to make sure that NASTRAN finds similar results. A three dimensional model, similar to the one analyzed by the finite element program, will be run on NASTRAN. A comparison will be done between the NASTRAN results and the finite element program results. This study will deal mainly with the aerodynamic loads on the wing and surrounding support structure at an attack angle of 10 degrees. Author (revised)

N93-29779*# Kansas Univ. Center for Research, Inc., Lawrence. Dept. of Aerospace Engineering.
SELECTION AND STATIC CALIBRATION OF THE MARSH J1678 PRESSURE GAUGE
CHARLES R. OXENDINE and HOWARD W. SMITH *In its* The Ultra Light Aircraft Testing 32 p 1993
(Contract NAG1-345)
Avail: CASI HC A03/MF A02

During the experimental testing of the ultralight, it was determined that a pressure gauge would be required to monitor the simulated flight loads. After analyzing several factors, which are indicated in the discussion section of this report, the Marsh J1678 pressure gauge appeared to be the prominent candidate for the task. However, prior to the final selection, the Marsh pressure gauge was calibrated twice by two different techniques. As a result of the calibration, the Marsh gauge was selected as the appropriate measuring device during the structural testing of the ultralight. Although, there are commerical pressure gauges available on the market that would have proven to be more efficient and accurate. However, in order to obtain these characteristics in a gauge, one has to pay the price on the price tag, and this value is an exponential function of the degree of accuracy efficiency, precision, and many other features that may be designed into the gauge. After analyzing the extent of precision and accuracy that would be required, a more expensive gauge wouldn't have proven to be a financial benefit towards the outcome of the experiment. Author (revised)

N93-29851# Naval Research Lab., Washington, DC.
A PARALLEL IMPLICIT INCOMPRESSIBLE FLOW SOLVER USING UNSTRUCTURED MESHES Interim Report

RAVI RANIAMURTI and RAINALD LOHNER 17 Jan. 1993 33 p
(AD-A263395; NRL/MR/6410-93-7178) Avail: CASI HC A03/MF A01

An incompressible flow solver based on unstructured grids is implemented on a parallel distributed memory computer architecture. An important phase in the flow solver is the solution of the elliptic equations for the velocities and pressure. This elliptic solver is parallelized and incorporated into both the explicit and implicit versions of the incompressible flow solver. Performance and scalability studies are carried out on both Intel iPSC 860 and the Intel Delta prototype, and show that the code is scalable. A parallelizable load balancing algorithm is developed to be used in conjunction with the incompressible flow solver. Steady and unsteady flows over a tri-element airfoil and NACA0012 airfoil are computed using the parallel incompressible flow solver. DTIC

N93-29935# Wright Lab., Wright-Patterson AFB, OH. Aero Propulsion and Power Directorate.
HEAT TRANSFER IN HIGH TURBULENCE FLOWS: A 2-D PLANAR WALL JET
R. B. RIVIR, W. T. TROHA, W. A. ECKERLE (Cummins Engine Co., Inc., Columbus, IN.), and W. J. SCHMOLL (Dayton Univ. Research Inst., OH.) *In* AGARD, Heat Transfer and Cooling in Gas Turbines 12 p Feb. 1993
Copyright Avail: CASI HC A03/MF A04

The accurate prediction of turbine heat transfer remains beyond our current capabilities. To investigate this condition, nonconventional turbulence generation techniques have been employed to explore the impact of high turbulence or unsteadiness on heat transfer. The heat transfer from a 2D planar wall jet is compared with an axisymmetric wall jet with twice the turbulence scale and more turbulent kinetic energy - with an increased heat transfer shown by the planar configuration. The resulting comparisons of wall jet augmented heat transfer to engine turbine blade heat transfer is quite favorable. Derived from text

N93-29936# Purdue Univ., West Lafayette, IN. School of Mechanical Engineering.
HEAT TRANSFER WITH MODERATE FREE STREAM TURBULENCE
S. N. B. MURTHY *In* AGARD, Heat Transfer and Cooling in Gas Turbines 33 p Feb. 1993
(Contract F49620-87-K-0008)
Copyright Avail: CASI HC A03/MF A04

Turbulence in turbine flows of gas turbine engines is generally inhomogeneous and is also characterized by wide ranges of intensity and scale. The interaction between Free Stream Turbulence (FST) and boundary layer turbulence (BLT) is complicated in all but the case of low values of both intensity and scale. In a recent investigation, an attempt was made to establish the effect of homogeneous FST on wall friction (when there is no heat transfer) in the relatively simple case of a flat plate, zero pressure gradient boundary layer. In the current paper, the method was extended for the prediction of heat transfer in the same flow field. In any problem involving heat and momentum transport, it is common to introduce some type of similarity between the two transport processes. The current method is based on the application of a similarity rule governing the spectra of turbulence intensity and temperature variance. The principal outcome is a method of establishing heat transfer in a given flow field for which experimental data are available under cold flow conditions and have been verified with the model prediction scheme.
Author (revised)

N93-29937# University Coll. of Swansea (Wales). Dept. of Mechanical Engineering.
THE EFFECT OF ORTHOGONAL-MODE ROTATION ON FORCED CONVECTION IN A CIRCULAR-SECTIONED TUBE FITTED WITH FULL CIRCUMFERENTIAL TRANSVERSE RIBS
W. D. MORRIS and R. SALEMI *In* AGARD, Heat Transfer and Cooling in Gas Turbines 11 p Feb. 1993 Sponsored in part by Science Research Council and Rolls-Royce Ltd.
Copyright Avail: CASI HC A03/MF A04

This paper presents the results of an experimental program aimed at investigating the effect of Coriolis forces and centripetal buoyancy on forced convection in an internally finned circular tube which rotates about an axis orthogonal to the tube's central axis. This geometric arrangement typifies the internal coolant channels of gas turbine rotor blades. It is demonstrated that, as with smooth-walled tubes, Coriolis-driven secondary flows give rise to relatively better heat transfer on the trailing edge of the tube compared with that on the leading edge. Leading edge heat transfer is shown to be significantly impaired in relation to that which occurs under non-rotating conditions. Centripetal buoyancy is shown to improve local heat transfer on the leading and trailing edges for a given value of the through flow Reynolds number and the Rossby number. Although duct rotation tends to improve heat transfer on the trailing edge in comparison with normal stationary duct forced convection, serious overprediction of heat transfer results from ignoring rotational effects on the leading edge. This is an important observation in the context of the design of turbine rotor blade cooling systems. Author (revised)

N93-29941# Pratt and Whitney Aircraft of Canada Ltd., Longueuil (Quebec).
PREDICTION OF JET IMPINGEMENT COOLING SCHEME CHARACTERISTICS (AIRFOIL LEADING EDGE APPLICATION)
A. RIAHI, H. J. SAABAS, and W. ABDEL MESSEH *In* AGARD, Heat Transfer and Cooling in Gas Turbines 14 p Feb. 1993
Copyright Avail: CASI HC A03/MF A04

A control volume, finite difference method based on the work of Rhie in conjunction with a high Reynolds k-epsilon model and a two layer turbulence model was used to predict the heat transfer coefficients underneath an impinging circular jet in the absence of cross flow. The numerical results are compared to experimental measurements for two different impingement height to jet diameter ratios: H/D = 2, and H/D = 10. The comparisons indicate that, although both the k-epsilon and the two layer turbulence models are adequate in the prediction of the flow field, the two layer model resulted in heat transfer predictions that were closer to experimental observations. It was also observed that the predicted heat transfer coefficients for the case of H/D = 2 were sensitive to the assumed jet exit turbulence levels, whereas they were not for H/D = 10. This information is useful to the designer of cooled turbine components. Author (revised)

N93-29953# Technische Univ., Darmstadt (Germany).
THE EFFECT OF MAIN STREAM FLOW ANGLE ON FLAME TUBE FILM COOLING
H. KLINGER and D. K. HENNECKE *In* AGARD, Heat Transfer and Cooling in Gas Turbines 12 p Feb. 1993 Sponsored in part by BMFT
Copyright Avail: CASI HC A03/MF A04

Generally film cooling configurations are positioned such that they are oriented perpendicular to the main stream flow direction. However in many cases, in particular combustor applications, different flow angles may occur. Then, due to the interaction between the main stream and the cooling film, a complex three-dimensional flow field with a vortex is formed. An experimental study was done to study the basic effects. The cooling configuration was a vertical slot which could be turned by up to about 60 degrees from the position perpendicular to the main stream. Velocity distributions were measured and the adiabatic film cooling effectiveness was determined using the liquid crystal technique. The results show that, along lines parallel to the slot, the film cooling effectiveness varies strongly, even with small slot turning angles. This would lead to hot and cold spots in a combustor application. A simple semi-empirical correlation for the average cooling effectiveness is derived using the main stream velocity component perpendicular to the slot. Author

N93-29954# Leeds Univ. (England). Dept. of Fuel and Energy.
IMPINGEMENT/EFFUSION COOLING
G. E. ANDREWS, A. M. ALDABAGH, A. A. ASERE, F.

BAZDIDI-TEHRANI, M. C. MKPADI, and A. NAZARI *In* AGARD, Heat Transfer and Cooling in Gas Turbines 10 p Feb. 1993
(Contract SRC-GR/D/53029)
Copyright Avail: CASI HC A02/MF A04

Impingement/effusion cooling offers one of the most effective ways of cooling gas turbine combustor walls and turbine blades. The design principles are reviewed and cooling effectiveness data presented for a range of typical geometries with holes at 90 degrees to the surface. The main variable studied was the number of impingement/effusion holes. Comparison was made with the effusion cooling effectiveness. Optimum configurations were demonstrated with a 0.7 overall cooling effectiveness at a mass flow per unit surface area of 0.2 kg/sm(exp 2)bar. This was equivalent to 10 percent of the combustor air flow for a typical gas turbine combustor. Data is also presented for the overall wall heat transfer coefficient. The mechanism of the enhanced heat transfer within the impingement/effusion double skin wall was investigated using a CFD code. This predicted the complex aerodynamics in the impingement gap and also gave good agreement with the measured overall heat transfer data.
Author (revised)

N93-29968# Naval Postgraduate School, Monterey, CA.
THREE-DIMENSIONAL FIBER-OPTIC LDV MEASUREMENTS IN THE ENDWALL REGION OF A LINEAR CASCADE OF CONTROLLED-DIFFUSION STATOR BLADES M.S. Thesis
DAVID M. DOBER 25 Mar. 1993 127 p
(AD-A263513) Avail: CASI HC A07/MF A02

Measurements were taken of the vortex system that results from the interaction between a stator blade tip and the approaching endwall boundary layer in a linear cascade of controlled-diffusion compressor stator blades. Measurements were taken at Reynolds numbers based on stator blade chord of 240000 and 711000. Total pressure measurements were first conducted upstream and downstream of the controlled-diffusion stator blades. The approaching boundary layer was characterized and the location of the downstream vortices were approximated. Upstream and downstream three-dimensional fiber-optic LDV surveys were then conducted to observe the velocity profiles of the approaching boundary layer and to map the location and velocity characteristics of the downstream vortex system. Results clearly show the effect that the over-all secondary flow in the blade passage has on the location of the two oppositely rotating vortices. The downstream flow characteristics were also shown to be periodic. DTIC

N93-29969# Naval Postgraduate School, Monterey, CA.
PRELIMINARY DEVELOPMENT OF A VTOL UNMANNED AIR VEHICLE FOR THE CLOSE-RANGE MISSION M.S. Thesis
GREGORY A. KRESS 29 Sep. 1992 88 p
(AD-A263514) Avail: CASI HC A05/MF A01

The preliminary development of a full-scale Vertical Takeoff and Landing (VTOL) Unmanned Air Vehicle (UAV) for the Close-Range mission was completed at the Naval Postgraduate School (NPS). The vehicle was based on half-scale ducted-fan investigations performed at the UAV Flight Research Lab. The resulting design is a fixed-duct, tail-sitter UAV with a canard-configured horizontal stabilizer. Major airframe components are used from previous UAV's and include the wings from a U.S. Army Aquila and the ducted fan from the U.S. Marine Corps AROD. Accomplishments include: (1) the design and fabrication of a carry-through spar, and (2) the design and construction of an engine test stand. The through spar was designed using finite element analysis and constructed from composite materials. The purpose of the test stand is to measure torque, horsepower, and thrust of an entire ducted fan or an individual engine. Completion of this thesis will pave the way for future NPS research into the growing interest in VTOL UAV technology. DTIC

N93-30291 Concordia Univ., Montreal (Quebec).
MODELS FOR PERFORMANCE ASSESSMENT OF HF ANTENNAS ON THE CH-135/TWIN HUEY HELICOPTER
STANLEY J. KUBINA and SHAHRAM ESFANDIARI *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 3 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

The performance of two practical radio-antenna designs for the Bell CH-135 helicopter was evaluated by developing wire-grid models for moment-method modeling of the corresponding radiating system. The first model evaluated a tranline antenna, with the rotor lined up along the helicopter's length. The second model involved a zig-zag antenna with the rotor in the same position. Other models were developed for the same two antenna types with the rotor blade at different positions. The validity of each model was assessed by comparing the computed radiation patterns with scale-model measured patterns, and by comparing the high-frequency assessment parameters. The effect of rotor modulation on these parameters is discussed. Computer model validation for shorted loop antennas was achieved throughout the 2-30 MHz range. Author (CISTI)

N93-30309 Concordia Univ., Montreal (Quebec). Dept. of Electrical and Computer Engineering.
COUPLING GAIN COMPUTATION BETWEEN ANTENNAS ON CIRCULAR CYLINDERS AT SHF/EHF FREQUENCIES
D. CHATTERJEE, S. J. KUBINA, and R. PAKNYS *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 3 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

In analysis of electromagnetic compatibility of collocated avionics systems, aircraft fuselages are modeled by circular cylinders and antennas by a set of keyhole gains at their individual locations. When the antennas are completely hidden from each other by the fuselage, the unwanted signal reaching the receiver antenna travels round the fuselage in a creeping wave. The creeping wave shading loss between a pair of isotropic sources is simulated using half-wave, magnetic type, axial dipoles on a circular cylinder via the basic scattering code (NECBSC2). The results presented were obtained without modifying the NECBSC2 code and compare fairly well with previously published data. This simulation technique and a probable cause for the discrepancies between the NECBSC2 and AAPG codes are discussed.
Author (CISTI)

N93-30320 Concordia Univ., Montreal (Quebec).
RCS OF FUNDAMENTAL SCATTERERS IN THE HF BAND BY WIRE-GRID MODELLING
C. W. TRUEMAN and S. J. KUBINA *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 4 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

To extract the maximum information from the return of a radar target such as an aircraft, the target's scattering properties must be well known. Wire grid modeling allows a detailed representation of the surface of a complex scatterer such as an aircraft, in the frequency range where the aircraft size is comparable to a wavelength. A moment method analysis determines the currents on the wires of the grid including the interactions between all parts of the structure. Wire grid models of fundamental scatterers (plates, strips, cubes, and spheres) of sizes comparable to the wavelength in the 2-30 MHz range are analyzed. The study of the radar cross section (RCS) of wire grids in comparison with measured RCS data helps to establish guidelines for building wire grid models, specifying such parameters as where to locate wires, how short the segments must be, and what radius to use. The guidelines so developed can then be applied to build wire grid models of much more complex bodies such as aircraft with much greater confidence. Author (CISTI)

N93-30337 Thompson-Hickling Aviation, Inc., Ottawa (Ontario).
ENGINEERING MANAGEMENT CONSIDERATION FOR AN INTEGRATED AERONAUTICAL MOBILE SATELLITE SERVICE
JOHN M. BELCHER *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1

and 2 4 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

In order to meet local air traffic control terminal requirements as well as national and transborder requirements, countries have developed communications, navigation, and surveillance (CNS) systems having little systems integration and a solely ground-based solution to air traffic control problems. It is believed that the application of satellite technology is the only currently viable solution that will enable international civil aviation to overcome the shortcomings of the presently available CNS systems. If properly implemented, available satellite system technology integrated with avionics and ground based capabilities, can be used to meet new global aviation demands. A clear transition plan has to be implemented so as to ensure continuity of service, recognize user-borne costs, and satisfy institutional and national objectives in the progress toward a universal air traffic management (ATM) system. ATM systems design should rely on a modular approach for flexibility and upgrading. An aeronautical mobile satellite service is intended to provide a worldwide satellite data link and direct air/ground voice communication. Institutional and financial roadblocks for implemetation of a global based approach will likely be far greater than technical constraints.
Author (CISTI)

N93-30342 Communications Research Centre, Ottawa (Ontario).
DESIGN ISSUES AND INITIAL PERFORMANCE OF AN ADAPTIVE AIR/GROUND/AIR HF COMMUNICATION SYSTEM
G. R. NOURRY and D. G. MCLACHLAN *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 7 p 1990
Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

Airplanes flying in the Canadian Arctic are often without communication to an appropriate air traffic control center for substantial periods of time. Attempts to provide continuous communication coverage for such aircraft must take the special geography of the region into account. High frequency communications appears to be the only practical single medium that can potentially provide this service. The constraints and the issues involved in the design of an air-ground-air high frequency communication system for arctic operation are discussed. The system design incorporates both the Link-11 standard and an automatic link establishment (ALE) unit. It is demonstrated that Link-11 and ALE techniques are, in some cases, complementary and that for the specific case of high frequency skywave propagation, ALE techniques are necessary for efficient operation of a Link-11 system. The system has been implemented in an experimental configuration at four stations in the Canadian Arctic, which will be operated for a year at a period of sunspot maximum in order to evaluate system performance and to study high frequency transmission in polar regions. Author (CISTI)

N93-30369# Cincinnati Univ., OH.
SIMULATION, CHARACTERIZATION AND CONTROL OF FORCED UNSTEADY VISCOUS FLOWS USING NAVIER-STOKES EQUATIONS Final Report, Feb. 1990 - May 1992
K. N. GHIA and U. GHIA Nov. 1992 133 p
(Contract AF-AFOSR-0249-90)
(AD-A264333; AFL-RN-92-11-78; AFOSR-93-0207TR) Avail: CASI HC A07/MF A02

A two-and-a-quarter-year multi-tasked research project was pursued by the present investigators to study dynamic stall phenomenon under AFOSR sponsorship between Feb. 1990 - May 1992. The major objective was to predict and control the dynamic stall phenomenon in 2-D and 3-D flows. In the process of achieving these objectives, significant effort was directed towards developing mathematical models and the corresponding computational methods which were made available to interested researchers and organizations involved in computational fluid dynamics (CFD) research. The analyses developed included a two-dimensional Navier-Stokes (NS) analysis for a general body undergoing arbitrary three-degree-of-freedom maneuvers; detailed results are provided for this class of flows. For enhancement of accuracy and efficiency, an adaptive-grid time-accurate flow solution technique was developed to enable improved resolution of the various length scales in a vortex-dominated unsteady flow. A multi-block grid generation analysis is developed for a 3-D rectangular planform wing. For the corresponding flow analysis using velocity-vorticity variables and direct-solution philosophy, the difficulties experienced were clearly discussed in the annual report submitted a year ago in November 1991. This 3-D flow analysis was therefore temporarily set aside. It will be pursued further in a subsequent grant, and the progress made on it will be reported in a forthcoming annual report for that grant. In the current grant, the study of 3-D flows was continued, using an iterative solution methodology. Hence, a 3-D unsteady Navier-Stokes analysis, again using velocity-vorticity variables, and an iterative solution technique with multi-grid acceleration were developed. DTIC

N93-30374*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.
STATIC AND DYNAMIC LARGE DEFLECTION FLEXURAL RESPONSE OF GRAPHITE-EPOXY BEAMS
MARK D. SENSMEIER, O. HAYDEN GRIFFIN, JR., and ERIC R. JOHNSON Washington Mar. 1988 251 p
(Contract NAG1-343; RTOP 505-63-01-11)
(NASA-CR-4118; NAS 1.26:4118; VPI-E-87-7) Avail: CASI HC A12/MF A03

An experimental and analytical study of large deflection flexural response of graphite-epoxy beams subjected to eccentric axial compression was conducted. The beam specimens were subjected to axial impact and to static axial loads, in order to assess the damage caused by impact. A one-dimensional geometrically and materially nonlinear finite element model was developed to predict static beam response. The model incorporated width-wise effects by assuming specific forms of the displacements across the width, with lengthwise variation introduced as a degree of freedom. The resulting 22 degree of freedom element accurately predicted the load deflection and strain-deflection responses of the static test specimens. Author (revised)

N93-30375*# Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics.
TOPOLOGY AND GRID ADAPTION FOR HIGH-SPEED FLOW COMPUTATIONS Final Report, 1 Jan. - 31 Dec. 1987
JAMSHID S. ABOLHASSANI and SURENDRA N. TIWARI Washington Mar. 1989 139 p
(Contract NCC1-68; RTOP 505-90-21-02)
(NASA-CR-4216; NAS 1.26:4216) Avail: CASI HC A07/MF A02

This study investigates the effects of grid topology and grid adaptation on numerical solutions of the Navier-Stokes equations. In the first part of this study, a general procedure is presented for computation of high-speed flow over complex three-dimensional configurations. The flow field is simulated on the surface of a Butler wing in a uniform stream. Results are presented for Mach number 3.5 and a Reynolds number of 2,000,000. The O-type and H-type grids have been used for this study, and the results are compared together and with other theoretical and experimental results. The results demonstrate that while the H-type grid is suitable for the leading and trailing edges, a more accurate solution can be obtained for the middle part of the wing with an O-type grid. In the second part of this study, methods of grid adaption are reviewed and a method is developed with the capability of adapting to several variables. This method is based on a variational approach and is an algebraic method. Also, the method has been formulated in such a way that there is no need for any matrix inversion. This method is used in conjunction with the calculation of hypersonic flow over a blunt-nose body. A movie has been produced which shows simultaneously the transient behavior of the solution and the grid adaption. Author (revised)

N93-30406# Battelle Columbus Labs., OH.
HIGH RELIABILITY, MAINTENANCE-FREE INS BATTERY DEVELOPMENT Interim Report, 27 Sep. 1991 - 31 Jul. 1992

DAVID G. VUTETAKIS and DAVID J. SURD 31 Jul. 1992 136 p
(Contract F33657-90-D-2190)
(AD-A264521; WL-TR-92-2082) Avail: CASI HC A07/MF A02

This report documents the findings of a study undertaken to develop a high reliability, maintenance-free battery (HRMFB) for application in the Litton LTN-72 and Delco Carousel 4 Inertial Navigation Systems (INS). The results indicated that the sealed lead-acid battery technology is the best candidate from a cost and risk standpoint. A specification sheet was developed detailing the performance and test requirements for the proposed INS HRMFB. DTIC

N93-30489# Texas A&M Univ., College Station. Dept. of Nuclear Engineering.
MULTIPARTICLE IMAGING TECHNIQUE FOR TWO-PHASE FLUID FLOWS USING PULSED LASER SPECKLE VELOCIMETRY
T. A. HASSAN Dec. 1992 114 p
(Contract DE-FG02-88ER-12813)
(DE93-011734; DOE/ER-12813/1) Avail: CASI HC A06/MF A02

The practical use of Pulsed Laser Velocimetry (PLV) requires the use of fast, reliable computer-based methods for tracking numerous particles suspended in a fluid flow. Two methods for performing tracking are presented. One method tracks a particle through multiple sequential images (minimum of four required) by prediction and verification of particle displacement and direction. The other method, requiring only two sequential images uses a dynamic, binary, spatial, cross-correlation technique. The algorithms are tested on computer-generated synthetic data and experimental data which was obtained with traditional PLV methods. This allowed error analysis and testing of the algorithms on real engineering flows. A novel method is proposed which eliminates tedious, undesirable, manual, operator assistance in removing erroneous vectors. This method uses an iterative process involving an interpolated field produced from the most reliable vectors. Methods are developed to allow fast analysis and presentation of sets of PLV image data. Experimental investigation of a two-phase, horizontal, stratified, flow regime was performed to determine the interface drag force, and correspondingly, the drag coefficient. A horizontal, stratified flow test facility using water and air was constructed to allow interface shear measurements with PLV techniques. The experimentally obtained local drag measurements were compared with theoretical results given by conventional interfacial drag theory. Close agreement was shown when local conditions near the interface were similar to space-averaged conditions. However, theory based on macroscopic, space-averaged flow behavior was shown to give incorrect results if the local gas velocity near the interface was unstable, transient, and dissimilar from the average gas velocity through the test facility. DOE

N93-30553# Naval Command, Control and Ocean Surveillance Center, San Diego, CA.
UPLINK LASER PROPAGATION MEASUREMENTS THROUGH THE SEA SURFACE, HAZE AND CLOUDS
G. T. KAYE, ROGER NIES, and MICHAEL LOVERN Mar. 1993 14 p
(AD-A264687) Avail: CASI HC A03/MF A01

An Airborne Optical Receiver (AOR) was developed and tested to investigate the propagation and reception of optical communications uplinks from a submerged laser source to an overflying fleet aircraft. The AOR was flown in a P-3C Orion aircraft for an at-sea test off the southern California coast in August, 1990. A green laser transmitter was suspended from the Research Platform FLIP at depths of 15 to 45 m. During six nights of operations, the AOR received the laser light at various test geometries and through clear and cloudy conditions. This represents the first optical uplink cloud experiment at visible wavelengths. Results show that optical pulses in clouds are significantly more forward-scattered than modeled. The results can be explained by Mie scattering theory. Measured cloud attenuation and pulse stretching agreed with an existing optical propagation model. Significant attenuation and signal spreading due to haze and fog was measured and compared with theory. DTIC

N93-30571# Naval Surface Warfare Center, Bethesda, MD. Machinery Research and Development Directorate.
SOME IMPLICATIONS OF A DIFFERENTIAL TURBOMACHINERY EQUATION WITH VISCOUS CORRECTION
HERMAN B. URBACH Mar. 1993 27 p
(AD-A264693; CDNSWC-MRD-80-93-10) Avail: CASI HC A03/MF A01

A differential equation describing the energy transfer between a fluid and a body moving in that fluid was derived. The derivation, based upon the Coriolis form of the Navier-Stokes equation, contains a rigorous viscous correction. For inviscid ideal cases, the equation demonstrates that the rate of total enthalpy transfer from (or to) the system is a function of the transverse component of the pressure gradient. Therefore, for practical turbomachinery rotors, the derivative, del(p)/del(theta) can never vanish. On integration of the differential equations, a form of the Euler Turbomachinery Equation with viscous correction is derived. The resultant form contains two distinct work rate terms for the axial and radial components of the flow. The fact that integration yields a result which approximates the classic Euler Turbomachinery Equation constitutes confirmation of the derivation. An application of the equation to an ideal infinite linear cylinder with bound vorticity was developed, yielding the expected known result. DTIC

N93-30611# Federal Aviation Administration, Cambridge, MA.
AN ANALYSIS OF EN ROUTE CONTROLLER-PILOT VOICE COMMUNICATIONS
KIM M. CARDOSI Mar. 1993 25 p
(AD-A264784; DOT-VNTSC-FAA-93-2; DOT/FAA/RD-93/11)
Avail: CASI HC A03/MF A01

The purpose of this analysis was to examine current pilot-controller communication practices in the en route environment. Forty-eight hours of voice tapes from eight different Air Route Traffic Control Centers (ARTCC's) were examined. There were 5,032 controller-to-pilot transmissions and 3,576 clearances (e.g., instructions to maneuver or change radio frequencies, routing changes, etc.) in this sample. The complexity of the clearance (i.e., the number of pieces of information) was examined and the number of erroneous readbacks and pilot requests for repeats were analyzed as a function of clearance complexity. Pilot acknowledgements were also analyzed; the numbers of full and partial readbacks, and acknowledgements only (i.e., 'roger') were tallied. Fewer than one percent of the clearances resulted in communications errors. Among the error factors examined were the following: complexity of the clearance, type of acknowledgement, use of call sign in the acknowledgement, type of information in error, and whether or not the controller responded to the readback error. Instances in which the controller contacted the aircraft with one call sign and the pilot acknowledged the transmission with another call sign were also examined. The report concludes with recommendations to further reduce the probability of communication problems. DTIC

N93-31031*# Science Applications International Corp., Torrance, CA. Thermal Sciences Div.
EFFECTS OF BUOYANCY ON GAS JET DIFFUSION FLAMES Final Report
M. YOUSEF BAHADORI and RAYMOND B. EDELMAN Apr. 1993 364 p
(Contract NAS3-22822; RTOP 694-03-0A)
(NASA-CR-191109; E-7720; NAS 1.26:191109) Avail: CASI HC A16/MF A03

The objective of this effort was to gain a better understanding of the fundamental phenomena involved in laminar gas jet diffusion flames in the absence of buoyancy by studying the transient phenomena of ignition and flame development, (quasi-) steady-state flame characteristics, soot effects, radiation, and, if any, extinction phenomena. This involved measurements of flame size and

development, as well as temperature and radiation. Additionally, flame behavior, color, and luminosity were observed and recorded. The tests quantified the effects of Reynolds number, nozzle size, fuel reactivity and type, oxygen concentration, and pressure on flame characteristics. Analytical and numerical modeling efforts were also performed. Methane and propane flames were studied in the 2.2 Second Drop Tower and the 5.18-Second Zero-Gravity Facility of NASA LeRC. In addition, a preliminary series of tests were conducted in the KC-135 research aircraft. Both micro-gravity and normal-gravity flames were studied in this program. The results have provided unique and new information on the behavior and characteristics of gas jet diffusion flames in micro-gravity environments. Author (revised)

N93-31036*# Arizona State Univ., Tempe. Telecommunications Research Center.
ADVANCED ELECTROMAGNETIC METHODS FOR AEROSPACE VEHICLES Semiannual Progress Report, 1 Jan. - 30 Jun. 1993
CONSTANTINE A. BALANIS, WEIMIN SUN, EL-BUDAWY EL-SHARAWY, JAMES T. ABERLE, CRAIG R. BIRTCHER, JIAN PENG, PANAYIOTIS A. TIRKAS, DAVID KOKOTOFF, and FRANK ZAVOSH 1993 91 p Conference held at Tempe, AZ, 28-29 Oct. 1992, and meeting held on 19-20 May 1993
(Contract NAG1-1082)
(NASA-CR-193468; NAS 1.26:193468; TRC-EM-CAB-9306)
Avail: CASI HC A05/MF A01

The Advanced Helicopter Electromagnetics (AHE) Industrial Associates Program has continuously progressed with its research effort focused on subjects identified and recommended by the Advisory Task Force of the program. The research activities in this reporting period have been steered toward practical helicopter electromagnetic problems, such as HF antenna problems and antenna efficiencies, recommended by the AHE members at the annual conference held at Arizona State University on 28-29 Oct. 1992 and the last biannual meeting held at the Boeing Helicopter on 19-20 May 1993. The main topics addressed include the following: Composite Materials and Antenna Technology. The research work on each topic is closely tied with the AHE Consortium members' interests. Significant progress in each subject is reported. Special attention in the area of Composite Materials has been given to the following: modeling of material discontinuity and their effects on towel-bar antenna patterns; guidelines for composite material modeling by using the Green's function approach in the NEC code; measurements of towel-bar antennas grounded with a partially material-coated plate; development of 3-D volume mesh generator for modeling thick and volumetric dielectrics by using FD-TD method; FDTD modeling of horn antennas with composite E-plane walls; and antenna efficiency analysis for a horn antenna loaded with composite dielectric materials. Author (revised)

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GEOSCIENCES

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

A93-41269* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
IMPLICATIONS OF THREE-DIMENSIONAL TRACER STUDIES FOR TWO-DIMENSIONAL ASSESSMENTS OF THE IMPACT OF SUPERSONIC AIRCRAFT ON STRATOSPHERIC OZONE
ANNE R. DOUGLASS, RICHARD B. ROOD (NASA, Goddard Space Flight Center, Greenbelt, MD), CLARK J. WEAVER, MARK C. CERNIGLIA (Applied Research Corp., Landover, MD), and KURT F. BRUESKE (Research and Data Systems, Landover, MD) Journal of Geophysical Research (ISSN 0148-0227) vol. 98, no. D5 May 20, 1993 p. 8949-8963. Research supported by NASA refs
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A 2D model which uses residual circulation and diffusion and a 3D model which uses winds from a stratospheric data assimilation system are used to estimate transport and dispersion of supersonic aircraft exhaust in the lower stratosphere. The seasonal behavior of the exhaust fields in the two models is similar, but there is a significant difference in the placement of stratosphere/troposphere exchange in the two models. In the 2D model, exhaust transport to the troposphere occurs mostly at high latitudes, while in the 3D model it occurs at middle latitudes and is clearly associated with synoptic scale events. This may be particularly important to assessment calculations, as the pollutant source is mostly in middle latitudes. The 3D model is also used to examine the transport and dispersion of exhaust in three typical flight corridors: North Atlantic, North Pacific, and tropical. There are no systematic differences that suggest that one corridor is inherently more or less polluting than another. AIAA

A93-42659
THE IMPACT OF AIR TRAFFIC ON THE ATMOSPHERIC ENVIRONMENT [L'IMPACT DU TRAFIC AERIEN SUR L'ENVIRONNEMENT ATMOSPHERIQUE]
JEAN CARPENTIER (DRET, Paris, France) Nouvelle Revue d'Aeronautique et d'Astronautique no. 1 April 1993 p. 49-60. In FRENCH refs
Copyright

It is noted that, if the effects of various aircraft emissions (nitrogen oxides, carbon dioxide, water vapor, etc.) favor the partial destruction of ozone, some restrictions on air traffic in the stratosphere would have to be considered. However, progress already achieved in aerodynamics and propulsion as well as advances foreseeable in the medium term, together with theoretical atmospheric-physics research carried out by the ONERA Aeronautics Research Institute, encourage the hope that this will not be necessary. However, for sound decisions to be made, it is necessary to improve our knowledge of the atmosphere and its natural fluctuations. Particular attention is given to the impact of supersonic-transport emissions on the stratosphere. AIAA

N93-29257# Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
CONTRIBUTIONS TO THE AMERICAN METEOROLOGICAL SOCIETY'S 26TH INTERNATIONAL CONFERENCE ON RADAR METEOROLOGY
MARILYN W. WOLFSON 1 Apr. 1993 36 p Conference held in Norman, OK, 24-28 May 1993
(Contract DTFA-01-91-Z-02036; F19628-90-C-0002)
(AD-A263385; ATC-199; DOT/FAA/RD-93/14) Avail: CASI HC A03/MF A01

The work reported included Terminal Doppler Weather Radar (TDWR), Air Surveillance Radar-9, and Integrated Terminal Doppler Weather Radar Surveillance Systems (TASS). The staff members of the Weather Sensing Group have documented their studies in four major areas: Operational Systems (TDWR Operational Test and Evaluation results); Radar Operations (future airport weather surveillance requirements, a 'machine intelligent' gust front detection algorithm, microburst asymmetry study results, a shear-based microburst detection algorithm, and a hazard index for TWDR-detected microbursts); Signal Processing (coherent processing across multi-PRI waveforms, clutter filter design for multiple-PRT signals, and identification of anomalous propagation associated with thunderstorm outflows); and Analysis Methods (multiple-single Doppler wind analysis using NEXRAD data, and an adjoint method wind retrieval scheme). DTIC

N93-30044 Cornell Univ., Ithaca, NY.
SURFACE SHEAR STRESS ESTIMATES FROM GEOSTROPHIC WINDS FOR USE IN SENSIBLE AND LATENT HEAT FLUX FORMULATIONS Ph.D. Thesis
RICHARD D. CRAGO 1993 251 p
Avail: Univ. Microfilms Order No. DA9309552

The surface shear stress (or friction velocity, u(sub *)) is found in many formulations for evapotranspiration (LE) and sensible heat flux (H) from land surfaces, but is difficult to estimate without actually measuring wind speeds. ABL (Atmospheric Boundary Layer) similarity theory is used to estimate u(sub *) from the geostrophic wind (i.e., from the atmospheric pressure field). Atmospheric pressure is routinely measured at most weather stations across many continents on an hourly basis. Data from the First ISLSCP (International Satellite Land Surface Climatology Project) Field Experiment (FIFE) were analyzed. The values of the similarity variables B and B(sub W) were determined, and several formulations for the variables were compared. The optimal formulation (i.e., the one which produced the best match with the reference u(sub *) values obtained from surface layer similarity) used the magnitude (G) of the geostrophic wind and a stability-dependent B(sub W) function. The effects of random errors, baroclinicity, and inertial effects on the results were analyzed. Random measurement errors and the omission of inertial effects in the optimal formulation may cause considerable scatter. No dependence of the similarity variables on baroclinicity or scale-height ratio was discernable amidst the scatter, but they may still at times be important. Contrary to the findings of Hasse and Wagner, no tendency was found in the low wind speed range for near surface wind speeds to be greater than geostrophic wind speeds. The geostrophic drag coefficient (i.e., u(sub *)/G) did not vary with stability or baroclinicity; a constant value of 0.1006 (for z(sub 0) = 1.05 m) gave unbiased estimates of u(sub *) and a higher correlation with the reference values than the optimal ABL similarity formulation. Estimates of H and LE using ABL similarity for temperature, the surface energy budget for LE, and the optimal B(sub W) formulation for u(sub *) gave correlations with values measured at the surface wing the Bowen-ratio with energy-budget method of 0.73 and 0.92, respectively. ABL similarity with measured winds provided better estimates, but is less applicable for widespread use in hydrology. Reduction of measurement error and incorporation of accurate acceleration estimates could improve results. Dissert. Abstr.

N93-30298 MacDonald, Dettwiler and Associates Ltd., Richmond (British Columbia).

METEOROLOGICAL INFORMATION FOR AVIATION: A SYSTEMS APPROACH

R. G. HUMPHRIES, J. N. GEDDES, W. C. CREE, and L. W. DIEHL *In* Engineering Inst. of Canada, Canadian Conference on Electrical and Computer Engineering, Volumes 1 and 2 4 p 1990

Avail: Engineering Inst. of Canada, 2050 rue Mansfield, Suite 700, Montreal, Quebec H3A 1Z2 Canada

The use of meteorological information by the aviation community, particularly by air traffic control, is reviewed. Meteorological data are available in three basic forms: alphanumeric, binary, and graphics. Current informational systems do not allow for manipulation or analysis of the data to provide specially derived products and weather alerts, or to select significant information of interest to a particular user. A modernization program is under way at Canada's Atmospheric Environment Service (AES) to improve support for weather office operations and data transfer. The program is providing the potential for accessing new types of information and for accessing information in digital form. In aviation applications, a modernized weather information system would have three principal components: ingestion of data from weather radar, weather satellite, and AES products; data processing to allow extraction and organizing of relevant information from the data stream; and information delivery at fully interactive workstations. An example of such an information system is outlined, based on the MacDonald Dettwiler VORTEX system. Author (CISTI)

N93-30487# Los Alamos National Lab., NM.

A COMPUTER SIMULATION OF THE PRODUCTION OF AN ARTIFICIALLY IONIZED LAYER USING THE ARECIBO FACILITY

G. M. MILIKH, J. M. HINDS, and L. M. DUNCAN (Clemson Univ., SC.) 1993 46 p

(Contract W-7405-ENG-36)

(DE93-010817; LA-SUB-93-152) Avail: CASI HC A03/MF A01

A computer model simulating the formation of an artificially ionized layer in the atmosphere by a series of microwave pulses was developed and is presented. The approach utilizes possible opportunities offered by the existing Arecibo transmitter and antenna. A modified version of the kinetic theory of the breakdown of air by a powerful microwave emission was incorporated into a model of electromagnetic propagation through the atmosphere by a converging ionizing microwave pulse. This model takes into consideration radio wave self-action as well as absorption, and produces profiles of electron concentration formed in the atmosphere by both an isolated pulse and a series of pulses. Effects of varying the shape of the ionizing pulse are considered as well as the influence of the ambient electron concentration. Also, the dependence of the electron concentration on the energy and duration of the pulse is investigated. The possible increase in the rate of electron production is considered when using an intense pulse to initiate the breakdown followed by a series of pulses of lesser energy. The influence of the refraction of the microwave beam is estimated. The computer model presented shows that an AIL (Artificial Ionized Layer) of electrons reaching concentrations on the order of 10(sup 8) cm(sup -3) could be formed over a height range of 40-70 km, if the Arecibo antenna and radio facility were reconfigured so that it would be able to generate microwaves with f = 2.38 GHz and a power of approximately 1-4 MW. In addition, a pulse compressor would be used to form pulses with durations of approximately 0.1-0.15 (mu)s with a repetition frequency of 103 Hz. DOE

N93-31010# Beleidscommissie Remote Sensing, Delft (Netherlands).

ERS-1 DIRECTIONAL WAVE SPECTRA VALIDATION WITH THE AIRBORNE SAR PHARS

J. C. M. KLEIJWEG (Physics and Electronics Lab. TNO, The Hague, Netherlands.) and H. GREIDANUS (Physics and Electronics Lab. TNO, The Hague, Netherlands.) Oct. 1992 57 p

(BCRS-92-18; FEL-92-C282; ISBN-9-05-411061-9; ETN-93-94090)

Avail: CASI HC A04/MF A01

The ERS-1 calibration/validation campaign 'RENE91' is reported. The purpose was to validate ERS-1 geophysical products using other remotely sensed data and in situ measurements. For three days during this campaign, the airborne 'PHARS' (Phased Array SAR (Synthetic Aperture Radar)) measured ocean wave spectra concurrent with the ERS-1 and with a surface radar system and a wave buoy. The results of these instruments are compared, and subsequently interpreted on the basis of SAR ocean wave imaging theory. A total of seven ERS-1 and 14 PHARS wave spectra are analyzed, together with numerous surface radar and buoy spectra. All these spectra contained a total of 13 different wave systems. From the intercomparison, it was found that: very short waves (less than 70 m wavelength) are not seen by ERS-1, nor by PHARS; roughly half the wave occurrences are detected by both ERS-1 and PHARS, the remaining are missed by either or both; peak wavelength and direction of the same wave component can differ considerably as imaged by the various sensors; ERS-1 misses more wave systems than PHARS, especially azimuth traveling ones. All these effects can be understood in terms of the elements of the SAR ocean wave imaging process: scanning distortion, velocity bunching, and defocusing. ESA

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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.

A93-40495
A SOFTWARE FOR OPTIMUM DESIGN OF AN AIRCRAFT STRUCTURE
MULAN CHEN, XU LIU, XIN QIAO (Nanjing Aeronautical Inst., China), GUANGXI PAN, and YANQI ZHANG (Shanghai Aircraft Research Inst., China) Nanjing Aeronautical Institute, Journal (ISSN 1000-1956) vol. 25, no. 2 April 1993 p. 228-234. In CHINESE refs

Based on the FEM, an optimization design of minimum weight of thin-walled structures under constraints of multiple load conditions and stress displacement and size is studied in this paper. Using Kuhn-Tucker necessary conditions, a multidisplacement constrained problem is simplified to a single displacement constraint and called the most critical displacement constraint, eliminating the need to calculate a large set of lagrange multipliers for the effective constraints and deriving an optimization criterion. A recursion formula for stress and displacement constraints is incorporated into a design algorithm envelope method which approaches the optimum design along the most effective constraint boundary. The method is applied successfully to optimum design of an aft fuselage. Author (revised)

A93-41296*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A PERFORMANCE ASSESSMENT OF A BYZANTINE RESILIENT FAULT-TOLERANT COMPUTER
STEVEN D. YOUNG, CARL R. ELKS (NASA, Langley Research Center, Hampton, VA), and R. L. GRAHAM (Planning Research Corp., Hampton, VA) *In* AIAA Computers in Aerospace Conference, 7th, Monterey, CA, Oct. 3-5, 1989, Technical Papers. Pt. 2 Washington American Institute of Aeronautics and Astronautics 1989 p. 623-633. refs
(AIAA PAPER 89-3064) Copyright

This report presents the results of a performance analysis of a quad-redundant Fault-Tolerant Processor (FTP). The FTP is a computing system specifically designed for applications where very high reliability is required. Examples of such applications are flight control systems, nuclear power systems, and spacecraft control systems. The FTP performance was analyzed in a hierarchical manner encompassing the hardware, the operating system, and the application. At the hardware level, the hardware organization and design was assessed in relation to system throughput and response. Analysis at the operating system level revealed that the scheduler took only 3.2 percent of each 40ms frame, while the redundancy management software took 10.4 percent. The application level performance was analyzed via a synthetic workload and a representative flight control model. The estimated throughput for this application was found to be 317.6 KIPS if not exercising the voter. Exercising the voter to ensure fault tolerance will diminish this number linearly as the number of votes is increased. This performance analysis method was proven effective by uncovering undesirable behavior and anomalies in the FTP system. Author

A93-41364
A THERMAL/STRUCTURAL ANALYSIS PROCESS INCORPORATING CONCURRENT ENGINEERING
TERRI A. WELLS (McDonnell Aircraft Co., Saint Louis, MO) Jul. 1992 10 p. SAE, International Conference on Environmental Systems, 22nd, Seattle, WA, July 13-16, 1992 refs
(SAE PAPER 921185) Copyright

The design of advanced aircraft structure requires that the design, structural, and thermal disciplines work in unison during the configuration synthesis iteration process. Automatic transfer of data between the disciplines is required to reduce duplication of work and overall cycle time. This paper presents a state-of-the-art process that incorporates concurrent engineering principles and allows a thermal engineer to provide accurate temperature distributions for large structural models (8000+ elements) in approximately two weeks. The primary tasks include obtaining CAD geometry from the structural designer, defining finite elements, applying thermal boundary conditions, computing temperatures, plotting results as X-Y or color contour plots, and transferring the temperatures to a corresponding structural model.
Author (revised)

A93-41891* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONSTRAINED CONTROL ALLOCATION
WAYNE C. DURHAM (Virginia Polytechnic Inst. and State Univ., Blacksburg) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 16, no. 4 July-Aug. 1993 p. 717-725. AIAA Guidance, Navigation and Control Conference, Hilton Head Island, SC, Aug. 10-12, 1992, Technical Papers. Pt. 3, p. 1147-1155. Previously cited in issue 23, p. 4208, Accession no. A92-55262 refs
(Contract NCC1-158)
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A93-42556
A NONLINEAR CONTROL STRATEGY FOR ROBUST SLIDING MODE PERFORMANCE IN THE PRESENCE OF UNMATCHED UNCERTAINTY
S. K. SPURGEON and R. DAVIES (Leicester Univ., United Kingdom) International Journal of Control (ISSN 0020-7179) vol. 57, no. 5 May 1993 p. 1107-1123. refs
(Contract SERC-GR/H/23368)
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It is well known that sliding mode control schemes provide robustness to the class of uncertainty acting within channels implicit in the control inputs: the so-called matched uncertainty. However, the unmatched uncertainty will affect the ideal dynamics prescribed by the chosen switching surfaces. This paper develops a control strategy to minimize the effects of the unmatched uncertainty upon the dynamic performance prescribed by the switching surfaces. This is achieved for a subclass of the uncertainty class considered by previous authors. The practical application of the control strategy to the design of a stability augmentation system for a light aircraft is presented. For this problem an ideal performance is well known and it is desirable that these ideal dynamics are exhibited across a wide range of flight conditions without degradation. Author

A93-42785
EXPERT SYSTEM FOR REDUNDANCY AND RECONFIGURATION MANAGEMENT
P. R. PUKITE, J. PUKITE (DAINA, Columbia Heights, MN), and D. S. BARNHART (USAF, Wright Lab., Wright-Patterson AFB, OH) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 1 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 233-240. refs
(Contract F33615-90-C-1464)
Copyright

State-of-the-art avionics architectures are highly distributed systems with fault-tolerant capabilities. The distribution of resources coupled with recovery capabilities make these systems resistant to failure during an aircraft mission. The typical mission requires a variety of computational functions that must be provided through the architecture. By providing redundancy of functional modules and efficient reconfiguration of the available CPU resources, further fault-tolerance is achieved. The authors discuss the issues involved in creating an expert-system-based redundancy and reconfiguration manager for an integrated architecture, including the use of a Prolog-style interpreter written in Ada and a rule processor interface generator (RPIG). a.

A93-42797
APPLYING VARIATIONS OF THE QUANTITATIVE FEEDBACK TECHNIQUE (QFT) TO UNSTABLE, NON-MINIMUM PHASE AIRCRAFT DYNAMICS MODELS
MARK A. MCCLURE and RANDALL N. PASCHALL (USAF, Inst. of Technology, Wright-Patterson AFB, OH) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 1 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 334-341. refs

Variations of the quantitative feedback technique (QFT) are applied to a multi-input-multi-output (MIMO) flight control problem with unstable, nonminimum phase plants. The authors present specialized techniques that enable the designer to achieve acceptable results for effective plants which are both unstable and nonminimum phase. The weighting matrix function is discussed, and a method of developing frequency dependent compensation is presented. The longitudinal control system, defined as a single-input-single-output (SISO) system, is designed using the loop transmission function. The limitations imposed by right-half-plane (RHP) poles and zeros are discussed as the design is presented. A straightforward approach to designing a prefilter is also presented. Singular-G and optimal blending methods are used to improve the achievable stability characteristics of the lateral-directional (MIMO) effective plant. A brief discussion of the design of prefilters for a MIMO system is included. a.

A93-42822
AVIONICS SOFTWARE PERFORMABILITY
ANN T. TAI, HERBERT HECHT (SoHaR, Inc., Beverly Hills, CA), and MARC PITARYS (USAF, Wright Lab., Wright-Patterson AFB, OH) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 558-564. refs
(Contract F33615-90-C-1468)
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The authors describe and illustrate a framework for modeling avionics software performability. The model captures the dependencies and interactions between performance and dependability in avionics software systems and permits the investigation of operational software behavior and tradeoffs between performance and dependability. Simple examples are presented which indicate how the performability models can provide insights into design considerations that are not easily attained without a unified approach. The preliminary results show that performability modeling can provide answers that form the basis for objective, quantitatively derived decisions for designs and operational aspects of avionics software. a.

A93-42824
REAL-TIME MONITORING FOR SOFTWARE DEVELOPMENT AND TESTING
KHALED JUNDI and DON MOON (Dayton Univ., OH) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 572-580. refs
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The authors propose a design technique for tracing and monitoring instruction execution where general-purpose registers are used as the main source for manipulating data and results within a RISC (reduced-instruction-set computer)-based microprocessor design. The R3000 MIPS processor will be used as an example of a RISC-based microprocessor target to be monitored in an embedded computer system. The design will be independent of the way the cache memory is implemented on the unit being monitored, i.e., it will monitor on-chip or off-chip cached systems. a.

A93-42829
COMPLEXITY METRICS FOR AVIONICS SOFTWARE
KAM S. TSO, MYRON HECHT (SoHaR, Inc., Beverly Hills, CA), and KENNETH LITTLEJOHN (USAF, Wright Lab., Wright-Patterson AFB, OH) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 603-609. refs
(Contract F33615-91-C-1753)
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The authors describe extensions to the Halstead Software Science measures for avionics software written in Ada. The Halstead measures are based only on the syntax of the program text (operators and operands) without considering the semantics of the applications. Multitasking real-time software, widely used in avionics control, is generally more difficult to design, implement, test, and comprehend due to the interaction of concurrent processes and real-time constraints. Because Ada was designed to support the development of real-time embedded systems, it has introduced concepts such as tasking, exception handling, and intertask communication. The metrics extensions make use of these new Ada language constructs to capture the characteristics of avionics software and measure its complexity. A metrics study conducted on production-grade real-time software indicated that the extended Halstead metric has a stronger correlation to bug reports found during testing. a.

A93-42830
SOME QUESTIONS OF SCALE IN SIMULATION, AND A FEW ANSWERS
JAMES E. KESTER (SofTech, Inc., Fairborn, OH) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 610-616. refs
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The author discusses areas in which the scale of objects and events may drive design choices regarding the model or simulation system to be built. Spatial considerations encompass both the geometric scale of the system and the desired resolution of information. For modeling of electromagnetic phenomena, the scale for adequate resolution will usually include a resolution cell or pixel size. With each determination of spatial scale, there is a correlated determination of temporal increment or resolution. Pixel size and resolution cell size are both related to time-based measures of the electromagnetic system, pulse length and frequency, for instance. The physics (or algorithms) of the system must also be analyzed for relevance based on a spatial and/or temporal scale. An example from computational fluid dynamics demonstrates that, for a given geometry and subject of interest, some effects will be negligible, while others will dominate. The author provides some considerations in answering the following questions: (1) What are the technological limits of scale in various parts of the system? (2) How does one validate the quality of the output of a simulation system? a.

A93-42831
DATABASE MANAGEMENT FOR INTEGRATED AVIONICS SYSTEM
IRA GLICKSTEIN, STEVE RUBERG, and JOHN MARSH (IBM Corp., Federal Systems Div., Owego, NY; USAF, Wright Lab., Wright-Patterson AFB, OH) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 617-622. refs

Utilizing AI (artificial intelligence) knowledge bases and digital-map-based spatiotemporal databases as primary examples, the authors describe the requirements for an avionics DBMS (database management system) and offer potential design solutions that could be implemented in an integrated avionics architecture. It is noted that one is witnessing an explosion of databases, including AI knowledge bases and sensor/map spatiotemporal databases, that will require a real-time, distributed DBMS that is interfaced with the entire avionics platform. The FIRM (Functional Integrated Resource Manager) project is developing a broad-based,

object-oriented DBMS solution that will be applicable to future systems and upgrades to current systems. Given projected advances in onboard sensors and parallel processors, the FIRM DBMS will enable real-time AI and CA (cellular automata)-based data correlation that will greatly improve the ability to conduct challenging missions, such as precision strike and air superiority and defense. In addition, a standard DBMS will increase software maintainability and reusability, resulting in weapon system life-cycle cost savings. a.

A93-42832
FUNCTIONALLY INTEGRATED RESOURCE MANAGER FOR REAL-TIME AVIONICS DATA
STEVEN RUBERG, JOHN MARSH (USAF, Wright Lab., Wright-Patterson AFB, OH), CAROLYN BOETTCHER, and EDWARD TRUJILLO (Hughes Aircraft Co., El Segundo, CA) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 623-627. refs
Copyright

The authors describe avionics database issues in systems fielded by the Air Force, and the impact of integrated avionics on the database problem, and contrast current approaches to management of avionics data with object-oriented design (OOD) approaches being developed under the FIRM (Functionally Integrated Resource Manager) Program. Potential cost savings during development and maintenance that could result from using an OOD are discussed, as well as issues and tradeoffs in implementing an efficient OOD in Ada. The FIRM program has been initiated to define the requirements, develop a conceptual design, and demonstrate critical components of a real-time database management system for avionics. a.

A93-42833
ADDITIONAL DEVELOPMENTS IN EMBEDDED COMPUTER PERFORMANCE MEASUREMENT
DIANE KOHALMI, JOHN NEWPORT (U.S. Navy, Naval Avionics Center, Indianapolis, IN), DIANE PAUL, CHUCK ROARK, and DAVID G. STRUBLE (Texas Instruments, Inc., Defense Systems and Electronics Group, Plano) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 628-634. refs
Copyright

The authors report on the results of Phase II of the Advanced Avionics Technology Demonstration (AATD) Embedded Computer Performance Measurement (ECPM) Program performed by Texas Instruments (TI) for the Naval Avionics Center (NAC). During the first phase of the AATD program, which began in June 1990, a novel method was developed for measuring spare processor and I/O (input/output) throughput reserves. These measurements are typical of those required by Navy standards such as the Tactical Digital Standard (TADSTAND-D). The Phase I work was based on a 16-b MIL-STD-1750A processor embedded in the TI Mission Display Processor (MDP) developed for the DEM/VAL phase of the YF-22 prototype. During Phase II, additional experiments were conducted using the MDP to host the MIPS R3000 reduced-instruction-set computer and TI TMS320C30 signal processor. The authors report on the results of those experiments and summarize important lessons learned during the AATD program. a.

A93-42846
PILOT TASK MONITORING USING NEURAL NETWORKS
BRIAN K. SIEGEL and KIRBY J. KELLER (McDonnell Aircraft Co., Saint Louis, MO) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 709-714. refs
Copyright

Kohonen and backpropagation neural networks were used to process physiological data in order to identify pilot tasks and to cluster pilot tasks with similar workloads. Electrooculargrams, electrocardiograms, and head motion data were collected from three pilots during a night close air support air-to-ground mission in a manned combat simulator. A backpropagation network and a Kohonen network were configured and trained. The backpropagation network was trained to a 99.9 percent recognition of the four flight modes within the training data. The network produced a 67 percent recognition with the testing data. Its performance was limited by the training data selection. The Kohonen network made four clusters which corresponded to four flight modes: navigation, threat evasion, target search, and target tracking. The Kohonen network had a 98 percent accuracy in determining the flight mode. A measure of pilot workload was also produced by the Kohonen network. Pilot tasks with similar workloads were clustered together. a.

A93-42851
EVALUATING THE IOBIDS SPECIFICATION USING GATE-LEVEL SYSTEM SIMULATION
CHRISTOPHER F. DONNELLY (Protocol, Mount Olive, NJ) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 748-759.
Copyright

In September of 1990, the ATF SPO (Air Force Advanced Tactical Fighter Systems Programs Office) awarded Protocol the IOBIDS program in order to apply GLSS (gate-level system simulation) to the measurement of computer module performance and the evaluation of software specifications. The IOBIDS specification, which defines a software interface layer for common modules, was chosen as a test case for these demonstrations to determine whether the additional software layer would degrade module performance to unacceptable levels and because applying GLSS to a relatively immature specification can test its completeness and uncover ambiguities. The IOBIDS program used simulation models of a JIAWG (Joint Integrated Avionics Working Group) CAP-16 (Common Avionics Processor 16-bit) module to perform two types of demonstrations. Performance demonstrations used GLSS to measure the performance impact of IOBIDS by executing a benchmark on a JIAWG common module with and without the IOBIDS software. Exchangeability demonstrations used GLSS to evaluate the IOBIDS specification and demonstrate common module exchangeability by executing a common Ada program across JIAWG common modules developed by multiple contractors. The results of the performance demonstrations indicate that IOBIDS software will have a negative impact on system performance of 3 to 10 percent, depending on the application's utilization of IOBIDS routines. As a result of the exchangeability demonstrations, Protocol documented numerous incompatibilities related to the IOBIDS specification, demonstrating the value of evaluating software specifications using GLSS. a.

A93-42852
NEW DEVELOPMENTS IN A PI-BUS SPECIFICATION BY THE JIAWG AND SAE
CHUCK ROARK (Texas Instruments, Inc., Defense Systems and Electronics Group, Plano) and FRED JACKSON (IBM Corp., Federal Sector Div., Owego, NY) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 760-766. refs
Copyright

The JIAWG (Joint Integrated Avionics Working Group) together with the SAE has developed a Backplane PI-Bus specification to insure interoperability of modules across a PI-Bus on JIAWG platforms. This specification, while based on the VHSIC Phase 2 Interoperability Standards PI-Bus specification, adds clarifications and modifications required for interoperability. The authors discuss the interoperability problems between existing PI-Bus implementations and why the VHSIC PI-Bus specification required

an additional interoperability specification. The details of the major clarifications and modifications to the VHSIC PI-Bus specification are presented. a.

A93-42856
THE PAVE PACE INTEGRATED CORE PROCESSOR
DOMINICK J. IMBESI and WESLEY K. KAPLOW (AT&T Bell Labs., Whippany, NJ) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 806-814.
(Contract F33615-89-C-1110)
Copyright

The signal and data processor in the Pave Pace architecture, the Pave Pace Integrated Core Processor (ICP), is described. Technology and architectural innovations were primarily used to improve reliability, maintainability, survivability, affordability, weight, and volume. In addition, turn-of-the-century avionics applications require that the ICP must be able to provide more than 20 GFLOPS and more than 750 MIPS. The ICP is a modular, logically integrated multiprocessor where components may be physically distributed throughout a platform. To achieve this, large Pave Pace electrical backplanes are replaced by small electrical/photonic backplanes and a photonic exchange network, interconnecting the smaller backplanes via fiber optics. The ICP operating system and architecture provide a uniform logical view to the application programmer, improving programmability and survivability. The Principles of Operation (POPS) is a critical component of the ICP design. The ICP POPS provides the open software architecture required for an advanced avionics processor. It synchronizes and controls the large number of autonomous processors to gain the maximum benefit from a highly concurrent architecture. a.

A93-42862
GETTING A HANDLE ON DESIGNING FOR AVIONICS SOFTWARE SUPPORTABILITY AND MAINTAINABILITY
CHARLES P. SATTERTHWAITE (USAF, Wright Lab., Wright-Patterson AFB, OH) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 3 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 944-947. refs

The author addresses the acquisition, logistics, and use of avionics software by showing cases of avionics software supportability and maintainability and the design methodology. He defines supportability and maintainability and gives an idealistic example of a strongly designed supportable and maintainable futuristic fighter. The state of supportability and maintainability today is reviewed. The field of software engineering and to focus it to affect design for supportability and maintainability are considered. The engineering design process and how it can accommodate supportability and maintainability are reviewed. The engineering design process is applied to software scenarios and it is shown where supportability and maintainability should be considered in software designs. a.

A93-42863
COMPUTER-AIDED DESIGN OF AVIONIC DIAGNOSTICS ALGORITHMS
ROBERT HAMMETT (Charles Stark Draper Lab., Inc., Cambridge, MA) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 3 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 948-954. refs
Copyright

The author describes the application of a computer-aided design tool developed to complement an alternative approach to diagnostics design using the failure signatures or syndromes. The computer-aided design tool can analyze fault-tolerant architectural networks, provide network design guidance, and generate syndrome data for inclusion in the embedded software diagnostic algorithms. The tool accepts as input a graphical description of the system to be analyzed and produces as output a complete failure dependency analysis and the syndrome vectors needed for a table look-up implementation of the diagnostics. The failure syndrome also provides analysis of the theoretical performance potential of the system. Additional benefits are that transient and intermittent failures can be conveniently handled, and the method can be extended to diagnose multiple sequential failure conditions. a.

A93-42865
TEAMS - TECHNICAL EXPERT AIRCRAFT MAINTENANCE SYSTEM
MICHAEL P. LISCHKE and KENNETH L. MEYER (McDonnell Aircraft Co., Saint Louis, MO) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 3 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 960-964.
Copyright

The technical expert aircraft maintenance system (TEAMS) is an interactive system that supports the diagnosis of problems on new aircraft. The system uses expert system technology to provide the aircraft mechanic with the knowledge and experience needed to successfully repair an aircraft. TEAMS consists of a number of expert-system modules. The authors give an overview of the TEAMS effort, a description of the method used to develop each expert system, and a short discussion on how user acceptance was obtained. The development of each expert system was partitioned into four distinct phases: project identification, knowledge acquisition, knowledge codification, and testing. These activities are described. The results to date have been very encouraging. The expert systems are being introduced for use on a regular basis for the repair of aircraft. a.

A93-43113
USING NUMERICAL CONTROL ALGORITHMS IN STABILIZATION SYSTEMS WITH DIGITAL CORRECTION [ISPOL'ZOVANIE TSIFROVYKH ALGORITMOV UPRAVLENIYA V SISTEMAKH STABILIZATSII S TSIFROVOJ KORREKTSIEJ]
S. A. AGAPITOV, S. N. BYKOV, and V. A. FALEV *In* Methods and equipment for data processing and acquisition in information management systems Leningrad Leningradskij Institut Aviatsionnogo Priborostroeniya 1990 p. 84-88. In RUSSIAN refs
Copyright

The use of numerical control methods in the development of flight vehicle stabilization systems is examined with particular reference to the design of numerical controllers for digital stabilization systems with pulse-width modulation. The design of such numerical controllers includes calculation of the transfer function, selection of its implementation form, a study of the effect of level quantization, and its implementation in hardware and software. The individual stages of the controller design procedure are briefly discussed. AIAA

A93-43115
SOFTWARE SUPPORT FOR A COMPUTERIZED AIR SITUATION DOCUMENTATION SYSTEM [PROGRAMMNOE OBESPECHENIE AVTOMATIZIROVANNOJ SISTEMY DOKUMENTIROVANIYA VOZDUSHNOJ OBSTANOVKI]
A. M. LUPAL and G. I. PAVLOV *In* Methods and equipment for data processing and acquisition in information management systems Leningrad Leningradskij Institut Aviatsionnogo Priborostroeniya 1990 p. 111-115. In RUSSIAN
Copyright

An implementation of a microcomputer-based system for the processing of aircraft position data stored on a floppy disk is described. The objectives of the computerized air situation documentation system include precise mapping of aircraft routes onto a geographic map, without any restrictions on the scale and the monitored area, and generation of specific documents. The software for the system is written in Turbo Pascal and runs under the CP/M operating system. The features and capabilities of the system are summarized. AIAA

A93-43470
ADAPTIVE WAVEFORM SELECTION WITH A NEURAL NETWORK
A. G. HUIZING and J. A. SPRUYT (TNO, Delft, Netherlands) *In* Radar 92; Proceedings of the International Conference, Brighton, United Kingdom, Oct. 12, 13, 1992 London and Piscataway, NJ Institution of Electrical Engineers 1992 p. 419-421. refs
Copyright

An approach based on a neural network trained to predict radar detection performance in various environmental conditions is proposed. A technique for optimization of radar performance based on simulated annealing is used to find the optimum parameter combination. A computer model, called CARPET, was used to evaluate the radar performance. It is pointed out that the use of the CARPET model for adaptive selection of waveform parameters presents problems associated with excessive computation times. It is concluded that the proposed approach that uses a neural network to predict radar performance and the simulated annealing technique to select the optimum waveform parameters is feasible. AIAA

N93-29187# Sandia National Labs., Albuquerque, NM.
ABLATION PROBLEMS USING A FINITE CONTROL VOLUME TECHNIQUE
B. F. BLACKWELL, A. L. THORNTON, and R. E. HOGAN 1993 8 p Presented at the Moving Boundaries 1993: Computational Modeling of Free and Moving Boundary Problems, Milan, Italy, 23-25 Jun. 1993
(Contract DE-AC04-76DP-00789)
(DE93-009861; SAND-93-0284C; CONF-9306128-1) Avail: CASI HC A02/MF A01

An element based finite control volume procedure is applied to the solution of ablation problems for 2-D axisymmetric geometries. A mesh consisting of four node quadrilateral elements was used. The nodes are allowed to move in response to the surface recession rate. The computational domain is divided into a region with a structured mesh with moving nodes and a region with an unstructured mesh with stationary nodes. The mesh is constrained to move along spines associated with the original mesh. Example problems are presented for the ablation of a realistic nose tip geometry exposed to aerodynamic heating from a uniform free stream environment. DOE

N93-29192*# Boeing Commercial Airplane Co., Seattle, WA. Flight Deck Research.
SPURIOUS SYMPTOM REDUCTION IN FAULT MONITORING
WILLIAM D. SHONTZ, ROGER M. RECORDS, and JAI J. CHOI Jun. 1993 108 p
(Contract NAS1-18027; RTOP 505-64-13-22)
(NASA-CR-191453; NAS 1.26:191453) Avail: CASI HC A06/MF A02

Previous work accomplished on NASA's Faultfinder concept suggested that the concept was jeopardized by spurious symptoms generated in the monitoring phase. The purpose of the present research was to investigate methods of reducing the generation of spurious symptoms during in-flight engine monitoring. Two approaches for reducing spurious symptoms were investigated. A knowledge base of rules was constructed to filter known spurious symptoms and a neural net was developed to improve the expectation values used in the monitoring process. Both approaches were effective in reducing spurious symptoms individually. However, the best results were obtained using a hybrid system combining the neural net capability to improve expectation values with the rule-based logic filter. Author (revised)

N93-29490# Federal Aviation Administration, Atlantic City, NJ. Technical Center.
DATA MULTIPLEXING NETWORK (DMN) EQUIPMENT OPERATIONAL TEST AND EVALUATION (OT&E) INTEGRATION TEST REPORT
WAYNE E. BELL and PHILLIP P. HOANG Mar. 1993 26 p
(AD-A263172; DOT/FAA/CT-TN9) Avail: CASI HC A03/MF A01

This test report contains the test results of the Operational Test and Evaluation (OT and E) Integration testing of Data Multiplexing Network (DMN) Phase 3B Commercial Off-The-Shelf (COTS) equipment. The OT and E Integration testing was accomplished by conducting unit level tests at the Federal Aviation Administration (FAA) Technical Center, and integration tests at the Air Route Traffic Control Center (ARTCC) in Minneapolis, Minnesota. Based on the test results, it is concluded that the Motorola Codex COTS equipment performed its function of providing data exchange between NAS facilities and is considered qualified for the NAS environment. DTIC

N93-30104# European Space Agency, Paris (France).
THREE-DIMENSIONAL GRAPHICAL REPRESENTATION OF OBJECTS ACCORDING TO MOVEMENT DATA IN REALTIME
KLAUS ALVERMANN (Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick, Germany.) Nov. 1991 48 p Transl. into ENGLISH of Dreidimensionale Darstellung von Objekten nach Bewegungsdaten in Echtzeit (Brunswick, Germany, DLR) 30 Oct. 1990 p 1-70 Original language document was announced as N91-23725
(ESA-TT-1258; DLR-FB-90-51; ETN-93-93713) Avail: CASI HC A03/MF A01; original German version available from DLR Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Germany, HC

A system capable of showing three dimensional images of flying objects is described. The objects are moved by flight data coming from several possible sources, that is, a (real time) simulation or telemetry. The system is implemented on a personal computer and a transputer network. The transputer network is capable of showing the movement in real time, that is, there are enough images per second to have a smooth movement. The basic concepts of three dimensional images are defined, the mathematical background is prepared, and both implementations are described. ESA

N93-30688*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
VALIDATION AND UPGRADING OF PHYSICALLY BASED MATHEMATICAL MODELS
RONALD DUVAL *In its* NASA/FAA Helicopter Simulator Workshop p 123-129 Apr. 1992
Avail: CASI HC A02/MF A02

The validation of the results of physically-based mathematical models against experimental results was discussed. Systematic techniques are used for: (1) isolating subsets of the simulator mathematical model and comparing the response of each subset to its experimental response for the same input conditions; (2) evaluating the response error to determine whether it is the result of incorrect parameter values, incorrect structure of the model subset, or unmodeled external effects of cross coupling; and (3) modifying and upgrading the model and its parameter values to determine the most physically appropriate combination of changes. Derived from text

N93-31029 Notre Dame Univ., IN.
STRUCTURAL DESIGN USING NEURAL NETWORKS Ph.D. Thesis
RICHARD ALAN SWIFT 1993 208 p
Avail: Univ. Microfilms Order No. DA9308230

At the early stages of design, it is necessary to obtain an understanding of the design space characteristics for the structural concepts under consideration. This involves developing a representation of the structural system's behavior to variations in the design variables of interest. The effort was to efficiently obtain both qualitative and quantitative structural design space mappings for use in preliminary design studies. Recent advances in finite element based structural optimization techniques provide the means to address this concern, but these approaches typically involve the determination of 'points' in the design space, rather than a mapping of the design space. Neural networks, mathematical models of biologically occurring neural systems, were employed to quantify the design space representations. The neural networks form the representation of the design space based on a set of

optimal designs obtained from math-programming and fully-stressed design optimization programs. Feed-forward, back propagation neural networks were used to form the design space representation. The neural network representations were then used to ascertain trends in the design space, and the neural networks were also 'searched' using various optimization procedures to define those regions of the design space that showed the most promising design characteristics. Math-programming techniques and simulated annealing procedures were employed to perform the searches of the design spaces. Recursive learning was explored to minimize the amount of training data necessary (training data generation being the most computationally expensive part of the neural network procedure). Continuous as well as discrete design variables were examined. The continuous design variable cases involved configurations design, while the discrete design variable cases involved material selection. Planar trusses, a 3-D space truss, and three semi-monocoque wings were used to describe the implementation of the neural network procedure. The results obtained from these models show that the design spaces are effectively represented by the neural networks. The neural networks also provide the means to determine significantly improved designs, with reductions in objective function values of over 10 percent noted for several cases. The neural network approach to design space representation appears to hold promise to a wide range of structural design problems. Dissert. Abstr.

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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.

A93-41929
NOISE TRANSMISSION OF SKIN-STRINGER PANELS USING A DECAYING WAVE METHOD
DONALD E. HUNTINGTON and CONSTANTINOS S. LYRINTZIS (San Diego State Univ., CA) AIAA Journal (ISSN 0001-1452) vol. 31, no. 7 July 1993 p. 1338-1340. refs
(Contract NSF MSM-90-08953)
Copyright

A finite element/decaying wave (FEDW) method is used to examine the vibration of a skin-stringer-frame structure imbedded in an acoustic enclosure's wall. Noise transmission from a three-bay single-row structure into an enclosure with normal and infinite acoustic impedance in the $z = 0$ and $z = d$ walls is examined first. Noise transmission from a forty-bay structure of one and two rows into an acoustic enclosure is examined next in order to illustrate the effect of multiple rows on the interior noise for identical external loading. AIAA

A93-42580
SCATTERING KERNELS FOR GAS-SURFACE INTERACTION
CARLO CERCIGNANI (Milano, Politecnico, Milan, Italy) *In* Hypersonic flows for reentry problems. Vol. 1 Berlin and New York Springer-Verlag 1991 p. 35-54. refs
Copyright

The problem of the interaction between a gas molecule and the surface layers is attacked from a semiphenomenological point of view. After extracting from physics all the general information which is available, theoretical models embodying this information, sufficiently simple and flexible to cope with different physical situations, are discussed. Other approaches and comparisons with experimental data are also reviewed. Author

A93-42584* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
INTRUSIVE AND NONINTRUSIVE MEASUREMENTS OF FLOW PROPERTIES IN ARC JETS
CARL D. SCOTT (NASA, Johnson Space Center, Houston, TX) *In* Hypersonic flows for reentry problems. Vol. 1 Berlin and New York Springer-Verlag 1991 p. 139-169. refs
Copyright

While numerous diagnostic techniques are available for determining the flow properties of arc jets, these have to be used complementarily in order to cover all the requisite information. Although intrusive techniques disturb the flow, they yield much information. The determination of total enthalpy remains a major challenge, and accurate heat-flux measurements entail knowledge of atom recombination and chemical energy recombination coefficients. Such state-specific methods as the spectroscopic and laser techniques are useful in understanding the chemistry and nonequilibrium reaction and excitation rates of the flow. AIAA

N93-29189# Argonne National Lab., IL.
FORCES ON A MAGNET MOVING PAST FIGURE-EIGHT COILS
T. H. MULCAHY, JIANLIANG HE, D. M. ROTE, and T. D. ROSSING (University of Northern Illinois, De Kalb.) 1993 4 p Presented at the International Magnetics Conference, Stockholm, Sweden, 13-16 Apr. 1993
(Contract W-31-109-ENG-38)
(DE93-009965; ANL/MCT/CP-77846; CONF-930416-1) Avail: CASI HC A01/MF A01

For the first time, the lift, drag, and guidance forces acting on a permanent magnet are measured as the magnet passes over different arrays of figure-eight (null-flux) coils. The experimental results are in good agreement with the predictions of dynamic circuit theory, which is used to explain more optimal coil arrays. DOE

N93-29384# Duke Univ., Durham, NC. Dept. of Mechanical Engineering and Materials Science.
CHAOS IN MECHANICAL SYSTEMS WITH ESPECIAL REFERENCE TO ROTORCRAFT AND MISSILES Final Report, 9 Feb. 1987 - 31 Aug. 1990
EARL H. DOWELL Feb. 1993 5 p
(Contract DAAL03-87-K-0023)
(AD-A263703; ARO-23555.12-EG) Avail: CASI HC A01/MF A01

Work has focussed on the following topics using the buckled beam as prototypical generic system: (1) the effect of higher modes on the response of the buckled beam; (2) initial condition maps and their interpretation; (3) Lyapunov exponents (nonlinear eigenvalues) as a predictor of chaos; (4) necessary and sufficient conditions for chaos to occur; (5) systems with both positive and negative linear stiffness; (6) systems with nonlinear damping; (7) a (buckled) beam-tube with an internal flowing fluid; (8) a survey paper summarizing much of our work; (9) a buckled beam under a constant as well as oscillating transverse load; (10) a curved beam (or plate) held (on one side) against a rigid surface; (11) the development of'turbulence' in an aeroelastic system that is responding chaotically in many degrees of freedom; and (12) an experimental study of a simple prototypical system exhibiting sensitivity to initial conditions and chaos. Transl. by SCITRAN

N93-29480# Army Test and Evaluation Command, Aberdeen Proving Ground, MD.
EXTERNAL ACOUSTICAL NOISE MEASUREMENTS FOR AVIATION SYSTEMS Final Report
5 Feb. 1993 14 p Supersedes TOP-7-3-5-526 dated 10 Jun. 1971
(AD-A263138; TOP-7-3-526) Avail: CASI HC A03/MF A01

This TOP describes procedures for measuring external acoustical noise of Army helicopters. It covers test procedures for the measurements of steady-state and impulse noise. DTIC

N93-30110# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
COMPUTATION OF FAR-FIELD HELICOPTER ROTOR TONE NOISE Ph.D. Thesis - Univ. de Tech. de Compiegne, 1985 [CALCUL DU BRUIT DE RAIES EMIS PAR UN ROTOR D'HELICOPTERE EN CHAMP LOINTAIN]

MICHEL CAPLOT 1990 236 p In FRENCH
(ISSN 0078-379X)
(ONERA-P-1990-5; ETN-93-93722) Avail: CASI HC A11/MF A03

The prediction of helicopter main rotor tone noise in subsonic regime is addressed. A synthesis of the different approaches to this problem is given and a method in the frequency domain is proposed, and compared to a more usual time domain method. For the velocities considered, it appears that the two main tone noise sources are the thickness noise of the monopolar type and the loading noise of the dipolar type. A noise prediction computation code was developed that allows the study of these two sources. For thickness noise, the important factors are the advancing blade and rotational top Mach numbers and the geometric characteristics of the rotor blade. For loading noise, the study is more complicated because the input data are issued from an aerodynamic code. Nevertheless, the use of the frequency method, associated with harmonic analysis of the rotor loads, has real advantages, especially for future developments in the case of blade-vortex interactions. To predict levels under acoustic certification conditions for helicopters, sound wave reflections on the ground and the Doppler effect were introduced in the calculation scheme. ESA

N93-30980 Stanford Univ., CA.
STRONG PARALLEL BLADE-VORTEX INTERACTION AND NOISE PROPAGATION IN HELICOPTER FLIGHT Ph.D. Thesis
SOOGAB LEE 1992 152 p
Avail: Univ. Microfilms Order No. DA9309693

Rotor impulsive noise is, of all the known sources of helicopter far-field noise radiation, the one which tends to dominate the acoustic spectrum generated by most helicopters. The helicopter generates a highly directional and rather unique form of impulsive noise which is thought to be generated by two source mechanisms: (1) high-speed impulsive noise due to formation of a shock on the advancing blade tip, and (2) Blade-Vortex Interaction (BVI) noise in low-powered descending flight or maneuvers, especially during an approach to a landing. As an experimental approach, a shock tube was built to generate a compressible viscous vortex which was being convected at a constant velocity in a quasi-uniform subsonic or transonic stream. The vortex then interacted with a target airfoil (NACA 0012 shape). In order to measure quantitatively the flow field, a DPHI (Dual Pulsed Holographic Interferometry) technique was utilized for both flow visualization and density field measurements, and fast-response Kulite transducers were used to obtain pressure histories at the surfaces of both the test section and the airfoil. Secondly, as a numerical approach, the Thin-Layer Navier-Stokes equations were solved not only to simulate the experimental measurements, but also to develop the fundamental understanding of flow field and sound generating mechanisms and, furthermore, to understand the effect of several important parameters on the sound generation due to blade-vortex interaction. The results indicate that the main noise generating mechanism in strong blade-vortex interactions is the severe pressure fluctuation near the leading-edge, caused by rapid oscillation of the stagnation point and formation of a suction peak. In strong parallel BVI, a secondary vortex may be generated by separation on the lower surface if the original vortex is clockwise. In that case, the induced vortex has an opposite rotation. The generated noise level is strongly dependent on Mach number, miss distance, angle of attack, and vortex structure (circulation and core size). The near-field acoustic behavior also depends on the leading-edge shape and thickness of the airfoil rather than the chord length. Results also indicate that transpiration on the leading-edge can suppress pressure fluctuation near the leading-edge and reduce the amplitude of propagating noise. Dissert. Abstr.

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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.

A93-40474
TOBACCO SMOKING IN AIRCRAFT - A FOG OF LEGAL RHETORIC?
R. I. R. ABEYRATNE (McGill Univ., Montreal, Canada) Air & Space Law (ISSN 0927-3379) vol. 18, no. 2 April 1993 p. 50-60. refs
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The possible dangers of smoking in aircraft are examined by reviewing the known instances of fires aboard aircraft, caused by cigarette smoking in lavatories, as well as the medical evidence on the effect of smoking on the ability of humans to tolerate altitude and on health in general. Particular attention is given to the role of the international community in enacting laws which prohibit smoking in aircraft and to legal aspects of a dispute between the smoker, the nonsmoking passengers, and the airline. It is concluded that, although tobacco smoke is now known to be extremely dangerous to human health and to sensitive aircraft equipment, and the inhalation of tobacco smoke is known to impair the capability of the pilot, smoking as a tort has not yet been adjudicated in the courts. AIAA

A93-42828
REUSABLE ADA AVIONICS SOFTWARE PACKAGES LIBRARY SYSTEM
ERIC BESER (Westinghouse Electronics Systems Group, Baltimore, MD) and JAMES S. WILLIAMSON (USAF, Wright Lab., Wright-Patterson AFB, OH) *In* NAECON 92; Proceedings of the IEEE 1992 National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1992. Vol. 2 New York Institute of Electrical and Electronics Engineers, Inc. 1992 p. 598-602. Research supported by USAF refs
Copyright

The goal of the Reusable Ada Avionics Software Packages (RAASP) project is to develop a flexible library of Reusable Software Objects (RSOs) that can be adapted into Ada-based avionics systems. The specific goal of this project is to achieve avionics software reuse at both the requirements (top-level and detailed design) and source code level. This goal is realized via a means and methodology of reuse management, using a hypermedia-based library and retrieval mechanism to browse and select RSOs. a.

A93-42997
FEDERAL PREEMPTION IN COMMERCIAL AVIATION - TORT LITIGATION UNDER 49 U.S.C. SECTION 1305
STUART J. STARRY (Fleming, Hovenkamp & Grayson, Houston, TX) Journal of Air Law and Commerce (ISSN 0021-8642) vol. 58, no. 3 Spring 1993 p. 657-701. refs
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Whether the Airline Deregulation Act of 1978 preempts all state common law tort causes of action for wrongful air carrier conducted is discussed. Whether an implied federal statutory remedy should be recognized and whether in the absence of the latter the victims of airline negligence should be granted a federal common law cause of action are addressed. AIAA

A93-42998
THE FOREIGN SOVEREIGN IMMUNITIES ACT OF 1976 - MISJOINDER, NONJOINDER, AND COLLUSIVE JOINDER
J. T. THORNTON and AURORA A. ARES (Thornton, David, Murray, Richard, and Davis, P.A., Miami, FL) Journal of Air Law and Commerce (ISSN 0021-8642) vol. 58, no. 3 Spring 1993 p. 703-742. refs
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This article examines the rules that govern the joinder of a foreign state in personal injury and wrongful death actions arising from aviation accidents. It addresses how the joinder of a foreign state, even as third party defendant, permits the removal of the entire case to federal court, including the first-party claims brought against private entities, and show such removal facilitates the dismissal of actions brought by foreign plaintiffs under the federal forum non conveniens standard. Recent decisions on the law of fraudulent and collusive joinder are noted which further facilitate the joinder of the foreign state defendant, even when the joinder results in the removal of the action to federal court against the plaintiff's wishes. AIAA

A93-42999
NO RESCUE IN SIGHT FOR WARSAW PLAINTIFFS FROM EITHER COURTS OR LEGISLATURE - MONTREAL PROTOCOL 3 DROWNS IN COMMITTEE
ELOISE COTUGNO Journal of Air Law and Commerce (ISSN 0021-8642) vol. 58, no. 3 Spring 1993 p. 745-793. refs
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The history of the Warsaw Convention and various attempts at is modification are briefly reviewed, and judicial decisions applying its provisions in the area of personal injury or death are examined. Montreal Protocol 3 in its current embodiment is discussed and its potential impact on future cases is considered. AIAA

A93-43623
ILYUSHIN TAKES ON THE MARKET
MIKE TAVERNA Interavia/Aerospace World (ISSN 0983-1592) vol. 48 May 1993 p. 26-28.
Copyright

The IL-96M aircraft equipped with state-of-the-art Pratt & Whitney PW2337 engines, the propulsion system used on the 757 and the C-17A, and the avionics system by Rockwell Collins is presented. The aircraft made its first flight on April 6, 1993 and will debut in the Paris Airshow. This high-performance version of the IL-96-300 four-engine long range aircraft will be competitive with the Airbus A340, the MD-11, and Boeing's future 777 twin. AIAA

A93-43677
SALES, NOT SUBSIDIES, ARE THE STICKING POINT
T. F. ROGERS Aerospace America (ISSN 0740-722X) vol. 31, no. 6 June 1993 p. 10-14.
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It appears that a still-wider agreement than that currently in force (signed July, 1992) will be pursued in late 1993 by negotiators at the General Agreement on Tariffs and Trade talks, covering civil engine as well as commercial airframe manufacturers and all types of civil aviation aircraft. While some European industry officials worry that the U.S. will pull out of the July, 1992 agreement, both sides have pledged to continue talks concerning the issue of indirect subsidies. Nevertheless, the trend toward international distribution of component manufacturing is blurring the distinctions among 'American' and 'European' aircraft. AIAA

A93-43869
BEING AN ENGINEER - A RISKY OCCUPATION? PROCEEDINGS OF THE CONFERENCE, LONDON, UNITED KINGDOM, JUNE 8, 1993
London Royal Aeronautical Society 1993 63 p. No individual items are abstracted in this volume
(ISBN 1-85768-120-7) Copyright

Aviation engineering is examined with emphasis on liability issues. Attention is given to such topics as product liability and the duty of care, the role of regulatory authorities in civil aviation, military compliance with legal requirements, and engineering integrity. Consideration is also given to liability insurances and the engineering manufacturing industry, and to proper qualification of the individual. AIAA

N93-29322*# National Aeronautics and Space Administration, Washington, DC.
THE NASA SBIR PRODUCT CATALOG
J. A. GILMAN (Futron Corp., Bethesda, MD.), J. B. PAIGE (Futron Corp., Bethesda, MD.), and F. CARL SCHWENK (Futron Corp., Bethesda, MD.) Oct. 1992 99 p
(NASA-TM-108242; NAS 1.15:108242) Avail: CASI HC A05/MF A02

The purpose of this catalog is to assist small business firms in making the community aware of products emerging from their efforts in the Small Business Innovation Research (SBIR) program. It contains descriptions of some products that have advanced into Phase 3 and others that are identified as prospective products. Both lists of products in this catalog are based on information supplied by NASA SBIR contractors in responding to an invitation to be represented in this document. Generally, all products suggested by the small firms were included in order to meet the goals of information exchange for SBIR results. Of the 444 SBIR contractors NASA queried, 137 provided information on 219 products. The catalog presents the product information in the technology areas listed in the table of contents. Within each area, the products are listed in alphabetical order by product name and are given identifying numbers. Also included is an alphabetical listing of the companies that have products described. This listing cross-references the product list and provides information on the business activity of each firm. In addition, there are three indexes: one a list of firms by states, one that lists the products according to NASA Centers that managed the SBIR projects, and one that lists the products by the relevant Technical Topics utilized in NASA's annual program solicitation under which each SBIR project was selected. Derived from text

N93-29323*# National Aeronautics and Space Administration, Washington, DC.
NASA SBIR ABSTRACTS OF 1991 PHASE 1 PROJECTS
F. CARL SCHWENK (Futron Corp., Bethesda, MD.), J. A. GILMAN (Futron Corp., Bethesda, MD.), and J. B. PAIGE (Futron Corp., Bethesda, MD.) Sep. 1992 133 p
(NASA-TM-108240; SBIR-91-2; NAS 1.15:108240) Avail: CASI HC A07/MF A02

The objectives of 301 projects placed under contract by the Small Business Innovation Research (SBIR) program of the National Aeronautics and Space Administration (NASA) are described. These projects were selected competitively from among proposals submitted to NASA in response to the 1991 SBIR Program Solicitation. The basic document consists of edited, non-proprietary abstracts of the winning proposals submitted by small businesses. The abstracts are presented under the 15 technical topics within which Phase 1 proposals were solicited. Each project was assigned a sequential identifying number from 001 to 301, in order of its appearance in the body of the report. Appendixes to provide additional information about the SBIR program and permit cross-reference of the 1991 Phase 1 projects by company name, location by state, principal investigator, NASA Field Center responsible for management of each project, and NASA contract number are included. Author (revised)

N93-29396# Research and Development Labs., Culver City, CA.
SUMMER RESEARCH PROGRAM (1992). HIGH SCHOOL APPRENTICESHIP PROGRAM (HSAP) REPORTS. VOLUME 16: ARNOLD ENGINEERING DEVELOPMENT CENTER CIVIL ENGINEERING LABORATORY Annual Report, 1 Sep. 1991 - 31 Aug. 1992
GARY MOORE 28 Dec. 1992 227 p
(Contract F49620-90-C-0076)
(AD-A262024; AFOSR-93-0126TR-VOL-16) Avail: CASI HC A11/MF A03

The following reports were completed during the Air Force 1992 Summer Research Program: Graphics Library Routines for ETF Analysis Software; Visualization of Quantum Chemical Calculations for Molecules; Development of a Versatile Spreadsheet for Estimating Electrical Power and Operating Hours for AEDC's Tunnel 16T; Calibration and Application of a

Spectrapro(Trademark)-275 Spectrometer; A Study of the Continuous Monitoring Station at Arnold Engineering Development Center; and Comparison of the HNU 311 Portable and Hewlett Packard 5890 Series 2 Gas Chromatographs. DTIC

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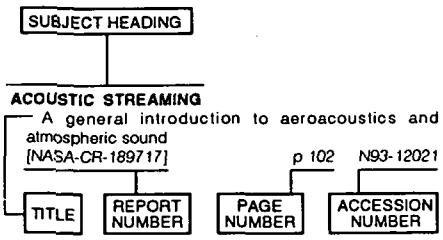
GENERAL

N93-29452*# National Aeronautics and Space Administration, Washington, DC.
RESEARCH AND TECHNOLOGY OBJECTIVES AND PLANS: SUMMARY FISCAL YEAR 1991
Mar. 1991 164 p
(NASA-TM-103086; NAS 1.15:103086) Avail: CASI HC A08/MF A02

This publication represents the NASA research and technology program for FY 1991. It is a compilation of the Summary portions of each of the RTOP's (Research and Technology Objectives and Plans) used for management review and control of research currently in progress throughout NASA. The RTOP Summary is designed to facilitate communication and coordination among concerned technical personnel in government, industry, and in universities. The first section contains citations and abstracts of the RTOP's and is followed by four indexes: Subject, Technical Monitor, Responsible NASA Organization, and RTOP Number. Author

Typical Subject Index Listing



The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of document content, a title extension is added, separated from the title by three hyphens. The accession number and the page number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document. Under any one subject heading, the accession numbers are arranged in sequence.

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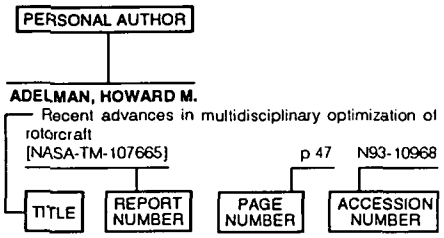

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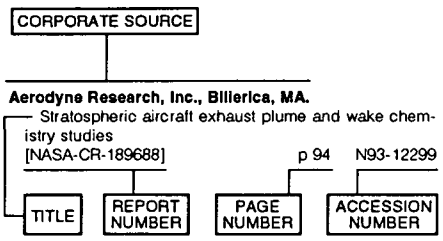

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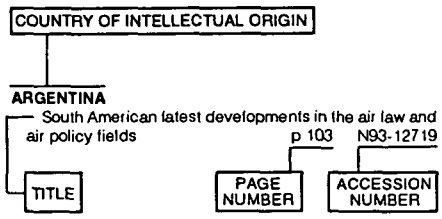

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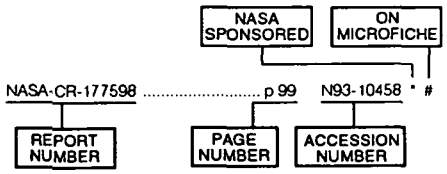

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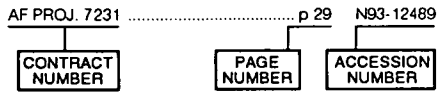

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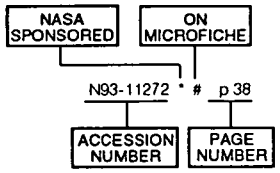

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REPORT DOCUMENT PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA SP-7037 (295)		

4. Title and Subtitle	5. Report Date
Aeronautical Engineering A Continuing Bibliography (Supplement 295)	September 1993
	6. Performing Organization Code JTT
7. Author(s)	8. Performing Organization Report No.
	10. Work Unit No.
9. Performing Organization Name and Address NASA Scientific and Technical Information Program	11. Contract or Grant No.
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546-0001	13. Type of Report and Period Covered Special Publication
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This report lists 581 reports, articles and other documents recently announced in the NASA STI Database.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Aeronautical Engineering Aeronautics Bibliographies	Unclassified - Unlimited Subject Category - 01

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	170	A08/HC

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