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Aeronautical Engineering
A Continuing Bibliography with Indexes

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National Aeronautics and Space Administration

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ACCESSION NUMBER RANGES

Accession numbers cited in this Supplement fall within the following ranges.

STAR (N-10000 Series)	N90-28489 — N90-30170
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NASA SI

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 260)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in December 1990 in

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

National Aeronautics and Space Administration
Office of Management
Scientific and Technical Information Division
Washington, DC 1991

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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 405 reports, journal articles and other documents originally announced in December 1990 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

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

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

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

An annual cumulative index will be published.

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

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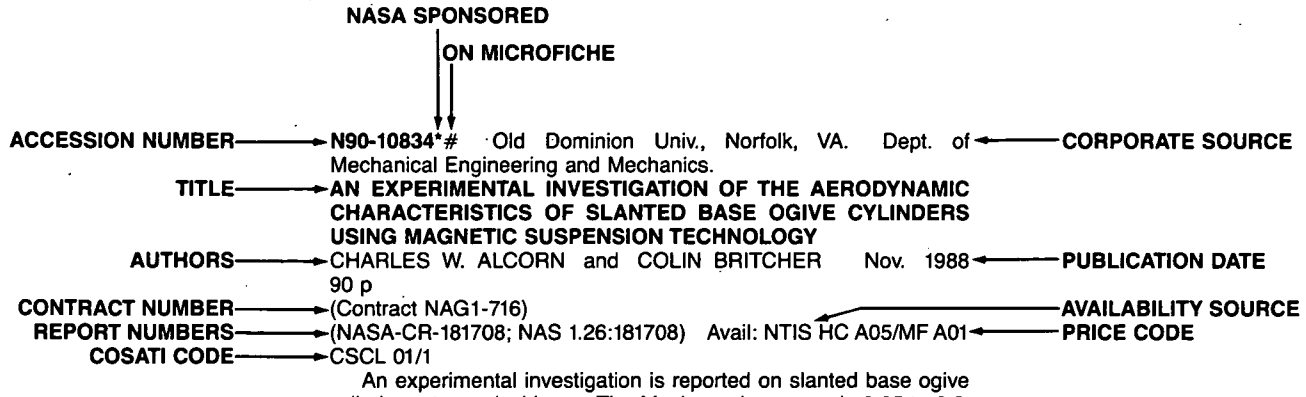
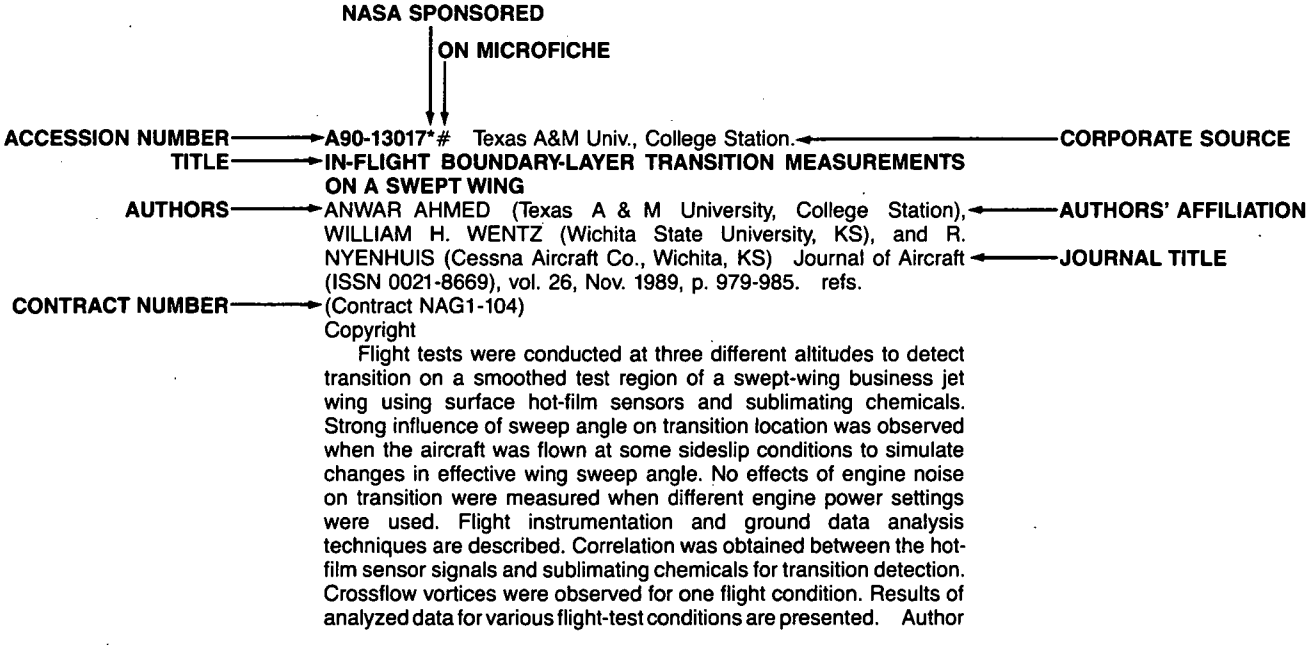
TYPICAL REPORT CITATION AND ABSTRACT



TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 260)

JANUARY 1991

01

AERONAUTICS (GENERAL)

A90-49876
AERONAUTICAL FATIGUE IN THE ELECTRONIC ERA; PROCEEDINGS OF THE FIFTEENTH ICAF SYMPOSIUM, JERUSALEM, ISRAEL, JUNE 21-23, 1989
A. BERKOVITS, ED. (Technion - Israel Institute of Technology, Haifa) *Symposium sponsored by ICAF, Technion - Israel Institute* of Technology, Ministry of Defence of Israel, et al. Warley, England, *Engineering Materials Advisory Services, Ltd., 1989, 551 p.* For individual items see A90-49877 to A90-49896.
Copyright

The present conference on advanced aerospace structure fatigue detection and characterization discusses the assessment of service load experience, an operational loads monitoring system, the tracking of B-1B aircraft with a structural data recorder, the reassessment of F-16 damage tolerance and durability life, the survivability of centrifugal compressors, FEM acoustic-fatigue analysis, and the use of a novel fastening system to enhance the fatigue life of a thin sheet structure. Also discussed are damage tolerance for helicopters, structural evaluation programs for aging jet transports, a double crack growth gage algorithm for application to fleet tracking of fatigue, recent trends in the understanding of composite fatigue, and a probabilistic approach to the fatigue durability certification of composite structures. O.C.

A90-49877
ASSESSMENT OF SERVICE LOAD EXPERIENCE
J. B. DE JONGE (Nationaal Lucht- en Ruimtevaartlaboratorium, Emmeloord, Netherlands) IN: Aeronautical fatigue in the electronic era; Proceedings of the Fifteenth ICAF Symposium, Jerusalem, Israel, June 21-23, 1989. Warley, England, Engineering Materials Advisory Services, Ltd., 1989, p. 1-42. *refs*
Copyright

After noting the various existing methods for accurately predicting the magnitude and frequency of occurrence of structural load types for a given aircraft design, attention is given to the character and origin of variations in such loadings with different aircraft use regimes; this variability is least in transport aircraft and greatest in combat aircraft. The evaluation of actual service load spectra entails actual flight load measurements or service use monitoring which can now employ microprocessor control at moderate cost. The determination of average mission-type spectra from flight multiparameter recordings can be accomplished in combat aircraft in conjunction with mission usage monitoring for individual aircraft. O.C.

A90-49881
RE-ASSESSING THE F-16 DAMAGE TOLERANCE AND DURABILITY LIFE OF THE RNLAF F-16 AIRCRAFT
D. J. SPIEKHOUT (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: Aeronautical fatigue in the electronic era; Proceedings of the Fifteenth ICAF Symposium, Jerusalem, Israel, June 21-23, 1989. Warley, England, Engineering Materials Advisory Services, Ltd., 1989, p. 121-142.
Copyright

The use of RNLAF F-16s is substantially different from the range of uses envisioned during the aircraft's design phase; a complete reevaluation of its damage tolerance and durability performance had therefore to be carried out. The reevaluation encompassed operational strain measurements of both single-channel and multichannel strain/acceleration type, flight-load and mechanical-strain recorders' data handling, crack growth tests and calculations, and the determination of severity ratios between F-16 aircraft used at different air bases and different aircraft. A fleet structural maintenance plan was tailored to the analytical results derived from these data. O.C.

A90-49889
AGING JET TRANSPORT STRUCTURAL EVALUATION PROGRAMS
U. G. GORANSON and M. MILLER (Boeing Commercial Airplanes, Seattle, WA) IN: Aeronautical fatigue in the electronic era; Proceedings of the Fifteenth ICAF Symposium, Jerusalem, Israel, June 21-23, 1989. Warley, England, Engineering Materials Advisory Services, Ltd., 1989, p. 319-353.
Copyright

Economic and market conditions have resulted in the use of commercial jet airplanes beyond their original economic design life objectives. The average age of the world airline jet transport fleet has increased from 8 to 12 years since 1980. Standard Boeing practices to support continuing airplane structural integrity include inspection and overhaul recommendations contained in maintenance manuals and service bulletins. As airplanes exceed their economic design life objectives, the incidence of fatigue increases and corrosion may become more widespread. This presentation is focused on recent special activities to assess the condition of the aging airplane fleet and other joint Boeing, airline and airworthiness authority reviews of service bulletins, corrosion control programs, basic maintenance and supplemental structural inspection programs, and structural repair quality. These initiatives will provide timely preventive maintenance recommendations that will support continued safe operation of aging jet transports until their retirement from service. Author

A90-49890
DEVELOPMENT OF A DOUBLE CRACK GROWTH GAGE ALGORITHM FOR APPLICATION TO FLEET TRACKING OF FATIGUE DAMAGE
A. DUMANIS and A. F. GRANDT, JR. (Purdue University, West Lafayette, IN) IN: Aeronautical fatigue in the electronic era; Proceedings of the Fifteenth ICAF Symposium, Jerusalem, Israel, June 21-23, 1989. Warley, England, Engineering Materials Advisory Services, Ltd., 1989, p. 355-368. *refs*
(Contract F33615-80-C-3234)
Copyright

This paper describes development of a numerical algorithm for use with the crack growth gage approach for evaluating structural fatigue damage. The crack growth gage concept consists of mounting precracked coupons (or gages) to structural components, and uses measurable gage crack extensions to determine growth of an assumed structural flaw under service loading. The cracked coupon effectively acts as an analog computer which monitors

flight loads seen in service, and responds with an output (crack growth in the gage) which can be related to the current status of the parent structure. Author

A90-49892
A PROBABILISTIC APPROACH FOR THE ESTABLISHMENT OF AN AIRCRAFT STRUCTURE INSPECTION PROGRAM
A. ALBIN, L. GRANDPIERRE, and B. HECIAK (Aerospatiale, Toulouse, France) IN: Aeronautical fatigue in the electronic era; Proceedings of the Fifteenth ICAF Symposium, Jerusalem, Israel, June 21-23, 1989. Warley, England, Engineering Materials Advisory Services, Ltd., 1989, p. 395-424. Research supported by the Aerospatiale, Airbus Industrie, MBB GmbH, et al. refs
Copyright

This paper presents a statistical approach of damage tolerance which has been developed in order to give to Airbus A 300 operators the required flexibility for the establishment of the Supplemental Structural Inspection Program tasks. The method is able to account for the low probability of occurrence of the crack, and for the probability to be missed by the various inspections which are performed during the aircraft operation. The benefit of the inspections performed on a few lead aircraft is also considered. Author

A90-50232
ASSURING THE FUTURE OF CIVIL AIRCRAFT INDUSTRY IN GERMANY [ZUKUNFTSICHERUNG DER ZIVILEN LUFTFAHRTINDUSTRIE IN DEUTSCHLAND]
U. GANZER (MBB GmbH, Ottobrunn, Federal Republic of Germany) IN: Yearbook 1988 II; DGLR, Annual Meeting, Darmstadt, Federal Republic of Germany, Sept. 20-23, 1988, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1988, p. 768-795. In German.
(DGLR PAPER 88-004) Copyright

The Airbus family of aircraft is discussed. The development plans, air traffic programs, and international cooperation aspects of the aircraft development are examined. Development aspects relating to competition, market potential, the influences of new technologies and materials are addressed along with factors like passenger comfort and safety as well as costs. C.D.

A90-50544
HEALTH MONITORING AIRCRAFT
TONY G. GERARDI (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) Journal of Intelligent Material Systems and Structures (ISSN 1045-389X), vol. 1, July 1990, p. 375-385.
Copyright

A description is given of the health monitoring aircraft concept, which will incorporate innovative sensors, AI, and advanced analytical techniques to provivide real-time and continual aircraft health assessment. According to this concept, all flight-critical structures will be evaluated for integrity as part of the automated preflight checklist. The pilot will be given a visual display of the health of all systems prior to takeoff. Any in-flight change in the health of the aircraft wil be displayed along with recommended action. In order to achieve these capabilities, state-of-the-art structural integrity computer programs, together with AI/neutral network decision-making software, will be incorporated as part of the aircraft computing capability. The life history of the aircraft will be continually and automaticaly updated so that acccurate structural integrity assessments can be made. B.J.

A90-52575
HIGH ALPHA
F. CLIFTON BERRY, JR. Air Force Magazine (ISSN 0730-6784), vol. 73, Oct. 1990, p. 54-58.
Copyright

The ability of quick maneuvering at high angles of attack (or, in technical terms, high alpha), which can be a critical factor in close, air-to-air combat, is discussed with regard to the X-29 and X-31 experimental fighter programs and the specially modified F/A-18. The X-29 wings are swept forward and the airflow is directed toward the root of the wing, leaving the wingtips in a less disturbed flow at high angles of attack, which improves the control of the aircraft both at low speeds and at high angles of attack. New technologies are involved, leading to smaller and lighter aircraft. The X-29 was tested at angles of attack as high as 66 degrees. The X-31, in comparison with the X-29, has improved maneuverability in the poststall condition, achieved by thrust vectoring of the engine exhaust. The controls integrate flight and propulsion functions totally, which maximizes the maneuverability. Since the separated airflows at high angles of attack are extremely complex and cannot be adequately modeled during the design process, NASA, using a modified F/A-18, is conducting research on the thrust-vectoring process. B.P.

A90-52699
AIRBUS TECHNOLOGIES - AN EVOLUTIONARY PROCESS [AIRBUS-TECHNOLOGIEN - EIN EVOLUTIONAERER PROZESS]
DIETER SCHMITT (Airbus Industrie, Toulouse, France) Luft- und Raumfahrt (ISSN 0173-6264), vol. 11, 3rd Quarter, 1990, p. 38-45. In German.
Copyright

Current subsonic-transport R&D activities at Airbus Industrie are surveyed and illustrated with extensive drawings, diagrams, graphs, and photographs. The areas addressed include: (1) advanced engine concepts being evaluated in cooperation with the engine manufacturers (e.g., open-rotor pusher and tractor configurations); (2) aerodynamics (natural and suction approaches to a laminar-flow nacelle, riblet films for application to the aircraft body, and wing-tip structures to lower induced drag); (3) new structures and materials (especially composites and hybrids); (4) advanced digital avionics systems; and (5) improved production techniques. It is predicted that the sum of all these efforts could be a reduction of 30-35 percent in the energy cost per passenger mile, although this would require a significant breakthrough in the area of laminar flow. T.K.

N90-28489# Boeing Commercial Airplane Co., Seattle, WA.
WORLD JET AIRPLANE INVENTORY AT YEAR-END 1989
Mar. 1990 101 p
(PB90-207218) Avail: NTIS HC A06/MF A01 CSCL 01B

Presented is the latest edition of World Jet Airplane Inventory, which contains data on the world commercial jet airplane fleet (including some military derivatives) and reflects the status of the fleet as accurately as possible as of December 31, 1989. Any fleet changes that have occurred since year-end 1989 will not be reflected in these data. GRA

N90-29160# European Space Agency, Paris (France).
FLIGHT TEST ENGINEERING WITH THE ATTAS
PETER HAMEL and HEINZ WINTER (Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Cologne, Germany, F.R.) *In its* Scientific Colloquium in Honor of Prof. Dr. Rer. Nat. Hermann L. Jordan p 10-44 May 1990 Transl. into ENGLISH from Wissenschaftliches Kolloquim Gewidmet Herrn Professor Dr. Rer. Nat. Hermann L. Jordan zum 65 Geburtstag (Cologne, Fed. Republic of Germany, DFVLR), Jun. 1987 p 9-36 Original language document was announced as N88-17433
Avail: NTIS HC A06/MF A01

ATTAS (Advanced Technologies Testing Aircraft System) which is available as technology platform and flying simulator for many research and test projects, predominantly from the field of flight mechanics/flight guidance, into the year 2000, is described. The system engineering of the ATTAS test platform is described and various application programs, which were defined, carried out and evaluated in close collaboration with industrial and official partners and partly within the framework of international cooperation are discussed. ESA

N90-29299# Federal Aviation Administration, Washington, DC. Vertical Flight Program Office.
FAA ROTORCRAFT RESEARCH, ENGINEERING, AND DEVELOPMENT BIBLIOGRAPHY 1962-1989

ROBERT D. SMITH May 1990 169 p
(AD-A224256; DOT/FAA/RD-90/1) Avail: NTIS HC A08/MF A01 CSCL 01/3

The FAA Helicopter/Heliport Research, Engineering, and Development - Bibliography, 1964 to 1986 and FAA Rotorcraft Research, Engineering, and Development Bibliography, 1962 to 1988, are both supplemented. Both bibliographies are limited to documents in which the research, engineering, and development elements of the FAA were involved as sponsors, participants, or authors. This bibliography contains the abstracts of 68 technical reports. The indexes address these 68 reports as well as the 53 reports in FAA/DS-98/03 and the 133 reports in FAA/PM-86/47. GRA

02

AERODYNAMICS

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

A90-50235
PROJECT FALKE - PERFORMANCE OF FREE FLIGHT TESTS IN THE SUPERSONIC, TRANSONIC, AND SUBSONIC REGIMES FROM BALLOONS [PROJEKT FALKE - DURCHFUEHRUNG VON FREIFLUGVERSUCHEN IM UEBER-, TRANS-, UND UNTERSCHALLBEREICH VON BALLONEN AUS]
A. TEGTMEIER (OHB-System GmbH, Bremen, Federal Republic of Germany) and G. NETTER (MBB-ERNO, Bremen, Federal Republic of Germany) IN: Yearbook 1988 II; DGLR, Annual Meeting, Darmstadt, Federal Republic of Germany, Sept. 20-23, 1988, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1988, p. 847-857. In German.
(DGLR PAPER 88-018) Copyright

Project Falke has as its aim the development of a new aerodynamic measurement method in which a spacecraft returning to earth can serve as a supersonic aircraft. The Falke philosophy and planning are reviewed, and its missions are described. The Falke spacecraft is described, and the types of data that the project attempts to obtain are presented as a function of Mach number. C.D.

A90-50637*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EULER ANALYSIS COMPARISON WITH LDV DATA FOR AN ADVANCED COUNTER-ROTATION PROPFAN AT CRUISE
CHRISTOPHER J. MILLER and GARY G. PODBOY (NASA, Lewis Research Center, Cleveland, OH) AIAA, Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990. 22 p. Previously announced in STAR as N90-25946. refs
(AIAA PAPER 90-3033) Copyright

A fine mesh Euler solution of the F4/A4 unducted fan (UDF) model flowfield is compared with laser Doppler velocimeter (LDV) data taken in the NASA Lewis 8- by 6-Foot Supersonic Wind Tunnel. The comparison is made primarily at one axial plane downstream of the front rotor where the LDV particle lag errors are reduced. The agreement between measured and predicted velocities in this axial plane is good. The results show that a dense mesh is needed in the centerbody stagnation region to minimize entropy generation that weakens the aft row passage shock. The predicted radial location of the tip vortex downstream of the front rotor agrees well with the experimental results but the strength is overpredicted. With 40 points per chord line, the integrated performance quantities are nearly converged, but more points are needed to resolve passage shocks and flow field details. Author

A90-50638*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A CLOSER LOOK AT THE INDUCED DRAG OF CRESCENT-SHAPED WINGS
STEPHEN C. SMITH (NASA, Ames Research Center, Moffett Field, CA) and ILAN M. KROO (Stanford University, CA) AIAA, Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990. 11 p. refs
(AIAA PAPER 90-3063) Copyright

Recent interest in the induced drag characteristics of crescent-shaped wings has led to a closer look at the methods used for determination of induced drag from computational aerodynamic methods. Induced drag may be computed by integration of surface pressure, or by evaluation of a contour integral in the Trefftz plane. A high-order panel method was used to study the induced drag of crescent and elliptical wings using both techniques. Induced drag computations using surface-pressure integration were strongly affected by panel density and angle of attack. Accurate drag computations for the crescent wing were obtained only when the spanwise as well as chordwise panel density was extremely high. Trefftz-plane results for the two wing planforms do not show this sensitivity to panel density or angle of attack. Span efficiencies of 0.994 for the crescent wing and 0.987 for the elliptical wing were computed by the Trefftz-plane technique. Substitution of a force-free, rolled-up wake geometry on the crescent wing did not change the pressure-integrated drag significantly. The slightly higher span efficiency of the crescent wing is attributed to a more nearly elliptical spanwise lift distribution. The chord distribution of the elliptical wing was modified to produce an elliptical span-loading on a wing with an unswept quarter-chord line. This wing demonstrated a span efficiency equal to that of the crescent wing. Author

A90-50815
FLOW PAST TWO CYLINDERS AND TWO SPHERES [OBTEKANIE DVUKH TSILINDROV I DVUKH SFER]
O. N. IVANOV Moskovskii Universitet, Vestnik, Seriia 1 - Matematika, Mekhanika (ISSN 0579-9368), July-Aug. 1990, p. 89-93. In Russian. refs
Copyright

Wind tunnel experiments were carried out to investigate pressure distributions in subsonic and transonic (M = 0.4-1.2) flows past two cylinders (diameter, 32 mm; length, 250 mm) and two spheres (diameter, 40 mm). The pressure on the model surface, static pressure of undisturbed flow, deceleration pressure in the test section, and pressure in the plenum chamber were measured with an accuracy of + or -2 percent. The discussion covers singularities in nonsymmetric pressure distribution, mutual effects of the bodies, and wake flows. V.L.

A90-50816
EFFECT OF THE MACH NUMBER AND SHAPE OF THE FRONT PART OF THE OBSTACLE ON THE SEPARATION ZONE LENGTH IN SUPERSONIC FLOW [VLIIANIE CHISLA MAKHA I FORMY PEREDNEI CHASTI PREPIATSTVIIA NA DLINU OTRYVNOI ZONY V SVERKHZVUKOVOM POTOKE]
IU. A. VINOGRADOV, A. I. ZUBKOV, B. E. LIAGUSHIN, IU. A. PANOV, and S. A. IAKUSHEV Moskovskii Universitet, Vestnik, Seriia 1 - Matematika, Mekhanika (ISSN 0579-9368), July-Aug. 1990, p. 93-95. In Russian.
Copyright

The effect of the Mach number and of the shape of the front part of the obstacle on the dimensions of the separation zone ahead of three-dimensional obstacles comparable in size with the boundary layer thickness was investigated experimentally. The experiments were conducted in a wind tunnel with a test section of 70x90 mm using obstacles in the form of cylinders of varying height, 2 and 5 mm in diameter, and parallelepipeds of square cross section with sides of 2 and 5 mm. It is shown that the size of the separation zone is determined by a combination of the following parameters: h/delta, k/delta, d/delta, and d/k (where h and d are the height and diameter of cylindrical obstacles,

respectively; delta is the boundary layer thickness, and k is the parallelepiped side). The effect of the Mach number is negligible. V.L.

A90-50817
EFFECT OF INCOMING FLOW TURBULENCE ON THE AERODYNAMIC CHARACTERISTICS OF A SMOOTH SYMMETRIC BODY AT LARGE ANGLES OF ATTACK [VLIIANIE STEPENI TURBULENTNOSTI NABEGAIUSHCHEGO POTOKA NA AERODINAMICHESKIE KHARAKTERISTIKI GLADKOGO OSESIMMETRICHNOGO TELA PRI BOL'SHIKH UGLAKH ATAKI]
S. A. FESHCHENKO and G. E. KHUDIAKOV Moskovskii Universitet, Vestnik, Seriia 1 - Matematika, Mekhanika (ISSN 0579-9368), July-Aug. 1990, p. 95-98. In Russian. refs
Copyright
The effect of the incoming flow turbulence on the aerodynamic characteristics of bodies at large angles of attack was investigated in a systematic manner in a subsonic wind tunnel using a cylinder (0.15 m in diameter) with conical nose with a half-angle of taper of 12 degrees. The incoming flow velocity was 10-45 m/s; the turbulence of the incoming flow, determined thermoanemometrically from the longitudinal pulsed velocity component, was 0.2, 0.8, 3.5, and 5.8 percent; the angle of attack varied from 50 to 90 degrees. It is shown, in particular, that an increase in turbulence significantly affects the dependence of the lateral force coefficient, Czb, on the angle of attack. V.L.

A90-51003
A DESIGN METHOD FOR TURBOMACHINERY BLADING IN THREE-DIMENSIONAL FLOW
W. S. GHALY (Ghaly Consultants Enr., Quebec, Canada) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 10, Jan. 1990, p. 179-197. Research supported by Cummins Engine Co., Inc. refs
Copyright
A mixed spectral finite element scheme for the implementation of a design method for turbomachinery blading in three-dimensional subcritical compressible flow is presented. The method gives the detailed blade shape that would produce a prescribed tangential mean swirl schedule, given the hub and shroud profiles, the number of blades and their stacking position. After a presentation of the mathematical formulation of the design theory, the current numerical approach is described. It is then applied to the design of blading for radial inflow turbine impellers in three-dimensional flow. Author

A90-51006 Purdue Univ., West Lafayette, IN.
CASCADE AERODYNAMIC GUST RESPONSE INCLUDING STEADY LOADING EFFECTS
HSIAO-WEI D. CHIANG and SANFORD FLEETER (Purdue University, West Lafayette, IN) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 10, Feb. 1990, p. 285-303. Research supported by USAF and NASA. refs
Copyright
To predict the unsteady convected gust aerodynamic response of a cascade comprised of arbitrary thick and cambered aerofoils in an incompressible, inviscid, flow field, a complete first-order model is formulated. The flow is analyzed by considering a periodic flow channel. The velocity potential is separated into steady and unsteady harmonic components, each described by a Laplace equation. The strong dependence of the unsteady aerodynamics on the steady effects of aerofoil and cascade geometry and incidence angle is manifested in the coupling of the unsteady and steady flow fields through the unsteady boundary conditions. Analytical solutions in individual grid elements of a body-fitted computational grid are then determined, with the complete solution obtained by assembly of these local solutions. The validity and capabilities of this model and solution technique are then demonstrated by analyzing the steady and unsteady aerodynamics of both theoretical and experimental cascade configurations. Author

A90-51009
A PROPER ORTHOGONAL DECOMPOSITION OF A SIMULATED SUPERSONIC SHEAR LAYER
M. KIRBY, J. P. BORIS, and L. SIROVICH (Brown University, Providence, RI) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 10, March 1990, p. 411-428. Research supported by DARPA. refs
(Contract N00014-86-K-0754)
Copyright
The Karhunen-Loeve procedure is applied to the analysis of an ensemble of snapshots obtained from a conditionally sampled localized shear layer simulation. The computed set of optimal basis functions is used to economically characterize sampled flow realizations. Pictorially it is seen that the essential features (and roughly 80 percent of the energy) of typical flows are captured by retaining roughly 10-20 parameters in the expansion. Smaller-scale features are resolved by retaining more terms in the series. Author

A90-51013* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LEAST-SQUARES FINITE ELEMENT METHODS FOR COMPRESSIBLE EULER EQUATIONS
BO-NAN JIANG (NASA, Lewis Research Center, Cleveland, OH) and G. F. CAREY (Texas, University, Austin) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 10, April 1, 1990, p. 557-568. Research supported by the University of Texas and U.S. Navy. refs
Copyright
A method based on backward finite differencing in time and a least-squares finite element scheme for first-order systems of partial differential equations in space is applied to the Euler equations for gas dynamics. The scheme minimizes the L-sq-norm of the residual within each time step. The method naturally generates numerical dissipation proportional to the time step size. An implicit method employing linear elements has been implemented and proves robust. For high-order elements, computed solutions based on the L-sq method may have oscillations for calculations at similar time step sizes. To overcome this difficulty, a scheme which minimizes the weighted H1-norm of the residual is proposed and leads to a successful scheme with high-degree elements. Finally, a conservative least-squares finite element method is also developed. Numerical results for two-dimensional problems are given to demonstrate the shock resolution of the methods and compare different approaches. Author

A90-51014
AN IMPROVED SIP SCHEME FOR NUMERICAL SOLUTIONS OF TRANSONIC STREAMFUNCTION EQUATIONS
BAO-GUO WANG and NAI-XING CHEN (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 10, April 1, 1990, p. 591-602. refs
Copyright
An improved strongly implicit procedure (SIP) is developed for solving large sets of transonic streamfunction equations with matrix of coefficients, which yields reliable converged solutions. It is shown that, with an appropriate choice of the iterative parameter, the rate of convergence of the improved SIP should be faster than that of the original SIP. Numerical results are presented, demonstrating that the improved algorithm is efficient and robust for calculating transonic cascade flow fields. I.S.

A90-51017
APPLICATION OF A VORTEX LATTICE NUMERICAL MODEL IN THE CALCULATION OF INVISCID INCOMPRESSIBLE FLOW AROUND DELTA WINGS
G. BANDYOPADHYAY (Indian Institute of Technology, Kharagpur, India) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 10, May 1990, p. 729-740. refs
Copyright
The flow over a flat plate delta wing at incidence and in sideslip

is studied using vortex lattice models based on streamwise panelling. For the attached flow problem the effect of sideslip is simulated by modifying the standard vortex lattice model for zero sideslip by aligning the trailing vortices aft of the wing along the resultant flow direction. For the separated flow problem a non-linear vortex lattice model is developed for both zero and non-zero sideslip angles in which the shape and position of the leading edge separation vortices are calculated by an iterative procedure starting from an assumed initial shape. The theoretical values are compared with available theoretical and experimental results. Author

A90-51020* Ballistic Research Labs., Aberdeen Proving Ground, MD.
NUMERICAL SIMULATION OF THREE-DIMENSIONAL TRANSONIC FLOWS
JUBARAJ SAHU (U.S. Army, Ballistics Research Laboratory, Aberdeen Proving Ground, MD) and JOSEPH L. STEGER (NASA, Ames Research Center, Moffett Field, CA) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 10, June 1990, p. 855-873. refs
Copyright

The three-dimensional flow over a projectile has been computed using an implicit, approximately factored, partially flux-split algorithm. A simple composite grid scheme has been developed in which a single grid is partitioned into a series of smaller grids for applications which require an external large memory device such as the SSD of the CRAY X-MP/48 or multi-tasking. The accuracy and stability of the composite grid scheme have been tested by numerically simulating the flow over an ellipsoid at an angle of attack and comparing the solution with a single-grid solution. The flow field over a projectile at M = 0.96 and 1.1, and 4-deg angle of attack has been computed using a fine grid and compared with experiment. Author

A90-51025
THE CALCULATION OF INCOMPRESSIBLE SEPARATED TURBULENT BOUNDARY LAYERS
A. KOGAN and S. MIGEMI (Israel Aircraft Industries, Ltd., Lod) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 11, July 5, 1990, p. 39-56. refs
Copyright

The algebraic turbulent model of Baldwin and Lomax was incorporated into the incompressible full Navier-Stokes code FIDAP. It is believed that the incorporation of the model into the finite element code has resulted in a practical method to compute a variety of separated turbulent two-dimensional flows. Firstly, the model is used to compute the attached flow about an airfoil. Next, the application of the model to separated flows is presented by computing the flows at high angles of attack up to maximum lift. It is shown that the model is capable of predicting separation, steady stall and CLmax. Author

A90-51028
A COMPREHENSIVE ANALYSIS OF THE VISCOUS INCOMPRESSIBLE FLOW IN QUASI-THREE-DIMENSIONAL AEROFOIL CASCADES
E. A. BASKHARONE and D. R. MCARTHUR (Texas A & M University, College Station) International Journal for Numerical Methods in Fluids (ISSN 0271-2091), vol. 11, July 20, 1990, p. 227-245. Research supported by Texas A & M University. refs
Copyright

A rigorous model of the fully elliptic flow over the blade-to-blade stream surface in an annular aerofoil cascade is developed. The model accuracy stems from its precise simulation of the meridional hub-to-casing flow effects, including those of the shear stress components that are created by the spanwise velocity gradients. These stresses are unprecedentedly introduced in the flow-governing equations in the form of source terms and are modeled as such. The final set of flow-governing equations are solved using the Galerkin weighted residual method coupled with a biquadratic finite element of the Lagrangian type. The flow solution is verified against the numerical results of a fully three-dimensional flow model and a set of experimental data, both concerning a low-aspect-ratio stator of an axial flow turbine under a low Reynolds number and subsonic flow operation mode. The numerical results in this case show well predicted aerofoil loading and pitch-averaged exit flow conditions. Also evident is a substantial capability of the analysis in modeling such critical regions as the wake subdomain. It is further proven that the new terms in the governing equations enhance the quality of the numerical predictions in this class of flow problems. Author

A90-51256#
THROUGHFLOW THEORY FOR NONAXISYMMETRIC TURBOMACHINERY FLOW. I - FORMULATION. II - ASSESSMENT
R. P. DRING (United Technologies Research Center, East Hartford, CT) and G. C. OATES ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 112, July 1990, p. 320-337. refs
(Contract N62271-86-M-0272; N62271-87-M-0200)
(ASME PAPER 89-GT-304; ASME PAPER 89-GT-305) Copyright

The accuracy of throughflow theory has thus far been compromised by its inability to account for the axisymmetries arising from the finite numbers of rotor and stator airfoils. The present formulation proceeds from the derivation of a system of throughflow equations for nonaxisymmetric flow. In the second part of this work, a benchmark data base is used to furnish inputs for the calculation as well as to help identify the dominant terms. It is shown that the dominant effect of nonaxisymmetry is contained in two terms that relate to total pressure of the averaged flow to the mass-averaged total pressure. This formulation demonstrates that the present formulation yields results more accurate than those of the conventional blockage-based formulation. O.C.

A90-51257#
A PARAMETRIC STUDY OF RADIAL TURBOMACHINERY BLADE DESIGN IN THREE-DIMENSIONAL SUBSONIC FLOW
W. S. GHALY (Ecole Polytechnique, Montreal, Canada) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 112, July 1990, p. 338-345. Research supported by Cummins Engine Co., Inc. refs
(ASME PAPER 89-GT-84) Copyright

An aerodynamic design method is described and used to implement a parametric study of radial turbomachinery blade design in three-dimensional subsonic flow. Given the impeller hub and shroud, the number of blades and their stacking position, the design method gives the detailed blade shape, flow, and pressure fields that would produce a prescribed tangentially averaged swirl schedule. The results from that study show that decreasing the number of blades increases the blade wrap, and that the blade loading is strongly affected by the rate of change of mean swirl along the mean streamlines. The results also show that the blade shape and the pressure field are rather sensitive to the prescribed mean swirl schedule, which suggests that, by carefully tailoring the swirl schedule, one might be able to control the blade shape and the pressure field and hence secondary flow. Author

A90-51258#
ANALYSIS OF THREE-DIMENSIONAL TURBOMACHINERY FLOWS ON C-TYPE GRIDS USING AN IMPLICIT EULER SOLVER
K. F. WEBER, D. W. THOE, and R. A. DELANEY (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 112, July 1990, p. 362-369. refs
(ASME PAPER 89-GT-85) Copyright

A three-dimensional Euler analysis for turbomachinery flows on a C-type grid is presented. The analysis is based on the Beam and Warming implicit algorithm for solution of the unsteady Euler equations and is derived from the ARC3D code developed by Pulliam at NASA Ames Research Center. Modifications made to convert this code from external flow applications to internal turbomachinery flows are given in detail. These changes include the addition of inflow, outflow, and periodic boundary point calculation procedures. Also presented are the C-grid construction

procedures. Finally, results of code experimental verification studies for three-dimensional compressor cascade and rotor flows are presented. Author

A90-51259#
UNSTEADY LIFTING SURFACE THEORY FOR A ROTATING CASCADE OF SWEPT BLADES
H. KODAMA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) and M. NAMBA (Kyushu University, Fukuoka, Japan) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 112, July 1990, p. 411-417. refs
(ASME PAPER 89-GT-306) Copyright

A lifting surface theory is developed to predict the unsteady three-dimensional aerodynamic characteristics for a rotating subsonic annular cascade of swept blades. A discrete element method is used to solve the integral equation for the unsteady blade loading. Numerical examples are presented to demonstrate effects of the sweep on the blade flutter and on the acoustic field generated by interaction of rotating blades with a convected sinusoidal gust. It is found that increasing the sweep results in decrease of the aerodynamic work on vibrating blades and also remarkable reduction of the modal acoustic power of lower radial orders for both forward and backward sweeps. Author

A90-51483
A PANEL METHOD COMPUTATION FOR OSCILLATING AEROFOIL IN COMPRESSIBLE FLOW
SWEE HUNG LEONG (Nanyang Technological Institute, Singapore) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 29, no. 3, March 1990, p. 559-578. refs
Copyright

An unsteady subcritical compressible panel method has been formulated and modeled to solve for unsteady aerodynamic loads of an oscillating airfoil. Responses are assumed to be first-order harmonics only, and incremental effects are accounted for. The zero-loading condition is satisfied at the trailing edge. The effects of oscillating frequency parameter (OFP), free-stream Mach number M(infinity), incidence, and change of pivoting point are studied. Loads are compared with linear theory and a discrepancy is found at higher M(infinity) and high OFP due to airfoil thickness implementation of the model and incidence effects. Pressure predictions compare favorably with subsonic experimental results and a subcritical solution of a transonic computational model. The results show that the method is feasible for subcritical aerodynamic prediction and can be extended to unsteady transonic flows via the field panel method approach. C.D.

A90-51507
NEW EXPERIMENTAL RESULTS ON THE ORIGIN AND STRUCTURE OF FERRI AND DAILEY INSTABILITIES ('BUZZ') [NEUE EXPERIMENTELLE ERGEBNISSE ZUR ENTSTEHUNG UND STRUKTUR VON FERRI- UND DAILEY-INSTABILITAETEN /'BRUMMEN'/]
G. JUNGCLAUS (MBB GmbH, Munich, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 14, Aug. 1990, p. 256-262. In German. refs
Copyright

An experimental correlation between the strength and distance from the lip of a shear layer and the onset of the Ferri instability is presented for supersonic inlets with different geometries. The change from Ferri instability to Dailey instability is investigated. An analysis is also made of the structure of both kinds of instabilities, using high-speed photography and pressure measurement. Author

A90-51526
MULTIGRID METHODS IN COMPUTATIONAL FLUID DYNAMICS
P. WESSELING (Delft, Technische Universiteit, Netherlands) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Universitaet Karlsruhe, Federal Republic of Germany, Mar. 28-31, 1989) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 70, no. 5, 1990, p. T 337-T 347. refs
Copyright

The basic nonlinear multigrid algorithm is presented and its role as a fast solution method in computational fluid dynamics is outlined. Applications to the transonic potential equation, the compressible Euler and Navier-Stokes equations and to the incompressible Navier-Stokes equations are discussed. Author

A90-51530
A NUMERICAL TECHNIQUE FOR COMPUTING THE UNSTEADY TRANSONIC FLOW AROUND A WING PROFILE IN ARBITRARY OSCILLATION [EIN NUMERISCHES VERFAHREN ZUR BERECHNUNG DER INSTATIONAEREN TRANSSONISCHEN STROEMUNG UM EIN BELIEBIG SCHWINGENDES PROFIL]
FENGWEI LI (Northwestern Polytechnic University, Xian, People's Republic of China) and E. QUIN (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Universitaet Karlsruhe, Federal Republic of Germany, Mar. 28-31, 1989) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 70, no. 5, 1990, p. T 398-T 400. In German. refs
Copyright

Unsteady transonic flows around wing profiles in torsional and translational (horizontal and vertical) oscillation are investigated by means of numerical simulations. A formulation based on the Euler equations is employed which avoids artificial boundary conditions. The transformations applied in the derivation are explained, and the numerical solution methods are outlined. Results for a NACA 0012 profile at freestream Mach numbers 0.63 and 0.8 are presented in graphs and briefly characterized. T.K.

A90-51531
THE INVERSE PROBLEM IN THE MULTIELEMENT AIRFOIL THEORY
JACEK ROKICKI (Warszawa, Politechnika, Warsaw, Poland) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Universitaet Karlsruhe, Federal Republic of Germany, Mar. 28-31, 1989) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 70, no. 5, 1990, p. T 401, T 402. refs
Copyright

The problem of finding a wing-profile shape which will produce a prescribed velocity distribution when immersed in uniform inviscid incompressible flow is investigated analytically. The conformal-mapping method applied by Mangler (1938) and Lighthill (1945) to the single-profile case is extended to the multielement case, as proposed by Prosnak (1976 and 1977). Particular attention is given to the formulation of the inverse problem, the solution algorithm, and the characteristics of the optimal solution. T.K.

A90-51533
THE EFFECT OF ENERGY INPUT ON THE CHARACTERISTICS OF PROFILES IN COMPRESSIBLE FLUID MEDIA [BEEINFLUSSUNG VON PROFILEIGENSCHAFTEN DURCH ENERGIEZUFUHR IN KOMPRESSIBLEN STROEMUNGSMEDIEN]
GUENTER H. SCHNERR and ULRICH DOHRMANN (Karlsruhe, Universitaet, Federal Republic of Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Universitaet Karlsruhe, Federal Republic of Germany, Mar. 28-31, 1989) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 70, no. 5, 1990, p. T 407-T 409. In German. refs
Copyright

Steady two-dimensional transonic flows on circular-arc and NACA-0012 profiles are characterized, summarizing the results of redent theoretical and experimental investigations. The focus is on the effects of heating (due to the homogeneous condensation of the water vapor in moist air) on the profile pressure-drag coefficients. The basic theory of energy-input effects is reviewed,

and typical computational predictions for freestream Mach numbers 0.8 and 0.87 are compared with measurement data in graphs. It is shown that the decisive factor determining whether energy input increases or decreases drag is the initial position of the shock in the adiabatic flow: drag decreases if the shock is very close to the trailing edge, but increases if the shock is between the point of maximum thickness and the trailing edge. T.K.

A90-51534
A STRAIGHT ATTACHED SHOCK WAVE AT THE PROFILE TIP AT FREESTREAM MACH NUMBER GREATER THAN ABOUT 1 [DER GERADE ANLIEGENDE STOSS AN DER PROFILSPITZE M/INFINITY/ GREATER THAN ABOUT 1]
J. ZIEREP and G. H. SCHNERR (Karlsruhe, Universitaet, Federal Republic of Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Universitaet Karlsruhe, Federal Republic of Germany, Mar. 28-31, 1989) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 70, no. 5, 1990, p. T 409-T 412. In German. refs
Copyright

The relationship between profile and shock-wave curvature is investigated analytically for the case of a shock attached at the tip of a body at freestream Mach numbers greater than about 1. The derivation of the governing equations is outlined, and the basic characteristics of the flow are shown in graphs. Particular attention is given to the implications of a shock-curvature singularity for the shock equations. T.K.

A90-51537
THEORETICAL PREDICTION OF PRESSURE DISTRIBUTION ON WEDGED DELTA WING AT HIGHER SUPERSONIC MACH NUMBERS AND ITS AGREEMENT WITH EXPERIMENTAL RESULTS
ADRIANA NASTASE and CORNELIU RUDIANU (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Universitaet Karlsruhe, Federal Republic of Germany, Mar. 28-31, 1989) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 70, no. 5, 1990, p. T 427-T 433. refs
Copyright

A90-51538
PREDICTION OF PRESSURE DISTRIBUTION ON OPTIMUM-OPTIMORUM DELTA WING AT HIGHER ANGLES OF ATTACK IN SUPERSONIC FLOW AND ITS AGREEMENT WITH EXPERIMENTAL RESULTS
ADRIANA NASTASE and EMIL STANISAV (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Universitaet Karlsruhe, Federal Republic of Germany, Mar. 28-31, 1989) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 70, no. 5, 1990, p. T 433-T 440. refs
Copyright

Results are reported from wind-tunnel tests on the delta wing design proposed by Nastase (1973, 1977, 1979, 1980, and 1990), which is fully optimized for cruising flight at freestream Mach number 2. Lift and pitching-moment data obtained at angles of attack between -13 and +13 deg and freestream Mach numbers 1.25-2.2 in the 60 x 60-cm test section of the trisonic wind tunnel at DLR Koeln-Porzwahn are presented in extensive graphs and briefly characterized. Good general agreement between the experimental measurements and the theoretically predicted performance is demonstrated. T.K.

A90-51539
THE FORMATION OF VORTEX STREETS IN SUPERSONIC FLOWS [UEBER DIE BILDUNG VON WIRBELSTRASSEN IN UEBERSCHALLSTROEMUNGEN]
CLAUS-DIETER MUNZ (Kernforschungszentrum Karlsruhe GmbH, Institut fuer Neutronenphysik und Reaktortechnik, Federal Republic of Germany) and LUTZ SCHMIDT (Karlsruhe, Universitaet, Federal Republic of Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Universitaet Karlsruhe, Federal Republic of Germany, Mar. 28-31, 1989) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 70, no. 5, 1990, p. T 447-T 450. In German.
Copyright

The formation of a vortex street in the wake of a blunt body in compressible flow is investigated by means of numerical simulations. The approach is based on the two-dimensional Navier-Stokes equations for two spatially infinite two-dimensional shear flows which are periodically perturbed; the time evolution of the instability is followed, whereas in reality the vortex street develops spatially. Results for Mach numbers 1, 3, and 5 and Reynolds numbers 1475, 4425, 7375, and 59,000 are presented in graphs and briefly characterized. T.K.

A90-51543
GENERALIZED SIMILARITY SOLUTIONS FOR THREE-DIMENSIONAL LAMINAR COMPRESSIBLE WING BOUNDARY LAYERS [LOESUNGEN VERALLGEMEINERTER AEHNLICHKEIT FUER DREIDIMENSIONALE LAMINARE KOMPRESSIBLE FLUEGELGRENZSCHICHTEN]
V. SALJNIKOV, Z. BORICIK, and D. NIKODIJEVIC (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Universitaet Karlsruhe, Federal Republic of Germany, Mar. 28-31, 1989) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 70, no. 5, 1990, p. T 462-T 465. In German. refs
Copyright

The three-dimensional steady laminar flow of an ideal gas with temperature-dependent dynamic viscosity on an infinitely long yawed profile cylinder is investigated analytically using boundary-layer equations. The derivation of the mathematical model is given in detail, and selected numerical results are presented in graphs and briefly characterized. It is shown that the present numerical integration method can provide generally valid solutions for arbitrary combinations of the parameters Pr, M(infinity), beta, and Tw/T0; it also allows analytical predictions to be made prior to detailed boundary-layer calculations for specific pressure distributions. T.K.

A90-51545
THE AERODYNAMIC DESIGN OF THE CONTRACTION FOR A SUBSONIC WIND TUNNEL [ZUR AERODYNAMISCHEN AUSLEGUNG DER KONTRAKTION FUER EINEN UNTERSCHALLWINDKANAL]
ALEXANDER WIEDERMANN (Hannover, Universitaet, Hanover, Federal Republic of Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Universitaet Karlsruhe, Federal Republic of Germany, Mar. 28-31, 1989) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 70, no. 5, 1990, p. T 471-T 474. In German. refs
Copyright

The flow in a wind-tunnel section with contraction ratio k = 2.73, presently being evaluated for use in the boundary-layer wind tunnel of the Institut fuer Mechanik in Hanover (FRG), is investigated theoretically. The selection of the contraction contour on the basis of two-dimensional cross-section studies is described, and numerical results obtained by applying a panel method to calculate the three-dimensional potential flow patterns for inviscid and viscous flows are presented in graphs and briefly characterized. It is concluded that, despite certain limitations on the validity of panel methods when applied to regions with concave curved surfaces, the results give a good indication of the flow quality in the contraction. T.K.

A90-51559
MULTIGRID SCHEME FOR THE COMPRESSIBLE EULER-EQUATIONS
S. TSANGARIS and D. DRIKAKIS (Athens, National Technical University, Greece) (Gesellschaft fuer angewandte Mathematik

und Mechanik, Wissenschaftliche Jahrestagung, Universitaet Karlsruhe, Federal Republic of Germany, Mar. 28-31, 1989) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 70, no. 6, 1990, p. T 664-T 666.
Copyright

A multigridlike technique known as mesh sequencing is presented in this paper. Acceleration of the convergence of the unsteady compressible Euler equations to steady state solution is achieved using this method. The efficiency of the method is demonstrated for the transonic flow around a NACA 0012 airfoil using a fine grid. The convergence history is presented using two grid levels. C.D.

A90-52030#
MULTIGRID ACCELERATION OF TVD SCHEMES IN TRANSONIC EULER FLOW CALCULATION
KUEN-CHUAN WU and PONG-JEU LU (National Cheng Kung University, Tainan, Republic of China) Chinese Society of Mechanical Engineers, Journal (ISSN 0257-9731), vol. 11, June 1990, p. 193-202. refs

An explicit finite-volume scheme based on Runge-Kutta multistage time stepping is used to integrate semidiscretized Euler equations to a steady state. Allowance is made for enthalpy damping and residual smoothing to enhance the convergence rate of the multigrid algorithm. It is shown that the multigrid method is effective in accelerating either upwind or symmetric total variation diminishing schemes. K.K.

A90-52592#
PREDICTION OF TRANSITION ON A SWEPT WING
G. CASALIS and D. ARNAL (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 1, 1990, p. 13-22. refs
Copyright

On a swept wing of infinite span, the laminar boundary layer becomes increasingly unstable as the distance from the leading edge increases; traveling waves develop that induce the beginning of transition. This article presents a theoretical model of the primary instability using the spatial theory in incompressible flow. With this model, the characteristics of these waves can be computed efficiently, to evaluate the location of the transition through an extension of the e exp n method. The model and those described by Cebeci et al. (1988) and Mack (1984 and 1988) are investigated and tested in comparison with experimental results; the aim is to predict the transition location as well as the most unstable frequencies. Author

A90-52607#
AN APPLICATION OF TOPOLOGICAL ANALYSIS TO STUDYING THE THREE-DIMENSIONAL FLOW IN CASCADES. I - TOPOLOGICAL RULES FOR SKIN-FRICTION LINES AND SECTION STREAMLINES
SHUN KANG (Harbin Institute of Technology, People's Republic of China) Applied Mathematics and Mechanics (English Edition) (ISSN 0253-4827), vol. 11, May 1990, p. 489-495.

Topological rules adapted to analyzing the skin-friction lines and the section streamlines in cascades are established. These rules, based on the works of Lighthill (1963) and Hunt et al. (1978) are: (1) for a rotor cascade without shroud band, the total number of nodal points equals that of the saddle points on the skin-friction line vector fields in each pitch range; (2) in an annular or straight cascade without clearances at the blade ends, the total number of saddle points is twice that of nodal points on the skin-friction line fields in a pitch; (3) the total number of saddles in the secondary flow fields on cross-sections in cascade is one fewer than that of nodes; (4) for the section streamline vector fields on a meridian surface penetrating a flow passage, and on leading and trailing edge sections, the total number of nodes is equal to that of saddles; and (5) for the streamline vector fields of a blade-to-blade surface, the total number of nodes is one less than that of saddles.
R.E.P.

A90-52618*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AN LDA INVESTIGATION OF THE NORMAL SHOCK WAVE BOUNDARY LAYER INTERACTION
R. M. CHRISS, W. R. HINGST, A. J. STRAZISAR (NASA, Lewis Research Center, Cleveland, OH), and T. G. KEITH (Toledo, University, OH) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 2, 1990, p. 1-15. refs
Copyright

Nonintrusive measurements have been made of two normal shock wave-boundary layer interactions. Two-dimensional measurements were made throughout the interaction region while three-dimensional measurements were made in the vicinity of the shock wave. The measurements were made in the corner of the test section of a continuous flow supersonic wind tunnel in which a normal shock wave had been stabilized. LDA, surface pressure measurement and flow visualization techniques were employed for two freestream Mach number test cases: 1.6 and 1.3. The former contained separated flow regions and a system of shock waves. The latter was found to be far less complicated. The reported results define the flowfield structure in detail for each case. Author

A90-52620#
NEW METHODS OF BUFFETING PREDICTION ON CIVIL AIRCRAFT
R. DESTUYNDER, I. LEGRAIN, and P. NAUDIN (ONERA, Chatillon, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 2, 1990, p. 31-38. refs
Copyright

Feasibility studies were conducted using various models to predict the appearance of aircraft buffeting or to compute the unsteady aerodynamic coefficients created by separation flow on a three-dimensional wing in transonic state. Wind tunnel models are used to analyze buffeting and to attempt to establish the link between the separation and the excitation. The definition of the problem, test conditions and the similarity model, and the determination of the unsteady aerodynamic coefficients during buffeting are discussed. The method suggested for separating the coupled unsteady aerodynamic forces from the forces due to buffeting allows only approximate results to be determined.
R.E.P.

A90-52621#
NUMERICAL SIMULATION OF NONREACTIVE FLOWS IN TURBOMACHINES
GEORGES MEAUZE and JACQUES PAULON (ONERA, Chatillon, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 2, 1990, p. 39-58. refs
Copyright

A summary of computer codes that are currently available or being developed to simulate the complex flows through compressors or axial and axial-radial turbines is presented. A scheme is developed for simulating viscous effects, including the friction on the blades and the casings, and the effects of the radial gap between the outer edge of the moving blade and the outer wall of the compressor or turbine. Finally, experimental data are described for two compressor blade rows, one transonic and the other supersonic. The complexity that characterizes the flows encountered in a turbomachine is then discussed. R.E.P.

A90-52776#
VARYING SPECIFIC HEAT GASDYNAMIC FUNCTION FORMULAE SIMPLIFICATION AND ANALYTICAL SOLUTION OF NORMAL SHOCK WAVES
CHIH-YA TSUI (Beijing University of Aeronautics and Astronautics, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 11, May 1990, p. 123-125. In Chinese, with abstract in English.

A90-52777#
A METHOD OF PREDICTING 3-D COMPRESSIBLE BOUNDARY LAYER ON THE ROTATING BLADE OF TURBOMACHINERY

YAONAN HUA (Chinese Academy of Sciences, Energetics Research and Development Center, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 11, May 1990, p. 143-150. In Chinese, with abstract in English. refs

Taking account of the rotation effect of the rotor in turbomachinery, three-dimensional boundary layer differential equations are established in terms of nonorthogonal curvilinear coordinates and an algebra eddy turbulence model is adopted. If boundary conditions and suitable initial conditions are given, the parameters at every point inside the boundary layer can be obtained by solving the parabolic differential equation after discretization is carried out by the finite difference method. The results of the calculation of the three-dimensional boundary layer on the pressure and suction surface of a compressor rotor blade show that the numerical solution is in good agreement with experimental data. Author

A90-52778#
ANALYSIS AND CALCULATION FOR INTERACTION BETWEEN SHOCK WAVE AND LAMINAR BOUNDARY LAYER
JISHENG FANG (Notre Dame, University, IN) and WENQUAN WU (Shanghai Institute of Mechanical Engineering, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 11, May 1990, p. 151-158. In Chinese, with abstract in English. refs

Based upon the experimental results for transonic flow in cascade, the characteristics of the system of shock waves in the cascade passage is analyzed, and the concept of the main branch of the system is suggested. The main branch is located at the front of the system and where the sharpest decrease of flow Mach number occurs. The method for calculating the interaction between the shock wave and the laminar boundary layer was programmed. A numerical test for a typical transonic flow with interaction between the shock wave and boundary layer is presented, and agreement with the experimental results was found to be quite good. Author

A90-52779#
AN INVESTIGATION OF CHARACTERISTICS OF TRANSONIC AND VISCOUS FLOWS FOR TURBINE CASCADES
XIN YUAN and ZIKANG JIANG (Tsinghua University, Beijing, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 11, May 1990, p. 159-164. In Chinese, with abstract in English. refs

A computer code QHVIS2D, based on a three-region algebraic eddy viscosity model and a fully implicit finite-difference scheme, can be used to predict the characteristics of subsonic and transonic, viscous, separated flows in turbine cascades at design and off-design conditions. Four turbine cascades under widely varying flow conditions are calculated by using this code. All of the numerical results show very good agreement with experimental data. Author

N90-28491# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluid Dynamics Div.
DO INVISCID VORTEX SHEETS ROLL-UP
RAJENDRA K. BERA May 1990 17 p
(PD-CF-9010) Avail: NTIS HC A03/MF A01

The Betz conjecture, its extensions and applications, regarding the final rolled-up structure of a vortex sheet in the absence of viscous effects is reexamined. It is argued that the conjecture, and consequently, its extensions and applications are theoretically incorrect. A plausible explanation is provided as to why, inspite of its incorrectness, the results correlate reasonably well with flight experiments on wakes behind aircraft wings. Author

N90-28492# National Aeronautical Lab., Bangalore (India). Experimental Aerodynamics Div.
STING-SUPPORT INTERFERENCE ON AFTERBODY DRAG AT TRANSONIC SPEEDS
P. R. VISWANATH and G. RAJENDRA Nov. 1989 42 p
(NAL-TM-EA-8902) Avail: NTIS HC A03/MF A01

Experiments have been performed on several boat-tailed afterbodies and sting combinations with a view to assessing sting corrections on afterbody drag at transonic speeds. Measurements made included afterbody total drag and base pressure in the Mach number range of 0.6 to 1.0 and at relatively high Reynolds number. Correlations of base pressure and boat-tail pressure drag for the sting diameter and flare effects have been proposed using dimensional arguments. The correlations provide quick and reliable estimates of corrections to the zero lift drag of axisymmetric bodies with either contoured or conical boat-tailing. Author

N90-28493*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONTROL OF SUBMERSIBLE VORTEX FLOWS
D. M. BUSHNELL and C. D. DONALDSON (Donaldson, C. D., Gloucester, VA) Jun. 1990 48 p Presented at the Submarine Technology Symposium, Baltimore, MD, 8-10 May 1990
(NASA-TM-102693; NAS 1.15:102693) Avail: NTIS HC A03/MF A01 CSCL 01A

Vortex flows produced by submersibles typically unfavorably influence key figures of merit such as acoustic and nonacoustic stealth, control effectiveness/maneuverability, and propulsor efficiency/body drag. Sources of such organized, primarily longitudinal, vorticity include the basic body (nose and sides) and appendages (both base/intersection and tip regions) such as the fairwater, dive planes, rear control surfaces, and propulsor stators/tips. Two fundamentally different vortex control approaches are available: (1) deintensification of the amplitude and/or organization of the vortex during its initiation process; and (2) downstream vortex disablement. Vortex control techniques applicable to the initiation region (deintensification approach) include transverse pressure gradient minimization via altered body cross-section, appendage dillets, fillets, and sweep, and various appendage tip and spanload treatment along with the use of active controls to minimize control surface size and motions. Vortex disablement can be accomplished either via use of control vortices (which can also be used to steer the vortices off-board), direct unwinding, inducement of vortex bursting, or segmentation/tailoring for enhanced dissipation. Submersible-applicable vortex control technology is also included derived from various aeronautical applications such as mitigation of the wing wake vortex hazard and flight aircraft maneuverability at high angle of attack as well as the status of vortex effects upon, and mitigation of, nonlinear control forces on submersibles. Specific suggestions for submersible-applicable vortex control techniques are presented. Author

N90-28494*# Nielsen Engineering and Research, Inc., Mountain View, CA.
PREDICTION OF SUBSONIC VORTEX SHEDDING FROM FOREBODIES WITH CHINES Final Report
MICHAEL R. MENDENHALL and DANIEL J. LESIEUTRE Washington NASA Sep. 1990 174 p
(Contract NAS1-17077)
(NASA-CR-4323; NAS 1.26:4323; TR-391) Avail: NTIS HC A08/MF A01 CSCL 01A

An engineering prediction method and associated computer code VTXCHN to predict nose vortex shedding from circular and noncircular forebodies with sharp chine edges in subsonic flow at angles of attack and roll are presented. Axisymmetric bodies are represented by point sources and doublets, and noncircular cross sections are transformed to a circle by either analytical or numerical conformal transformations. The lee side vortex wake is modeled by discrete vortices in crossflow planes along the body; thus the three-dimensional steady flow problem is reduced to a two-dimensional, unsteady, separated flow problem for solution. Comparison of measured and predicted surface pressure distributions, flow field surveys, and aerodynamic characteristics are presented for noncircular bodies alone and forebodies with sharp chines. Author

N90-28495# Sandia National Labs., Albuquerque, NM. Dept. of Advanced Systems Development.
HYPERSONIC ARBITRARY-BODY AERODYNAMICS (HABA) FOR CONCEPTUAL DESIGN
DAVID E. SALGUERO 15 Mar. 1990 103 p
(Contract DE-AC04-76DP-00789)
(DE90-014750; SAND-90-0078) Avail: NTIS HC A06/MF A01

The Hypersonic Arbitrary-Body Aerodynamics (HABA) computer program predicts static and dynamic aerodynamic derivatives at hypersonic speeds for any vehicle geometry. It is intended to be used during conceptual design studies where fast computational speed is required. It uses the same geometry and hypersonic aerodynamic methods as the Mark IV Supersonic/Hypersonic Arbitrary-Body Program (SHABP) developed under sponsorship of the Air Force Flight Dynamics Laboratory; however, the input and output formats have been improved to make it easier to use. This program is available as part of the Department 9140 computer aided engineering (CAE) software. DOE

N90-28496 Arizona Univ., Tucson.
AERODYNAMICS OF BODIES IN SHEAR FLOW Ph.D. Thesis
HALDUN GUVENEN 1989 175 p
Avail: Univ. Microfilms Order No. DA9013174

Spanwise periodic shear flow past two-dimensional bodies is investigated. The flow is assumed to be inviscid and incompressible. Using singular perturbation techniques, the solution is developed for epsilon = L/l is much less than 1, where L represents body cross-sectional size, and l the period of the oncoming flow (U(z). The singular perturbation analysis involves three regions: the inner, wake and outer regions. The leading order solutions are developed in all regions, and in the inner region higher order terms are obtained. In the inner region near the body, the primary flow (U sub 0, V sub 0, P sub 0) corresponds to potential flow past the body with a local free stream value of U(z). The spanwise variation in U(z) produces a weak O(epsilon) secondary flow W(sub 1) in the spanwise direction. As the vortex lines of the upstream flow are convected dowstream, they wrap around the body, producing significant streamwise vorticity in a wake region of thickness O(L) directly behind the body. This streamwise vorticity induces a net volume flux into the wake. In the outer region far from the body, a nonlifting body appears as a distribution of three-dimensional dipoles, and the wake appears as a sheet of mass sinks. Both singularity structures must be included in describing the leading outer flow. For lifting bodies, the body appears as a lifting line, and the wake appears as a sheet of shed vorticity. The trailing vorticity is found to be equal to the spanwise derivative of the product of the circulation and the oncoming flow. For lifting bodies the first higher order correction to the inner flow is the response of the body to the downwash produced by the trailing vorticity. At large distances from the body, the flow takes on remarkably simple form. Dissert. Abstr.

N90-28498# European Space Agency, Paris (France).
EXPERIMENTAL INVESTIGATIONS ON THE STABILITY AND VORTICITY OF THE VORTEX BREAKDOWN PHENOMENON ABOVE DELTA WINGS, MEASURED BY THE ULTRASONIC LASER METHOD
ROLF H. ENGLER (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen, Germany, F.R.) Feb. 1990 91 p Transl. into ENGLISH of Experimentelle Untersuchungen der Struktur und des Aufplatzens der Wirbel an Einem Schlanken Deltafluegel Ausgefuehrt im Windkanal Mittels Ultraschall (Goettingen, Fed. Republic of Germany, DFVLR), Feb. 1987 88 p Original language document was announced as N88-10017
(ESA-TT-1079; DFVLR-FB-87-06; ETN-90-97552) Avail: NTIS HC A05/MF A01

The breakdown of vortices above a delta wing is investigated by using a new, acoustical/optical measurement technique which does not interfere with the flow. The results from seven rows of measurements provide detailed information on the velocity and circulation distribution within the vortex. It is shown that four turns of the spirally wound shear layer can be clearly recognized in the vortex radius range between the viscous vortex core and a charateristic radius defined (in the stability theory by Ludwieg and Hall) as being relevant to this vortex. The circulation steps appearing on the individual turns were measured. Potential flow conditions can be used for calculations between the sheer layer turns. On the basis of this information and under these conditions, the validity of the Ludwieg stability theory can be confirmed; this theory requires that the shape parameter K at the breakdown position must be less than a critical value of 1.16. ESA

N90-28500# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction de l'Aerodynamique.
SOLUTION OF EULER EQUATIONS APPLIED TO A ROTOR OF A HELICOPTER IN STEADY FLIGHT Final Report [RESOLUTION DES EQUATIONS D'EULER APPLIQUEE A UN ROTOR D'HELICOPTERE EN VOL D'AVANCEMENT, RAPPORT DE SYNTHESE FINAL]
J. SIDES Jan. 1990 37 p In FRENCH
(Contract DRET-89-34-001)
(ONERA-RSF-1/3731-AY-002A; ETN-90-97502) Avail: NTIS HC A03/MF A01

The three dimensional compressible flow, around a helicopter rotor during steady flight, is simulated by solving the Euler equation. An implicit multifield prospective approach, covering C and H meshes, for two dimensional analysis is proposed. The three dimensional modulus, initially defined for an arrow wing configuration, is extended to other configurations. A centered implicit method is used for solving a pseudo-unsteady Euler equation system. The simulation method is applied to the analysis of a single rotor blade in steady flight. ESA

N90-28503*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE EFFECTS OF STRUCTURAL FLAP-LAG AND PITCH-LAG COUPLING ON SOFT INPLANE HINGELESS ROTOR STABILITY IN HOVER
WILLIAM G. BOUSMAN Washington May 1990 65 p Sponsored by Army Aviation Systems Command, Saint Louis, MO Prepared in cooperation with Army Aviation Systems Command, Moffett Field, CA
(NASA-TP-3002; A-89093; NAS 1.60:3002;
AVSCOM-TR-89-A-002) Avail: NTIS HC A04/MF A01 CSCL 01A

A 1.62-m-diameter rotor model was tested in hover to examine the effects of structural flap-lag and pitch-lag coupling on isolated rotor blade lead-lag stability. Flap-lag coupling was introduced by inclining the principal axes of the blade structure up to 60 degrees. Pitch-lag coupling was obtained either alone or in combination with flap-lag coupling through the use of skewed flexural hinges. The principal results confirm the predictions of theory, and show that both structural flap-lag and pitch-lag coupling when used separately are beneficial to blade stability. Moreover, when the couplings are combined, the lead-lag damping is significantly greater than it would be if the individual contributions were superimposed. Pitch-flap coupling is shown to have only a minor effect on blade lead-lag damping. Differences between theory and experiment observed at zero blade pitch and flexure angles during the initial testing were determined in a second test to be caused by stand flexibility. Other differences between theory and experiment warrant further investigation. Author

N90-28505*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
IN-FLIGHT FLOW VISUALIZATION WITH PRESSURE MEASUREMENTS AT LOW SPEEDS ON THE NASA F-18 HIGH ALPHA RESEARCH VEHICLE
JOHN H. DELFRATE, DAVID F. FISHER, and FANNY A. ZUNIGA Oct. 1990 45 p Presented at the AGARD Vortex Flow Aerodynamics Conference, Scheveningen, Netherlands, 1-4 Oct. 1990
(NASA-TM-101726; H-1651; NAS 1.15:101726) Avail: NTIS HC A03/MF A01 CSCL 01A

In-flight results from surface and off-surface flow visualizations

and from extensive pressure distributions document the vortical flow on the leading edge extensions (LEX) and forebody of the NASA F-18 high alpha research vehicle for low speeds and angles of attack up to 50 degs. Surface flow visualization data, obtained using the emitted fluid technique, were used to define separation lines and laminar separation bubbles. Off-surface flow visualization data, obtained by smoke injection, were used to document both the path of the vortex cores and the location of vortex core breakdown. The location of vortex core breakdown correlated well with the loss of suction pressure on the LEX and with the flow visualization results from ground facilities. Surface flow separation lines on the LEX and forebody corresponded well with the end of pressure recovery under the vortical flows. Correlation of the pressures with wind tunnel results show fair to good correlation. Author

N90-29302# JAI Associates, Inc., Mountain View, CA.
NUMERICAL SIMULATIONS OF BLADE-VORTEX INTERACTIONS AND LIFTING HOVERING ROTOR FLOWS Final Technical Report, Feb. 1988 - Feb. 1990
GANAPATHI R. SRINIVASAN Apr. 1990 68 p
(Contract DAAL03-88-C-0006)
(AD-A224238; JAIA-TR-90-1; ARO-25575.7-EG) Avail: NTIS HC A04/MF A01 CSCL 01/1

Viscous, 3-D numerical solutions of two related problems of a helicopter rotor are presented. An implicit, finite difference numerical procedure is used for the solution of the thin layer Navier-Stokes equations to simulate the flowfield solutions of helicopter rotor blade encountering a passing concentrated line vortex, and a lifting hovering rotor, at both sub- and super-critical flowfield conditions. For the first problem, the Euler equations were also solved independently to assess the importance of the viscous effects in the interacting flowfield. A prescribed vortex method is adopted to preserve the structure of the interacting vortex. Both parallel and oblique blade-vortex interactions were calculated. The second problem considered is that of calculating lifting hovering rotor flowfields without using any ad hoc wake models. The induced effects of the wake, including the interaction of tip vortices with successive blades, are captured as a part of the overall flowfield solution and hence no wake models are used. In order to preserve the structure of the vortex wake, a completely upwind finite difference numerical procedure is used for this problem. Comparison of the numerical results show excellent agreement with the experimental data and with the previously published Navier-Stokes calculations that used a simple wake model. GRA

N90-29304# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
THE SECOND ARO WORKSHOP ON ROTORCRAFT INTERACTIONAL AERODYNAMICS Final Report
N. M. KOMERATH Apr. 1990 57 p Workshop held in Atlanta, GA, 26-27 Mar. 1990
(Contract DAAL03-90-G-0037)
(AD-A223310; GIT/AER-90-1; ARO-27619.1-EG-CF) Avail: NTIS HC A04/MF A01 CSCL 01/1

The proceedings of the workshop are presented. Some areas of research were as follows: Full scale investigation of rotor/fuselage interaction; Experimental rotorcraft flowfield research at LARC/ASTD; Computational rotorcraft research at LARC/ASTD; The efficient calculation of rotor flows including blade vortex interactions using vortex embedding; Studies of rotor-body interactions in forward flight; New vortex/surface interaction methods for the prediction of wake induced airframe loads; The interaction of a rotor wake and an airframe with and without flow separation; Interaction of discrete vortices in shear flows using high order computational schemes; The unsteady interaction of a 3-D vortex filament with a cylinder. GRA

N90-29305# Colorado Univ., Boulder.
DYNAMIC SEPARATION: SEARCH FOR THE CAUSE OF DYNAMIC STALL AND SEARCH FOR ITS CONTROL Final Report, 1 Feb. 1989 - 31 Aug. 1990
PETER FREYMUTH May 1990 4 p
(Contract AF-AFOSR-0241-88)
(AD-A223412; AFOSR-90-0687TR) Avail: NTIS HC A01/MF A01 CSCL 01/1

Dynamic separation was investigated for various configurations and forcing dynamics. The details which differentiate 2-D vortex dynamics from those involving 3-D aspects were investigated. In addition, different dynamic stall control strategies were tested. GRA

N90-29307# Calspan Corp., Arnold AFS, TN.
CAVITY AEROACOUSTICS Technical Paper, Oct. 1985 - Apr. 1990
RICHARD E. DIX and CARROLL BUTLER (Air Force Armament Lab., Eglin AFB, FL.) Jun. 1990 36 p Presented at the Store Carriage, Interaction, and Release Conference, Bath, England
(Contract AF PROJ. 2567)
(AD-A223853; AFATL-TP-90-08) Avail: NTIS HC A03/MF A01 CSCL 01/1

Consider the retraction or hiding of items in a cavity that is closed and smooth to the flow over the body. At an appropriate time, doors or panels open as part of a desired operational sequence, and the storage volume, or cavity, together with the contents, are exposed to the external flow. Two important flow phenomena occur with exposure of a cavity in high speed aircraft: (1) development of a shear layer within which transition from the stagnant cavity environment to the active external flow occurs, and (2) the creation of a concomitant fluctuating pressure environment. A program of experiments has been undertaken since 1985 to investigate these phenomena which have resulted in a rather large data base describing the aeroacoustic environment associated with cavities of three different length-to-height ratios, equipped with a variety of acoustic suppression devices and doors, and exposed to external flows of subsonic and supersonic speeds. A series of experiments and the results are presented. GRA

N90-29320# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.).
APPLICATIONS OF LIF TO HIGH SPEED FLOWS
K.-A. BUETEFISCH, P. KROGMANN, H. VOGES, G. MEIJER, A. KOCH, and H. WOLFRUM (Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn, Germany, F.R.) *In* VKI, Measurement Techniques for Hypersonic Flows 21 p 1990
Avail: NTIS HC A17/MF A03

The application of LIF (Laser Induced Fluorescence) to a jet flow, as well as to a hypersonic wind tunnel flow, discussed using NO in a concentration of less than 0.2 percent in a pure nitrogen at a density equivalent to a pressure of up to about 1 atmosphere at room temperature. So far, quenching has to be taken into account. The aim is to discuss the main steps which have to be performed if the LIF method is applied to a flow problem and quantitative results are expected. ESA

N90-29323# Physical Sciences, Inc., Andover, MA.
LASER INDUCED FLUORESCENCE: PRACTICAL APPLICATIONS
S. J. DAVIS and M. G. ALLEN *In* VKI, Measurement Techniques for Hypersonic Flows 21 p 1990
Avail: NTIS HC A17/MF A03

Diagnostic instrumentation for large scale, supersonic test facilities based upon a method known as Planar Laser Induced Fluorescence (PLIF) is addressed. Using this approach it is possible to obtain simultaneous, two dimensional distributions of species concentration and temperature. The PLIF technique and the instrumentation that is being developed based upon this method are described. Particular attention is given to some of the more practical aspects of the incorporation of these advanced diagnostics into large scale test stands. Recent laboratory results of velocity measurements using laser induced fluorescence are presented. ESA

N90-29325# Naples Univ. (Italy). Faculty of Engineering.
INFRARED THERMOGRAPHY

G. M. CARLOMAGNO *In* VKI, Measurement Techniques for Hypersonic Flows 28 p 1990
Avail: NTIS HC A17/MF A03

A review of current IR technology is addressed together with a critical analysis of the main parameters characterizing the performance of an IRSR (Infrared Scanning Radiometer). In particular, the formulation of a cascade model for the evaluation of the actual Modulation Transfer Function (MTF) of a sampled IR imaging system is discussed. Significant results referring to flow visualizations and heat transfer measurements performed with an IRSR in a blowdown hypersonic wind tunnel on a delta wing/ramp configuration and simple and double ellipsoidal models are discussed. Experimental tests within the European space program Hermes to develop the first European Space Shuttle are carried out. ESA

N90-29326# National Aerospace Lab., Tokyo (Japan).
INVESTIGATION OF ATP BLADES, PART 2. VALIDATION OF TWO-DIMENSIONAL VISCOUS FLOW SIMULATION CODES AROUND THIN AIRFOILS
MASAHIRO FUKUDA, NAOKI HIROSE, NOBUHIRO KAWAI, KAZUHIRO NAKAHASHI, and EIJI KIKUNO Dec. 1989 63 p In JAPANESE; ENGLISH summary
(NAL-TR-1046; ISSN-0389-4010) Avail: NTIS HC A04/MF A01

The two-dimensional Navier-Stokes codes, NSFOIL and NS2D, are validated in terms practical thin-airfoils analysis for conventional propeller systems and compared with data obtained from wind-tunnel tests. This research was done as part of an aerodynamic research project on propeller blades for advanced turboprop (ATP) engines. The comparison was made at a Reynolds number of 8 million which was equivalent to the actual flight condition of ATP, and it was shown that these codes provide very effective tools for predicting nonlinear characteristics of thin-airfoils. In the course of careful comparison, some improvements on these codes were clarified. Author

N90-29327# National Aerospace Lab., Tokyo (Japan).
TRANSONIC 3-D EULER ANALYSIS OF FLOWS AROUND FANJET ENGINE AND TPS (TURBINE POWERED SIMULATOR). COMPARISON WITH WIND TUNNEL EXPERIMENT, EVALUATION OF TPS TESTING METHOD AND 3-D FLOW
NAOKI HIROSE, KEISUKE ASAI, and KATSUYA IKAWA Nov. 1989 163 p In JAPANESE; ENGLISH summary
(NAL-TR-1045; ISSN-0389-4010) Avail: NTIS HC A08/MF A01

A three-dimensional Euler flow analysis code for Fan-Jet Engine and Turbine Powered Simulator (TPS) wind tunnel testing was developed utilizing MacCormack's scheme in the finite volume form for the purpose of confirming the validity of the TPS testing method in the NAL 2 x 2 m Transonic Wind Tunnel. The present analysis is made for the preliminary single axisymmetric TPS configuration. The wind tunnel experimental data for this model was available. The result of the numerical computation was compared with this data. The pressure distributions on the inlet cowl surface and core-jet cowl surface showed excellent agreement between the experiment and the computation. Different engine conditions between the real fan-jet engine and TPS simulation, i.e., difference of core-jet exhaust temperature and difference of mass flux relations, were analyzed, simulating respective engine conditions. The result shows that the two flows do not differ much qualitatively in the external flow field surrounding the exhaust jet plume. This comes from the fact that the use of the Euler code and the coarse mesh precluded obtaining a result amenable to quantitative discussion including the effects of viscosity and the turbulence/shock wave interactions in the plume field. Nevertheless the present result shows that the TPS testing method is a good full-configuration aerodynamic testing method for fan-jet engines. To extend the method, three-dimensional flow analysis was made and it revealed the angle of attack effects in the inlet flow field, such as the flow uniformity at the fan face and in the jet exhaust plume including the formation of a pair of longitudinal vortices in the shear layer between the jet plume and the external flow. Author

N90-29328# National Aerospace Lab., Tokyo (Japan). Aircraft Aerodynamics Div.
A BOUNDARY-LAYER TRANSITION MODEL FOR THE NAVIER-STOKES COMPUTATION FOR A NATURAL-LAMINAR-FLOW AIRFOIL
NOBUHIRO KAWAI Nov. 1989 22 p
(NAL-TR-1038T; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

Boundary-layer transition modeling is one of the most important deciding factors for the computation of natural laminar flow. So, a transition model for solving the two-dimensional Navier-Stokes equations with an algebraic turbulence model is presented. Michel's transition criterion is employed as the transition model and is compared with the conventional Baldwin-Lomax's transition criterion. Computation was made for the low-speed flow around a natural-laminar-flow airfoil and for the transonic flow around a supercritical natural-laminar-flow airfoil. The results computed by using the Michel's criterion agree well with the experimental results for low-speed flow and exhibit the bucket of the drag polar curve which is typical of a natural-laminar-flow airfoil. Author

N90-29332# National Aerospace Lab., Tokyo (Japan). Aircraft Aerodynamics Div.
SOME TOPICS IN COMPUTATIONAL TRANSONIC AERODYNAMICS: REVISION
NAOKI HIROSE and SUSUMU TAKANASHI Apr. 1989 21 p Presented at the IUTAM Symposium Transsocicum 3, Geottingen, Federal Rep. of Germany, 24-27 May 1988
(NAL-TR-1018T; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

Transonic aerodynamics research has been extensively conducted at NAL, Japan. Progress in CFD application is remarkable. N-S codes for airfoil, wing and full-configuration were developed. The codes revealed various viscous effects which otherwise were not predicted by past inviscid codes and were validated with wind tunnel test results. These N-S codes proved to be excellent as practical design tools for designing such aircraft as the Boeing-Japan 7J7. A versatile wing design code was combined with various flow solvers and used for practical purpose. Some topics of recent computational aerodynamics in transonic research are covered. Author

03

AIR TRANSPORTATION AND SAFETY

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

A90-51618
AIRCRAFT FIELD EXPERIENCE WITH AUTOMOTIVE GASOLINE IN THE UNITED STATES
HARRY C. ZEISLOFT IN: Future fuels for general aviation; Proceedings of the Symposium on Future Fuels for General Aviation Intermittent Combustion, Baltimore, MD, June 29, 1988. Philadelphia, PA, American Society for Testing and Materials, 1989, p. 19-37. refs
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The history behind the incentives for the use of automobile gasoline in small aircraft powered by engines rated for 80-octane fuel is reviewed. FAA records covering accidents, incidents, and service difficulties as well as Experimental Aircraft Association reports show increased engine reliability when FAA-approved autogas is used. Maintenance costs are reduced as well. K.K.

A90-51619
FIELD EXPERIENCE WITH TYPE CERTIFICATED CIVIL AIRCRAFT OPERATED ON MOTOR GASOLINES AND WORLDWIDE SURVEY OF MOTOR GASOLINE CHARACTERISTICS
PAUL O. PENDLETON (FAA, Wichita, KS) IN: Future fuels for general aviation; Proceedings of the Symposium on Future Fuels

for General Aviation Intermittent Combustion, Baltimore, MD, June 29, 1988. Philadelphia, PA, American Society for Testing and Materials, 1989, p. 38-55.
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The results obtained from operating civil type certified aircraft on automotive (motor) gasoline are examined. A comparison is made between automotive fuel consumption and aviation gasoline in the aircraft operating environment. An attempt is also made to assess the dispensing procedures for motor gasolines that have resulted as the aviation usage of this product has increased. K.K.

A90-52093
ELECTRIC CHARGE ACQUIRED BY AIRPLANES PENETRATING THUNDERSTORMS
J. J. JONES (New Mexico Institute of Mining and Technology, Socorro) Journal of Geophysical Research (ISSN 0148-0227), vol. 95, Sept. 20, 1990, p. 16589-16600. refs
(Contract NSF ATM-82-05468; NSF ATM-82-18621; NSF ATM-89-19697)
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Three airplanes - a sailplane, a piston powered sailplane, and a twin turboprop - have been instrumented to measure electric fields inside electrified clouds and the net electric charge on the airplanes. In unelectrified clouds the powered airplanes become negatively charged during collisions with liquid cloud water droplets whereas the sailplane does not. In thunderstorm clouds, several airplane charging mechanisms are found to operate. These involve collisions with liquid water droplets of the cloud and the shedding of polarization charge in the presence of strong electric fields. For these charging processes, the sign of the acquired charge depends on the sign of the component of the atmospheric electric field along the direction of flight. When the amounts of charge on the powered airplanes are small, the engine exhaust acts to discharge the airplane, while for larger charges, corona emission becomes the predominant mechanism of discharge. Author

N90-28507# Transportation Systems Center, Cambridge, MA.
AIRPORT CAPACITY ENHANCEMENT PLAN 1989 Final Report, May 1988 - Apr. 1989
May 1989 357 p
(PB90-197997; DOT-TSC-FAA-89-1; DOT/FAA/CP-89-4) Avail: NTIS HC A16/MF A02 CSCL 01E

The Airport Capacity Enhancement Plan plays a major role in the Federal Aviation Administration's (FAA) effort to increase airport capacity and efficiency without compromising the safety of passengers or the environment. The Plan identifies the cause and extent of capacity and delay problems currently associated with the U.S. air system, projects the effects of increased air traffic on airport capacity over the next decade, and outlines various planned and ongoing FAA projects intended to reduce capacity-related problems. The projects are directed toward one or more of four airport capacity enhancement areas: airport development; airspace control procedures; additional equipment and systems; and capacity planning studies. A description of each project is provided, along with significant milestones and expected capacity-related benefits. GRA

N90-29333# National Aerospace Lab., Tokyo (Japan). Thermofluid Dynamics Div.
AIRLINE PRODUCTIVITY RELATING ON THE FUEL COST. (2): FUEL CONSUMPTION VALUES AND FUEL EFFICIENCY [SAIKIN NO EA-RAIN NO NENYUHI NIKANSURUICHIKOUSATSU. (2): NENRYO SHOUHI TO HIYOU TAI KOUKA]
GIICHI TANABE Mar. 1989 29 p In JAPANESE
(NAL-TM-604-2; ISSN-0452-2982; JTN-90-80191) Avail: NTIS HC A03/MF A01

Steady progress is being made toward newer aircraft designs which consume much less fuel. Actual data of fuel consumption of presently operating aircraft have been recorded. The data was arranged with emphasis on operating costs vs. transported freight, historical flight range rate change, transported freight, transportation efficiency, and fuel consumption. At U.S. airlines, in operations from 1985 to 1987 transportation efficiency is below 5000 kg km/kg and total cost per km ranged from $0.09 to $0.87. Therefore, because total costs are not reduced, even if transportation freight are reduced, it is very important to keep track of freight amounts as a management tool. Other problems in air transportation are alternative fuels and environmental pollution. In the 21st Century, liquefied hydrogen may be used as an alternative to fossil fuel. The reduction of environmental pollution must be considered. reducing pollution are required. NASDA

N90-29334# Loughborough Univ. of Technology (England). Dept. of Transport Technology.
THE COST OF AIR SERVICE FRAGMENTATION
S. TOLOFARI, N. J. ASHFORD, and R. E. CAVES Jul. 1990 97 p Sponsored by Science Research Council
(TT-9010; ISBN-0-904947-25-4) Avail: NTIS HC A05/MF A01

Examination of short-run economies of density for the seven British Airport Authority airports of the sample showed that the 'average' airport enjoys economies of density (i.e. economies of capacity utilization). An examination of these economies for the individual airports of the sample revealed generally the same trend for all the airports with the exception of London-Heathrow which was found to be experiencing diminishing returns to density. Analyses of short-run average and marginal costs showed that in 1986 and 1987, London-Gatwick had the lowest average variable and marginal costs followed by Heathrow; with both Stansted and Prestwick showing the highest costs. Savings in operating costs were found for different combinations of airport operating/service characteristics. High levels of passengers per air transport movement (i.e. average aircraft load) combined with high levels of terminal capacity utilization were found to result in reductions in operating costs. It is concluded as a result of the economies found with respect to passenger average loads, both in terms of cost savings and in terms of their contribution to output levels; that it is plausible to expect that even after an airport's capacity has reached its optimal utilization level, higher average loads can still be used as an operating strategy to achieve cost economies without further capacity expansions. Author

N90-29335 Civil Aviation Authority, London (England).
UK AIRMISSES INVOLVING COMMERCIAL AIR TRANSPORT: MAY - AUGUST 1989
Apr. 1990 88 p
(ISSN-0951-6301; ETN-90-97613) Copyright Avail: Civil Aviation Authority, Greville House, 37 Gratton Road, Cheltenham, England

Airmisses in the United Kingdom involving commercial air transport are addressed. Their origins, filed only by the pilots concerned, are discussed. The purpose of the reports, investigation and categorization are reported. The relating involvement of commercial air transport aircraft is discussed. Airmisses related to flying hours are discussed. Airmiss reports from May to August 1989 are given. Statistical tables of the number of incidents, the number of aircraft involved and airmisses related to flying hours are presented. ESA

N90-29336 Civil Aviation Authority, London (England).
AIRCRAFT EVACUATIONS: THE EFFECT OF PASSENGER MOTIVATION AND CABIN CONFIGURATION ADJACENT TO THE EXIT
HELEN MUIR, CLAIRE MARRISON, and ALYSON EVANS Nov. 1989 47 p Prepared in cooperation with Cranfield Inst. of Tech., England
(CAA-PAPER-89019; ISBN-0-86039-406-9; ETN-90-97614)
Copyright Avail: Civil Aviation Authority, Greville House, 37 Gratton Road, Cheltenham, England

An experimental program of research into passenger behavior in aircraft emergencies is reported. The main objective was to investigate the influence of changes to the cabin configuration involving access to the emergency exits, on the rate at which passengers could evacuate an aircraft. The configurations evaluated involved a range of widths for the passageway through

a bulkhead leading to floor level exits, and a range of seating configurations adjacent to a type 3 overwing exit. The configurations were evaluated when passengers were competing to evacuate the aircraft, as can happen in an accident when the conditions in the cabin become life threatening, and when passengers were evacuating in an orderly manner as occurs in aircraft certification evacuations and in some accidents. Detailed results are given. The results suggested that the optimum distance between the seat rows either side of the exit would involve a vertical seat projection of between 13 and 25 inches. ESA

N90-29337# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
TESTS FOR AIRCRAFT INTERIOR MATERIALS IN FIRE ACCIDENT
M. A. D. VANDERHEIJDE May 1989 89 p
(LR-622; ETN-90-97635) Avail: NTIS HC A05/MF A01

A survey of terms often used in connection with aircraft interior materials flammability tests is given. A description of a lot of often referred to small scale test methods and of some full scale test methods is given. The effects of inhalation of toxic gases and exposure to radiant heat on human beings are described. A full description of the actual flammability requirements in Federal Aviation Regulation part 25 is provided. ESA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A90-50747
OPERATION OF AVIATION RADIO AND ELECTRONIC EQUIPMENT (HANDBOOK) [EKSPLUATATSIIA AVIATSIONNOGO RADIOELEKTRONNOGO OBORUDOVANIIA /SPRAVOCHNIK/]
PAVEL S. DAVYDOV and PETR A. IVANOV Moscow, Izdatel'stvo Transport, 1990, 240 p. In Russian. refs
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Reference data are presented on the general design and parameters of airborne radio and electronic equipment, its reliability, and its effect on flight safety and efficiency. Fail-safe characteristics of radio equipment are examined, and methods are presented for calculating reliability indices. The fundamentals of the engineering support of radio and electronic equipment are discussed. The discussion also covers types of technical maintenance, trouble-shooting methods and equipment, principles of selection and calculation of diagnostic parameters, and metrological support. V.L.

A90-50775
MILITARY NAVIGATION - THE FOURTH GENERATION
BILL SWEETMAN Interavia (ISSN 0020-6512), vol. 45, Sept. 1990, p. 767, 769, 770, 773, 775.
Copyright

The fourth generation of aircraft navigation technology is distinguished by two new devices: the satellite navigation system and the terrain database. Satellite navigation systems are fielded by the Global Positioning System (GPS),their accuracy is unaffected by distance from the beacon and their multi-point signals are resistant to jamming. The terrain database uses storage devices such as high-capacity dynamic random excess memory chips and optical disks to store data on the world's land-masses. An integration of GPS with an inertial reference system can help resolve ambiguities in the GPS signal. The digital map can be combined with terrain-matching, linking the database, the internal reference system and the radar altimeter to determine the aircraft's three-dimensional position with an accuracy measured in feet. Coupled to the automatic flight control system, this permits virtually silent terrain-following, regardless of weather. Quiet navigation techniques are essential to any aircraft which is to survive primarily by avoiding detection. However, the fourth-generation systems described were not mature when the B-2 and F-117 were launched into full-scale development. Both these aircraft use unusual and slightly different systems. B.P.

A90-50778
ANALYSIS AND SYNTHESIS OF METEOROLOGICAL SUPPORT SYSTEMS FOR AIRPORTS [OB ANALIZE I SINTEZE SISTEM METEOROLOGICHESKOGO OBESPECHENIIA AVIATSII]
A. S. SOLONIN IN: Methodology and tools for meteorological observations. Leningrad, Gidrometeoizdat, 1989, p. 26-32. In Russian.
Copyright

The problem of the meteorological support of flight operations is examined using the method of multivariate analysis. A system of multivariate relations is synthesized which describes a model of processes aimed at providing meteorological data for a real-time hierarchical air traffic control system. V.L.

A90-50779
COORDINATION STRATEGIES IN A HIERARCHICAL AIR TRAFFIC CONTROL SYSTEM WITH ALLOWANCE FOR METEOROLOGICAL CONDITIONS [O KOORDINIRUIUSHCHIKH STRATEGIIAKH V IERARKHICHESKOI SISTEME UPRAVLENIIA VOZDUSHNYM DVIZHENIEM S UCHETOM METEOROLOGICHESKIKH USLOVII]
A. S. SOLONIN IN: Methodology and tools for meteorological observations. Leningrad, Gidrometeoizdat, 1989, p. 33-39. In Russian.
Copyright

Coordination strategies for eliminating possible conflicts between subsystems in a hierarchical air traffic control system are proposed which allow for meteorological conditions along air routes in the vicinity of airports. In accordance with the approach proposed here, the optimal coordination and operation control actions are carried out using modified regulation, comparison, and multivariate interaction strategies. V.L.

A90-51060
PASSIVE LOCATION ACCURACY VIA A GENERAL COVARIANCE ERROR MODEL
RICHARD W. DAY and DALE R. OXE (Ultrasystems Defense, Inc., Irvine, CA) IN: 1989 IEEE Aerospace Applications Conference, Breckenridge, CO, Feb. 12-17, 1989, Conference Digest. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, 13 p. refs
Copyright

A least-squares covariance analysis approach for determining geolocation accuracy using long-baseline interferometry (LBI) measurements from airborne platforms is described. The equations derived determine the accuracy of the emitter location by extraction of the position error ellipse from the covariance matrix. The model is applicable, however, to both ground-fixed and moving emitters. Emitter position and velocity vector accuracy are evaluated using three aircraft configurations. The sources of error modeled include random and bias measurement error. The results confirm that the covariance approach enables quantitative assessment of the key factors in the engineering synthesis of requirements for aircraft deployment, signal measurement, and geolocation accuracy. I.E.

A90-51339
THE E-SAT 300A - A MULTICHANNEL SATELLITE COMMUNICATION SYSTEM FOR AIRCRAFT
MOHAMED A. ABDELRAZIK and JOHN F. HODAPP (E-Systems, Inc., Greenville, TX) IN: GLOBECOM '89 - IEEE Global Telecommunications Conference and Exhibition, Dallas, TX, Nov. 27-30, 1989, Conference Record. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 1423-1427. refs
Copyright

The authors provide a technical description and highlight the advantages of a multichannel airborne digital satellite communication system that meets the operational requirements of the aeronautical standard for the Inmarsat and the airworthiness requirements of the FAA. The system has been named the E-SAT 300A aircraft earth station (AES). At present, the E-SAT 300A AES is designed to provide aircraft with telephone and data communication capabilities through three simultaneous full duplex channels. The E-SAT 300A AES uses a small mechanical steered antenna system to achieve a maximum antenna coverage of 360 deg in azimuth and -30 deg to +90 deg in elevation. The E-SAT 300A antenna system is installed inside an aerodynamically shaped radome that is mounted on top of the aircraft fuselage. The E-SAT 300A AES was designed for installation on aircraft similar in size to Gulfstream IV or larger. I.E.

A90-52415
ORGANIZATION OF AIR TRAFFIC CONTROL [ORGANIZATSIIA UPRAVLENIIA VOZDUSHNYM DVIZHENIEM]
VLADIMIR I. ALESHIN, IURII P. DARYMOV, and GEORGII A. KRYZHANOVSKII Moscow, Izdatel'stvo Transport, 1988, 264 p. In Russian. refs
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The principles and methods governing the organization and structure of air traffic control are reviewed. In particular, attention is given to the main factors determining the structure of an air traffic control system, methods for evaluating the efficiency of organizations and structures, and efficient organization of radio and communication equipment. The discussion also covers organization of air traffic control at airports and district centers; principles of air traffic planning; methods of ensuring flight safety; and conditions and methods for improving the efficiency of air traffic. V.L.

A90-52613#
A SUPPLEMENT TO GPS/NAVSTAR FOR CIVIL USE [EINE ERGAENZUNG VON GPS/NAVSTAR FUER ZIVILE NUTZUNG]
J. HAMMESFAHR (DLR, Oberpfaffenhofen, Federal Republic of Germany) Ortung und Navigation (ISSN 0474-7550), no. 2, 1990, p. 206-211. In German. refs

The potential for developing a civil supplement to the GPS navigation system, which is primarily for military use, is addressed. Such an extension would allow the user to obtain signals from both Navstar satellites and from geostationary satellites to determine position. The practical distinctions between GPS and the supplement system are listed, and the configuration of the supplement system is shown and discussed. The preliminary work that needs to be done before such a system can be built is examined. C.D.

A90-52614#
INSPECTION OF INSTRUMENT LANDING SYSTEMS [VERMESSUNG VON INSTRUMENTENLANDESYSTEMEN]
MANFRED HAVERLAND (Aerodata Flugmesstechnik GmbH, Brunswick, Federal Republic of Germany) Ortung und Navigation (ISSN 0474-7550), no. 2, 1990, p. 220-232. refs

This paper describes the flight test of an integrated GPS/INS position reference system for the inspection of instrument landing systems (ILS). The GPS principle and differential GPS are reviewed, and the coupling of differential GPS and INS sensors is described. ILS flight inspection with the GPS/INS position reference is discussed, and results from an experimental flight inspection system are reported. C.D.

A90-52615#
INTEGRATION AND AUTOMATION OF NAVIGATION FUNCTIONS USING KALMAN FILTERS [INTEGRATION UND AUTOMATISIERUNG VON NAVIGATIONSFUNKTIONEN MIT HILFE VON KALMAN-FILTERN]
UWE KROGMANN (Bodenseewerk Geraetetechnik GmbH, Ueberlingen, Federal Republic of Germany) Ortung und Navigation (ISSN 0474-7550), no. 2, 1990, p. 233-254. In German. refs

An inertial navigation system is described which uses information from the GPS and from a Doppler calculator. The integration of navigational information from various sensors and sensor systems is addressed as a problem of optimal processing techniques, leading to an extended Kalman filter for determining an optimal estimation rate for navigational status. A linearized Kalman filter based on a linear filter model is described. It finds optimal values for navigational errors and for sensor and measurement errors, given appropriate models. An example involving gyroscope drift is used to show how the stochastic error model can be found and the measurement procedure can be integrated. C.D.

N90-28509# Federal Aviation Administration, Atlantic City, NJ.
DALLAS/FORTH WORTH SIMULATION. PHASE 2: TRIPLE SIMULTANEOUS PARALLEL INSTRUMENT LANDING SYSTEM (ILS) APPROACHES (TURBOJETS) Final Report, Oct. - Jan. 1990
Mar. 1990 183 p Prepared in cooperation with Computer Technology Associates, Inc., McKee City, NJ
(Contract DTFA03-89-C-00023)
(DOT/FAA/CT-90/2) Avail: NTIS HC A09/MF A01

A dynamic, real-time simulation was conducted to evaluate triple simultaneous independent parallel approach operations for the Dallas/Fort Worth (D/FW) Airport. The simulation was part of an ongoing effort to evaluate plans for increasing air traffic capacity in the D/FW area and to evaluate multiple parallel approaches in general. An additional parallel runway (16L), with centerline 5,000 ft east of the existing 17L runway, was simulated in a triple simultaneous parallel operation conducted under Instrument Meteorological Conditions (IMC). The results of the study indicated that controllers were able to maintain miss distances, between blundering aircraft and nonblundering aircraft, in the proposed D/FW triple simultaneous parallel Instrument Landing System (ILS) approach operation, that were statistically equivalent to the miss distances maintained in the approved dual approach condition. None of the blunders in the triple or dual approach conditions resulted in a slant range miss distance of less than 1,000 ft. Finally, controllers, controller observers, and ATC management observers concluded that the triple simultaneous ILS approach operation at D/FW is acceptable, achievable, and safe. Author

N90-28510*# Army Aviation Systems Command, Moffett Field, CA.
COMPARISON OF SPEECH INTELLIGIBILITY IN COCKPIT NOISE USING SPH-4 FLIGHT HELMET WITH AND WITHOUT ACTIVE NOISE REDUCTION
JEFFREY W. CHAN and CAROL A. SIMPSON (Psycho-Linguistic Research Associates, Woodside, CA.) Jul. 1990 38 p
(Contract NAS2-12425; NAS2-13188)
(NASA-CR-177564; A-90264; NAS 1.26:177564; USAAVSCOM-TR-90-G-1) Avail: NTIS HC A03/MF A01 CSCL 17B

Active Noise Reduction (ANR) is a new technology which can reduce the level of aircraft cockpit noise that reaches the pilot's ear while simultaneously improving the signal to noise ratio for voice communications and other information bearing sound signals in the cockpit. A miniature, ear-cup mounted ANR system was tested to determine whether speech intelligibility is better for helicopter pilots using ANR compared to a control condition of ANR turned off. Two signal to noise ratios (S/N), representative of actual cockpit conditions, were used for the ratio of the speech to cockpit noise sound pressure levels. Speech intelligibility was significantly better with ANR compared to no ANR for both S/N conditions. Variability of speech intelligibility among pilots was also significantly less with ANR. When the stock helmet was used with ANR turned off, the average PB Word speech intelligibility score was below the Normally Acceptable level. In comparison, it was above that level with ANR on in both S/N levels. Author

N90-28511# Transportation Research Board, Washington, DC.
MODELING AND ANALYSIS OF AIRPORT AND AIRCRAFT OPERATIONS
C. F. WHEELER, A. I. OXOKA, N. ASHFORD, D. BAROL, and J.

R. G. BRANDER 1989 64 p
(PB90-222167; TRB/TRR-1214; ISBN-0-309-04817-6; LC-90-31527) Avail: NTIS HC A04/MF A01 CSCL 01C

Strategies for maximizing the profitability of airline hub-and-spoke networks; application of disaggregate modeling in aviation systems planning in Nigeria; the measuring secondary economic impacts using regional input-output modeling system; entry, exclusion, and explusion in a single hub airport system; congestion, concentration, and contestability: the case of the airline industry; analysis of airline and aircraft safety posture using service difficulty reports; estimating practical maximum flight hours for general aviation turboprop and jet aircraft are discussed. GRA

N90-28512*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
VELOCITY FILTERING APPLIED TO OPTICAL FLOW CALCULATIONS
YAIR BARNIV Aug. 1990 58 p
(NASA-TM-102802; A-90108; NAS 1.15:102802) Avail: NTIS HC A04/MF A01 CSCL 20D

Optical flow is a method by which a stream of two-dimensional images obtained from a forward-looking passive sensor is used to map the three-dimensional volume in front of a moving vehicle. Passive ranging via optical flow is applied here to the helicopter obstacle-avoidance problem. Velocity filtering is used as a field-based method to determine range to all pixels in the initial image. The theoretical understanding and performance analysis of velocity filtering as applied to optical flow is expanded and experimental results are presented. Author

N90-29338# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Guidance and Control Panel.
ANALYSIS, DESIGN AND SYNTHESIS METHODS FOR GUIDANCE AND CONTROL SYSTEMS
C. T. LEONDES, ed. (California Univ., Los Angeles.) Jun. 1990 489 p Original contains color illustrations
(AGARD-AG-314; ISBN-92-835-0566-2) Copyright Avail: NTIS HC A21/MF A03; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The field of modern guidance and control systems has been raised to a very high level of capability because of the powerful high technology advances of the past several decades. This NATO AGARDograph captures the spirit of these powerful capabilities. Topics include integrated guidance and control systems; NAVSTAR/GPS Systems; optical gyroscope and control systems; integrated communication and navigation systems; integrated navigation flight control systems; civil aircraft navigation and traffic control; and land navigation systems.

N90-29339# Navstar Systems Development, Monument, CO.
GPS INTEGRITY REQUIREMENTS FOR USE BY CIVIL AVIATION
ALISON K. BROWN *In* AGARD, Analysis, Design and Synthesis Methods for Guidance and Control Systems 12 p Jun. 1990
Copyright Avail: NTIS HC A21/MF A03; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

At the request of the Federal Aviation Administration (FAA), the Radio Technical Commission for Aeronautics (RTCA) established the Special Committee 159 on September 20, 1985. The purpose of SC-159 was to prepare a Minimum Aviation System Performance Standard (MASPS) for the operation and use of the evolving Global Positioning System (GPS) in civil air navigation. To assist in preparing the MASPS, SC-159 formed an Integrity Working Group to investigate and report on civil integrity problems relating to GPS. The purpose was to establish GPS integrity monitoring requirements and to discuss suitable integrity monitoring techniques for civil aviation. The Integrity Working Group recommendations to SC-159 are summarized. Author

N90-29341# McDonnell Aircraft Co., Saint Louis, MO.
APPLICATION OF MULTIFUNCTION INERTIAL REFERENCE SYSTEMS TO FIGHTER AIRCRAFT
CARLOS A. BEDOYA and JOHN M. PERDZOCK (Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.) *In* AGARD, Analysis, Design and Synthesis Methods for Guidance and Control Systems 33 p Jun. 1990
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As requirements for Flight Control, Fire Control, Propulsion Control and Navigation Systems are developed for future fighter aircraft, reliability, maintainability, availability, redundancy, and survivability become key issues. These systems require dependable and accurate sources of inertial measurement data. The Multifunction Flight Control Reference System (MFCRS) was developed to demonstrate the use of a minimum number of inertial sensors. The MFCRS Program used two extensively modified Ring Laser Gyro (RLG) navigation units to perform the flight control reference and navigation functions on board an F-15 fighter aircraft. An overview is given of the various stages of development that were completed on this program, the lessons learned to date, and what is planned for the future. Evaluation of MFCRS was undertaken to evaluate performance at the system level and evaluate flight control outputs, redundancy management, electronic MRU to MRU alignment, reaction time, navigation performance, performance under vibration, temperature, EMI environments, and operation when integrated with the F-15 Flight Control System. Following the MFCRS laboratory evaluation a ground structural mode interaction test and a two phase flight test program was performed. Subsequent to the successful completion of the phase two flight test evaluation, changes to the MFCRS hardware and software structure, which would improve system performance and expand the MFCRS flight envelope, were identified. Following the laboratory evaluation additional flight testing was planned to verify that the EMFCRS configuration would result in level 1 handling qualities in both supersonic and subsonic flight was well as in tracking of target aircraft. Unfortunately, during ground testing prior to flight, a 22 Hz structural mode interaction was found in the control system pitch channel. The system changes developed during the EMFCRS studies, the laboratory test results, and the aircraft testing are discussed, as well as the follow on development of multifunction system now in process under the name of Ada Based Integrated Controls System (ABICS) Phase 3. Author

N90-29344# Singer Co., Wayne, NJ. Electronic Systems Div.
THE INTEGRATION OF MULTIPLE AVIONIC SENSORS AND TECHNOLOGIES FOR FUTURE MILITARY HELICOPTERS
ALBERT J. SHAPIRO *In* AGARD, Analysis, Design and Synthesis Methods for Guidance and Control Systems 20 p Jun. 1990
Previously announced in IAA as A83-40301
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The expanding role of the helicopter in the battlefield environment has burdened the pilot with missions of greater complexity and risk with a concomitant increase in pilot workload. Navigation of the helicopter is an essential supportive element to the prime mission and has been until recent years, a significant contributor to the workload. Technological advances in navigational electronics such as Doppler navigation radar, computers, integrated avionic control and display systems, etc., now can provide automated navigation with vital benefits in cost, size, weight and power, which permit incorporation of these advances into the helicopter. Cost reductions are particularly important since helicopters are used in large quantities in modern military forces. Multisensor navigation systems already available and in use in helicopters are discussed, followed by a review of the system trade-offs and considerations leading to new systems that use more advanced digital electronic techniques to achieve the goals of reduced pilot workload and improved performance with minimum size, weight, and cost. The beneficial impact of ongoing

technological advances in improving the operating capabilities of future avionics systems is indicated. Author

N90-29350# Naval Air Development Center, Warminster, PA.
AN ANALYSIS OF GPS AS THE SOLE MEANS NAVIGATION SYSTEM IN US NAVY AIRCRAFT
GEORGE LOEWENSTEIN, JOHN PHANOS, and EDWARD C. RISH (Synetics Corp., Vienna, VA.) *In* AGARD, Analysis, Design and Synthesis Methods for Guidance and Control Systems 8 p Jun. 1990
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The Department of Defense (DOD) is developing the Global Positioning System (GPS) to acquire a worldwide navigation capability. This satellite based system provides appropriately equipped users with precision three dimensional position and velocity, and precise time. The current edition of the U.S. Federal Radionavigation Plan, issued in 1984, presents a consolidated Federal plan on the management of those Radionavigation systems which are used by both the civilian and military sectors. It states the DOD goal to phase out the use of TACAN, VOR/DME, OMEGA, Loran C and TRANSIT in military platforms and for GPS to become the standard radionavigation system for DOD. This would eliminate all the current sole means air navigation systems (TACAN and VOR/DME) aboard military aircraft. Instrument Flight Rule (IFR) operations within controlled airspace requires an operating sole means air navigation system to be aboard the aircraft. The requirements are investigated for GPS certification as a sole means air navigation system in the U.S. National Airspace System (NAS), the implication are discussed for GPS User Equipment (UE) hardware and software, the actual UE implementation and approaches for UE integration with flight instruments on Navy aircraft are described. Author

N90-29356# TRW Defense and Space Systems Group, San Diego, CA. Military Electronics and Avionics Div.
DISTRIBUTED CONTROL ARCHITECTURE FOR CNI PREPROCESSORS
V. R. SUBRAMANYAN and L. R. STINE *In* AGARD, Analysis, Design and Synthesis Methods for Guidance and Control Systems 5 p Jun. 1990 Previously announced in IAA as A88-34056
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Next-generation avionics systems need to incorporate extensive integration, including the Communication, Navigation, and Identification (CNI) functions. An important element in such a highly integrated CNI system is a set of programmable preprocessors, each of which can process baseband outputs from a receiver to perform real-time signal dependent processing, such as matched filtering, PN despreading, code and carrier tracking, phase rotation, correlation, convolution, pulse shape discrimination, threshold crossing, time-of-arrival detection, demodulation message formatting, and on-line status reporting. Control of the total integrated CNI system is characterized by a distributed-control architecture, wherein the execution times range from seconds at the data processor level down to a few nanoseconds at the preprocessor level. Any candidate control architecture for the preprocessor must support reprogrammability, flexibility in event scheduling, and testability, while fully meeting the requirements of each CNI function. A distributed-control architecture is described for a generic CNI preprocessor that meets the above requirements. Author

N90-29360# California Univ., San Diego, La Jolla. Dept. of Applied Mechanics and Engineering Sciences.
OBSERVABILITY OF RELATIVE NAVIGATION USING RANGE-ONLY MEASUREMENTS
ALAN M. SCHNEIDER *In* AGARD, Analysis, Design and Synthesis Methods for Guidance and Control Systems 13 p Jun. 1990 Previously announced in IAA as A85-42399 Prepared in cooperation with Naval Ocean Systems Center, San Diego, CA
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A simulation tool is described which is capable of determining the observability of various fleet configurations and maneuvers in a relative navigation environment. The motion of the relative grid established by the navigation controller is explicitly modeled as a function of the errors in his dead-reckoning sensors. The simulation uses centralized, optimal processing of an extended Kalman filter. Results show observability on a good geometry, with some degradation in performance when dead-reckoning sensor errors change rapidly. Author

N90-29362# Litton Guidance and Control Systems, Woodland Hills, CA.
INTEGRATED NAVIGATION/FLIGHT CONTROL FOR FUTURE HIGH PERFORMANCE AIRCRAFT
ROBERT E. EBNER and A. DAVID KLEIN *In* AGARD, Analysis, Design and Synthesis Methods for Guidance and Control Systems 8 p Jun. 1990 Previously announced in IAA as A88-35560
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Litton has delivered an Advanced Development Model (ADM) of an Integrated Inertial Sensor Assembly (IISA) on contract to the U.S. Naval Air Development Center. IISA is designed to provide all inertial sensor needs for modern military aircraft, including flight control and navigation, with reduced avionics cost through the use of redundant skewed inertial navigation sensors. Various design aspects of using six ring-laser gyros and six inertial-grade accelerometers in two, separated clusters are described. The redundancy management mechanization and the system design features for maximum flight safety are given. Navigation performance limits of strapdown INS, including the effects of skewed sensors, are presented. Laboratory testing will be performed by the Navy and flight testing will be conducted on an F-15 as part of a joint Navy/Air Force program. Author

N90-29363# McDonnell Aircraft Co., Saint Louis, MO.
SURVIVABLE PENETRATION
CARLOS A. BEDOYA, GARY N. MAROON, WILLIAM J. MURPHY, and CHARLES W. CHAPOTON (Texas Instruments, Inc., McKinney.) *In* AGARD, Analysis, Design and Synthesis Methods for Guidance and Control Systems 34 p Jun. 1990
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Threat densities expected on a modern battlefield do not allow penetrating tactical aircraft the option of simply flying around individual threats. As the threat becomes even more sophisticated in the 1990s new aircraft avionic systems will need to be fielded that will enable survivable penetration of tactical aircraft in an even more lethal threat environment. Recent advances in onboard mission planning, navigation, and terrain following/terrain avoidance/threat avoidance (TF/TA/TA) technologies and the onboard availability of stored digital terrain data enable the mechanization of such a survivable penetration capability. Onboard mission planning constructs a survivable penetration reference corridor which takes into account terrain data, the location of known threats, the expected densities of unknown and mobile threats, and mission goals. An advanced aided navigation capability, using information from the global positioning system, aiding sensors such as radar, and terrain navigation features, is necessary to make maximum use of the onboard terrain data. The TF/TA/TA function computes flyable, three-dimensional paths within the reference corridor accounting for aircraft performance limits, knowledge of the surrounding terrain, and information about the threat. All three technologies use the Defense Mapping Agency's Digital Land Mass System (DLMS) terrain to provide look-ahead terrain masking and aided navigation. Through this survivable penetration methodology, advanced tactical aircraft can have enhanced aircraft survivability. Author

N90-29364# Mitre Corp., McLean, VA.
INDEPENDENT GROUND MONITOR COVERAGE OF GLOBAL POSITIONING SYSTEM (GPS) SATELLITES FOR USE BY CIVIL AVIATION
KAREN J. VIETS *In* AGARD, Analysis, Design and Synthesis Methods for Guidance and Control Systems 8 p Jun. 1990
(Contract DTFA01-84-C-00001)
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The Federal Aviation Administration plans to independently monitor signals-in-space from the Global Positioning System (GPS) for the purpose of providing immediate awareness to civil aviation users of the operational status of GPS when it is used in the National Airspace System. The operational status will be disseminated to Air Traffic Control and will possibly be broadcast from ground monitoring stations to GPS aviation users via a dedicated integrity channel. An algorithm is described that measures the coverage of a configuration of ground monitoring station locations, and applies the algorithm to several different configurations of ground monitoring stations to compare the coverage provided. Also included are the resulting ground monitoring station configurations that provide the best coverage of GPS signals for several specific geographical areas, the conterminous United States (CONUS), Canada, and Alaska.
Author

N90-29366# Litton Guidance and Control Systems, Woodland Hills, CA.
FAULT DETECTION AND ISOLATION (FDI) TECHNIQUES FOR GUIDANCE AND CONTROL SYSTEMS
MARK A. STURZA *In* AGARD, Analysis, Design and Synthesis Methods for Guidance and Control Systems 13 p Jun. 1990
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Fault Detection and Isolation (FDI) techniques are described with particular emphasis on strapdown inertial system and Global Positioning System (GPS) applications. A generalized measurement model is considered with a single fault, step bias shift fault model. The parity vector is developed and analyzed. Equivalence is established between the parity and innovations approachs to FDI. A fault detection technique based on the parity vector is presented and analyzed. The Probabilities of False Alarm (P sub FA) and Missed Detection (P sub MD) are derived. The Detector Operating Characteristic (DOC) relating these probabilities is constructed. DOCs are presented for several inertial sensor and GPS satellite configurations. A maximum likelihood fault identification technique is described. A nonparity approach to FDI analysis is presented. The final section lists areas for future work. Author

N90-29367# Northrop Corp., Hawthorne, CA. Electronics Div.
CONTROL AND ESTIMATION FOR AEROSPACE APPLICATIONS WITH SYSTEM TIME DELAYS
EDWARD J. KNOBBE *In* AGARD, Analysis, Design and Synthesis Methods for Guidance and Control Systems 5 p Jun. 1990
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In many practical aerospace applications, guidance and control accuracy is significantly degraded as a result of system transport lags (or time delays). Historically, solutions to problems of this type were required when significant digital computer data delays were encountered or when human operators (e.g., aircraft pilots) became an integral part of the closed-loop operation. More recently, this type of problem is encountered in current SDI (Strategic Defense Initiative) related problems such as laser beam pointing and tracking and, atmospheric laser beam wavefront correction. The problem of controlling a linear discrete-time system where both the measured output and the process evolution are functions of time-delayed states is assessed. The optimal control solution is developed by re-casting the original system representation, with explicit time-delayed states, into a standard regulator form using state vector augmentation. Practical considerations are discussed regarding the implementation of this control law. This solution should prove useful in this and other advanced aerospace applications where system time delays are present and where precision guidance and control is required. Author

N90-29371# GEC Avionics Ltd., Rochester (England). Guidance Systems Div.
THE POTENTIAL FOR DIGITAL DATABASES IN FLIGHT PLANNING AND FLIGHT AIDING FOR COMBAT AIRCRAFT
J. STONE *In* AGARD, Analysis, Design and Synthesis Methods for Guidance and Control Systems 10 p Jun. 1990
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The forces opposing the NATO alliance are constantly improving their capability in the detection, location and interception of attacking aircraft. The ground attack pilot's survival depends upon his ability to conceal his approach by minimizing his aircraft signature in all visual, thermal, acoustic and electronic aspects. In attempting to achieve this, the pilot is forced to fly at altitudes and periods of the day which make the very essence of his mission most difficult to accomplish. From this background has emerged the general concept of stealth. The introduction of passive electro optical sensors in the form of FLIR and NVGs has been a significant step forward in aiding the combat pilot in this hostile environment. TF radars enable low level flight in all weathers. However, the FLIR/NVG combination is not all weather and TF radars are not stealthy. Recent developments in data storage, advanced processing techniques and highly efficient display presentation have been instrumental in enabling covert operations to take place in all weathers. Precise autonomous navigation and terrain following, with the threat of detection minimized, is now available to the modern combat pilot, freeing him to concentrate on successfully achieving the aims of his mission. The potential for digital databases in Flight Planning and Flight Aiding for Combat Aircraft is recognized and equipments are now being procured for military use. The capabilities described in this paper are all feasible, and are being integrated into GEC Avionics' system of Total Terrain Avionics (T sup 2A). Author

N90-29378 Rice Univ., Houston, TX.
OPTIMAL TRAJECTORIES FOR HYPERVELOCITY FLIGHT Ph.D. Thesis
WOON YUNG LEE 1989 99 p
Avail: Univ. Microfilms Order No. DA9012824

Optimal trajectories are discussed for hypervelocity flight of interest in aeroassisted orbital transfer. Both coplanar orbital transfer and noncoplanar orbital transfer are studied. For these cases, the GEO-to-LEO transfer, the HEO-to-LEO transfer, and the LEO-to-LEO transfer are considered in connection with a spacecraft which is controlled during the atmospheric pass via the angle of attack (coplanar case) or via the angle of attack and the angle of bank (noncoplanar case). For the noncoplanar case, three transfer maneuvers are studied. Type 1 involves four impulses and four space plane changes; Type 2 involves three impulses and three space plane changes; and Type 3 involves three impulses and no space plane change. In Type 1, the initial impulse directs the spacecraft away from Earth, and then is followed by an apogee impulse propelling the spacecraft toward Earth; in Types 2 and 3, the initial impulse directs the spacecraft toward Earth. A common element of these maneuvers is that they all include an atmospheric pass, with velocity depletion coupled with plane change. Within the framework of classical optimal control, the following problems are studied: (P1) minimize the energy required for orbital transfer; (P2) maximize the time of flight during the atmospheric portion of the trajectory; and (P3) minimize the time integral of the square of the path inclination. Within the framework of minimax optimal control, the following problem is studied: (P4) minimize the peak heating rate. Numerical solutions for Problems (P1), (P2), (P3), (P4) are obtained by means of the sequential gradient-restoration algorithm for optimal control problems. The engineering implications of the results obtained are discussed. In particular, it is shown

that the nearly-grazing solution is a useful engineering compromise between energy requirements and aerodynamic heating requirements. Dissert. Abstr.

N90-29380 Physics and Electronics Lab. TNO, The Hague (Netherlands).
STUDY IMPROVEMENT TRAINING FACILITIES GROUND CONTROL AIR TRAFFIC CONTROLLERS. PART 1: ALTERNATIVE SOLUTIONS AND THEIR CONSEQUENCES
Final Report, Part 1, Sep. 1988 - Sep. 1989
W. G. DEJONG, J. C. M. MOOIJEKIND, and G. VANDERVEEN
Jan. 1989 60 p In DUTCH; ENGLISH summary
(Contract A88/KLU/621)
(FEL-89-A257-PT-1; TD-89-3874-PT-1; ETN-90-97413) Copyright
Avail: TNO Physics and Electronics Lab., P.O. Box 96864, 2509 JG The Hague, The Netherlands

The consequences of moving the air traffic control training facilities to another location as well as possible improvements were investigated. The aim was to become independent of the operational radars of the air base to which the present simulator is linked. The problems of the present system were analyzed and a number of alternative solutions were considered. It is shown that an integration of radar simulation and target generation is preferable with a control from a computer assisted supervisor-instructor's position. The existing position approach radar consoles can be replaced by adapted workstation. ESA

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AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A90-49878
DESCRIPTION AND RECONSTITUTION OF MANOEUVRE LOADINGS
O. BUXBAUM and H. STEINHILBER (Fraunhofer-Institut fuer Betriebsfestigkeit, Darmstadt, Federal Republic of Germany) IN: Aeronautical fatigue in the electronic era; Proceedings of the Fifteenth ICAF Symposium, Jerusalem, Israel, June 21-23, 1989. Warley, England, Engineering Materials Advisory Services, Ltd., 1989, p. 43-63. refs
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The nature of usage-related loadings, e.g. resulting from flight maneuvers, does not allow a description by means of power spectral density. Hence, a method comprising comparable advantages is presented that is based upon Poisson distributions for both, interarrival times and durations of usage-related segments. Finally, it is demonstrated how such loadings can be reconstituted in real time and in a statistically correct manner. Author

A90-49888
DAMAGE TOLERANCE FOR HELICOPTERS
JOHN W. LINCOLN (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: Aeronautical fatigue in the electronic era; Proceedings of the Fifteenth ICAF Symposium, Jerusalem, Israel, June 21-23, 1989. Warley, England, Engineering Materials Advisory Services, Ltd., 1989, p. 263-290. refs
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The damage tolerance experience in the United States Air Force with fixed wing aircraft and with engines indicated that similar success could be achieved with rotary wing aircraft. The results of the damage tolerance assessment for the HH-53C and the HH-60A helicopters are examined and compared with the results of the conventional safe life approach typically used in the design of these aircraft. The pros and cons of the damage tolerance approach are discussed and recommendations are given for future damage tolerance assessment of existing helicopters and on the incorporation of damage tolerance capability in new designs. Author

A90-49894
DAMAGE TOLERANCE DEMONSTRATION FOR A310-300 CFRP-COMPONENTS
O. GOKGOL (MBB GmbH, Hamburg, Federal Republic of Germany) IN: Aeronautical fatigue in the electronic era; Proceedings of the Fifteenth ICAF Symposium, Jerusalem, Israel, June 21-23, 1989. Warley, England, Engineering Materials Advisory Services, Ltd., 1989, p. 453-470. refs
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The damage tolerance philosophy employed in the CFRP fin-box structure of A310 series commercial aircraft is discussed, with a view to the treatment of damage due to dimensional tolerances and quality assurance steps taken during construction. Various components of this CFRP structure (spar box, skin panels, shear webs, rudder actuator fittings, module nodes, etc.) were subjected to fatigue and/or static testing prior to damage defect types evaluations. The damage types extended to manufacturing defects, accidental damage, and impact damage. Environmental damage could come from APU rotor failure and lightning-strike damage. O.C.

A90-50246
A METHOD FOR CALCULATING THE ROTOR-FUSELAGE INTERFERENCE IN HELICOPTERS [EIN VERFAHREN ZUR BERECHNUNG DER ROTOR-RUMPF-INTERFERENZ BEIM HUBSCHRAUBER]
F.-W. MEYER (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: Yearbook 1988 II; DGLR, Annual Meeting, Darmstadt, Federal Republic of Germany, Sept. 20-23, 1988, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1988, p. 947-953. In German. refs
(DGLR PAPER 88-060) Copyright

A panel method using an iterative program has been developed for calculating the aerodynamic interference between rotor and fuselage in a helicopter in forward flight. The initial values are obtained via a conventional trimming calculations with the rotor representation given by blade element theory. The rotor wake is generated by an eddy cascade method with reduced fuselage representation. A closed, relaxed solution of the rotor-fuselage wake potential is obtained using relatively small memory requirements. The results of a coupled calculation are presented and compared with the results of a fuselage solution. The wake structure is discussed, and the line of separation of the flow around the fuselage obtained using the coupled method is compared with the one obtained using the uncoupled method. C.D.

A90-51450#
PURSUIT OF THE HIGH-SPEED CIVIL TRANSPORT
R. T. CATHERS (Douglas Aircraft Co., Long Beach, CA) AIAA, Aerospace Engineering Conference and Show, Los Angeles, CA, Feb. 13-15, 1990. 11 p.
(AIAA PAPER 90-1814) Copyright

The role of aviation in transportation and its impact on society are traced with emphasis on supersonic flight developments and bariers to, and benefits of, a high-speed civil transport (HSCT). The goal of the HSCT is to match the range capability of the subsonics of the 1960s with the time savings made possible by supersonic cruising speeds. The development and testing of various aircraft from 1942 through 1965 is reviewed, pointing out that NACA (the predecessor of NASA), as well as many civilian companies, participated in high-speed aircraft research during this time. The period of U.S. supersonic commercial transports from 1958 through 1971 is outlined, citing the nine companies involved in serious investigations of a feasible supersonic transport (SST) at that time. Reviews are also given of SST R&D in Great Britain (1957-1990), France (1960-1990), and the USSR (1960-1990). Possible avenues for future developments are discussed. L.K.S.

A90-51899#
UNMANNED HELICOPTERS FOR BATTLEFIELD AND MARITIME SURVEILLANCE
HOLGER SCHUETTE and KLAUS BENDER Dornier Post (ISSN 0012-5563), no. 3, 1990, p. 11-13.
Copyright

The design, development, and testing of a demonstrator for a future battlefield surveillance and target acquisition system called Geamos is presented. This demonstrator consists of an unmanned rotorcraft with a moving target indication (MTI) radar, a telemetry/telecommand station, a pilot control station, and an MTI radar station. The telemetry/command station houses the datalink components and can accommodate and display all the digital data emanating from both the helicopter and ground stations. Successful test flights were conducted in 1989. The operational Geamos will be compact and designed for minimum IR signatures and radar. Specifications for an unmanned ship-based target acquisition system are also being developed. Tests for this Seamos system will utilize a platform which can simulate a ship's rolling, heaving, and pitching motions and which carries the positioning sensor on a lateral outrigger to create realistic test conditions. R.E.P.

A90-52574
AVIATION WEEK EDITOR FLIES TOP SOVIET INTERCEPTOR
DAVID M. NORTH Aviation Week and Space Technology (ISSN 0005-2175), vol. 133, Sept. 24, 1990, p. 32-35, 41.
Copyright

The managing editor of Aviation Week was allowed to fly the Su-27 and MiG-29, the most advanced Soviet fighters, exhibiting a superb blend of aerodynamic design with high-thrust, reliable engines, and he describes his experience. He notes that the Su-27 has excellent maneuvering capability and slow-speed handling characteristics. The cockpit instrumentation, very similar in design for both interceptors, lacks computer and system integration technology, which is a disadvantage in terms of situation awareness. The Su-27 is equipped with a four-channel analog fly-by-wire flight control system with its own computer and air data source mounted on the fuselage. Both Su-27 and the MiG-29 incorporate simplicity of design and less complex technology than their Western counterparts to allow operation in all environments. There has been a trend to make these aircraft and components more durable than their forerunners. B.P.

N90-28513# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.
AERODYNAMICS OF COMBAT AIRCRAFT CONTROLS AND OF GROUND EFFECTS
Apr. 1990 337 p In ENGLISH and FRENCH Symposium held in Madrid, Spain, 2-5 Oct. 1989
(AGARD-CP-465; ISBN-92-835-0555-7; AD-A223680) Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

An updated review is provided for the aerodynamic design of controls for combat aircraft. The scope included the aerodynamic design of controls for take-off and landing conditions; for maneuvering at subsonic, transonic, and supersonic speeds; for high angles of attack and yaw; and for departure prevention and post-stall maneuvering. Ground effects; computational experimental methods; and jet effects on flow-field forces and intake flows were also reviewed.

N90-28514# Wright Research Development Center, Wright-Patterson AFB, OH.
AERODYNAMIC AND PROPULSIVE CONTROL DEVELOPMENT OF THE STOL AND MANEUVER TECHNOLOGY DEMONSTRATOR
DAVID J. MOORHOUSE, JAMES A. LAUGHREY, and RICHARD W. THOMAS (McDonnell Aircraft Co., Saint Louis, MO.) *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 23 p Apr. 1990
Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The STOL and Maneuver Technology Demonstrator (S/MTD) program was structured to investigate, develop, and validate through analysis, experiment, and test flight, four specific technologies related to providing current and future high performance fighters with both STOL capability and enhanced combat mission performance. The four technologies are: two-dimensional thrust vectoring and reversing exhaust nozzle; integrated flight propulsion control (IFPC) system; advanced pilot vehicle interface (PVI) and rough/soft field landing gear. In addition to the required technologies, all-moving canard surfaces were also incorporated into the baseline F-15B. Starting with an existing aircraft, wind tunnel tests were performed to define the incremental effects of the specific technology items. A single data base was defined that was used by all the different functional design groups. The components of most interest are the canard and jet effects, both in and out of ground effects, and their use as control effectors. The intent is to present the progress of the S/MTD configuration towards meeting its goals. First, the design requirements and their rationale are discussed. Second, the aerodynamics of the canard and jet effects of vectoring and reversing are discussed followed by their implementation and impact on the control system. Ground effects with and without reversing are discussed, including a comparison of static and moving model test approaches. The results of a test to define inlet ingestion are presented. Then the control laws to counter the ground effects are discussed. Lastly, some preliminary flight test correlations are presented. Author

N90-28519# Technische Univ., Brunswick (Germany, F.R.). Institut fuer Stroemungsmechanik.
EFFECTS OF CANARD POSITION ON THE AERODYNAMIC CHARACTERISTICS OF A CLOSE-COUPLED CANARD CONFIGURATION AT LOW SPEED
D. HUMMEL and HANS-CHRISTOPH OELKER *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 18 p Apr. 1990
(Contract DFG-HU-254/8)
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Comprehensive wing-tunnel investigations were carried out on a close-coupled A = 2.31 delta-canard configuration at low speed. Based on three-component, surface pressure, and flowfield measurements as well as on oilflow patterns, the flow about the coplanar normal configuration may be regarded as well understood. Three parameters describing the position of the canard relative to the wing were varied systematically within certain limits: vertical distance (3 locations: high, coplanar, low), longitudinal distance (3 locations: front, mid, rear), and canard setting angle (-12 deg is less than or equal to epsilon is less than or equal to 12 deg). The results of three-component measurements are presented and the corresponding flow structure is analyzed by means of pressure distribution measurements and oilflow patterns. For a large variety of parameter combinations in the vicinity of the normal configuration the same state of the flow with two separate vortex systems for canard and wing was found, and the effects of different canard positions relative to the wing on the aerodynamic coefficients could be explained by this mechanism. For low canard positions and large setting angles, however, the formation of vortices on the lower surface of the wing as well as the merging of the canard vortices with the wing vortex system on the upper surface was observed. This flow structure leads to abrupt changes in the aerodynamic coefficients which are unacceptable for practical flight conditions. Author

N90-28520# Royal Aerospace Establishment, Bedford (England). Dept. of Aerodynamics.
THE EFFECTS OF FOREPLANES ON THE STATIC AND DYNAMIC CHARACTERISTICS OF A COMBAT AIRCRAFT MODEL
C. O. OLEARY and B. WEIR *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 13 p Apr. 1990
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On a close coupled canard configuration there are strong aerodynamic interactions between the forebody, foreplanes, and wings which are likely to affect both the longitudinal characteristics and the lateral/directional stability of the aircraft, especially at high angle-of-attack. The nature and strength of these interactions is likely to depend on the planform and deflection of the foreplanes. Tests were made to investigate these effects on the RAE HIRM2 model in the 4 x 2.7 m Low Speed Wind Tunnel. The model was tested with trapezoidal and gothic foreplanes on a static force balance and on a lateral oscillatory rig. Effects on lift and pitching moment were similar for the different types of foreplane. There were significant effects on lateral and directional stability due to foreplane and foreplane deflection. Author

N90-28523# Stanford Univ., CA. Dept. of Aeronautics and Astronautics.

CONTROL OF VORTEX AERODYNAMICS AT HIGH ANGLES OF ATTACK

L. ROBERTS and N. J. WOOD (Bath Univ., England) *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 9 p Apr. 1990

(Contract F49620-86-10-0020)

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The concept of tangential leading edge blowing was investigated as a means of controlling the vortical flow over delta wings at high angles of attack. At pre-stall angles of attack, tangential leading edge blowing exerts rapid control of the vertical flow and can control or impose asymmetries with either leading edge influence uncoupled from the other. At post-stall angles of attack, the response of the vortical flow to transient blowing is slower due to the presence of vortex burst. However, a burst vortex may be unburst by tangential leading edge blowing and significant rolling moments produced at conditions where conventional controls are ineffective. At these very high angles of attack, the left and right side vortical flows appear to be strongly coupled. Author

N90-28524# Wright Research Development Center, Wright-Patterson AFB, OH.

A LOOK AT TOMORROW TODAY

LAWRENCE A. WALCHLI *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 10 p Apr. 1990

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A broad overview of the X-29 forward swept wing technology demonstrator traces its development and test path during the past five years. Brief descriptions of the aircraft and its flight control system provide insight for evaluating this vehicle. Results are presented in several key technical areas and some general comparisons are made with current frontline fighters. The baseline flight control system provided a starting point for safe concept evaluation and envelope expansion for the aircraft. Subsequent up-dates resulted in performance levels favorably comparable to current fighter aircraft. Plans are cited for expanding the X-29's capabilities into the high angle-of-attack regime of flight. Aircraft and flight control system modifications are described which will permit the X-29 to fully exploit its technologies. Author

N90-28526# Royal Aerospace Establishment, Bedford (England). Dept. of Aerodynamics.

THE STEADY AND TIME-DEPENDENT AERODYNAMIC CHARACTERISTICS OF A COMBAT AIRCRAFT WITH A DELTA OR SWEPT CANARD

D. G. MABEY, B. L. WELSH, and C. R. PYNE *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 13 p Apr. 1990

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The steady and time-dependent aerodynamic characteristics for a low speed half model of a typical combat aircraft configuration fitted with a 65 deg delta canard are compared with those for the same model fitted with a 44.3 deg swept canard. The tests were made in the RAE 13 x 9 ft wind tunnel on a large model of the RAE High Incidence Research Model (HIRM 1), modified to represent the Experimental Aircraft (EAP) configuration. For the same platform area, the delta canard gives higher lift and comparable pitching moments for trimming. For canard and wing buffeting the differences are small. The pressures induced on the wing by oscillation of either the delta or the swept canard are very small and comparable. Overall, these low speed measurements suggest that delta canards might have advantages for future combat aircraft. Author

N90-28527# Imperial Coll. of Science and Technology, London (England). Dept. of Aeronautics.

THE EFFECT OF RAPID SPOILER DEPLOYMENT ON THE TRANSIENT FORCES ON AN AEROFOIL

P. W. BEARMAN, J. M. R. GRAHAM, and P. KALKANIS *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 11 p Apr. 1990

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The Discrete Vortex Method (DVM) is used to simulate the two-dimensional separated flow generated by a spoiler over the upper surface of an airfoil. Cases of fixed and moving spoilers are presented and particular attention is paid to the phenomenon of short duration adverse lift which can be induced by rapid spoiler deployment. Forces and pressure distributions on the airfoil and spoiler are calculated and compared, where possible, with experimental results. The model that was developed predicts the delay times to maximum adverse lift at very high spoiler deployment rates, as well as allowing the forces on the airfoil and the spoiler to be computed separately. Numerical results are in good agreement with the experiment. Author

N90-28528# Dornier-Werke G.m.b.H., Friedrichshafen (Germany, F.R.).

INFLIGHT THRUST VECTORING: A FURTHER DEGREE OF FREEDOM IN THE AERODYNAMIC/FLIGHT MECHANICAL DESIGN OF MODERN FIGHTER AIRCRAFT

P. MANGOLD and G. WEDEKIND *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 17 p Apr. 1990

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Two different aspects of inflight thrust vectoring are discussed. In the first, more general part a rationale for the future use of thrust deflection including reverser modes is given by highlighting the overall possibilities and the potential of thrust vector devices within the aerodynamic/flight mechanical design of modern fighters. In the second part the most interesting results from 3 low speed wind tunnel test periods is presented showing beneficial and detrimental effects of in-flight thrust reverse on aerodynamic stability and control characteristics. Author

N90-28529# Dornier-Werke G.m.b.H., Friedrichshafen (Germany, F.R.).

AERODYNAMIC INTERFERENCES OF IN-FLIGHT THRUST REVERSERS IN GROUND EFFECT

G. WEDEKIND and P. MANGOLD *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 9 p Apr. 1990

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Overall design studies for future fighter aircraft have shown that it may be desirable or even necessary to install an in-flight thrust reversing mode during approach and landing in order to fulfill the growing requirements for optimum mission, maneuver, and point performance. With this device an additional optimization task is introduced into the aerodynamic design process, because

adverse aerodynamic interference effects have to be avoided. The problems related to approach and landing may roughly be divided into two main subjects. Reingestion of the hot exhaust gases into the inlet of the engines has to be retarded. Detrimental aerodynamic interferences in terms of abrupt changes of the aerodynamic forces and moments are not tolerable, because the controllability of the aircraft has to be guaranteed within the whole approach and landing phase. In a close cooperation between Dornier and Northrop a design study for a twin engine fighter equipped with an in-flight thrust-reverser (N/D-102) was performed. During this period several low speed wind tunnel test phases were run in order to study the principal effects of such a device. Test results including force measurements are summarized, flow visualization is presented, and some design rules for a reverser system are derived. To illustrate a possible optimization procedure the most interesting results of the two test periods are presented and discussed.
Author

N90-28530# Centre d'Essais Aeronautique Toulouse (France).
STUDY OF THE GROUND EFFECTS IN THE CEAT AEROHYDRODYNAMIC TUNNEL: USING THE RESULTS [ETUDE DE L'EFFET DE SOL AU CEAT EXPLOITATION DES RESULTATS]
GEORGES VIDAL and JACQUES DESCHAMPS (Avions Marcel Dassault-Breguet Aviation, Merignac, France) *In* AGARD, Aerodynamics of Combat Aircraft Control and of Ground Effects 33 p Apr. 1990 In FRENCH; ENGLISH summary
Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Since 1979, the Aero-Hydrodynamic Tunnel (AHT) of CEAT Toulouse is equipped with a faired platform powered by an electrical linear induction motor enabling a maximum speed of 40 m/s. This method is chiefly used in aerodynamic tests to analyze the aircraft behavior in ground effect. The purpose is to show the equipment and facilities used for the ground effect tests, and to provide measurement data. For aircraft manufacturers it is essential to know the effects of ground proximity on the aerodynamics of the wing. The ground effect was studied on a Falcon 900 model (scale 1/10) at the AHT of Toulouse. Results show that ground effect increases the lift coefficient and the pitching moment (nose down) for usual angle-of-attack. In the same way the drag decreases and the lift-to-drag ratio increases as the wing approaches the ground. On the contrary, stall C1 and stall angle-of-attack decrease in the ground effect. Numerical computation of pressure distribution by a panel method shows that on a wing profile the ground effect increases the pressure on the lower surface and decreases the pressure on the forward part ot the upper surface. The overall result of ground effect is an increase in normal force. The computational results are in good agreement with the test results obtained at the Aero-Hydrodynamic Tunnel.
Author

N90-28531*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DYNAMIC GROUND EFFECTS
JOHN W. PAULSON, JR., GUY T. KEMMERLY, and WILLIAM P. GILBERT *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 12 p Apr. 1990
Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive CSCL 01/3

A research program is underway at the NASA Langley Research Center to study the effect of rate of descent on ground effects. A series of powered models were tested in the Vortex Research Facility under conditions with rate of descent and in the 14 x 22 Foot Subsonic Tunnel under identical conditions but without rate of descent. These results indicate that the rate of descent can have a significant impact on ground effects particularly if vectored or reversed thrust is used.
Author

N90-28532# Institut de Mecanique des Fluides de Lille (France).
STUDY OF GROUND EFFECTS ON FLYING SCALED MODELS [ETUDE DE L'EFFET DE SOL SUR MAQUETTE EN VOL]
J. L. COCQUEREZ, P. COTON, and R. VERBRUGGE *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 11 p Apr. 1990 In FRENCH; ENGLISH summary Sponsored by Direction des Recherches, Etudes et Techniques
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The Institute of Fluid Mechanics of Lille (IFML), an establishment of ONERA, has developed for many years specific experimental methods based on the exploitation of flying scaled models in the laboratory. These methods are especially used to characterize and model the aircraft flight qualities in a disturbed or undisturbed environment. The methods were applied to ground effect studies in order to get a better control on approach and landing phases. The experimental technique and facilities are especially well adapted to this kind of study: realistic representation of the aircraft behavior and the involved aerodynamic phenomena (ground representation, no support interference, incompressible flow, and well-known environment); high accuracy on weight, inertia, and structural characteristics of the model; flight test data obtained through redundant measurements which allow an optimal evaluation of the state variables and the dynamic coefficients; application of parameters identification techniques widely complementary with low speed wind tunnel and other moving model techniques; and abilities to illustrate static and dynamic ground effect. The experimental techniques are emphasized. Some experimental results on ground effects, especially dynamic ones, are presented. The future developments of the mathematical modeling of the aircraft longitudinal behavior are also mentioned. Some ideas are suggested concerning aircraft on carrier or landing with atmospheric disturbances.
Author

N90-28533*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
AN IN-FLIGHT INVESTIGATION OF GROUND EFFECT ON A FORWARD-SWEPT WING AIRPLANE
ROBERT E. CURRY, BRYAN J. MOULTON, and JOHN KRESSE *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 11 p Apr. 1990 Previously announced as N90-14202
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A limited flight experiment was conducted to document the ground effect characteristics of the X-29A research aircraft. This vehicle has an aerodynamic platform which includes a forward-swept wing and close-coupled, variable incidence canard. The flight-test program obtained results for errors in the air data measurement and for incremental normal force and pitching moment caused by ground effect. Correlations with wind-tunnel and computational analyses were made. The results are discussed with respect to the dynamic nature of the flight measurements, similar data from other configurations, and pilot comments. The ground effect results are necessary to obtain an accurate interpretation of the vehicle's landing characteristics. The flight data can also be used in the development of many modern aircraft systems such as autoland and piloted simulation.
Author

N90-28534# Aerospatiale, Toulouse (France).
DETERMINATION OF THE GROUND EFFECT ON THE CHARACTERISTICS OF THE A320 AIRCRAFT [DETERMINATION DE L'EFFET DE SOL SUR LES CARACTERISTIQUES DE L'AVION A320]
A. CONDAMINAS and J. P. BECLE (Office National d'Etudes et de Recherches Aerospatiales, Modane, France) *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 12 p Apr. 1990 In FRENCH; ENGLISH summary Previously announced in IAA as A90-21048

 Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The ground effect on the aerodynamic response of the A320 is investigated experimentally using a 1:7.6-scale model equipped with two motorized nacelles in the S1 wind tunnel at ONERA Modane-Avrieux. The design and instrumentation of the model are described; the measurement apparatus and procedures are explained; and the results are presented in extensive graphs and characterized in detail. Particular attention is given to the treatment of the floor boundary layer and the corrections for the side walls and model support in the data analysis. Good general agreement with flight-test data is demonstrated with respect to life and mean deflection; the airspeed errors are found to be comparable to the precision of the pressure sensors. Author

N90-28535 Kansas Univ., Lawrence.
LIFE CYCLE COST IN THE CONCEPTUAL DESIGN OF SUBSONIC COMMERCIAL AIRCRAFT, VOLUMES 1 AND 2 Ph.D. Thesis
VICKI S. JOHNSON 1989 391 p
Avail: Univ. Microfilms Order No. DA9009907

A methodology was developed which makes it possible to identify an aircraft concept that will meet the mission requirements and have the lowest life cycle cost (LCC). Provision is made in the methodology for sensitivities to advanced technologies to also be investigated. The methodology consists of: (1) a LCC module composed of elements to calculate RDT&E (research, development, testing, and evaluation) cost, production cost, DOC (direct operating cost), and IOC (indirect operating cost); and (2) an existing conceptual design and analysis code, the Flight Optimization System (FLOPS). Using this methodology, a configuration can be optimized for minimum life cycle cost, direct operating cost, or acquisition cost, in addition to minimum takeoff gross weight (TOGW), fuel burned, or maximum range. Use of the methodology on short-, medium-, and medium-to-long range subsonic commercial aircraft has demonstrated that optimization parameter has a definite effect on the aircraft; optimizing for minimum LCC results in a different airplane than when optimizing for minimum TOGW, fuel burned, DOC, or acquisition cost. Additionally, the economic assumptions can have a strong impact on the configurations optimized for minimum LCC or DOC. Also, results show that advanced technology can be worthwhile, even if it results in higher manufacturing and operating costs.
Dissert. Abstr.

N90-28536 Virginia Polytechnic Inst. and State Univ., Blacksburg.
SYSTEM RELIABILITY OPTIMIZATION OF AIRCRAFT WINGS Ph.D Thesis
JU-SUNG YANG 1989 96 p
Avail: Univ. Microfilms Order No. DA9013527

System reliability based design of aircraft wings is studied. A wing of a light commuter aircraft designed according to the FAA regulations is compared with one designed by system reliability optimization. Both the level 3, and the advanced first order, second moment (AFOSM) method are employed to evaluate the probability of failure of each failure element of the system representing the wing. In the level 3 method the statistical correlation between failure modes is neglected. The AFOSM method allows evaluation of the sensitivity derivatives of the system safety index analytically. Furthermore, it accounts for the statistical correlation between failure modes. The results demonstrate the potential of stochastic optimization, and the importance of accounting for the statistical correlation between failure modes. Finally, it is shown that the problem associated with discontinuity of sensitivity derivatives encountered when using second order Ditlevsen upper bounds to estimate the system failure probability, is circumvented if a penalty function method is used for optimization. Dissert. Abstr.

N90-28537*# Boeing Commercial Airplane Co., Seattle, WA.
HIGH-SPEED CIVIL TRANSPORT STUDY: SPECIAL FACTORS Final Report, Sep. 1986 - Nov. 1988
Sep. 1990 126 p
(Contract NAS1-18377)
(NASA-CR-181881; NAS 1.26:181881) Avail: NTIS HC A07/MF A01 CSCL 01/3

Studies relating to environmental factors associated with high speed civil transports were conducted. Projected total engine emissions for year 2015 fleets of several subsonic/supersonic transport fleet scenarios, discussion of sonic boom reduction methods, discussion of community noise level requirements, fuels considerations, and air traffic control impact are presented.
Author

N90-28538# Aeronautical Research Inst. of Sweden, Stockholm. Dept. of Structures.
DAMAGE TOLERANCE OF THE FIGHTER AIRCRAFT 37 VIGGEN. PART 1: ANALYTICAL ASSESSMENT
BJORN PALMBERG, PER-OLOF BOMAN, MATS-OLOF OLSSON, and ANDERS F. BLOM 25 Feb. 1990 12 p Presented at FATIGUE 1990, Honolulu, HI, 15-20 Jul. 1990 Sponsored by Defence Materiel Administration, Stockholm, Sweden
(FFA-TN-1990-12-PT-1; ETN-90-97510) Avail: NTIS HC A03/MF A01

The analytical part of an extensive damage tolerance evaluation of the fighter aircraft 37 Viggen is presented. The complementing experimental investigation is discussed in the companion paper. Topics addressed include load spectra, stress analysis, fracture mechanics and fatigue crack propagation. The following conclusions are made: the methodology used is verified and is state of the art; damage tolerance is analytically proven and experimentally demonstrated; extension of the original design life is currently being considered. ESA

N90-28539# Aeronautical Research Inst. of Sweden, Stockholm. Dept. of Structures.
DAMAGE TOLERANCE OF THE FIGHTER AIRCRAFT 37 VIGGEN. PART 2: EXPERIMENTAL VERIFICATION
MATS-OLOF OLSSON, PER-OLOF BOMAN, BJORN PALMBERG, and ANDERS F. BLOM 20 Mar. 1990 19 p Presented at FATIGUE 1990, Honolulu, HI, 15-20 Jul. 1990 Sponsored by Defence Materiel Administration, Stockholm, Sweden
(FFA-TN-1990-13-PT-2; ETN-90-97511) Avail: NTIS HC A03/MF A01

An experimental test program carried out within a larger damage tolerance evaluation of the fighter aircraft 37 Viggen is presented. The analytical part of the work is described in the companion paper. Emphasis is put on full scale spectrum testing of both a fighter version main wing attachment frame as well as the fin of the same aircraft version. The following conclusions are made: the tested components are damage tolerant during their original fail safe design lives; analytical methodology is verified both in terms of global and local stress levels and spectrum fatigue crack growth prediction capability; extended usage of this aircraft may be possible following further considerations. ESA

N90-28540*# Stanford Univ., CA.
THE AERODYNAMIC DESIGN OF THE OBLIQUE FLYING WING SUPERSONIC TRANSPORT
ALEXANDER J. M. VANDERVELDEN and ILAN KROO Jun. 1990 69 p
(Contract NCA2-343)
(NASA-CR-177552; A-90168; NAS 1.26:177552) Avail: NTIS HC A04/MF A01 CSCL 01/3

The aerodynamic design of a supersonic oblique flying wing is strongly influenced by the requirement that passengers must be accommodated inside the wing. It was revealed that thick oblique wings of very high sweep angle can be efficient at supersonic speeds when transonic normal Mach numbers are allowed on the upper surface of the wing. The goals were motivated by the ability to design a maximum thickness, minimum size oblique flying wing. A 2-D Navier-Stokes solver was used to design airfoils up to 16 percent thickness with specified lift, drag and pitching moment. A new method was developed to calculate the required pressure distribution on the wing based on the airfoil loading, normal Mach

number distribution and theoretical knowledge of the minimum drag of oblique configurations at supersonic speeds. The wing mean surface for this pressure distribution was calculated using an inverse potential flow solver. The lift to drag ratio of this wing was significantly higher than that of a comparable delta wing for cruise speeds up to Mach 2. Author

N90-28541*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NASA LANGLEY RESEARCH CENTER NATIONAL AERO-SPACE PLANE MISSION SIMULATION PROFILE SETS
CRAIG W. OHLHORST, WALLACE L. VAUGHN, and JOHN J. BRESINA (National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.) Oct. 1990 18 p
(NASA-TM-102670; NAS 1.15:102670) Avail: NTIS HC A03/MF A01 CSCL 01/3

To provide information on the potential for long life service of oxidation resistant carbon-carbon (ORCC) materials in the National Aero-Space Plane (NASP) airframe environment, NASP ascent, entry, and cruise trajectories were analytically flown. Temperature and pressure profiles were generated for 20 vehicle locations. Orbital (ascent and entry) and cruise profile sets from four locations are presented along with the humidity exposure and testing sequences that are being used to evaluate ORCC materials. The four profiles show peak temperatures during the ascent leg of an orbital mission of 2800, 2500, 2000, and 1700 F. These profiles bracket conditions where carbon-carbon might be used on the NASP vehicle. Author

N90-28542*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
VALIDATION OF THE F-18 HIGH ALPHA RESEARCH VEHICLE FLIGHT CONTROL AND AVIONICS SYSTEMS MODIFICATIONS
VINCE CHACON, JOSEPH W. PAHLE, and VICTORIA A. REGENIE Oct. 1990 13 p Presented at the IEEE 9th Digital Avionics Systems Conference, Virginia Beach, VA, 15-18 Oct. 1990
(NASA-TM-101723; H-1632; NAS 1.15:101723) Avail: NTIS HC A03/MF A01 CSCL 01/3

The verification and validation process is a critical portion of the development of a flight system. Verification, the steps taken to assure the system meets the design specification, has become a reasonably understood and straightforward process. Validation is the method used to ensure that the system design meets the needs of the project. As systems become more integrated and more critical in their functions, the validation process becomes more complex and important. The tests, tools, and techniques which are being used for the validation of the high alpha research vehicle (HARV) turning vane control system (TVCS) are discussed and the problems and their solutions are documented. The emphasis of this paper is on the validation of integrated system. Author

N90-29381*# Notre Dame Univ., IN. Dept. of Aerospace and Mechanical Engineering.
THE DELTA MONSTER: AN RPV DESIGNED TO INVESTIGATE THE AERODYNAMICS OF A DELTA WING PLATFORM Final Design Proposal
KRISTEN CONNOLLY, MIKE FLYNN, RANDY GALLAGHER, CHRIS GREEK, MARC KOZLOWSKI, BRIAN MCDONALD, MATT MCKENNA, RICH SELLAR, and ANDY SHEARON 1989 172 p
(Contract NASW-4435)
(NASA-CR-186226; NAS 1.26:186226) Avail: NTIS HC A08/MF A01 CSCL 01/3

The mission requirements for the performance of aerodynamic tests on a delta wind planform posed some problems, these include aerodynamic interference; structural support; data acquisition and transmission instrumentation; aircraft stability and control; and propulsion implementation. To eliminate the problems of wall interference, free stream turbulence, and the difficulty of achieving dynamic similarity between the test and actual flight aircraft that are associated with aerodynamic testing in wind tunnels, the concept of the remotely piloted vehicle which can perform a basic aerodynamic study on a delta wing was the main objective for the Green Mission - the Delta Monster. The basic aerodynamic studies were performed on a delta wing with a sweep angle greater than 45 degrees. These tests were performed at various angles of attack and Reynolds numbers. The delta wing was instrumented to determine the primary leading edge vortex formation and location, using pressure measurements and/or flow visualization. A data acquisition system was provided to collect all necessary data. B.G.

N90-29382 Maryland Univ., College Park.
NONLINEAR STATIC AND DYNAMIC MODELING OF COMPOSITE ROTOR BLADES INCLUDING WARPING EFFECTS Ph.D. Thesis
ALAN DOUGLAS STEMPLE 1989 195 p
Avail: Univ. Microfilms Order No. DA9012524

A beam finite element formulation was developed to model helicopter rotor blades constructed of composite materials. The present formulation takes into account the warping effects of composite beams undergoing large deflections. This formulation can handle static and free vibration analysis of both rotating and non-rotating composite beams. The new approach can model thin to moderately thick walled beams with complicated cross-sections, tapers, planforms and pretwists. The formulation allows transverse shear deformation. The warping displacement parallel to the beam axis in the deformed configuration is superimposed over the cross-section. The strain is assumed to vary linearly through the thickness of the wall. This allows analytical integration through the thickness direction for arbitrary ply layups. The Fixed or Total Lagrangian description is adopted for the large deflection analysis. A body fixed system is used to describe the finite rotations. The natural modes and frequencies of both rotating and non-rotating composite beams are calculated using a subspace iteration technique. A comparative study with more elaborate finite element models is presented as well as correlation with experimental observations. Many numerical tests are presented, showing various features of the present analysis. Beams involving the various structural couplings, bending-torsion, extension-torsion and extension-bending, are examined. Correlation of numerical tests with shell and three-dimensional solid element formulations, as well as experimental results, demonstrate the validity and effectiveness of the present approach. Dissert. Abstr.

N90-29383*# Analytical Services and Materials, Inc., Hampton, VA.
AN ENHANCED INTEGRATED AERODYNAMIC LOAD/DYNAMIC OPTIMIZATION PROCEDURE FOR HELICOPTER ROTOR BLADES Final Report
ADITI CHATTOPADHYAY and Y. DANNY CHIU (Lockheed Engineering and Sciences Co., Hampton, VA.) Washington NASA Oct. 1990 17 p Presented at the 46th Annual Forum of the American Helicopter Society, Washington, DC, 21-23 May 1990
(Contract NAS1-18599; NAS1-19000)
(NASA-CR-4326; NAS 1.26:4326) Avail: NTIS HC A03/MF A01 CSCL 01/3

An enhanced integrated aerodynamic load/dynamic optimization procedure is developed to minimize vibratory root shears and moments. The optimization is formulated with 4/rev vertical and 3/rev inplane shears at the blade root as objective functions and constraints, and 4/rev lagging moment. Constraints are also imposed on blade natural frequencies, weight, autorotational inertia, centrifugal stress, and rotor thrust. The 'Global Criteria Approach' is used for formulating the multi-objective optimization. Design variables include spanwise distributions of bending stiffnesses, torsional stiffness, nonstructural mass, chord, radius of gyration, and blade taper ratio. The program CAMRAD is coupled with an optimizer, which consists of the program CONMIN and an approximate analysis, to obtain optimum designs. The optimization procedure is applied to an advanced rotor as a

reference design. Optimum blade designs, obtained with and without a constraint on the rotor thrust, are presented and are compared to the reference blade. Substantial reductions are obtained in the vibratory root forces and moments. As a byproduct, improvements are also found in some performance parameters, such as total power required, which were not considered during optimization. Author

N90-29384*# Lockheed Engineering and Sciences Co., Hampton, VA.
AIRCRAFT DESIGN FOR MISSION PERFORMANCE USING NONLINEAR MULTIOBJECTIVE OPTIMIZATION METHODS Final Report
AUGUSTINE R. DOVI and GREGORY A. WRENN Washington NASA Oct. 1990 29 p
(Contract NAS1-19000)
(NASA-CR-4328; NAS 1.26:4328) Avail: NTIS HC A03/MF A01 CSCL 01/3

A new technique which converts a constrained optimization problem to an unconstrained one where conflicting figures of merit may be simultaneously considered was combined with a complex mission analysis system. The method is compared with existing single and multiobjective optimization methods. A primary benefit from this new method for multiobjective optimization is the elimination of separate optimizations for each objective, which is required by some optimization methods. A typical wide body transport aircraft is used for the comparative studies. Author

N90-29385*# Technion Research and Development Foundation Ltd., Haifa (Israel).
MULTI-DISCIPLINARY OPTIMIZATION OF AEROSERVOELASTIC SYSTEMS Annual Report, 1 Oct. 1989 - 30 Sep. 1990
MORDECHAY KARPEL 12 Sep. 1990 31 p
(Contract NAGW-1708)
(NASA-CR-185931; NAS 1.26:185931) Avail: NTIS HC A03/MF A01 CSCL 01/3

Efficient analytical and computational tools for simultaneous optimal design of the structural and control components of aeroservoelastic systems are presented. The optimization objective is to achieve aircraft performance requirements and sufficient flutter and control stability margins with a minimal weight penalty and without violating the design constraints. Analytical sensitivity derivatives facilitate an efficient optimization process which allows a relatively large number of design variables. Standard finite element and unsteady aerodynamic routines are used to construct a modal data base. Minimum State aerodynamic approximations and dynamic residualization methods are used to construct a high accuracy, low order aeroservoelastic model. Sensitivity derivatives of flutter dynamic pressure, control stability margins and control effectiveness with respect to structural and control design variables are presented. The performance requirements are utilized by equality constraints which affect the sensitivity derivatives. A gradient-based optimization algorithm is used to minimize an overall cost function. A realistic numerical example of a composite wing *with four controls is used to demonstrate the modeling technique,* the optimization process, and their accuracy and efficiency. Author

N90-29386# Boston Univ., MA. Coll. of Engineering.
ANALYSIS OF DYNAMIC TRANSIENT RESPONSE AND POSTFLUTTER BEHAVIOR OF SUPER-MANEUVERING AIRPLANE Final Technical Report, 15 Apr. 1987 - 14 Aug. 1988
LUIGI MORINO and SLOBODAN R. SIPCIC 15 Aug. 1988 69 p
(Contract F49620-86-C-0040; AF PROJ. 2302)
(AD-A224126; AFOSR-90-0747TR) Avail: NTIS HC A04/MF A01

A general geometrically exact Lagrangian mechanics formulation for the aeroelastic analysis of a maneuvering aircraft is presented. The motion of the aircraft is expressed in terms of the location of the origin of the body frame of reference, the rigid body rotation of the body frame of reference, and a deformation. The Lagrangian equations of motion for the corresponding degrees of freedom were obtained. A formulation was specialized to the case of a fluttering buckled plate on an aircraft undergoing a pitching maneuver. Assuming that the maneuvering of the aircraft is prescribed, the Lagrange equations of motion for the elastic degree of freedom was derived. This equation was then used to study the response of the panel of an aircraft engaged in a pull-up maneuver. The large amplitude responses are investigated by using the digital computer. As the maneuvering (load factor) increases, systems exhibits complicated dynamic behavior including period multiplying and demultiplying bifurcations and chaos. Author

N90-29387# Dayton Univ., OH. Research Inst.
AIRCRAFT BATTLE DAMAGE REPAIR OF TRANSPARENCIES Interim Report, Oct. 1986 - Dec. 1988
SUSAN S. SALIBA Apr. 1990 61 p Submitted for publication
(Contract F33615-86-C-5031; AF PROJ. 2418)
(AD-A224168; WRDC-TR-89-4148) Avail: NTIS HC A04/MF A01 CSCL 11/4

Both induction heating and adhesive bonding techniques were used to perform rapid repairs on aircraft transparencies under 'field' conditions. Patches were applied on various plastic laminated materials and were tested both for air leak rate and structural durability (cockpit air pressure representing ground-air-ground cycles). GRA

N90-29389*# Kansas Univ., Lawrence. Dept. of Aerospace Engineering.
FIGHTER AGILITY METRICS M.S. Thesis
RANDALL K. LIEFER 1990 206 p Sponsored by NASA, Dryden Flight Research Center and AFIT, Wright-Patterson AFB, OH
(NASA-CR-187289; NAS 1.26:187289; AD-A224477;
AFIT/CI/CIA-90-035) Avail: NTIS HC A10/MF A02 CSCL 01/3

Fighter flying qualities and combat capabilities are currently measured and compared in terms relating to vehicle energy, angular rates and sustained acceleration. Criteria based on these measurable quantities have evolved over the past several decades and are routinely used to design aircraft structures, aerodynamics, propulsion and control systems. While these criteria, or metrics, have the advantage of being well understood, easily verified and repeatable during test, they tend to measure the steady state capability of the aircraft and not its ability to transition quickly from one state to another. Proposed new metrics to assess fighter aircraft agility are collected and analyzed. A framework for classification of these new agility metrics is developed and applied. A complete set of transient agility metrics is evaluated with a high fidelity, nonlinear F-18 simulation. Test techniques and data reduction methods are proposed. A method of providing cuing information to the pilot during flight test is discussed. The sensitivity of longitudinal and lateral agility metrics to deviations from the pilot cues is studied in detail. The metrics are shown to be largely insensitive to reasonable deviations from the nominal test pilot commands. Instrumentation required to quantify agility via flight test is also considered. With one exception, each of the proposed new metrics may be measured with instrumentation currently available. GRA

N90-29390# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
WINGDESIGN: PROGRAM FOR THE STRUCTURAL DESIGN OF A WING CROSS-SECTION
R. P. G. ZOONTJES and A. ROTHWELL Apr. 1990 15 p
(LR-627; ETN-90-97638) Avail: NTIS HC A03/MF A01

A computer program written in FORTRAN 77 for the structural design of a wing cross section is described. The program is typically intended for use at the preliminary design stage. The wing is assumed to be of conventional metal stressed-skin construction, with two spar webs. The analysis of a proposed design may be followed by optimization for minimum weight. Easy modification of the design, and the facility to fix any of its dimensions at any stage, allows the user to remain in control of the progress of the

design. The program is suitable for use on a personal computer. ESA

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A90-49879
THE OPERATIONAL LOADS MONITORING SYSTEM (OLMS)
H.-J. MEYER and V. LADDA (MBB Transport Aircraft Group, Bremen, Federal Republic of Germany) IN: Aeronautical fatigue in the electronic era; Proceedings of the Fifteenth ICAF Symposium, Jerusalem, Israel, June 21-23, 1989. Warley, England, Engineering Materials Advisory Services, Ltd., 1989, p. 65-80. refs
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The Operational Load Monitoring System (OLMS) is the on-board equipment for the prospected Airframe Condition Monitoring Procedure (ACMP). OLMS is an electronic device to be fitted on aircraft in airline service. The outstanding OLMS feature is to calculate which will be reduced instantly to frequency distributions. The OLMS input data will be received from advanced avionic systems providing full information about the actual operational condition. So OLMS is the tool for the Airline Service Data Collection as the first step in the Airframe Condition Monitoring Procedure which takes care of damage tolerance qualities and will increase the efficiency of structural inspections. Author

A90-49880
TRACKING B-1B AIRCRAFT WITH A STRUCTURAL DATA RECORDER
A. G. DENYER (Rockwell International Corp., El Segundo, CA) IN: Aeronautical fatigue in the electronic era; Proceedings of the Fifteenth ICAF Symposium, Jerusalem, Israel, June 21-23, 1989. Warley, England, Engineering Materials Advisory Services, Ltd., 1989, p. 81-102. refs
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As part of the USAF Aircraft Structural Integrity Program, an Individual Aircraft tracking (IAT) system has been developed for the B-1B aircraft. The IAT program accumulates and analyzes operational usage statistics and load spectra data from each aircraft in the fleet, in order to predict the current structural damage status at selected critical structural locations. The IAT analysis provides the data from which structural inspections, repairs and replacements are defined and scheduled. Author

A90-49882
EIGHT YEARS OF EXPERIENCE WITH SMALL COMPUTERIZED RETROFIT LOAD MONITORING SYSTEMS
B. BRUNNER (Eidgenoessische Flugzeugwerk, Emmen, Switzerland) and R. KAESER (Zuerich, Eidgenoessische Technische Hochschule, Zurich; Kaeser Engineering, Ltd., Switzerland) IN: Aeronautical fatigue in the electronic era; Proceedings of the Fifteenth ICAF Symposium, Jerusalem, Israel, June 21-23, 1989. Warley, England, Engineering Materials Advisory Services, Ltd., 1989, p. 143-172. refs
Copyright

Experiences with the development and operation of a one-channel load monitoring system are presented. Environmental effects on monitoring system and strain gage are reported. Attention is paid to the use of counting methods, class width and hysteresis. Outputs of measurements on a commercial aircraft are shown as rainflow matrices, exceedance plots and strain histories. Load monitoring with an improved system is presented which is used for fleet monitoring of military aircraft as a basis for inspection intervals and service life. Furthermore critical locations are investigated with a strain tracking program. Author

A90-49891
APPLICATION OF THE 'K-GAGE' TO AIRCRAFT STRUCTURAL TESTING
S. MIYAKE (Japan Defense Agency, 3rd Research and Development Center, Tokyo), Y. NAWA (Kawasaki Heavy Industries, Ltd., Aircraft Div., Japan), Y. KONDO, and T. ENDO (Mitsubishi Heavy Industries, Ltd., Takasago Research and Development Center, Japan) IN: Aeronautical fatigue in the electronic era; Proceedings of the Fifteenth ICAF Symposium, Jerusalem, Israel, June 21-23, 1989. Warley, England, Engineering Materials Advisory Services, Ltd., 1989, p. 369-394. refs
Copyright

The K-gage was developed for the purpose of providing a capability to directly measure the stress intensity factor (K value) at the crack tip on a structure's surface. To apply the K-gage to aircraft structural testing, verification tests were implemented, and it was confirmed that the K-gage is applicable for such tests. On the other hand, the development project of the intermediate jet trainer (XT-4) was in progress, and durability and damage tolerance tests were implemented using a full scale test article. In this damage tolerance testing, the K-gage was applied to the cracks which existed in the test article, and the stress intensity factor was measured. Author

A90-51058
THE MAST MOUNTED SIGHT 771 PROCESSOR UPGRADE PROGRAM
LOUIS M. TIBERIA (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: 1989 IEEE Aerospace Applications Conference, Breckenridge, CO, Feb. 12-17, 1989, Conference Digest. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, 8 p.
Copyright

The 771 microprocessor is used as the main control processor for the Mast Mounted Sight (MMS) on the OH-58A helicopter for the U.S. Army Advanced Helicopter Improvement Program. The 771 and its test-set development system were designed in January 1977. These 10-year-old designs currently have a wide range of problems in production, test, and software development. To increase system performance, lower manufacturing costs, and improve software development efforts, an upgraded 771 processor and development system has been developed. The new processor, the 771C, is implemented using application-specific integrated circuits and VLSI technology. The 771C increases memory and I/O capability, reduces board and part counts, and increases throughput by up to 73 percent. I.E.

A90-51658 National Aeronautics and Space Administration, Washington, DC.
THE METEOROLOGICAL MEASUREMENT SYSTEM ON THE NASA ER-2 AIRCRAFT
STAN G. SCOTT, T. PAUL BUI, K. ROLAND CHAN (NASA, Ames Research Center, Moffett Field, CA), and STUART W. BOWEN (San Jose State University, CA) Journal of Atmospheric and Oceanic Technology (ISSN 0739-0572), vol. 7, Aug. 1990, p. 525-540. Research supported by NASA. refs
Copyright

A Meteorological Measurement System (MMS) was designed and installed on one of the NASA high-altitude ER-2 aircraft (NASA 706). The MMS provides in situ measurements of free-stream pressure (+ or - 0.3 mb), temperature (+ or - 0.3 C), and wind vector (+ or - 1 m/s). It incorporates a high-resolution inertial navigation system specially configured for scientific applications, a radome differential pressure system for measurements of the airflow angles, and a compact, computer-controlled data acquisition system to sample, process and store 45 variables on tape and on disk. The MMS hardware and software development is described, and resolution and accuracy of the instrumentation discussed. Custom software facilitates preflight system checkout, inflight data acquisition, and fast postflight data download. It accommodates various modes of MMS data: analog and digital, serial and parallel, and synchronous and asynchronous. Flight

results are presented to demonstrate the capability of the system. Author

A90-52077
AIRBORNE AEROSOL INLET PASSING EFFICIENCY MEASUREMENT
B. J. HUEBERT, G. LEE, and W. L. WARREN (Rhode Island, University, Narragansett) Journal of Geophysical Research (ISSN 0148-0227), vol. 95, Sept. 20, 1990, p. 16369-16381. refs
(Contract NSF ATM-88-09795; NSF ATM 86-13121; NSF ATM-84-03049)
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The aerosol passing efficiency of a variety of inlet systems was evaluated during three experiments on the National Center for Atmospheric Research Electra. During the Dynamics and Chemistry of the Marine Stratocumulus (DYCOMS) program, discrepancies were found between concentrations in cloud water and the air below cloud, which are attributed to curved-inlet aerosol losses. In the FIRE program, the same curved inlet passed significantly less material than a straight one. In the Particulate Matter Airborne Sampling Inlet Experiment (PASIN), the material deposited within one inlet tube was analyzed to establish an efficiency reference. Six different inlets were used simultaneously with six filter samplers to evaluate the effects of tube diameter, radius of curvature, and surface coating. The PASIN filters collected different amounts of material when they should have been sampling the same aerosol. Extraction of the 1-inch metal reference tube routinely found that 50-90 percent of the aerosol material had been deposited in the tube. None of the inlets had an average bulk efficiency greater than about 50 percent for the aerosol species measured. In the commonly used 1-inch one-dimensional curved tube inlet, only 10-20 percent of marine sodium made it to the filter. Some changes in strategy to improve the collection of aerosols from aircraft are suggested. Author

A90-52410
AIRBORNE DIGITAL COMPUTERS AND SYSTEMS [BORTOVYE TSIFROVYE VYCHISLITEL'NYE MASHINY I SISTEMY]
VIKTOR I. MATOV, IURII A. BELOUSOV, and EFIM P. FEDOSEEV Moscow, Izdatel'stvo Vysshaia Shkola, 1988, 216 p. In Russian. refs
Copyright

Methods for the algorithmic synthesis of airborne digital computers and systems is presented which is based on a systems approach to the design of complex computer equipment designed for use on board flight vehicles. In particular, attention is given to the methodological principles of the organization of aviation systems; synthesis of an onboard computer; computational errors in arithmetic operations; and selection of the principal characteristics of data converters. The discussion also covers methods for monitoring the performance of airborned digital computers and reliability of onboard computer systems. V.L.

A90-52884
COMPARISON OF 1-D AND 2-D AIRCRAFT IMAGES
B. KANG, B. D. STEINBERG, and S. B. KESLER (Pennsylvania, University, Philadelphia) IN: IEEE International Conference on Systems Engineering, Dayton, OH, Aug. 24-26, 1989, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 525-528. Research supported by USAF and U.S. Army. refs
Copyright

A preliminary comparison is made between one- and two-dimensional images of airplanes, and the possible use of one-dimensional imagery for aircraft target identification is investigated. Observations are made at X-band (lambda = 3 cm). Graphical data are presented for both one-dimensional and two-dimensional images. The preliminary conclusions based on nine data runs on two types of aircraft are (1) one-dimensional high-resolution range profiles are highly aspect angle dependent and do not appear useful for TID and (2) two-dimensional high-resolution images do appear useful for TID. I.E.

A90-52953
8 X 8-INCH FULL COLOR COCKPIT DISPLAY
LIONEL ROBBINS, MEERA VIJAN, ADI ABILEAH YAIR BARON, VINCENT CANNELLA, JOHN MCGILL (Optical Imaging Systems, Inc., Troy, MI) et al. IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 5, Sept. 1990, p. 3-6. refs
Copyright

The operation of active-matrix liquid-crystal displays (AMLCDs), the preferred flat-panel displays for avionic and aerospace applications, is explained. An 8 x 8-inch full-color AMLCD for a military aircraft is described, as well as the principles of the p-i-n diode switch on which its design is based. The performance characteristics of the display are examined. I.E.

N90-28544# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH.
THE INTERACTION OF CHROMOSTEREOPSIS AND STEREOPSIS IN STEREOSCOPIC CRT (CATHODE RAY TUBES) DISPLAYS M.S. Thesis
JAMES ENNIS MCCLAIN 1989 79 p
(AD-A217906; AFIT/CI/CIA-89-027) Avail: NTIS HC A05/MF A01 CSCL 01/3

With the increased complexity in aircraft and space system information display capabilities, conventional two-dimensional (2-D) displays will eventually be replaced by more capable 3-D stereoscopic displays. Three-dimensional stereoscopic displays allow the vehicle operator to more effectively interact with an increasingly dynamic environment by presenting information consistent with the operator's perceptual experience and stereotypes. Important to the development of stereoscopic 3-D displays is the interaction of perceived depth created by hues (chromostereopsis) and perceived depth created by presenting different images of a single object to the left and right eye of the observer (stereopsis). GRA

N90-28545# Aquanautics Corp., Alameda, CA.
A RELIABLE, MAINTENANCE-FREE OXYGEN SENSOR FOR AIRCRAFT USING AN OXYGEN-SENSITIVE COATING ON POTENTIOMETRIC ELECTRODES Final Report, Nov. 1988 - May 1989
EMORY S. DECASTRO and MARK E. MEYERHOFF (Michigan Univ., Ann Arbor.) Mar. 1990 28 p
(Contract F33615-88-C-0638; AF PROJ. 7930)
(AD-A222696; USAFSAM-TP-89-20) Avail: NTIS HC A03/MF A01 CSCL 17/8

This report is on the preliminary development of a new kind of oxygen sensor. Based on sensing a potentiometric signal from oxygen-specific compounds, this approach offers a potentially stable, reliable, and vastly simplified sensor. The report represents two configurations for the oxygen-specific compound (oxygen reagent). One makes use of the reagent in a thin solution film confined by a membrane. The other uses the reagent immobilized in a polymer film, without any additional solvents. This last embodiment is essentially a solid-state probe of oxygen. This report demonstrates the feasibility of such an approach by reviewing relevant work dealing with: (1) proof of principle, (2) calibration curves over a range of oxygen pressure, (3) temperature effects, and (4) pressure effects. GRA

N90-28546*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DESCRIPTION OF THE PRIMARY FLIGHT DISPLAY AND FLIGHT GUIDANCE SYSTEM LOGIC IN THE NASA B-737 TRANSPORT SYSTEMS RESEARCH VEHICLE
CHARLES E. KNOX Aug. 1990 25 p Original contains color illustrations
(NASA-TM-102710; NAS 1.15:102710) Avail: NTIS HC A03/MF A01; 1 functional color page CSCL 01/4

A primary flight display format was integrated with the flight guidance and control system logic in support of various flight tests conducted with the NASA Transport Systems Research Vehicle B-737-100 airplane. The functional operation of the flight guidance

mode control panel and the corresponding primary flight display formats are presented. Author

N90-29391# National Aerospace Lab., Tokyo (Japan). Flight Research Div.
EVALUATION FOR DLC-FLAP MONITORING SYSTEM OF THE VSRA [KAHEN ANTEI OUTOU JIKKENKI NO DLC SHISUTEMU MONITANITSUITE]
KAZUTOSHI ISHIKAWA, TAKATSUGU ONO, and YUKICHI TSUKANO Jul. 1989 20 p In JAPANESE
(NAL-TM-607; ISSN-0452-2982; JTN-90-80192) Avail: NTIS HC A03/MF A01

The movement of an airplane in the strong backside region is simulated as is the movement of the space plane at landing. There is a limit in the ability to vertically control it using only the conventional elevon and the throttle. In order to simulate the motion, the flap of the variable stability and response airplane (VSRA) is modeled by adding the DLC (Direct Lift Control) system into the VSRA system, which controls a lift directly. The installation improves the control ability of the VSRA system. However, the system is very complicated. Therefore, system monitors are designed in order to keep it safe and to make it experimentally efficient. Results from the monitor of the software of a DLC system and its components are as follows: (1) Interlock and condition monitors are designed as is most suitable for the DLC system; (2) Quadratic model including dead time is constructed for the servo-dynamic monitor; and (3) an evaluation is made by the ground and the inflight tests, and it is concluded that the monitor can be operated efficiently. NASDA

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.

A90-49883
THE SURVIVABILITY OF CENTRIFUGAL COMPRESSORS IN MODERN AIRCRAFT ENGINES
K. N. SHOHET and R. N. TADROS (Pratt and Whitney Canada, Longueil) IN: Aeronautical fatigue in the electronic era; Proceedings of the Fifteenth ICAF Symposium, Jerusalem, Israel, June 21-23, 1989. Warley, England, Engineering Materials Advisory Services, Ltd., 1989, p. 173-184.
Copyright

Increasing demands for higher performance gas turbine engines are pushing the requirements from titanium centrifugal compressors to the limit of their structural capability. It has, therefore, become vital to research newer alloys, to be able to calculate stresses and temperatures very accurately and to relate them to a highly reliable and safe low cycle fatigue life. This paper describes the methods used for structural analysis of impellers, the latest advances in titanium alloys, and the related lifing system. Author

A90-50233
ASPECTS OF THE DESIGN OF A HYPERSONIC ENGINE SYSTEM AND THE SELECTION OF THE INTAKE AND TAIL [EINIGE GESICHTSPUNKTE ZUR AUSLEGUNG EINES HYPERSCHALL-ANTRIEBSYSTEMS IM HINBLICK AUF DIE ABSTIMMUNG VON EINLAUF UND HECK MIT DEM TRIEBWERK]
R. R. SCHWAB, M. GOEING (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, Federal Republic of Germany), F. AULEHLA, and H.-L. WEINREICH (MBB GmbH, Munich, Federal Republic of Germany) IN: Yearbook 1988 II; DGLR, Annual Meeting, Darmstadt, Federal Republic of Germany, Sept. 20-23, 1988, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1988, p. 822-839. In German. refs
(DGLR PAPER 88-040) Copyright

The problems relating to flow field in front of and behind the engine involved in the design of hypersonic combination engines are addressed. The requirements for inlet and nozzle which must be fulfilled to optimize the engine performance are discussed. A comparison of engine-specific aerodynamic cooling drag components is used to clarify the order of magnitude of the theoretically achievable cost savings. Working design criteria are given for the engine core cycle and for aerodynamic and constructional considerations. C.D.

N90-28547# Aeronautical Research Labs., Melbourne (Australia).
THE REDUCTION OF SMOKE EMISSIONS FROM ALLISON T56 ENGINES
F. W. SKIDMORE, D. R. HUNT, and P. N. DOOGOOD Mar. 1990 43 p Original contains color illustrations
(ARL-PROP-R-182; AR-006-055) Avail: NTIS HC A03/MF A01; 2 functional color pages

Aeronautical Research Laboratory (ARL) has been working to reduce smoke emissions from the Allison T56 engines used in the Lockheed P-3C Orion aircraft operated by the Royal Australian Air Force (RAAF). The work consisted of a literature survey, design and manufacture of a water tunnel model, water tunnel testing of various modifications to improve the fluid dynamics of the combustion system, testing the modifications in a single liner combustion test rig, smoke emission comparative tests in ground run engine trials, performance tests in a calibrated test cell and flight trials of a modified engine. The modification that was developed in this program was found to significantly reduce smoke emissions and give substantial improvements in the specific fuel consumption of the engine. In addition, there were indications, in line with theoretical predictions, that the modification would extend the life of the hot end components of the engine. Author

N90-28548 University of Technology, Loughborough (England).
EFFECTIVE OPTIMAL CONTROL OF A FIGHTER AIRCRAFT ENGINE Ph.D. Thesis
SAAD MUSTAFA MAHMOUD 1988 330 p
Avail: Univ. Microfilms Order No. BRDX88310

Typical modern fighter aircraft use two-spool, low by-pass ratio, turbojet engines to provide the thrust needed to carry out the combat maneuvers required by present-day air warfare tactics. The dynamic characteristics of such aircraft engines are complex and non-linear. The need for fast, accurate control of the engine throughout the flight envelope is of paramount importance and this research was concerned with the study of such problems and subsequent design of an optimal linear control which would improve the engine's dynamic response and provide the required correspondence between the output from the engine and the values commanded by a pilot. A detailed mathematical model was derived which, in accuracy and complexity of representation, was a large improvement upon existing analytical models, which assume linear operation over a very small region of the state space, and which was simpler than the large non-analytic representations, which are based on matching operational data. The non-linear model used in this work was based upon information obtained from DYNGEN, a computer program which is used to calculate the steady-state and transient responses of turbojet and turbofan engines. Dissert. Abstr.

N90-28549# Army Aviation Systems Command, Corpus Christi, TX. Depot Engineering and RCM Support Office.
ANALYSIS OF THE T63-A-700 ENGINE USED IN ALCOHOL TURBINE FUEL EXTENDER TEST
JOHN S. GLAESER Aug. 1990 17 p Sponsored by FAA, Atlantic City, NJ
(DOT/FAA/CT-TN90/18) Avail: NTIS HC A03/MF A01

The teardown analysis of the T63-A-700 engine used in fuel extender research was conducted in order to evaluate the use of alcohols as extenders for the existing turbine fuels. The turbine section of the engine displayed burned vanes on the first stage

gas producer. The blade tips of the second stage gas producer turbine rotor had rubbed the interior of the second stage gas producer nozzle. It was concluded that the vanes on the first stage gas producer burned during a series of hot or hung starts using extender fuels. The inefficiency of both the fuel nozzle and the fuel control unit using alcohol blends during starting operations caused the overtemperatures. The second stage gas producer nozzle was warped as a result of thermal cycling from ambient temperature to a hot or hung start condition that caused the turbine rotor tips to rub the nozzle. The remainder of the engine, including the seals, fuel control unit, fuel nozzle, bearings, and internal components, showed no discrepancies. Much of the change appears to have resulted from hung starts. Author

N90-28550 State Univ. of New York, Stony Brook.
CALCULATION OF TEMPERATURE DISTRIBUTION IN VARIOUS TURBINE BLADES USING A BOUNDARY-FITTED COORDINATE TRANSFORMATION METHOD Ph.D. Thesis
BYEONG SOO OH 1989 234 p
Avail: Univ. Microfilms Order No. DA9015633

Gas turbine engines operating at high temperature and high pressure ratio have been developed to increase power output and efficiency. However, due to the limitations of material properties, internal convective cooling is needed in many turbine blades. Knowledge of the temperature distribution in the cooled blade is necessary for its thermal stress analysis. Improvements in prediction capability in this area can benefit turbine life, reduce development and maintenance costs, and improve engine performance. Numerical solutions of partial differential equations in regions with arbitrarily shaped boundaries are relatively difficult. Finite-difference solutions in irregular domains have been hindered in the past by the problem of fitting curved boundaries into the computational grid. Here, the physical region where the heat transport occurs is mapped onto a rectangular computational domain by means of a boundary-fitted coordinate transformation method. The finite-difference approach is then used to give solutions that do not lack continuity of derivatives. A general convection-diffusion equation is derived for the transformed computational domain and a computer program is developed to solve the heat transfer in any blade shape. Only one outer blade shape, the Allison/NASA C3X vane, is studied with various inner hole geometries and boundary conditions. The study shows that by developing a multi-part technique the problem of complicated geometry can be solved. Regardless of the temperature distribution on the outer boundary, the best cooling effect is obtained when the inner cooling holes have a similar shape to the outer blade surface. It is shown that the cooling of the tail region is important especially at the tail end. Dissert. Abstr.

N90-28551*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
PROPULSION SYSTEM-FLIGHT CONTROL INTEGRATION AND OPTIMIZATION: FLIGHT EVALUATION AND TECHNOLOGY TRANSITION
FRANK W. BURCHAM, JR., GLENN B. GILYARD, and LAWRENCE P. MYERS Washington Jul. 1990 26 p Presented at the AIAA 26th Joint Propulsion Conference, Orlando, FL, 16-18 Jul. 1990
(NASA-TM-4207; H-1603; NAS 1.15:4207) Avail: NTIS HC A03/MF A01 CSCL 21/5

Integration of propulsion and flight control systems and their optimization offers significant performance improvements. Research programs were conducted which have developed new propulsion and flight control integration concepts, implemented designs on high-performance airplanes, demonstrated these designs in flight, and measured the performance improvements. These programs, first on the YF-12 airplane, and later on the F-15, demonstrated increased thrust, reduced fuel consumption, increased engine life, and improved airplane performance; with improvements in the 5 to 10 percent range achieved with integration and with no changes to hardware. The design, software and hardware developments, and testing requirements were shown to be practical. Author

N90-28552*# Hamilton Standard, Windsor Locks, CT.
MEASUREMENT OF THE STEADY SURFACE PRESSURE DISTRIBUTION ON A SINGLE ROTATION LARGE SCALE ADVANCED PROP-FAN BLADE AT MACH NUMBERS FROM 0.03 TO 0.78 Final Report
PETER BUSHNELL Jul. 1988 540 p
(Contract NAS3-23051)
(NASA-CR-182124; E-4137; NAS 1.26:182124) Avail: NTIS HC A23/MF A03 CSCL 21/5

The aerodynamic pressure distribution was determined on a rotating Prop-Fan blade at the S1-MA wind tunnel facility operated by the Office National D'Etudes et de Recherches Aerospatiale (ONERA) in Modane, France. The pressure distributions were measured at thirteen radial stations on a single rotation Large Scale Advanced Prop-Fan (LAP/SR7) blade, for a sequence of operating conditions including inflow Mach numbers ranging from 0.03 to 0.78. Pressure distributions for more than one power coefficient and/or advanced ratio setting were measured for most of the inflow Mach numbers investigated. Due to facility power limitations the Prop-Fan test installation was a two bladed version of the eight design configuration. The power coefficient range investigated was therefore selected to cover typical power loading per blade conditions which occur within the Prop-Fan operating envelope. The experimental results provide an extensive source of information on the aerodynamic behavior of the swept Prop-Fan blade, including details which were elusive to current computational models and do not appear in the two-dimensional airfoil data. Author

N90-28553*# General Electric Co., Cincinnati, OH. Aircraft Engine Group.
ENERGY EFFICIENT ENGINE HIGH PRESSURE TURBINE COMPONENT TEST PERFORMANCE REPORT
L. P. TIMKO 1984 173 p
(Contract NAS3-20643)
(NASA-CR-168289; NAS 1.26:168289; R82AEB406) Avail: NTIS HC A08/MF A01 CSCL 21/5

The high pressure turbine for the General Electric Energy Efficient Engine is a two stage design of moderate loading. Results of detailed system studies led to selection of this configuration as the most appropriate in meeting the efficiency goals of the component development program. To verify the design features of the high pressure turbine, a full scale warm air turbine test rig with cooling flows simulated was run. Prior to this testing, an annular cascade test was run to select vane unguided turn for the first stage nozzle. Results of this test showed that the base configuration exceeded the lower unguided turning configuration by 0.48 percent in vane kinetic energy efficiency. The air turbine test program, consisting of extensive mapping and cooling flow variation as well as design point evaluation, demonstrated a design point efficiency level of 90.0 percent based on the thermodynamic definition. In terms of General Electric cycle definition, this efficiency was 92.5 percent. Based on this test, it is concluded that efficiency goals for the Flight Propulsion System were met. Author

N90-28554*# General Electric Co., Cincinnati, OH. Aircraft Engine Business Group.
ENERGY EFFICIENT ENGINE COMBUSTOR TEST HARDWARE DETAILED DESIGN REPORT
D. L. BURRUS, C. A. CHAHROUR, H. L. FOLTZ, P. E. SABLA, S. P. SETO, and J. R. TAYLOR Mar. 1984 474 p
(Contract NAS3-20643)
(NASA-CR-168301; NAS 1.26:168301; R82AEB472) Avail: NTIS HC A20/MF A03 CSCL 21/5

The Energy Efficient Engine (E3) Combustor Development effort was conducted as part of the overall NASA/GE E3 Program. This effort included the selection of an advanced double-annular combustion system design. The primary intent was to evolve a design which meets the stringent emissions and life goals of the E3 as well as all of the usual performance requirements of combustion systems for modern turbofan engines. Numerous detailed design studies were conducted to define the features of the combustion system design. Development test hardware was

fabricated, and an extensive testing effort was undertaken to evaluate the combustion system subcomponents in order to verify and refine the design. Technology derived from this development effort will be incorporated into the engine combustion system hardware design. This advanced engine combustion system will then be evaluated in component testing to verify the design intent. What is evolving from this development effort is an advanced combustion system capable of satisfying all of the combustion system design objectives and requirements of the E3. Fuel nozzle, diffuser, starting, and emissions design studies are discussed. R.J.F.

N90-28555*# General Electric Co., Cincinnati, OH. Aircraft Engine Business Group.
ENERGY EFFICIENT ENGINE (E3) COMBUSTION SYSTEM COMPONENT TECHNOLOGY PERFORMANCE REPORT Draft Report
D. L. BURRUS, C. A. CHAHROUR, H. L. FOLTZ, P. E. SABLA, S. P. SETO, and J. R. TAYLOR Jul. 1984 494 p
(Contract NAS3-20643)
(NASA-CR-168274; NAS 1.26:168274; R82AEB401) Avail: NTIS HC A21/MF A03 CSCL 21/5

The Energy Efficient Engine (E3) combustor effort was conducted as part of the overall NASA/GE E3 Program. This effort included the selection of an advanced double-annular combustion system design. The primary intent of this effort was to evolve a design that meets the stringent emissions and life goals of the E3, as well as all of the usual performance requirements of combustion systems for modern turbofan engines. Numerous detailed design studies were conducted to define the features of the combustion system design. Development test hardware was fabricated, and an extensive testing effort was undertaken to evaluate the combustion system subcomponents in order to verify and refine the design. Technology derived from this effort was incorporated into the engine combustion hardware design. The advanced engine combustion system was then evaluated in component testing to verify the design intent. What evolved from this effort was an advanced combustion system capable of satisfying all of the combustion system design objectives and requirements of the E3. R.J.F.

N90-28556*# Pratt and Whitney Aircraft, East Hartford, CT. Engineering Div.
ENERGY EFFICIENT ENGINE EXHAUST MIXER MODEL TECHNOLOGY REPORT ADDENDUM; PHASE 3 TEST PROGRAM
M. J. LARKIN and J. R. BLATT Apr. 1984 197 p
(Contract NAS3-20646)
(NASA-CR-174799; NAS 1.26:174799; PWA-5594-271-ADD)
Avail: NTIS HC A09/MF A02 CSCL 21/5

The Phase 3 exhaust mixer test program was conducted to explore the trends established during previous Phases 1 and 2. Combinations of mixer design parameters were tested. Phase 3 testing showed that the best performance achievable within tailpipe length and diameter constraints is 2.55 percent better than an optimized separate flow base line. A reduced penetration design achieved about the same overall performance level at a substantially lower level of excess pressure loss but with a small reduction in mixing. To improve reliability of the data, the hot and cold flow thrust coefficient analysis used in Phases 1 and 2 was augmented by calculating percent mixing from traverse data. Relative change in percent mixing between configurations was determined from thrust and flow coefficient increments. The calculation procedure developed was found to be a useful tool in assessing mixer performance. Detailed flow field data were obtained to facilitate calibration of computer codes. Author

N90-28557*# General Electric Co., Cincinnati, OH. Aircraft Engine Business Group.
ENERGY EFFICIENT ENGINE ACOUSTIC SUPPORTING TECHNOLOGY REPORT
S. P. LAVIN and P. Y. HO Jun. 1985 371 p
(Contract NAS3-20643)
(NASA-CR-174834; NAS 1.26:174834; R84AEB246) Avail: NTIS HC A16/MF A02 CSCL 21/5

The acoustic development of the Energy Efficient Engine combined testing and analysis using scale model rigs and an integrated Core/Low Spool demonstration engine. The scale model tests show that a cut-on blade/vane ratio fan with a large spacing (S/C = 2.3) is as quiet as a cut-off blade/vane ratio with a tighter spacing (S/C = 1.27). Scale model mixer tests show that separate flow nozzles are the noisiest, conic nozzles the quietest, with forced mixers in between. Based on projections of ICLS data the Energy Efficient Engine (E3) has FAR 36 margins of 3.7 EPNdB at approach, 4.5 EPNdB at full power takeoff, and 7.2 EPNdB at sideline conditions. Author

N90-28558*# General Electric Co., Evendale, OH. Aircraft Engine Business Group.
ENERGY EFFICIENT ENGINE: FLIGHT PROPULSION SYSTEM FINAL DESIGN AND ANALYSIS Report, Nov. 1978 - Aug. 1983
DONALD Y. DAVIS and E. MARSHALL STEARNS Aug. 1985 170 p
(Contract NAS3-20643)
(NASA-CR-168219; NAS 1.26:168219; R83AEB488) Avail: NTIS HC A08/MF A01 CSCL 21/5

The Energy Efficient Engine (E3) is a NASA program to create fuel saving technology for future transport engines. The Flight Propulsion System (FPS) is the engine designed to achieve E3 goals. Achieving these goals required aerodynamic, mechanical and system technologies advanced beyond that of current production engines. These technologies were successfully demonstrated in component rigs, a core engine and a turbofan ground test engine. The design and benefits of the FPS are presented. All goals for efficiency, environmental considerations, and economic payoff were met. The FPS has, at maximum cruise, 10.67 km (35,000 ft), M0.8, standard day, a 16.9 percent lower installed specific fuel consumption than a CF6-50C. It provides an 8.6 percent reduction in direct operating cost for a short haul domestic transport and a 16.2 percent reduction for an international long distance transport. Author

N90-28559*# General Electric Co., Cincinnati, OH. Aircraft Engine Business Group.
ENERGY EFFICIENT ENGINE CORE DESIGN AND PERFORMANCE REPORT Report, Jan. 1978 - Dec. 1982
E. MARSHALL STEARNS et al. Dec. 1982 530 p
(Contract NAS3-20643)
(NASA-CR-168069; NAS 1.26:168069; R82AEB470) Avail: NTIS HC A23/MF A03 CSCL 21/5

The Energy Efficient Engine (E3) is a NASA program to develop fuel saving technology for future large transport aircraft engines. Testing of the General Electric E3 core showed that the core component performance and core system performance necessary to meet the program goals can be achieved. The E3 core design and test results are described. Author

N90-28560*# Pratt and Whitney Aircraft, East Hartford, CT. Engineering Div.
ENERGY EFFICIENT ENGINE PROGRAM ADVANCED TURBOFAN NACELLE DEFINITION STUDY
DAVID C. HOWE and T. A. WYNOSKY May 1985 165 p
(Contract NAS3-20646)
(NASA-CR-174942; NAS 1.26:174942; PWA-5394-315) Avail: NTIS HC A08/MF A01 CSCL 21/5

Advanced, low drag, nacelle configurations were defined for some of the more promising propulsion systems identified in the earlier Benefit/Cost Study, to assess the benefits associated with these advanced technology nacelles and formulate programs for developing these nacelles and low volume thrust reversers/spoilers to a state of technology readiness in the early 1990's. The study results established the design feasibility of advanced technology, slim line nacelles applicable to advanced technology, high bypass ratio turbofan engines. Design feasibility was also established for two low volume thrust reverse/spoiler concepts that meet or exceed

the required effectiveness for these engines. These nacelle and thrust reverse/spoiler designs were shown to be applicable in engines with takeoff thrust sizes ranging from 24,000 to 60,000 pounds. The reduced weight, drag, and cost of the advanced technology nacelle installations relative to current technology nacelles offer a mission fuel burn savings ranging from 3.0 to 4.5 percent and direct operating cost plus interest improvements from 1.6 to 2.2 percent. Author

N90-28561*# General Electric Co., Evendale, OH. Aircraft Engine Businees Group.
ENERGY EFFICIENT ENGINE INTEGRATED CORE/LOW SPOOL DESIGN AND PERFORMANCE REPORT Topical Report, Jan. 1978 - Aug. 1983
E. MARSHALL STEARNS et al. Feb. 1985 649 p
(Contract NAS3-20643)
(NASA-CR-168211; NAS 1.26:168211; R83AEB503) Avail: NTIS HC A99/MF A04 CSCL 21/5

The Energy Efficient Engine (E3) is a NASA program to create fuel saving technology for future transport aircraft engines. The E3 technology advancements were demonstrated to operate reliably and achieve goal performance in tests of the Integrated Core/Low Spool vehicle. The first build of this undeveloped technology research engine set a record for low fuel consumption. Its design and detailed test results are herein presented. Author

N90-28562*# General Electric Co., Evendale, OH. Aircraft Engine Business Group.
ENERGY EFFICIENT ENGINE: CONTROL SYSTEM COMPONENT PERFORMANCE REPORT
R. S. BEITLER and G. W. BENNETT Oct. 1984 205 p
(Contract NAS3-20643)
(NASA-CR-174651; NAS 1.26:174651; R83AEB623) Avail: NTIS HC A10/MF A02 CSCL 21/5

An Energy Efficient Engine (E3) program was established to develop technology for improving the energy efficiency of future commercial transport aircraft engines. As part of this program, General Electric designed and tested a new engine. The design, fabrication, bench and engine testing of the Full Authority Digital Electronic Control (FADEC) system used for controlling the E3 Demonstrator Engine is described. The system design was based on many of the proven concepts and component designs used on the General Electric family of engines. One significant difference is the use of the FADEC in place of hydromechanical computation currently used. Author

N90-28563*# General Electric Co., Cincinnati, OH. Aircraft Engine Business Group.
NASA/GE ENERGY EFFICIENT ENGINE LOW PRESSURE TURBINE SCALED TEST VEHICLE PERFORMANCE REPORT Topical Report, 1979-1982
M. J. BRIDGEMAN, D. G. CHERRY, and J. PEDERSEN Jul. 1983 259 p
(Contract NAS3-20643)
(NASA-CR-168290; NAS 1.26:168290; R83AEB143) Avail: NTIS HC A12/MF A02 CSCL 21/5

The low pressure turbine for the NASA/General Electric Energy Efficient Engine is a highly loaded five-stage design featuring high outer wall slope, controlled vortex aerodynamics, low stage flow coefficient, and reduced clearances. An assessment of the performance of the LPT has been made based on a series of scaled air-turbine tests divided into two phases: Block 1 and Block 2. The transition duct and the first two stages of the turbine were evaluated during the Block 1 phase from March through August 1979. The full five-stage scale model, representing the final integrated core/low spool (ICLS) design and incorporating redesigns of stages 1 and 2 based on Block 1 data analysis, was tested as Block 2 in June through September 1981. Results from the scaled air-turbine tests, reviewed herein, indicate that the five-stage turbine designed for the ICLS application will attain an efficiency level of 91.5 percent at the Mach 0.8/10.67-km (35,000-ft), max-climb design point. This is relative to program goals of 91.1 percent for the ICLS and 91.7 percent for the flight propulsion system (FPS). Author

N90-28564*# Pratt and Whitney Aircraft, East Hartford, CT. Engineering Div.
ENERGY EFFICIENT ENGINE PROGRAM TECHNOLOGY BENEFIT/COST STUDY. VOLUME 1: EXECUTIVE SUMMARY
D. E. GRAY and WILLIAM B. GARDNER Oct. 1983 19 p
(Contract NAS3-20646)
(NASA-CR-174766-VOL-1; NAS 1.26:174766-VOL-1; PWA-5594-258-VOL-1) Avail: NTIS HC A03/MF A01 CSCL 21/5

Under the NASA sponsored Energy Efficient Engine Program, Pratt and Whitney completed the Benefit/Cost Study to identify turbofan engine technologies required for the years 2000 to 2010, to assess the benefits of those technologies, and to formulate programs for developing the technologies required for that time period. The results verified that there are still many potential benefits to be realized from the advancement of gas turbine technology. The initial effort was to screen and rank preliminary technology concepts that might be amenable to future development. Cycle studies, flowpath definition studies, and mechanical configuration studies were then used to identify and establish the feasibility of the technologies that would be required in the 2000 to 2010 time frame. These efforts showed that a turbofan engine with advancements in aerodynamics, mechanical arrangements, and materials offered significant performance improvements over 1988 technology. The benefits of the technologies were assessed using fuel burn and direct operating cost plus interest (DOC+I). These concepts could yield thrust specific fuel consumption benefits of almost 16 percent, fuel burn benefits of up to 24 percent and DOC+I benefits of up to 14 percent in a long-range airplane relative to Energy Efficient Engine technology levels. Technology development programs were formulated and recommended to realize those benefits. Author

N90-28565*# Pratt and Whitney Aircraft, East Hartford, CT. Engineering Div.
ENERGY EFFICIENT ENGINE PROGRAM TECHNOLOGY BENEFIT/COST STUDY, VOLUME 2
D. E. GRAY and WILLIAM B. GARDNER Oct. 1983 109 p
(Contract NAS3-20646)
(NASA-CR-174766-VOL-2; NAS 1.26:174766-VOL-2; PWA-5594-251-VOL-2) Avail: NTIS HC A06/MF A01 CSCL 21/5

The Benefit/Cost Study portion of the NASA-sponsored Energy Efficient Engine Component Development and Integration program was successful in achieving its objectives: identification of air transport propulsion system technology requirements for the years 2000 and 2010, and formulation of programs for developing these technologies. It is projected that the advanced technologies identified, when developed to a state of readiness, will provide future commercial and military turbofan engines with significant savings in fuel consumption and related operating costs. These benefits are significant and far from exhausted. The potential savings translate into billions of dollars in annual savings for the airlines. Analyses indicate that a significant portion of the overall savings is attributed to aerodynamic and structure advancements. Another important consideration in acquiring these benefits is developing a viable reference technology base that will permit engines to operate at substantially higher overall pressure ratios and bypass ratios. Results have pointed the direction for future research and a comprehensive program plan for achieving this was formulated. The next major step is initiating the program effort that will convert the advanced technologies into the expected benefits. Author

N90-28566*# Pratt and Whitney Aircraft, East Hartford, CT. Engineering Div.
ENERGY EFFICIENT ENGINE INTEGRATED CORE/LOW SPOOL TEST HARDWARE DESIGN REPORT
JOHN W. BISSET and DAVID C. HOWE Mar. 1983 223 p

(Contract NAS3-20646)
(NASA-CR-168137; NAS 1.26:168137; PWA-5594-231) Avail: NTIS HC A10/MF A02 CSCL 21/5

The Energy Efficient Engine Program is designed to identify and verify the technology required to significantly lower fuel consumption and operating cost for future commercial gas turbine engines. A major task that was completed under this program is the design and analysis of test hardware for the integrated core/low spool, which is a test simulation of the conceptual study engine defined to meet performance, economic and environmental goals. An evaluation and verification of critical technologies is intended in a full engine operating environment. The design and results of design-related analyses for the integrated core/low spool and its subsystems are described. The design effort included a definition of the engine, major components, internal and external subsystems, test ducting, and test instrumentation. Various analytical representations, in addition to results acquired from supporting component rig and subscale model tests, were used to verify aerodynamic and structural design concepts as well as to predict performance. Author

N90-28567*# Pratt and Whitney Aircraft, East Hartford, CT. Engineering Div.
ENERGY EFFICIENT ENGINE PIN FIN AND CERAMIC COMPOSITE SEGMENTED LINER COMBUSTOR SECTOR RIG TEST REPORT
D. J. DUBIEL, R. P. LOHMANN, S. TANRIKUT, and P. M. MORRIS Sep. 1986 218 p
(Contract NAS3-20646)
(NASA-CR-179534; NAS 1.26:179534; PWA-5594-333; LC-86-23) Avail: NTIS HC A10/MF A02 CSCL 21/5

Under the NASA-sponsored Energy Efficient Engine program, Pratt and Whitney has successfully completed a comprehensive test program using a 90-degree sector combustor rig that featured an advanced two-stage combustor with a succession of advanced segmented liners. Building on the successful characteristics of the first generation counter-parallel Finwall cooled segmented liner, design features of an improved performance metallic segmented liner were substantiated through representative high pressure and temperature testing in a combustor atmosphere. This second generation liner was substantially lighter and lower in cost than the predecessor configuration. The final test in this series provided an evaluation of ceramic composite liner segments in a representative combustor environment. It was demonstrated that the unique properties of ceramic composites, low density, high fracture toughness, and thermal fatigue resistance can be advantageously exploited in high temperature components. Overall, this Combustor Section Rig Test program has provided a firm basis for the design of advanced combustor liners. Author

N90-28569*# Pratt and Whitney Aircraft, East Hartford, CT. Engineering Div.
ENERGY EFFICIENT ENGINE: CONTROL SYSTEM PRELIMINARY DEFINITION REPORT
DAVID C. HOWE Sep. 1986 126 p
(Contract NAS3-20646)
(NASA-CR-179578; NAS 1.26:179578; PWA-5594-331) Avail: NTIS HC A07/MF A01 CSCL 21/5

The object of the Control Preliminary Definition Program was to define a preliminary control system concept as a part of the Energy Efficient Engine program. The program was limited to a conceptual definition of a full authority digital electronic control system. System requirements were determined and a control system was conceptually defined to these requirements. Areas requiring technological development were identified and a plan was established for implementing the identified technological features, including a control technology demonstration. A significant element of this program was a study of the potential benefits of closed-loop active clearance control, along with laboratory tests of candidate clearance sensor elements for a closed loop system. Author

N90-28570*# Pratt and Whitney Aircraft, East Hartford, CT.
ENERGY EFFICIENT ENGINE: HIGH-PRESSURE COMPRESSOR TEST HARDWARE DETAILED DESIGN REPORT
DAVID C. HOWE and R. D. MARCHANT Mar. 1988 261 p
(Contract NAS3-20646)
(NASA-CR-180850; NAS 1.26:180850; PWA-5594-287) Avail: NTIS HC A12/MF A02 CSCL 21/5

The objective of the NASA Energy Efficient Engine program is to identify and verify the technology required to achieve significant reductions in fuel consumption and operating cost for future commercial gas turbine engines. The design and analysis is documented of the high pressure compressor which was tested as part of the Pratt and Whitney effort under the Energy Efficient Engine program. This compressor was designed to produce a 14:1 pressure ratio in ten stages with an adiabatic efficiency of 88.2 percent in the flight propulsion system. The corresponding expected efficiency for the compressor component test rig is 86.5 percent. Other performance goals are a surge margin of 20 percent, a corrected flow rate of 35.2 kg/sec (77.5 lb/sec), and a life of 20,000 missions and 30,000 hours. Low loss, highly loaded airfoils are used to increase efficiency while reducing the parts count. Active clearance control and case trenches in abradable strips over the blade tips are included in the compressor component design to further increase the efficiency potential. The test rig incorporates variable geometry stator vanes in all stages to permit maximum flexibility in developing stage-to-stage matching. This provision precluded active clearance control on the rear case of the test rig. Both the component and rig designs meet or exceed design requirements with the exception of life goals, which will be achievable with planned advances in materials technology. Author

N90-28571# Air Force Human Resources Lab., Brooks AFB, TX.
SOURCE EMISSION TEST OF GAS TURBINE ENGINE TEST FACILITY, KELLY AFB, TX Final Report
RONALD W. VAUGHN and PAUL T. SCOTT Apr. 1990 44 p
(AD-A223869; AFOEHL-90-064EQ00094DEF) Avail: NTIS HC A03/MF A01 CSCL 24/1

Source emission testing was conducted on the F-15 JFS and GT CP 85-180 gas turbine engines for particulates, carbon monoxide, total hydrocarbons, sulfur dioxide and nitrogen oxide. The present Gas Turbine Engine Test Facility is grandfathered per Texas Air Control Board and Federal (40CFR60) Regulations. The data will be used to initiate a permit application for a new Gas Turbine Engine Test Facility. GRA

N90-28572# Naval Ship Research and Development Center, Bethesda, MD. Propulsion and Auxiliary Systems Dept.
FLOW COUPLING BETWEEN A ROTOR AND A STATOR IN TURBOMACHINERY
YU-TAI LEE, IVAN CHEN WEN JIANG, and THOMAS W. BEIN Apr. 1990 33 p
(AD-A223882; DTRC/PAS-90/15) Avail: NTIS HC A03/MF A01 CSCL 20/4

Successful turbomachine design requires detailed information about flow characteristics in order to predict the performance of a candidate geometry. The design needs information about the complex interaction between the blade rows when multistage blade rows are considered. A three-dimensional steady potential-flow code for a single blade row has been developed, where integral equations were derived to model the solid surfaces and the inlet condition for both external and internal flows with rotating or nonrotating lifting blades. Global iterations for the surface-panel source densities and the vortex strengths were used in conjunction with a Neumann iteration for solving the integral equations. In this paper, two numerical coupling procedures between the rotor and the stator are described. The phenomena of flow interaction between the rotor and the stator are studied and two test cases are presented. The performance of a vaneaxial fan is predicted using this procedure and the results indicate that the present

numerical coupling procedure can be used by designers to select optimal blade shapes. GRA

N90-28573# Naval Research Lab., Washington, DC. Lab. for Computational Physics and Fluid Dynamics.
NUMERICAL SIMULATIONS OF FLOWFIELDS IN A CENTRAL-DUMP RAMJET COMBUSTOR. 3: EFFECTS OF CHEMISTRY Interim Report
KAZHIKATHRA KAILASANATH, JOHN H. GARDNER, JAY P. BORIS, and ELAINE S. ORAN 23 Jul. 1990 52 p Sponsored by ONR, Arlington, VA and Naval Air Systems Command
(AD-A224145; NRL-MR-6682) Avail: NTIS HC A04/MF A01 CSCL 21/5

This report is the third in a series which presents the results of numerical simulations performed to isolate and study acoustic-vortex-chemical interactions in an idealized ramjet consisting of an axisymmetric inlet and combustor and a choked nozzle. Both reactive and nonreactive flows have been simulated. The nonreactive flow calculations show complex interactions among the natural instability frequency of the shear layer at the inlet-combustor junction and the acoustics of both the inlet and the combustor. The entire flow oscillates at a low frequency which corresponds to that of a quarter-mode in the inlet. For the reactive flow cases studied, energy release alters the flow field substantially. Energy release in a large vortex is in phase with the pressure oscillation over a substantial region of the combustor and results in the observed amplification of the low-frequency oscillations and leads to combustion instability. The large pressure oscillation also modifies the vortex shedding process. GRA

N90-28574# Universal Technology Corp., Dayton, OH.
STOVL FIGHTER PROPULSION RELIABILITY, MAINTAINABILITY, AND SUPPORTABILITY CHARACTERIZATION Final Report, Oct. 1988 - Sep. 1989
RANDOLPH W. SPRATT Mar. 1990 120 p
(Contract F33615-88-C-2823; AF PROJ. 3066)
(AD-A224221; WRDC-TR-89-2150) Avail: NTIS HC A06/MF A01 CSCL 21/5

This report contains information on the Reliability, Maintainability and Supportability (RM and S) of STOVL fighter propulsion systems. Five STOVL propulsion concepts were investigated and evaluated. A RM and S evaluation method was developed for this project. This method could not be used to rate the propulsion concepts since the components of the propulsion systems had not been fully defined. An alternative method was to rank order the propulsion system for RM and S. Subjective ratings were given to the major components of each propulsion concept. These ratings were then weighted and summed to determine rank order of the propulsion concepts. Propulsion components critical to the RM and S ratings were identified. Recommendations for future RM and S study efforts are included in the report. GRA

N90-29393# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Propulsion and Energetics Panel Working Group 19.
RECOMMENDED PRACTICES FOR MEASUREMENT OF GAS PATH PRESSURES AND TEMPERATURES FOR PERFORMANCE ASSESSMENT OF AIRCRAFT TURBINE ENGINES AND COMPONENTS
H. I. H. SARAVANAMUTTOO 1990 162 p
(AGARD-AR-245; ISBN-92-835-0499-2) Copyright Avail: NTIS HC A08/MF A01; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The results of the Propulsion and Energetics Panel Working Group 19 are summarized. It is of interest to engineers concerned with steady state testing of aircraft turbine engines and their components, and provides information on gas path pressure and temperature measurement techniques and instrumentation. Manufacturers and research institutions throughout the world have developed their own practices for measurement techniques and instrumentation. These practices vary significantly, leading to confusion and misunderstanding between researchers, development organizations, contract agencies and customers. The trend towards multi-company and multi-national engine projects increases these difficulties. The goal is to recommend practices, the application of which will generate confidence through a common understanding, which will increase the quality of the data obtained. The recommended practices described address components and instrumentation, and the problems of interpreting the information obtained in terms of spatial and temporal resolution. Measurement uncertainties are discussed in detail. Author

N90-29394*# TRW Defense and Space Systems Group, Redondo Beach, CA.
GENERALIZED ADVANCED PROPELLER ANALYSIS SYSTEM (GAPAS). VOLUME 2: COMPUTER PROGRAM USER MANUAL
L. GLATT, D. R. CRAWFORD, J. B. KOSMATKA, R. J. SWIGART, and E. W. WONG Dec. 1986 484 p
(Contract NAS3-22251)
(NASA-CR-185277; NAS 1.26:185277) Avail: NTIS HC A21/MF A03 CSCL 01/3

The Generalized Advanced Propeller Analysis System (GAPAS) computer code is described. GAPAS was developed to analyze advanced technology multi-bladed propellers which operate on aircraft with speeds up to Mach 0.8 and altitudes up to 40,000 feet. GAPAS includes technology for analyzing aerodynamic, structural, and acoustic performance of propellers. The computer code was developed for the CDC 7600 computer and is currently available for industrial use on the NASA Langley computer. A description of all the analytical models incorporated in GAPAS is included. Sample calculations are also described as well as users requirements for modifying the analysis system. Computer system core requirements and running times are also discussed. Author

N90-29396# Dayton Univ., OH. Aerospace Mechanics Div.
STRUCTURAL TESTING AND ANALYTICAL RESEARCH OF TURBINE COMPONENTS Final Report, Sep. 1985 - Jun. 1989
M. SWAMINADHAM 2 Oct. 1989 307 p
(Contract F33615-85-C-2585; AF PROJ. 3066)
(AD-A223516; UDR-TR-89-60; WRDC-TR-89-2126) Avail: NTIS HC A14/MF A02 CSCL 21/5

Finite-element based deterministic and probabilistic analytical methods were applied for the normal mode and forced response characterization of simple-to-complex turbine and compressor components. Noncontacting blade deflection instrumentation - - four fiber optic plane-of-light sensors and dual Z-Grid wire systems were designed, built and tested for measuring blade tip deflections of rotating disks. Differential double pulse interferometry was applied for the mode shape definition of rotating bladed disks, and the full-field modal fringe patterns were quantitatively interpreted by the sine extrapolation technique. A joint effort for concurrent evaluation of the UTRC and UDRI non-interference blade measurement systems for measuring integral order vibration of a flexible disk was completed. Critical speeds and maximum blade tip deflections of a test disk from the two instrumentation systems were compared, and good agreement for the two test series results was seen. Results from the integrated NSMS (Noncontact Stress Measurement System) tests were also compared. The NSMS analysis software programs analyzed the optical probe array data and extracted blade-to-blade deflections and compared them with the interferometric data. GRA

N90-29398# National Aerospace Lab., Tokyo (Japan).
ANALYSIS OF SCRAMJET ENGINE CHARACTERISTICS
TAKESHI KANDA, GORO MASUYA, YOSHIO WAKAMATSU, NOBUO CHINZEI, and AKIO KANMURI Nov. 1989 24 p In JAPANESE; ENGLISH summary
(NAL-TR-1041; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

In a previous report, scramjet engine characteristics of different propellant feed cycles were compared, and engine performances discussed. In this study, a hydrogen fueled airframe-integrated scramjet was examined, considered the cooling of the airframe as well as the engine, and the dependence of engine characteristics on such parameters as flight Mach number, flight dynamic pressure, engine wall temperature, and engine scale were analyzed. It was found that the coolant required for the airframe is about 20 percent

of the total coolant. Simple equations were derived which correlate fuel flow rate, engine overall thrust and specific impulse with those parameters. As for the airframe cooling, a new cycle was proposed in which the airframe cooling system has its own coolant feed system and does not depend on the engine operating conditions. Author

08

AIRCRAFT STABILITY AND CONTROL

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

A90-50249
RECENT RESULTS OF NUMERICAL FLUTTER STUDIES IN HIGH PERFORMANCE GLIDERS [NEUERE ERFAHRUNGEN AUS RECHNERISCHEN FLATTERUNTERSUCHUNGEN VON HOCHLEISTUNGSSEGELFLUGZEUGEN]
F. KIESSLING and M. RIPPI (DLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) IN: Yearbook 1988 II; DGLR, Annual Meeting, Darmstadt, Federal Republic of Germany, Sept. 20-23, 1988, Reports. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1988, p. 1020-1028. In German. refs
(DGLR PAPER 88-038) Copyright

The practice of flutter research is discussed. The theory of the research is reviewed, and its application to problems of torsional flutter and to rigid body studies of aircraft is addressed. Approaches to reducing the danger from flutter are examined. C.D.

A90-50640#
BIFURCATION ANALYSIS OF A MODEL FIGHTER AIRCRAFT WITH CONTROL AUGMENTATION
JAMES B. PLANEAUX (USAF, Institute of Technology, Wright-Patterson AFB, OH), JEFFREY A. BECK, and DANIEL D. BAUMANN AIAA, Atmospheric Flight Mechanics Conference, Portland, OR, Aug. 20-22, 1990. 16 p. refs
(AIAA PAPER 90-2836)

Mathematical models of an F-15 fighter aircraft are constructed and analyzed, to determine how certain control augmentation strategies affect the nonlinear motion and stability. Using methods of continuation and bifurcation theory, entire families of equilibrium and limit cycle solutions are computed as control surface deflections and control system parameter are varied. As a primary application, strategies for suppressing wing rock by control augmentation are evaluated. The geometrical nature of the nonlinear results shows very clearly that the attempted controls will suppress wing rock, but will also increase divergence tendency and may lead to departures and spins. Onset of and departure from wing rock are shown to be different types of bifurcation phenomena. The type of information presented should be useful in high-alpha control system design applications. Author

A90-51154
ANALYZING MANIPULATOR AND FEEL SYSTEM EFFECTS IN AIRCRAFT FLIGHT CONTROL
RONALD A. HESS (California, University, Davis) IEEE Transactions on Systems, Man, and Cybernetics (ISSN 0018-9472), vol. 20, July-Aug. 1990, p. 923-931. refs
Copyright

The response characteristics of modern, highly augmented aircraft have reached the point where the vehicle and control system dynamics have begun to interact adversely with the actuation dynamics of the human pilot. To address this problem, a simple pilot/vehicle model is developed that can be used both to interpret pertinent flight-test and simulation results and to serve as a tractable tool for assessing proposed changes in manipulator-feel system characteristics. The model hypothesizes proprioceptive information to be a fundamental feedback quantity in the pilot's ability to adopt the compensation characteristics required by the crossover model of the human pilot. The model includes manipulator-feel system dynamics, vestibular (motion) feedback, and a rudimentary form of biodynamic feedback. Simple frequency domain control system analysis techniques are applied to the study of manipulator and force feel system effects and to an analysis of the roll ratchet phenomenon. I.E.

A90-52801#
BACKSIDE LANDING CONTROL OF A STOL AIRCRAFT USING APPROXIMATE PERFECT SERVO
SHOKICHI KANNO (Ichinoseki National College of Engineering, Japan) and TATSUO CHUBACHI Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 33, Aug. 1990, p. 43-54. refs

The automatic backside landing control of a CCV and STOL aircraft using the theory of approximate perfect servo is presented. The problem of backside landing control is known as a minimum phase system and it is a very difficult one. Using an adequate flap control, Zq and Zde of CCV and STOL aircraft are almost cancelled, and the unstable characters of the zeros of aircraft transfer function are corrected to a less unstable type. The control method is an approximate perfect servo, whose transfer function is almost equal to unity. This method is excellent in its convergence, and is effective for the control of pole zero unstable and weak nonlinear plant. Author

N90-28515# British Aerospace Public Ltd. Co., Lancashire (England). Military Aircraft Div.
COMBAT AIRCRAFT CONTROL REQUIREMENTS
T. B. SAUNDERS and J. H. TUCKER *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 20 p Apr. 1990
Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The various functions and requirements for combat aircraft controls which arise from consideration of the flight envelope, agility, handling qualities specifications, and control system design criteria are reviewed. Examples are drawn from supersonic and subsonic combat aircraft designed by British Aerospace including those employing powered lift (Harrier) and those which use a basically unstable airframe to enhance performance (EAP/EFA). The subject is discussed in terms of the basic functions of aircraft controls which are to trim, maneuver, and stabilize. These functions require certain forces and moments to be generated over the full design envelope of speed, Mach number, and angle of attack. A certain minimum level of linearity is desirable although, with some redundancy of controls, trim schedules can be chosen to avoid limited areas of ineffectiveness provided other constraints allow it. The achievable rate of application of control is an important variable which can have a serious impact on the sizing of actuators and power systems. Author

N90-28516*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONTROL RESEARCH IN THE NASA HIGH-ALPHA TECHNOLOGY PROGRAM
WILLIAM P. GILBERT, LUAT T. NGUYEN, and JOSEPH GERA (National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.) *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 18 p Apr. 1990
Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive CSCL 01/3

NASA is conducting a focused technology program, known as the High-Angle-of-Attack Technology Program, to accelerate the development of flight-validated technology applicable to the design of fighters with superior stall and post-stall characteristics and agility. A carefully integrated effort is underway combining wind tunnel testing, analytical predictions, piloted simulation, and full-scale flight research. A modified F-18 aircraft has been extensively instrumented for use as the NASA High-Angle-of-Attack

Research Vehicle used for flight verification of new methods and concepts. This program stresses the importance of providing improved aircraft control capabilities both by powered control (such as thrust-vectoring) and by innovative aerodynamic control concepts. The program is accomplishing extensive coordinated ground and flight testing to assess and improve available experimental and analytical methods and to develop new concepts for enhanced aerodynamics and for effective control, guidance, and cockpit displays essential for effective pilot utilization of the increased agility provided. Author

N90-28517# Eidetics International, Inc., Torrance, CA.
COMBAT AIRCRAFT CONTROL REQUIREMENTS FOR AGILITY
JOSEPH R. CHODY, JOHN HODGKINSON, and ANDREW M. SKOW *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 21 p Apr. 1990
Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The positive effect of increased aircraft agility on air-to-air combat effectiveness has created a need to quantify the impact of preliminary design on the agility potential of candidate aerodynamic configurations. Recently developed measures of agility can provide an important supplement to traditional energy maneuverability measures like specific excess power and turn rate. The very nature of agility, characterized by the combination of traditional energy maneuverability plus controllability, places additional controllability and departure resistance requirements on the aircraft design. Specific issues of aircraft controllability that require close attention during the preliminary design process are highlighted. This will help ensure that the agility potential of the final configuration is not compromised at some point in the design process due to inadvertent oversight. Methods for estimating agility potential early in the design process are given as well as extensions of currently used departure susceptibility prediction techniques. A brief synopsis of agility is given from a historical standpoint and several agility measures of merit currently being used, are discussed. The benefits of improved lateral agility are illustrated by mapping potential lateral agility improvements as a function of angle of attack onto a typical energy-maneuverability envelope showing regions of enhanced combat capability. Author

N90-28518# Aeronautica Macchi S.p.A., Varese (Italy).
AERODYNAMIC CONTROL DESIGN: EXPERIENCE AND RESULTS AT AERMACCHI
B. BUFACCHI, M. LUCCHESINI, L. MANFRIANI, and E. VALTORTA *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 13 p Apr. 1990
Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

A review of Aermacchi activities in the field of aerodynamic control design is presented. The aerodynamic balancing of the MB-326/339 elevator and of the AM-X control surfaces for the manual backup mode are described. The use of rotary balance wind tunnel testing and of simulation in assessing controllability at high angle of attack is discussed. Preliminary design studies of unconventional layouts are described and some features of control techniques on an unstable canard design are illustrated using wing tunnel results and flow visualization. Author

N90-28521*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INNOVATIVE CONTROL CONCEPTS AND COMPONENT INTEGRATION FOR A GENERIC SUPERCRUISE FIGHTER
BRET A. MARKS (McDonnell Aircraft Co., Saint Louis, MO.) and DAVID E. HAHNE *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 14 p Apr. 1990
Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive CSCL 01/3

The results of a series of low speed wind tunnel tests conducted in the NASA Langley Research Center (LaRC) 12 ft Low Speed Wind Tunnel (LSWT) are highlighted. The main objectives of the tests were to provide generalized component integration guidelines and to investigate a variety of innovative control concepts designed to improve the high angle of attack (AOA) controllability of a generic class of supercruise fighters. Author

N90-28522*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DEVELOPMENT OF NON-CONVENTIONAL CONTROL METHODS FOR HIGH ANGLE OF ATTACK FLIGHT USING VORTEX MANIPULATION
GERALD N. MALCOLM, T. TERRY NG, LIANE C. LEWIS (Eidetics International, Inc., Torrance, CA.), and DANIEL G. MURRI *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 17 p Apr. 1990 Previously announced in IAA as A89-47653
(Contract F33615-86-C-3623)
Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive CSCL 01/3

Methods of manipulating the forebody vortices on a generic fighter model to produce controlled yawing moments at high angles of attack were investigated. Forces and moments were measured on the complete configuration and on the isolated forebody. Two schemes for vortex control on the forebody were evaluated: individually-controlled tip strakes and individually-controlled blowing ports. The effectiveness of the forebody strakes in controlling forebody side forces was strongly dependent on the size and location of the strakes. A yawing moment can be produced by deploying the forebody strakes asymmetrically, or can be eliminated by deploying the strakes symmetrically. The most effective strake position was found to be near the primary separation point, between 105 and 120 deg from windward. Blowing on the surface of the model was also shown to have a strong effect on the yawing moment. Blowing either forward or aft tangential to the surface appears to be more effective than blowing normal to the surface. The most effective method to control the yawing moment on the forebody was to minimize the natural asymmetry with a pair of small symmetrically mounted tip strakes and to perturb the vortex system away from the symmetric condition with asymmetric blowing. Author

N90-28525# London Univ. (England).
UNSTEADY AERODYNAMICS OF CONTROLS
G. J. HANCOCK and D. G. MABEY (Royal Aerospace Establishment, Bedford, England) *In* AGARD, Aerodynamics of Combat Aircraft Controls and of Ground Effects 17 p Apr. 1990
Copyright Avail: NTIS HC A15/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The physics of quasi-steady aerodynamics are discussed. The concept of an aerodynamic rise time is defined, which indicates how quickly steady states are realized. Long rise times occur at low transonic speeds, but short rise times occur at high transonic speeds. Predictions of control surface characteristics compare poorly with experimental results. Experimental errors are possibly due to small gaps and wind tunnel wall interference while in the theoretical methods boundary layer approximations may be suspect. The interface of unsteady aerodynamics with control system design and validation is described. It is pointed out that the unsteady aerodynamic input is limited to approximate and tailored forms of linearized aerodynamics. It is not clear how more accurate, nonlinear transonic aerodynamics can be incorporated in control design procedures. Author

N90-28576# Aeronautical Research Labs., Melbourne (Australia).
A FLIGHT DYNAMIC MODEL OF AIRCRAFT SPINNING
S. D. HILL and C. A. MARTIN Jun. 1990 45 p
(AR-005-600; ARL-FLIGHT-MECH-R-180) Avail: NTIS HC A03/MF A01

A flight dynamic model of aircraft spinning was developed. It

is capable of simulating aircraft behavior from conventional flight through stall, spin entry, steady spin, and spin recovery. A data base storage technique has been used to provide the six force and moment coefficients required. The data base embodies rotary balance data measured for a basic training aircraft plus computed small disturbance data calculated from a line vortex model.
Author

N90-28577# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluids Dynamics Div.
A CONCEPTUAL FRAMEWORK FOR FIGHTER FLIGHT CONTROL SYSTEMS
RAJENDRA K. BERA Apr. 1990 28 p
(PD-CF-9009) Avail: NTIS HC A03/MF A01

A conceptual framework for the design of a combatworthy flight control system for air-superiority fighters is set down. An attempt is made to foresee possible pitfalls in attempting to implement a full-authority digital flight control system in the present Indian context and to suggest a viable means of circumventing them.
Author

N90-28578*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AERODYNAMIC PARAMETERS OF HIGH-ANGLE-OF ATTACK RESEARCH VEHICLE (HARV) ESTIMATED FROM FLIGHT DATA
VLADISLAV KLEIN, THOMAS R. RATVASKY, and BRENT R. COBLEIGH (George Washington Univ., Hampton, VA.) Aug. 1990 68 p
(NASA-TM-102692; NAS 1.15:102692) Avail: NTIS HC A04/MF A01 CSCL 01/3

Aerodynamic parameters of the High-Angle-of-Attack Research Aircraft (HARV) were estimated from flight data at different values of the angle of attack between 10 degrees and 50 degrees. The main part of the data was obtained from small amplitude longitudinal and lateral maneuvers. A small number of large amplitude maneuvers was also used in the estimation. The measured data were first checked for their compatibility. It was found that the accuracy of air data was degraded by unexplained bias errors. Then, the data were analyzed by a stepwise regression method for obtaining a structure of aerodynamic model equations and least squares parameter estimates. Because of high data collinearity in several maneuvers, some of the longitudinal and all lateral maneuvers were reanalyzed by using two biased estimation techniques, the principal components regression and mixed estimation. The estimated parameters in the form of stability and control derivatives, and aerodynamic coefficients were plotted against the angle of attack and compared with the wind tunnel measurements. The influential parameters are, in general, estimated with acceptable accuracy and most of them are in agreement with wind tunnel results. The simulated responses of the aircraft showed good prediction capabilities of the resulting model.
Author

N90-28579# Defence Research Establishment Suffield, Ralston (Alberta).
A SENSOR STABILIZATION/TRACKING SYSTEM FOR UNMANNED AIR VEHICLES
JEAN-PAUL DECRUYENAERE May 1990 45 p
(AD-A224008; DRES-SM-1321) Avail: NTIS HC A03/MF A01 CSCL 01/3

A control algorithm for the automatic steering of an imaging sensor has been developed at DRES. Both the tracking of a fixed ground point and the stabilization of the sensor are addressed. This system has been implemented in large part with pre-existing hardware and software in our unmanned air vehicles (UAV) system. This report describes the theoretical basis of the system as well as detailing the issues concerning the development of a working prototype.
GRA

N90-29399# National Aerospace Lab., Tokyo (Japan). Control Div.
SHORT PERIOD CONTROL USING ANGULAR ACCELERATION FEEDBACK: COMPENSATION FOR FIRST LAG SERVO [KAKU KASOKUDO FI-DOBAKKU NIYORU KOUKU-KI NOTANSHU-KI SEIGYO: ICHIJI OKURE SA-BO NO HOSHO]
MASAAKI YANAGIHARA, MASAHIKO NAGAYASU, and SHUICHI SASA Feb. 1989 16 p In JAPANESE
(NAL-TM-600; ISSN-0452-2982; JTN-90-80188) Avail: NTIS HC A03/MF A01

In order to insure the dynamic pitching stability of an aircraft, the Stability Augmentation System (SAS) with angular velocity feedback was used for the short period control. The pitching motion due to gust, etc., can be stabilized automatically by this system. When the time constant of a first lag in servo system which drives an elevator is large, however, the damping of SAS sometimes becomes less effective as the feed back gain increases. The recovery method for the damping effect of SAS in which the angular acceleration of an aircraft was measured with angular accelerometer and used for the additional feedback for SAS was investigated. As the result, the lag of servo system was found to be compensated by the feedback of the angular acceleration and this technique was shown to be effective for the control of the gust response.
NASDA

N90-29401# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.). Abt. fuer Flugversuchstechnik.
PROCEDURE FOR CALIBRATING FLY-BY-WIRE CONTROL CHAINS OF THE FLYING TESTBED ATTAS
ADOLF ZACH and WILHELM REESE 1990 37 p In GERMAN; ENGLISH summary
(DLR-MITT-90-02; ISSN-0176-7739; ETN-90-97537) Avail: NTIS HC A03/MF A01; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Federal Rep. of Germany, HC 16 deutsche marks

The computer system of the flying testbed ATTAS (Advanced Technologies Testing Aircraft System) is used to control the most important systems by electrohydraulic actuators (fly-by-wire). For static calibration, the signals of the fly-by-wire control chains were measured in tests on ground. Some transfer functions were investigated, such as rudder position-actuator position, rudder position-actuator position controlling, rudder-position control path and actuator position controlling-control path. The results were analyzed by the interactive data processing software package DIVA, conceived for the evaluation of very large test data systems.
ESA

N90-29402# National Aerospace Lab., Tokyo (Japan).
A DIGITAL CONTROLLER FOR ACTIVE AEROELASTIC CONTROLS
T. UEDA and K. MUROTA Feb. 1989 40 p In JAPANESE; ENGLISH summary
(NAL-TR-1014; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

A high-speed digital controller for aeroelastic controls was designed and made. The purpose was to minimize adverse phase lag which is inevitably produced by the CPU time of digital processing. The delay deteriorates control performances on rather rapid phenomena like aircraft flutter. With fix-point operation the controller realized 417 microseconds of throughput time including the A/D and D/A conversion. This corresponds to a high sampling rate of 2.4 kHz. The controller furnishes two channels, each of which can be implemented with up to the eighth order control laws allowing the coupling terms. Control laws can be loaded by changing coefficients for multiplication in its expansion form. These coefficients are calculated and transferred by a peripheral computer through the GP-IB busline. At the stage of D/A conversion, the number of bit-shifts associated with a scaling is made programmable to avoid overflow and to lessen inaccuracy due to the truncation error. A sample period is also selectable through the GP-IB busline. This period ranges from 1 ms to 500 microsec. In the appendix, a program is presented for converting from the continuous transfer function in the Laplace domain to a discrete

transfer function in the z-domain with the aid of Tustin's approximation. Author

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RESEARCH AND SUPPORT FACILITIES (AIR)

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

A90-52616#
EXPERIMENTAL WORK STATION SIMULATOR AT THE TEST STATION OF THE BUNDESANSTALT FUER FLUGSICHERUNG [EXPERIMENTELLER ARBEITSPLATZ SIMULATOR BEI DER ERPROBUNGSSTELLE DER BUNDESANSTALT FUER FLUGSICHERUNG]
WALTER P. SCHWARZOTT Ortung und Navigation (ISSN 0474-7550), no. 2, 1990, p. 255-260. In German.

An experimental work position simulator (EWS) has been developed for the German federal agency for flight safety. The EWS permits research and analysis of styles and methods of working in order to assist in the introduction of new flight safety systems. The development of the EWS is reviewed, and simulations are described which have been conducted to improve electronic data displays by replacing control strips with electronic data. C.D.

A90-52617#
DESIGN AND EVALUATION OF THE ATC INTERFACE - PLANNING SYSTEM FOR APPROACH FLIGHT [AUSLEGUNG UND BEWERTUNG DER SCHNITTSTELLE LOTSE - PLANUNGSSYSTEM AM BEISPIEL DER ANFLUGPLANUNG]
FRED V. SCHICK (DLR, Institut fuer Flugfuehrung, Brunswick, Federal Republic of Germany) Ortung und Navigation (ISSN 0474-7550), no. 2, 1990, p. 261-268. In German.

The development of a man-machine interface for air-traffic controllers is discussed, using planning for an approach flight interface as an example. The results of simulations and field tests are reviewed. The factors affecting the interface configuration are summarized. C.D.

A90-52700
AT A DEPTH OF 500 METERS - THE TU DRESDEN SUPERSONIC WIND TUNNEL [IN 500 METERN TIEFE - UEBERSCHALL-WINDKANAL DER TU DRESDEN]
Luft- und Raumfahrt (ISSN 0173-6264), vol. 11, 3rd Quarter, 1990, p. 48, 49. In German.

The design and operational capabilities of the wind-tunnel facilities of the Technische Universitaet Dresden are briefly described and illustrated with drawings and photographs. Particular attention is given to: (1) the low-speed tunnel, used primarily for aerodynamic studies of land vehicles and engineering structures and for investigations of the diffusion of gases in the atmospheric boundary layer; and (2) the Mach 4 wind tunnel, located in a potash mine in Thuringia, at a depth of 500 m. The latter tunnel works on the vacuum principle: three test sections are set up in pipes connecting a 1000-cu-m chamber at pressure 9 bars with a vacuum chamber at 0.2 bar. This permits flow velocities of up to Mach 4 for tests lasting up to 3 min. New plans to use this tunnel to test two model nozzles for the Saenger aerospace plane are discussed. T.K.

A90-52857
AIRPORT TECHNOLOGY INTERNATIONAL 1989/1990
MAURICE G. HUDSON, ED. London, Sterling Publications, Ltd., 1989, 336 p. No individual items are abstracted in this volume.

Topics presented include an air transport policy for the European Community, the essential elements in a U.S. transportation policy, solutions to airport and airspace capacity shortage, air transport growth in the Asia-Pacific region, and the competition between air and high-speed rail. Also presented are the world issues in heliport development, an airport commercial review, the design of effective national aviation security systems, and aircraft anti-icing fluid technology and application. Attention is also given to controlling run-up noise in the 1990s, the potential hazards of poor runway surfaces, the work of the ECAC Technical Committee, and civil air transport training for military pilots. R.E.P.

N90-28580# National Academy of Sciences - National Research Council, Washington, DC. Building Research Board.
PROCEEDINGS OF A WORKSHOP ON FUTURE AIRPORT PASSENGER TERMINALS
A. C. LEMER 1989 45 p Workshop held in Washington, DC, 6-7 Jun. 1989; sponsored in part by Building Research Board and the Transportation Research Board
(PB90-213620) Avail: NTIS HC A03/MF A01 CSCL 01/5

A report of a workshop on future airport passenger terminals, sponsored by the Building Research Board in cooperation with the Transportation Research held in the Washington Metropolitan Area Transit Authority (WMATA) is given. An introduction is given to the factors any jurisdiction has to look at when investing in transportation facilities. After reviewing the funding mechanisms and debt service already being borne by WMATA to set the context, the financial condition of each of the WMATA major funding contributors is examined in detail. Each jurisdiction's writeup includes its credit rating from Moody's and Standard and Poor's, its current mass transit service revenue commitment to the transit system, its economic situation, its current tax base and taxing rate restrictions, the composition of its general fund, its borrowing history (both in terms of amounts borrowed and from whom), and projected expenditures. Although oriented toward large projects, the document can introduce assessment of ability to pay to governments of any size. Author

N90-28581# Federal Aviation Administration, Washington, DC.
DEVELOPMENT OF ACCEPTANCE PLANS FOR AIRPORT PAVEMENT MATERIALS. VOLUME 1: DEVELOPMENT Final Report, 1 Oct. 1986 - 31 May 1990
JOHN E. FOSTER and KAMRAN MAJIDZADEH (Resource International, Inc., Columbus, OH.) May 1990 197 p
(Contract DTFA01-86-Y-01046)
(DOT/FAA/RD-90/15) Avail: NTIS HC A09/MF A02

Statistically based acceptance/rejection plans and payment adjustment schedules were developed for five specifications: (1) excavation and embankment; (2) crushed aggregate base course; (3) cement treated base course; (4) econocrete subbase course; and (5) portland cement concrete pavement. The statistical analysis of data, development of payment adjustment plans (PAP), and development of PAP computer diskette system are presented. Test data used for this effort were collected from field sources. The developed PAP formulas, schedules, and computer diskette system were verified using new pavement construction projects. Author

N90-28582# Soil and Materials Engineers, Inc., Ann Arbor, MI.
DEVELOPMENT OF A THICKNESS DESIGN PROCEDURE FOR STABILIZED LAYERS UNDER RIGID AIRFIELD PAVEMENTS Final Report, May 1987 - May 1990
STARR D. KOHN and CHAOUKI A. GEMAYEL May 1990 150 p
(Contract DTFA01-81-Y-10555)
(DOT/FAA/RD-90/22) Avail: NTIS HC A07/MF A01

The results of an analysis of two rigid layer pavement systems are presented. The outcome of the study resulted in the development of a design procedure which can account for the materials properties of the stabilized materials layer. The study employed the use of elastic layer theory and regression analysis to predict the interior stress under aircraft loading. Equivalent interior stress is used as the design criteria such that a single layer rigid pavement on subgrade is equated to a two layer system with a cement-treated base course and a portland cement concrete

surface. The comparison of the developed procedures to the existing procedures show both allowable decreases and increases in the thickness of the portland cement concrete layer. The design procedure is an iterative process and was computerized. Author

N90-28583 Southampton Univ. (England).
THREE-DIMENSIONAL MODEL TESTING IN THE TRANSONIC SELF-STREAMLINING WIND TUNNEL Ph.D. Thesis
GRAEME NEAL 1988 327 p
Avail: Univ. Microfilms Order No. BRDX88081

The wall interference effects present on three-dimensional models during wind tunnel testing are difficult to correct using post-test model data correction methods. Further, at transonic speeds, with the use of ventilated test sections these corrections become complex to apply and inaccurate. The high quality of wind tunnel testing that is required today means that such methods are no longer satisfactory. The flexible walled wind tunnel has in recent years shown its ability to obtain two-dimensional aerofoil data free from the effects of wall boundary restraint. The use of the two-dimensional Transonic Self-Streamlining Wind Tunnel was extended to the relief of wall interference effects on three-dimensional models. The compromise of using only two-wall single curvature movement avoids the problems that are inherent with the additional complexity of fully three-dimensional adaptive tunnels. A method of assessing the wall-induced interference velocity components from tunnel boundary pressure data, without reference to the model, was developed and validated against other wall interference assessment methods. The algorithm, suitable for use in adaptive tunnels, is used with a wall movement influence coefficient method of wall contour prediction resulting in the apparent removal of wall interference effects along a streamlining target line. A calibrated force-balance wing-body model was used to demonstrate the first successful streamlining around a three-dimensional model in the Transonic Self-Streamlining Wind Tunnel. Dissert. Abstr.

N90-28584# Federal Aviation Administration, Atlantic City, NJ.
ANALYSIS OF HELIPORT ENVIRONMENTAL DATA, INTRACOASTAL CITY
ROSANNE M. WEISS Jul. 1990 81 p
(Contract FAA-T0701U)
(DOT/FAA/CT-TN89/43) Avail: NTIS HC A05/MF A01

During a 2 day period in May 1988, heliport environmental data were collected at Petroleum Helicopter Incorporated's Heliport in Intracoastal City, LA. The purpose of this data collection activity was to gather measurements of rotorwash at a heavy used heliport frequented by larger helicopters with higher gross weights then observed during previous data collection activities. During this operation, ten wind vector transmitters were situated at various locations around the facility in order to gather information to describe the rotorwash induced wind speed and wind direction changes. The results of this data collection activity are documented. The data collection and analysis methodology are explained. Graphical presentations of the heliport environment and or rotorwash induced wind speeds and wind speed and direction changes are included. The Concepts Analysis Division Report, ACD-330-89-10, Analysis of Heliport Environment Data, Intracoastal City, LA, contains the heliport wind speed and direction plots for each flight. The results of this study will be considered in future modifications of the Federal Aviation Administration (FAA) Heliport Design Advisory Circular (AC) 150/5390-2. Author

N90-28586# Naval Postgraduate School, Monterey, CA.
DEVELOPMENT AND TESTING OF RAPID REPAIR METHODS FOR WAR DAMAGED RUNWAYS M.S. Thesis - Florida Univ.
PAUL A. SOARES 1990 164 p
(AD-A223970) Avail: NTIS HC A08/MF A01 CSCL 01/5

A need exists to establish a main runway repair method that is rapid, effective, and easy to install. The primary objective of this research was to develop a rapid runway repair method that could be implemented by the armed forces within their current resources. A method of mixing fine aggregate, coarse aggregate, cement, and water was developed using soil stabilizing equipment. The required testslab thickness was selected from known slab thicknesses in existence today. The mix design was developed for a roller compacted mix. The mix design was tested in a laboratory for compressive, tensile and flexural strength. Simplified relationships were developed between the degree of compaction versus the strength of concrete. Moist Rodded Unit Weight tests were performed on the fine and coarse aggregates to determine a pre-mix unit weight of each material. The mix proportions by weight of fine aggregate, coarse aggregate, and cement were converted to pre-mix volumes. An angle of repose test was performed on the fine and coarse aggregates. The pre-mix volumes were converted to layer thicknesses. A field test procedure was developed to conduct a large scale test of the method. A large scale test was performed. GRA

N90-29403 Loughborough Univ. of Technology (England). Dept. of Transport Technology.
THE POTENTIAL FOR AN EXTRA RUNWAY AT HEATHROW: A PRELIMINARY FEASIBILITY STUDY
ANGELOS BELIYIANNIS, KEVIN BYRNE, JOSEPH GAVRIILIDIS, CHRISTOPHER HIGGINS, ALEX HOFFMANN, MARIO MACEDO, AMOS MARAWA, MAHMOUD MEHALLI, RICARDO RODRIGUESPACHECO, MOHAMED SAEED et al. Apr. 1990 66 p
(TT-9007; ISBN-0-904947-21-1) Copyright Avail: Issuing Activity

A preliminary examination of the feasibility of providing an off-airport auxiliary runway at Heathrow is presented. The runway will include facilities that are fully integrated with the main Heathrow terminals. In addition, an assessment of the operational and environmental consequences is discussed. The operational criteria of fleet mix, air traffic, runway length and location, air transport capacity, terminal transfer, and ground access are addressed. The airside, terminal, and apron designs are also covered. Noise contours for varying runway lengths are provided as part of the noise impact assessment for Heathrow's planned auxiliary runway. Author

N90-29406# Environmental Research Inst. of Michigan, Ann Arbor. Advanced Concepts Div.
ELECTRO-OPTICS ENGINEERING SUPPORT FOR THE INTEGRATED LAUNCH AND RECOVERY TELEVISION SURVEILLANCE SYSTEM Final Report, 1 Oct. 1989 - 30 Apr. 1990
KENNETH K. ELLIS and BRAD D. NEAGLE Jun. 1990 46 p
(Contract DLA900-88-D-0392)
(AD-A223450; ERIM-213400-54-F) Avail: NTIS HC A03/MF A01 CSCL 15/4

The Integrated Launch and Recovery Television Surveillance (ILARTS) System is used aboard U.S. aircraft carriers to provide aircraft landing information. The images are used to supplement the LSO's view during landing information. The images are used to supplement the LSO's view during landing operations. In addition, recorded imagery is used during pilot de-briefings and accident investigations. Operational requirements of the system are analyzed. The results of a vendor camera survey are summarized. Recommendations are made for modifying the system specification without loss of performance. The possibility of replacing visible light cameras with FLIRs (forward look infrared) is examined. Methods for quantifying and reducing blooming are discussed. GRA

N90-29407# Dayton Univ., OH. Research Inst.
TERRAIN VISUAL CUE ANALYSIS FOR SIMULATING LOW-LEVEL FLIGHT: A MULTIDIMENSIONAL SCALING APPROACH Interim Report, Jun. 1987 - Feb. 1990
JAMES A. KLEISS Jun. 1990 27 p
(Contract F33615-87-C-0012)
(AD-A223564; AFHRL-TR-90-20) Avail: NTIS HC A03/MF A01 CSCL 08/2

Multidimensional scaling was used to analyze the features of real-world terrain that are salient to pilots during low-level flight. The stimuli were nine short (5-second duration) videotape segments

depicting low-level, high-speed flight over a variety of terrain types. The segments were paired in all possible combinations, yielding a total of 36 stimulus pairs. Fifteen experienced pilots rate the visual similarity of each terrain pair on a 10-point scale anchored at 0 with Highly Dissimilar and at with Highly Similar. The rating data were submitted to a nonmetric multidimensional scaling analysis using the procedure ALSCAL. A 2-D solution yielded dimensions corresponding to: (1) terrain flatness/verticality, and (2) a composite of the size, density and spacing of scene elements. The only two A-10 pilots in the investigation weighted Dimension 2 much more heavily than did any other subjects. These results suggest that: (1) efforts should be directed toward effectively modeling vertical features such as hills and ridge lines in simulator visual scenes; (2) a high density of small scale and closely spaced scene elements (e.g., desert bushes) is less effective than larger scale, more distinguishable scene elements (e.g., buildings); and (3) mission requirements for certain aircraft (e.g., the V-10) may place special emphasis on particular types of scene content. GRA

N90-29408# Federal Aviation Administration, Washington, DC. Office of Airport Safety and Standards.
RELIABILITY AND PERFORMANCE OF FRICTION MEASURING TIRES AND FRICTION EQUIPMENT CORRELATION Final Report
THOMAS H. MORROW Mar. 1990 377 p
(AD-A223694; DOT/FAA/AS-90/1) Avail: NTIS HC A17/MF A02 CSCL 01/3

This report contains the description and results of a test program conducted by the Federal Aviation Administration (FAA) at the National Aeronautics and Space Administration (NASA) Wallops Flight Facility (WFF) located at Wallops Island, Virginia. The field tests were conducted in August 1989. The purpose of the test program was twofold: (1) to establish the reliability, performance and consistency of friction measuring tires used by qualified friction devices; and (2) select the best performing tire(s) for friction equipment correlation for maintenance purposes. Four friction devices were used with their self wetting systems on five types of pavement surfaces. Tests were conducted at speeds of 40 and 60 mph (65 and 95 km/h). A total of 1,643 test runs were conducted, which resulted in 2,725 data points, and 156 regression analyses were performed for the tire performance evaluation and 31 regression analyses for friction equipment correlation. The results showed that the McCreary tire performed best on the Saab Friction Tester (SFT), Runway Friction Tester (RFT) and Skiddometer (SKD). The Dico Tire performed the best on the Mu Meter (MUM). The tire composition given in ASTM E 524 for the McCreary tire will be included in a new ASTM specification that will have the same tire dimensions given in ASTM E 630. The DICO tire will be included in the ASTM E 670 specification. GRA

N90-29409 Physics and Electronics Lab. TNO, The Hague (Netherlands).
STUDY IMPROVEMENT TRAINING FACILITIES GROUND CONTROL AIR TRAFFIC CONTROLLERS. PART 2: FUNCTIONAL ANALYSIS APPROACH CONTROL TRAINER Final Report, Part 2, Sep. 1988-Sep. 1989
W. G. DEJONG and J. C. M. MOOIJEKIND Oct. 1989 189 p In DUTCH; ENGLISH summary
(Contract A88/KLU/621)
(FEL-89-A280-PT-2; TD-89-3865-PT-2; ETN-90-97414) Copyright Avail: TNO Physics and Electronics Lab., P.O. Box 96864, 2509 JG The Hague, The Netherlands

A functional analysis was performed with a view to a feasibility study of alternatives for the improvement of the air traffic control training facilities. The approach air traffic control around the air bases of the Royal Netherlands Air Force is introduced. The functional specifications for an approach control trainer are presented. The functional analysis follows the Yourdon and DeMarco methodology which is introduced. The essential part of the functional analysis are the data flow diagrams, together with process and data specifications. ESA

N90-29411# National Aerospace Lab., Tokyo (Japan).
ESTIMATION OF POWER SPECTRAL DENSITY OF RUNWAY ROUGHNESS
KOSABURO YAMANE and TOKUO SOTOZAKI Oct. 1989 33 p In JAPANESE; ENGLISH summary
(NAL-TR-1037; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

Attention is focused on a power spectral density (PSD) method in order to evaluate runway roughness from the standpoint of airplane loads, and a procedure for estimating runway spectra is examined. It is shown that the low order trend (long wavelength component) included in a runway profile can seriously impair the estimated spectra, and therefore, a simple method to remove this trend is obtained. Next, power spectra of sixteen commercial runways are estimated, including the spectra of symmetric and anti-symmetric components between two tracks, to provide airplane design data on ground loads. Comparing the runway spectra obtained before and after overlay repair of runway surface, it is shown that the power spectral presentation is an effective method to evaluate runway roughness. Author

N90-29412# National Aerospace Lab., Tokyo (Japan).
THE FUNCTION OF THE INTERACTIVE MODEL ASSEMBLY PROGRAM (IMAP) FOR A FLIGHT SIMULATOR
KAORU WAKAIRO, AKIRA WATANABE, and SHUICHI SASA Jan. 1989 80 p In JAPANESE; ENGLISH summary
(NAL-TR-1034; ISSN-0389-4010) Avail: NTIS HC A05/MF A01

The National Aerospace Laboratory (NAL) has a flight simulator for research and development of aircraft. The flight simulator is composed of a cockpit system, a visual system, a motion system, and a computer system for real-time calculation. A visual system is indispensable for piloted aircraft simulation. In 1966, NAL installed a visual system with a miniature model board. It generated imagery by using a servo-drive TV method. However, several years later it was requested to improve the movement speed and the range. In 1983, NAL upgraded the visual system to a CGI (Computer Generated Imagery) type system for the research and development of a new STOL (Short Take-Off and Landing) research aircraft. A CGI type visual system needs a large visual digital data base for a wide range scene. NAL developed the Interactive Model Assembly Program (IMAP). It is easy to make a visual data base with this program. The characteristics of the IMAP are as follows: interactive generation of visual data base; ease of editing a visual data base; fast searching of visual data base; real-time display of visual data base; and line drawing of a visual scene by using a graphic display. Up to the present the IMAP has been used for various simulation tests, such as the NAL STOL aircraft simulation, spacecraft rendezvous simulation, and re-entry simulation of a space plane. It has been proven that the program contributes to decreasing the time needed to make visual data. The IMAP functions and its hardware configuration in use are described. Lastly results are compared between the IMAP and the BMAP (Batch-type Model Assembly Program). Author

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ASTRONAUTICS

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

N90-29433# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
SOLID FUEL COMBUSTION CHAMBER Progress Report No. 16, Jun. - Dec. 1989
H. WITTENBERG, P. A. O. G. KORTING, B. T. C. ZANDBERGEN, ed., T. WIJCHERS, P. J. M. ELANDS, J. P. DEWILDE, and F. DIJKSTRA Jun. 1990 23 p Prepared in cooperation with

Prins Maurits Lab. TNO, Rijswijk, Netherlands
(LR-634; PML-1990-C50; SFCC-59; ETN-90-97645) Avail: NTIS HC A03/MF A01

An overview of the July to December 1989 period of the Solid Fuel Combustion Chamber (SFCC) project (phase 2) is given. This project was initiated in 1982 and aims at developing a capability to predict the performance of SFCC's in order to be able to evaluate the SFCC for e.g., Solid Fuel Ramjet (SFRJ) propulsion, hybrid rocket propulsion, turbine propulsion and for the clean combustion of waste materials. The planned work is directed at improving the knowledge of the combustion behavior (i.e., regression behavior, combustion efficiency, flame temperature and composition flammability limits and combustion instability) in turbulent channel flows (variables to be considered chamber pressure, mass flow, air temperature, and oxygen content of the air); determining the effects of size, configuration variables (inlet shape, aft mixing chamber/bypass) and different fuels (including waste materials) on the combustion behavior. To this end, both experimental and theoretical research activities are planned. Management, finances and personnel, activities, project status, utilization aspects, student involvement, and publications, reports, presentations and contacts are reviewed. ESA

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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.

A90-49893
UNDERSTANDING COMPOSITE FATIGUE - NEW TRENDS
V. GIAVOTTO, C. CAPRILE, and G. SALA (Milano, Politecnico, Milan, Italy) IN: Aeronautical fatigue in the electronic era; Proceedings of the Fifteenth ICAF Symposium, Jerusalem, Israel, June 21-23, 1989. Warley, England, Engineering Materials Advisory Services, Ltd., 1989, p. 425-451. refs
Copyright

New trends in testing methods make fatigue of long fiber composites more tractable and understandable. Regarding specimen testing, the novelty includes extensive stiffness monitoring, and compression testing. The latter suggests the development of new specimen sections, capable to sustain compression without the use of the questionable anti-buckling guides. Author

A90-50056
INTERNATIONAL SAMPE SYMPOSIUM AND EXHIBITION, 35TH, ANAHEIM, CA, APR. 2-5, 1990, PROCEEDINGS. BOOKS 1 & 2
GERRY JANICKI, ED. (McDonnell Douglas Space Systems Co., Huntington Beach, CA), VINCE BAILEY, ED. (Ferro Corp., Composites Div., Los Angeles, CA), and HASSEL SCHJELDERUP, ED. Covina, CA, Society for the Advancement of Material and Process Engineering (Science of Advanced Materials and Process Engineering Series. Volume 35), 1990, p. Book 1, 1234 p.; book 2, 1227 p. For individual items see A90-50057 to A90-50155, A90-50157 to A90- 50160, A90-50162 to A90-50210, A90-50212 to A90-50230.
Copyright

The present conference discusses topics in the fields of ultralightweight structures, producibility of thermoplastic composites, innovation in sandwich structures, composite failure processes, toughened materials, metal-matrix composites, advanced materials for future naval systems, thermoplastic polymers, automated composites manufacturers, advanced adhesives, emerging processes for aerospace component fabrication, and modified resin systems. Also discussed are matrix behavior for damage tolerance, composite materials repair, testing for damage tolerance, composite strength analyses, materials workplace health and safety, cost-conscious composites, bismaleimide systems, and issues facing advanced composite materials suppliers. O.C.

A90-50057
DOMESTIC PRECURSOR TECHNOLOGY - A UNIQUE ROUTE TO CURRENT AND FUTURE GENERATION CARBON FIBERS
G. P. DAUMIT, J. D. RECTOR, J. G. VENNER, D. W. WILSON, and C. C. YOUNG (BASF Structural Materials, Inc., Charlotte, NC) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1-12. refs
Copyright

A melt-assisted extrusion process has been formulated as the basis for a fiber-spinning process offering a unique route to future carbon-fiber manufacture. The process has already been used to produce 3000-, 6000-, and 12,000-fiber precursor tows of aerospace grade; tests of the fibers' performance as reinforcements for a variety of resin systems shows them to be adequate replacements for G30-500 fibers manufactured from an imported precursor. The production process is sufficiently versatile to allow the modification of fiber cross-sectional shape and even fiber composition, allowing unique properties to be tailored. Improved compressive strength may be the first of the performance gains thus obtainable. O.C.

A90-50058
COMPARISON OF PROCESSING TECHNIQUES FOR FILMIX UNIDIRECTIONAL COMMINGLED FABRIC
JOHN D. RUSSELL (USAF, Materials Laboratory, Wright-Patterson AFB, OH) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 13-24. refs
Copyright

Thermoplastics are important to aerospace composites because of their ability to reform, shorter cycle time in processing, and increased damage tolerance over epoxies. A wide variety of thermoplastic preforms are currently available, such as prepreg tape, cowoven fabric, and commingled fabric. One type of commingled fabric has become available from Heltra. Heltra fabrics are different, because the reinforcing and thermoplastic tows are stretch broken and then spun into a continuous yarn. Different processing techniques of a 1300 denier Filmix unidirectional commingled fabric (AS4/PEEK) were investigated, and optimum processing was determined by the resulting laminate quality using C-scan, photomicrographs, and mechanical properties. Author

A90-50059
INNOVATIVE DESIGN CONCEPTS FOR THERMOPLASTIC COMPOSITE MATERIALS
MICHAEL C. Y. NIU (Lockheed Composites Development Center, Burbank, CA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 25-36.
Copyright

The development of new materials, material forms and fabrication method has progressed rapidly in recent years. Advances in structural design concepts have been negligible. The DoD and NASA are considering many new programs which will require 'new and innovative' composite structural designs that have not yet been developed in the composite design arena to data. Existing programs work around known composite limitations when designing new structural concepts instead of trying innovative approaches which would utilize composite materials to best advantage and eliminate weaknesses. The objective in composite design is the reduction of aircraft life cycle costs by advancing the state of the art of structural design concepts followed by reducing the costs of manufacturing, tooling, assembly and repair

methods for hybrid composite structures. Reduction of both part counts and mechanical fasteners is the primary driver to reach low manufacturing costs. Author

A90-50060
REPAIR OF THERMOPLASTIC COMPOSITE STRUCTURES BY FUSION BONDING
X. R. XIAO, S. V. HOA (Concordia University, Montreal, Canada), and K. N. STREET (Defence Research Establishment Pacific, Victoria, Canada) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 37-45. Research supported by DND. refs
Copyright

Heating methods for fusion bonding of advanced thermoplastic composites were discussed from the standpoint of repair application. Resistance and induction heating were considered to be potentially suitable methods and subjected to investigation. Experiments on PEEK based APC-2 composite using resistance heating indicated that current density, heating time, pressure and fiber orientation at the surface ply are among the parameters which affect the bond quality. Resistance heating produced lap shear strengths above 20 MPa (3000 psi). Preliminary tests on induction heating also gave promising results. Whereas resistance heating may be used for patching repair, induction heating could be applied to both healing and patching repairs. Author

A90-50062
INTERFACES PROPERTIES OF HIGH TEMPERATURE POLYMER COMPOSITE SYSTEMS
Y. T. LIAO, K. C. LEE, C. J. LIN, and W. L. LIU (Industrial Technology Research Institute, Materials Research Laboratories, Hsinchu, Republic of China) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 72-81. refs
Copyright

A microbond method was used to investigate the interface properties of high-temperature composite systems. The mechanical bondings play a major role in determining the fiber-matrix bond strengths for high-temperature composites. PEI increased both the fracture toughness and the interfacial shear strength simultaneously. Postcure decreased the interfacial shear strengths of BMI composite, but did not affect those of epoxy composite. The results obtained with the microbond method were also compared with those from a single-fiber/resin method for high-temperature composites. Author

A90-50063
POLY(ARYLENE ETHER KETONE)/POLY(ARYL IMIDE) HOMO- AND POLYDIMETHYLSILOXANE SEGMENTED COPOLYMER BLENDS - INFLUENCE OF CHEMICAL STRUCTURE ON MISCIBILITY AND PHYSICAL PROPERTY BEHAVIOR
J. C. HEDRICK, C. A. ARNOLD, M. A. ZUMBRUM, T. C. WARD, and J. E. MCGRATH (NSF, Science and Technology Center; Virginia Polytechnic Institute and State University, Blacksburg) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 82-96. Research supported by NSF and Virginia Polytechnic Institute and State University. refs
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The present investigation of the miscibility of the PEEK/'Ultem' polyimide polymer blend, which has been reported to be complete over all proportions, examines the structural and compositional variations in both components. An account is given of the compositional tailoring of both miscible and immiscible blends of the two components. The introduction of a siloxane into the blend system is noted to be potentially important for numerous prospective applications, in virtue of its improvement of atomic oxygen and flame resistance, as well as its reduction of water absorption. O.C.

A90-50066 College of William and Mary, Williamsburg, VA.
IN-SITU MEASUREMENT, MODELLING AND CONTROL OF THE IMIDIZATION REACTION IN PMR-15
D. KRANBUEHL, D. EICHINGER, D. RICE, A. WILLIAMSON, R. CLARK (College of William and Mary, Williamsburg, VA) et al. IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 123-131. Research supported by USAF and NASA. refs
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The Loos-Springer thermokinetic rheological model is presently applied to the results obtained by correlating the time-temperature dependence of PMR-15's viscosity and extent of imidization reaction with in situ on-line, frequency-dependent EM sensor measurements. Attention is given to the effects of varying the time-temperature cycles in such a way as to optimize flow and fiber wet-out and the removal of volatiles. Both sensor outputs and model predictions can then be used to monitor and control PMR-15's processing properties. O.C.

A90-50067
HIGH TEMPERATURE BEHAVIOR OF THE INNOVATION CARBON/CSPI COMPOSITE
S. E. HSU, H. LIU, C. H. LIU, J. C. CHEN, D. G. HWANG (Chung Shan Institute of Science and Technology, Lung-Tan, Republic of China) et al. IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 132-146. refs
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A high-temperature CSPI (Chung Shan polyimide) composite has been developed. In order to evaluate its performance in real applications with the temperatures up to 500 C, an all-carbon/CSPI composite wing has been designed and manufactured. A series of structural tests have been executed. The results of static structural tests (at both room temperature and elevated temperature) have shown that the carbon/CSPI composite wing possesses better performance than the original steel wing. Conditioned wind-tunnel tests with stagnation temperature up to 500 C have shown that the carbn/CSPI wing can withstand a high-Mach-number aerodynamic environment. Author

A90-50068* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THERMO-OXIDATIVE STABILITY STUDIES OF PMR-15 POLYMER MATRIX COMPOSITES REINFORCED WITH VARIOUS CONTINUOUS FIBERS
KENNETH J. BOWLES (NASA, Lewis Research Center, Cleveland, OH) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 147-161. refs
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An experimental study was conducted to measure the thermooxidative stability of PMR-15 composites reinforced with various fibers and to observe differences in the way they degrade in air. The fibers studied include graphite and the thermally stable Nicalon and Nextel ceramic fibers. Weight-loss rates for the different composites were assessed as a function of mechanical properties, specimen geometry, fiber sizing, and interfacial bond strength. Differences were observed in rates of weight loss, matrix cracking, geometry dependency, and fiber sizing effects. It was shown that Celion 6000 fiber-reinforced composites do not exhibit a straight-line Arrhenius relationship at temperatures above 316 C. Author

A90-50069
HIGH SERVICE TEMPERATURE, DAMAGE TOLERANT PREPREG SYSTEMS BASED ON CYANATE CHEMISTRY
FRANK W. LEE, MAUREEN A. BOYLE (Hexcel Corp., Dublin, CA), PIERRE LEFEBVRE, and JEAN-PIERRE BOTMAN (Hexcel, S.A., Welkenraedt, Belgium) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book

1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 162-174. refs
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A development history and current development status evaluation are presented for cyanate ester resin systems useful in high service temperature/high damage tolerance composite matrix applications. In addition to exhibiting excellent toughness without sacrificing other mechanical properties, these systems are much more easily processed than such other high service temperature resins as the BMIs; the moisture absorption characteristics of cyanate esters is also noted to be 3-4 times lower than state-of-the-art BMIs and epoxies. Accounts are given of prepreg and test specimen preparation methods. O.C.

A90-50070* Foster-Miller Associates, Inc., Waltham, MA.
EFFECTS OF ADDITIVES ON THE PROCESSING AND PROPERTIES OF LARC-TPI POLYIMIDE
L. ELANDJIAN, R. HAGHIGHAT, R. LUSIGNEA, and R. WALLIS (Foster-Miller, Inc., Waltham, MA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 189-198.
(Contract NAS1-18527)
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The blending of LARC-TPI polyimide with the thermotropic liquid crystal polymer designated Xydar and with four different oligomeric imide materials has facilitated the resulting resin systems' processing into films while enhancing their mechanical properties and lowering their coefficient of thermal expansion to virtually zero. Two film-formation processes have been evaluated: (1) the casting of polyamic acid films followed by thermal imidization and biaxial stretching, and (2) the blown-film melt-extrusion of fully imidized LARC-TPI polymer. The best results have been obtained through the use of Xydar as a processing aid at levels in the 10-30 percent range. O.C.

A90-50071
CERAMIC MATERIALS AND COATINGS FOR FUTURE AEROSPACE APPLICATIONS - CHALLENGE OF THE 1990'S
RONALD P. BANAS, JOHN F. CREEDON, and JOHN O. DONALDSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 199-213. refs
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This paper discussed Lockheed Missiles and Space Company's efforts since 1983 on the development and scale-up of a third generation rigid, fibrous ceramic (RFC) materials designated HTP. High Thermal Performance (HTP) is a family of RFC materials that utilize silicon dioxide and aluminum oxide fibers in various percentages. These HTP formulations are stronger and have a high temperature capability then the current RFC materials used on the Shuttle Orbiters. HTP has applications ranging from passive external insulation for future Space Transportation Systems to an internal cryogenic insulation for use in load-bearing fuel tanks. A brief overview of the current RFC materials used on the Shuttle Orbiters is also provided. The paper concludes with a projection of the requirements and challenges for RFC materials in the 1990's. Author

A90-50082
THE EFFECT OF JET FUEL ABSORPTION ON ADVANCED AEROSPACE THERMOSET AND THERMOPLASTIC COMPOSITES
DAVID B. CURLISS, DIANA M. CARLIN, and MICHAEL S. ARNETT (USAF, Materials Laboratory, Wright-Patterson AFB, OH) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 332-345. refs
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The commercially available prepreg systems designated AS-4/3501-6, IM-7/8551-7A, IM-7/977-2, IM-7/5250-4, IM-8/HTA, and AS-4/PEEK, which are respectively representative of standard epoxy, toughened epoxy, toughened BMI, and thermoplastic-matrix composites, have been tested for sensitivity to JP-4 military gas turbine fuel at 180 F. Weight gain for fuel-immersed samples was recorded as a function of the square root of duration. Generally, while the thermoset-matrix systems did not pick up significant levels of fuel in any of the sample layup types investigated, the thermoplastics were significant absorbers, depending on layup. The lower subsequent strengths of the thermosets were attributable to a degradation of the fiber/matrix interface. O.C.

A90-50083
STRUCTURAL AND DYNAMIC ANALYSIS OF THE A330/340 COMPOSITE RAT BLADE
PAT O'CALLAGHAN, GREG HORIHAN, and ANTHONY BLAKELEY (Sundstrand Corp., Advanced Technology Group, Rockford, IL) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 346-360.
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This paper presents the dynamic and structural analysis performed on Sundstrand's compression-molded ram air turbine (RAT) blade for use on the Airbus A330/340 aircraft. The blade is designed with the goals of reduced weight and comparable cost to a forged and machined aluminum blade, while providing equivalent performance and meeting aerospace structural requirements. This analysis is performed using the nonlinear capabilities of the ANSYS finite element code with the material thermoelastic properties obtained using the SMC Program developed at the University of Delaware. Boundary conditions are established for material variations inherent in sheet molding compound (SMC) such as fiber orientation and out-of-plane tilt to assess the sensitivity of the blade's structural performance to material microstructure and processing variations. A methodology for the determination of the structural response of statically determinant short-fiber composites is defined. Author

A90-50085
DURABILITY AND DAMAGE TOLERANCE OF GRAPHITE/EPOXY HONEYCOMB STRUCTURES
RICHARD WONG and RIC ABBOTT (Beech Aircraft Corp., Wichita, KS) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 366-380.
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Damage tolerance principles were followed in designing serviceable and economical graphite epoxy honeycomb sandwich structures for the Beech Starship. Intrinsic manufacturing quality, in-service damage, environmental effects, and discrete occurrences such as lightning strike were considered. Flaw growth data were obtained by cyclic loading of damaged test articles. Residual strength tests were performed on full scale test articles after two lifetimes of cyclic testing. Inspection criteria and intervals were established based on the results of damage tolerance tests.
Author

A90-50088
TOUGHENED CYANATES FOR AEROSPACE APPLICATIONS
G. ALMEN, P. MACKENZIE, V. MALHOTRA, and R. MASKELL (ICI Fiberite, Inc., Tempe AZ) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 408-418. refs
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Aromatic cyanate esters are a versatile class of thermoset resins, which typically exhibit, on curing, glass transition temperatures which are intermediate between those of standard epoxies and bismaleimides. Previous work has shown that these matrices can be toughened significantly by the incorporation of engineering thermoplastics. Composite data are presented for a

novel thermoplastic-modified cyanate, with excellent hot/wet performance (250-325 F), for primary structural aerospace applications. Author

A90-50089
977 - CHARACTERIZATION OF A FAMILY OF NEW TOUGHENED EPOXY RESINS
G. ALMEN, P. MACKENZIE, V. MALHOTRA, and R. MASKELL (ICI Fiberite, Inc., Tempe AZ) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 419-431.
Copyright

The 977 family of toughened epoxy resins has been developed for use in primary structural aerospace applications. Previous work has demonstrated that significant improvements in damage tolerance can be achieved when epoxy resins are modified with thermoplastics. Proper selection of the epoxy matrix and design of the thermoplastic modifier for each member of the 977 resin family give the morphological control necessary for optimum toughness under a variety of hot/wet service conditions. Further characterization of the 977 toughened epoxy resin family is presented. Author

A90-50125
HIGH TEMPERATURE ADHESIVES COMMERCIALLY AVAILABLE TO BE USED FOR EXTENDED TIME WITH PMR15 LAMINATES
STEPHANE CLER (Hispano-Suiza, Bois-Colombes Plant, France) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 893-906.
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Studies were conducted for thrust reverser applications to evaluate adhesive systems commercially available which could have good potential for extended use at 260 C. The adhesives selected for this program were Dexter Hysol EA9673, American Cyanamid HT424, FM35 and FM36. Single lap shear and flatwise tensile tests were carried out at room temperature and also at 260 C before and after thermal aging at 260 C and moisture aging. The substrates used for this evaluation were PMR15 laminates and AISI 410 steel. These tests have shown that only FM35 and FM36 can be considered as suitable candidates for extended use at 260 C. Author

A90-50128* Applied Sciences Corp., Yellow Springs, OH.
VAPOR GROWN CARBON FIBER FOR SPACE THERMAL MANAGEMENT SYSTEMS
MAX L. LAKE, J. KYLE HICKOK, KARREN K. BRITO, and LESTER L. BEGG (Applied Sciences, Inc., Yellow Springs, OH) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 960-969. Research supported by SDIO. refs
(Contract NAS3-25470)
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Research that uses a novel, highly graphitic, vapor grown carbon fiber (VGCF) to fabricate composites for thermal management applications is described. These VGCF/Carbon composites have shown a specific thermal conductivity with values of twenty-to-ten times that of copper in the 500-900 K temperature range needed for waste heat management. It is concluded that development of this high specific thermal conductivity composite for thermal radiator panels will provide the foundation for a reevaluation of space power designs heretofore limited by the mass of waste heat dissipation systems. Further, it is suggested that through optimization of fiber handling and composite processing, thermal conductivities exceeding 1000 W/m-K (at 300 K) are achievable in composites reinforced with VGCF. R.E.P.

A90-50130
PROCESS OPTIMIZATION OF HIGH TEMPERATURE COMPOSITE MATERIALS
LISA A. MCHUGH and MARIJO CLARK (Lockheed Composites Development Center, Burbank, CA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 986-993.
Copyright

Historically, processing development of high-temperature composite materials has been expensive and time-consuming. Statistical experimental design offers a multivariant experimental approach to optimizing processing parameters and ascertaining their interrelationships and significance in a cost-effective manner. Using the RS/1 Discover software package, a series of experiments were designed to optimize the autoclave processing of IM8/D/APC-HTA unidirectional tape. The effects of a series of simultaneous variations of time, temperature, pressure, and cooling rate on the properties and quality of the consolidated laminates are presented. Author

A90-50131
A THIRD-GENERATION BISMALEIMIDE PREPREG SYSTEM
JACK D. BOYD, GLENN E. C. CHANG (BASF Narmco, Anaheim, CA), VOLKER ALTSTAEDT, DALE GERTH, and WALTER HECKMANN (BASF AG, Ludwigshafen, Federal Republic of Germany) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 994-1006.
Copyright

This paper describes Rigidite X5260, a new commercialized bismaleimide (BMI) resin system for prepreg. Composites fabricated from X5260 are as damage tolerant as the toughest epoxies and thermoplastics, but maintain the up to 232 C service of the best BMI's. Damage tolerance typically is 322-350 MPa (47-51 KSI) at 6.7 kJ/M on a variety of intermediate-modulus fibers. In addition, X5260 has exceptional mechanical properties and wide processing capability, and thus warrants consideration for any composite application, from 82 C to 232 C. The X5260 system also has improved the thermooxidative stability compared to other BMI's. Author

A90-50132
INJECTABLE BISMALEIMIDE SYSTEMS
K. A. BARRETT, B. FU, and A. WANG (Ciba-Geigy Corp., Ardsley, NY) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1007-1020.
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This study demonstrates the formulating latitude of bismaleimides using new co-reactants to facilitate certain manufacturing processes. Specifically, a commercial bismaleimide/allyl phenol-based (Matrimid 5292) system was modified with several co-reactants to render the material more suitable for resin transfer molding (RTM) and filament winding. Reactive diluents have successfully lowered prepolymer viscosity, while a new bismaleimide extended pot-life at common processing temperatures. Changes in processing and performance characteristics are discussed. However, no attempt was made to optimize formulations or cure schedules. The systems studied had significantly higher Tg's and higher modulus retention values at elevated temperatures than materials currently used for these processes. This would enable the new materials to withstand the high temperature environments encountered by many aerospace components. Author

A90-50134* Mitsui Toatsu Chemicals, Inc., Yokohama (Japan).
IMPROVED MELT FLOW AND PHYSICAL PROPERTIES OF MITSUI TOATSU'S LARC-TPI 1500 SERIES POLYIMIDE
MASAHIRO OHTA, SHOJI TAMAI (Mitsui Toatsu Chemicals, Inc., Tokyo, Japan), T. W. TOWELL, N. J. JOHNSTON, and T. L. SAINT

CLAIR (NASA, Langley Research Center, Hampton, VA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1030-1044. refs
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The basic thermal properties and melt behavior of an improved form of LARC-TPI polyimide, LARC-TPI 1500, are investigated and compared with those of LARC-TPI 1000 and 2000. The LARC-TPI 1500 powders are thermally stable and melt processable. The absolute molecular weight of the polymer varies from 20,000 to 30,000, indicating recurring unit numbers of about 40-60. The melt flow properties of LARC-TPI 1500 are comparable to those of other engineering plastics, such as PEEK, PSU, and PES. The flexural modulus of injection molded parts of LARC-TPI 1500 is the highest among commercial thermoplastic polymers. V.L.

A90-50135
NEW CYANATE ESTER RESIN WITH LOW TEMPERATURE (125-200 C) CURE CAPABILITY
D. A. SHIMP and S. J. ISING (Hi-Tek Polymers, Inc., Louisville, KY) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1045-1056. refs
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The development of a liquid cyanate ester resin molecularly designed to process/cure like conventional epoxy resins and improve on three featured properties of polycyanurates (low moisture absorption, low dielectric loss, and dimensional stability) is described. Comparisons with commercial cyanate esters and other high-temperature thermosetting resins demonstrate new capabilities with respect to achieving practical conversions at 121-204 C curing temperatures. Typical RTX-366 homopolymer properties are a dielectric constant of 2.6-2.8, a dissipation factor of 0.0004-0.0008, 0.7 percent water absorption at 100 C saturation, no stress-inducing shrinkage during polymerization, and Tg range of 125-190 C. The asymmetrically linked, three-benzene-ring bisphenol derivative, RTX-366 dicyanate monomer, is shown to develop matrix performance properties associated with advancements in composites for radomes, microwave antennas, space structures, aircraft with low radar signatures, and high speed/high density electronic circuitry. Author

A90-50137
ADVANCED JOINT OF 3-D COMPOSITE MATERIALS FOR SPACE STRUCTURE
T. YAMAMOTO (Mitsubishi Heavy Industries, Ltd., Nagoya, Japan) and T. HIROKAWA (Shikishima Canvas, Co., Ltd., Omihachiman, Japan) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1069-1078.
Copyright

Advanced joint of graphite/epoxy composite materials reinforced by three-dimensional fabrics has been designed, fabricated, and evaluated. The compressive and tensile strengths of the advanced joint were measured, and fabrication cost was evaluated. Materials and fabrication costs were cut down 28 percent and the weight by 16 percent was compared with unidirectional tape laminated composites. Author

A90-50138
IMPROVED DAMAGE TOLERANCE BY CONTROLLING THERMOPLASTIC SOLUBILITY IN THERMOSET COMPOSITES
RUSSELL L. TURPIN and ANTHONY L. GREEN (Lockheed Aeronautical Systems Co., Burbank, CA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1079-1088.
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The use of thermoplastics to improve the damage tolerance and also to increase the glass transition temperature and reduce the water absorbency of thermoset composites is discussed. In particular, a procedure is described whereby the desired results are achieved without increasing the prepreg processing and autoclave cure. In the experiments reported here, a bismaleide was produced which cured at 350 F in two hours in the autoclave, with a postcure for two-three hours at 410-450 F, and yielded a dry Tg above 600 F and a total water absorbency of less than 0.6 percent by weight. Damage tolerance, previously available only at 180 F, now can be obtained at higher temperatures through the selection of the right resin and thermoplastic combination. V.L.

A90-50139
RIGIDITE 5255-3 - A HIGHLY DAMAGE TOLERANT PREPREG RESIN SYSTEM WITH A WELL BALANCED PROPERTY PROFILE
H. G. RECKER (BASF Narmco, Anaheim, CA), VOLKER ALTSTAEDT, WALTER HECKMANN, H. TESCH, and T. WEBER (BASF AG, Ludwigshafen, Federal Republic of Germany) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1103-1117. refs
Copyright

The principal physicomechanical properties of Rigidite 5255-3, a new thermoplastic modified epoxy system, are examined. The system is characterized by high impact resistance, well balanced properties at 104 C, and simple handling and processing characteristics. The high impact resistance and good overall mechanical properties at elevated temperatures make the 5255-3 system suitable for the design of primary and secondary aircraft structures operating at temperatures up to 104 C. V.L.

A90-50140
DURABILITY AND DAMAGE TOLERANCE OF S-2 GLASS/PEEK COMPOSITES
W. P. HOOGSTEDEN (USAF, Materials Laboratory, Wright-Patterson AFB, OH) and D. R. HARTMAN (Owens-Corning Fiberglas Research Center, Granville, OH) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1118-1130. refs
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A90-50142
CHEMICAL RESISTANCE OF CARBON FIBER REINFORCED POLYETHER ETHER KETONE AND POLYPHENYLENE SULFIDE COMPOSITES
CHEN-CHI M. MA, CHANG-LUN LEE (National Tsing Hua University, Hsinchu, Republic of China), CHING-LONG ONG, and MING-FA SHEU (Chung Shan Institute of Science and Technology, Hsinchu, Republic of China) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1143-1154. refs
Copyright

Experiments were conducted to investigate the resistance of carbon fiber reinforced polyether ether ketone (PEEK) and polyphenylene sulfide (PPS) composites to a variety of solvents and aircraft fluids, including hydraulic fluid, paint stripper, JP-4 jet fuel, methyl ethyl ketone, and methylene chloride. Both PEEK and PPS composites show good resistance to aircraft fluids and chemicals. Of the fluids studied, methylene chloride is absorbed by the composites to the highest extent. The absorption of fluids (except JP-4 and hydraulic fluid) in PEEK and PPS composites significantly lowers the glass transition temperature. In addition, paint stripper significantly affects the flexural properties of the composites. V.L.

A90-50145
THE CHANGES OF STRUCTURES AND PROPERTIES IN PAN-BASED CARBON FIBERS DURING HEAT TREATMENT IN CARBON DIOXIDE
PHAICHIT CHIRANAIRADUL, TSE-HAO KO, and CHUNG-HUA LIN (Feng Chia University, Taichung, Republic of China) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1173-1179. Research supported by the National Science Council of the People's Republic of China. refs

PAN-based carbon fibers are made by a continuous stabilization and carbonization process. During carbonization, the condensation reaction of the carbon basal plan in the lateral direction begins after 800 C. At more elevated temperature, pit holes emerge on the surface of fibers through denitrogenation, and the surface area of the fibers will increase after the carbon fibers are treated in carbon dioxide at 880 C for several minutes. The surface of carbon fibers will be etched and a new pore will be formed which introduces the decrease of mechanical properties of carbon fibers. If the carbonized temperature is lower than the heat treatment, the modulus of carbon fibers will increase because of the repacking of carbon fibers' turbostratic graphite structure. Author

A90-50147
HIGH TEMPERATURE DEFORMATION STUDIES ON CVD SILICON CARBIDE FIBERS
J. BEALE, E. LARA CURZIO, and S. S. STERNSTEIN (Rensselaer Polytechnic Institute, Troy, NY) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1193-1204. Research supported by DARPA. refs

The composite structure of SiC fibers produced by chemical vapor deposition is reviewed briefly in order to illustrate the complex mechanical behavior which such fibers can exhibit. A new apparatus for studying the creep behavior of fibers is described in which virtually isothermal gage lengths can be achieved at temperatures up to 1600 C. A second apparatus for measuring complex dynamic moduli from 0.1 to 25 Hz for temperatures to 1600 C is also presented. Loss (imaginary) modulus values greater than 1 part in 2000 of the storage (real) modulus can be measured. Example data are presented for a variety of loading histories, temperatures and stress levels. A new algorithm for the correction of nonisothermal mechanical data is used to compute isothermal dynamic moduli values to 1600 C. It is found that anelastic processes occur both dynamically and in creep at temperatures as low as 1100 C. Activation energies for dynamic loss mechanisms are presented. Author

A90-50155
DAMAGE TOLERANCE EVALUATION OF SEVERAL ELEVATED TEMPERATURE GRAPHITE COMPOSITE MATERIALS
RAY L. DEMPSEY and RAY E. HORTON (Boeing Co., Seattle, WA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1292-1305.

A comparative evaluation has been conducted of the damage tolerance of six GFRPs potentially applicable to advanced fighter aircraft primary airframe structures. The evaluation encompassed impactor dent depths, damage areas, and postimpact compression strengths. While the IM6/KIII thermoplastic and IM7/V391 bismaleimide exhibited higher postdamage compression strength than other materials in the lower impact-energy damage region, no material stood out as markedly superior in the higher impact-energy damage region. A tabulation is presented of the test results. O.C.

A90-50158
VISCOELASTIC RELAXATION IN BOLTED THERMOPLASTIC COMPOSITE JOINTS
RON R. SCHMITT (Boeing Military Airplanes, Wichita, KS) and WALTER J. HORN (Wichita State University, KS) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1336-1347. Research supported by Boeing Military Airplanes and Kansas Technology Enterprise. refs

An investigation has been conducted of the long-term effects of fastener preloads' through-the-thickness relaxation in two different thermoplastic-matrix CFRPs' mechanically-fastened joints. Specially designed bolt-force sensor washers were used to monitor the initial preload level and subsequent relaxation over a period of up to 1000 hrs. An effort is made to anticipate potential structure-supportability issues on the basis of the data thus obtained. The thermoplastics in question were IM6/KIII and IM8/APC(HTA); the joint fasteners studied were of protruding-head and countersink types. O.C.

A90-50162
PLASTIC MEDIA BLAST (PMB) PAINT REMOVAL FROM COMPOSITES
LAWRENCE M. BUTKUS, GARY D. MEUER (USAF, Materials Laboratory, Wright-Patterson AFB, OH), and ARTHUR K. BEHME, JR. (Dayton, University, OH) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1385-1397. refs

Plastic media blasting (PMB) for use on graphite/epoxy composites was compared with the manual sanding method to determine the possible damage to surfaces. It was shown that, using PMB on metal and composite airframe surfaces could streamline stripping operations, reduce health hazards, and eliminate the possible damage chemical strippers may cause. PMB was found to be a viable, less damaging paint removal method than manual sanding, provided some precautions are taken. Nondestructive evaluation, mechanical testing, and scanning electron microscopy of stripped and unstripped (baseline) graphite/epoxy panels was performed to determine the effects caused by a single application of PMB and 'hand' sanding. Experiments identified safe combination of PMB parameters, including: media size and hardness, standoff distance, angle of incidence, and nozzle pressure. B.P.

A90-50163
A HIGH PERFORMANCE AEROSPACE RESIN FOR RESIN TRANSFER MOLDING
STEVEN C. HACKETT and PHYLLIS C. GRIEBLING (3M Aerospace Materials Dept., Saint Paul, MN) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1398-1410.

Resin Transfer Molding (RTM) continues to attract attention throughout the aerospace industry as an alternative to prepreg for composite part manufacturing. This paper introduces a one-part epoxy resin system (PR 500) with excellent room-temperature storage capability which has attractive RTM processing characteristics. Composite data of RTM manufactured test specimens is given which establishes PR 500 as ideal for aerospace applications where high compression strength, improved toughness and excellent hot/wet performance are needed. Comparative data on a commercially available bismaleimide and two two-part epoxies additionally highlights the balance of high performance properties of PR 500. Author

A90-50166* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
IMPACT TESTING OF GLASS/PHENOLIC HONEYCOMB PANELS WITH GRAPHITE/EPOXY FACESHEETS
ALAN T. NETTLES and ANDREW J. HODGE (NASA, Marshall Space Flight Center, Huntsville, AL) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1430-1440. refs

A90-50167
VARIATIONS IN IMPACT TEST METHODS FOR TOUGH COMPOSITES
R. FALABELLA, K. A. OLESEN, and M. A. BOYLE (Hexcel Corp., Dublin, CA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1454-1465. refs

Equipment variations in the impact portion of the compression after impact (CAI) test for composite laminates are explored experimentally. Variables include the clamping used to secure the test coupon to the support fixture, the material used for the support fixture, and use of a stationary impactor (tup) instead of a falling tup. Quasi-isotropic laminates based on high strength graphite fiber and resin systems with varying impact resistance are used for the experiments. Variations in the impact apparatus cause large changes in the amount of impact damage produced when the impact energy is held constant. The sensitivity of the CAI strength of the laminates to changes in the size of the damage area is discussed in terms of recent theoretical work. Author

A90-50168
TOWARDS A UNIFIED METHOD OF CAUSING IMPACT DAMAGE IN THICK LAMINATED COMPOSITES
JON H. SHIVELY (California State University, Northridge) and DARWIN MOON IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1466-1478. Research supported by California State University. refs

In an effort to understand the factors that influence or control impact damage in laminated composites, the influence of impact test parameters on the size of delaminations and on the loss of post-impact compression properties in thick laminates was studied. The composite materials used in the experiments were AS-4-1806, AS4-934, and IM7-8551-7. The test coupons were sectioned from identical panels consisting of a 48 ply laminate with a symmetric lay-up using AS4/1806 prepregs. The momentum effect reported suggests that tests for impact damage may need to include force, velocity, and energy absorption measurements rather than indirect energy calculations based on the height of a falling object or air gun muzzle velocities. The study was undertaken to eventually develop an industry standard for impacting composites. B.P.

A90-50170
COMPRESSIVE VISCOELASTIC EFFECTS (CREEP) OF A UNIDIRECTIONAL GLASS/EPOXY COMPOSITE MATERIAL
BRIAN R. SPENCE (Spence Engineering, San Diego, CA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1490-1493.

A test was performed to determine the compressive viscoelastic effects of a unidirectional glass/epoxy composite material. A test specimen was loaded in compression for 840 hours at 21 C and stressed to 207 MPa, approximately 30 percent of its ultimate strength. The measured strain due to viscoelastic effects after 840 hours was 0.0004 cm/cm. Extrapolation of this data to 100,000 hours (10 years) correlates to a strain of 0.0009 cm/cm. Long-term viscoelastic strain in a unidirectional glass/epoxy composite appears negligible when loading to 30 percent of the material's ultimate compressive strength. Unidirectional glass/epoxy materials are suitable for providing long-term accurate stability under compressive loading. Author

A90-50175
IMPROVED THERMAL PERFORMANCE USING ALLYLNADIC-IMIDES
A. KRAMER, A. RENNER, F. STOCKINGER, R. BRUNNER, and R. SCHMID (Ciba-Geigy AG, Fribourg, Switzerland) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1566-1578.

Allylnadic-imide resins are being considered as matrix resins and structural adhesives for aerospace applications. Model formulations of allylnadic-imide resins with bisphenol-A-dicyanate or bismaleimides were studied in order to obtain basic information on the influence of thermosetting additives on resin properties, curing characteristics, and the cured neat resin properties. Compared to unmodified allylnadic-imide resins the resulting systems exhibit enhanced processing characteristics, excellent hot/wet performance, and a significant increase in mechanical properties at a Tg level up to 280 C for biscyanate blends and 350 C for bismaleimide blends. Author

A90-50176
COMPOSITES FOR AEROSPACE APPLICATION FROM KEVLAR ARAMID REINFORCED PEKK THERMOPLASTIC
S. KHAN, J. F. PRATTE, I. Y. CHANG, and W. H. KRUEGER (Du Pont de Nemours and Co., Composite Div., Wilmington, DE) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1579-1593. refs

A90-50177* Lockheed Engineering and Sciences Co., Hampton, VA.
CHARACTERIZATION OF LARC-TPI 1500 POWDERS - A NEW VERSION WITH CONTROLLED MOLECULAR WEIGHT
T. H. HOU (Lockheed Engineering and Sciences Co., Hampton, VA) and J. M. BAI (Old Dominion University, Norfolk, VA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1594-1608. refs
(Contract NAS1-19000; NAG1-569)

The crystallization behavior and the melt flow properties of two batches of 1500 series LaRC-TPI polymers have been investigated. The characterization methods include DSC, XRD, and melt rheology. The as-received materials posses initial crystalline melting peak temperatures of 295 and 305 C, respectively. These materials are less readily recrystallizable at elevated temperatures when compared to other semicrystalline thermoplastics. For the samples annealed at temperatures below 330 C, a semicrystalline polymer can be obtained. On the other hand, a purely amorphous structure is realized in samples annealed at temperatures above 330 C. The viscoelastic properties at elevated temperatures below and above T(g)s of the polymers were measured. Information with regard to the molecule sizes and distributions in these polymers were also extracted from melt rheology. Author

A90-50179
EVALUATION OF THE THERMOPLASTIC FILM INTERLEAF CONCEPT FOR IMPROVED DAMAGE TOLERANCE
J. L. FRAZIER (Oak Ridge Gaseous Diffusion Plant, TN) and A. CLEMONS (Oak Ridge National Laboratory, TN) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the

Advancement of Material and Process Engineering, 1990, p. 1620-1627.
(Contract DE-AC05-84OR-21400)
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Thermoplastic/graphite composites with interleaf film layers were evaluated to determine the possible benefits for improved damage tolerance. The particular structure under study is the C-130 belly skin, a fuselage panel located on the underside of the aircraft. The structure is subject to foreign object damage from runway debris during take-off and landing operations in remote landing sites. The mechanical strength of composite materials is often significantly reduced following impacts that produce little or no visible damage. Laminate designs incorporating polyether ether ketone thermoplastic film as an interleaf material were subjected to impacts of various energies and projectile velocities. Mechanical properties of unimpacted, open-hole, and impacted laminate panels were measured to determine the effectiveness of the interleaf concept for improving damage tolerance relative to the baseline material. Author

A90-50180
IMPROVED FIBER REINFORCED POLYPHENYLENE SULFIDE THERMOPLASTIC COMPOSITES
J. D. WINKEL, J. R. WAREHAM, R. L. HAGENSON, D. A. SOULES, and S. D. MILLS (Phillips 66 Co., Advanced Composites Div., Bartlesville, OK) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1628-1637. refs
Copyright

An improved polyphenylene sulfide (PPS) for composite material system matrices has been developed which has the same thermal transitions, excellent processing characteristics, intrinsic flame resistance, and high corrosion resistance of the original formulation. This optimized PPS polymer in addition furnishes greater toughness and improved morphology. A significant increase in interfacial cohesion to E-glass reinforcing fibers has been achieved by matching this improved composite-grade PPS to the optimum fiber package; as a result, such resin-dominated properties as transverse tensile strength are substantially enhanced in unidirectional composites, contributing to improved retention of properties under hot/wet service environment conditions. O.C.

A90-50186
AEROSPACE ARALL - THE ADVANCEMENT IN AIRCRAFT MATERIALS
JAN WILLEM GUNNINK (Akzo, Fibers and Polymers Div., Arnhem, Netherlands) and LAURENS B. VOGELESANG (Delft, Technische Universiteit, Netherlands) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1708-1721.
Copyright

There is a strong need for new materials that combine a high strength, low density and high modulus of elasticity with improved toughness, corrosion-resistance and good fatigue properties. Carbon composites cover almost all those requirements except for fracture toughness, which is and will be an important argument for using aluminum alloy in current aircraft structures, and aluminum alloy together with Arall in future primary aircraft structures. The unique set of Arall properties perfectly satisfies the present existing structural integrity requirements and the more demanding performance needs for next-generation aircraft. The goals of 30 percent weight-savings and no-repair structure have been demonstrated to be within reach. Author

A90-50188
SAFETY AND HEALTH TRENDS IN AEROSPACE COMPOSITE MATERIALS
GLENN L. WISE (Heath Tecna Aerospace Co., Kent, WA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1751-1760.
Copyright

The composite materials scare which hit the airframe fabrication industry in 1988 has brought a national focus on the 'unknown hazards' of dealing with composites on the shop floor. The world of the 'metal benders' has changed rapidly to one which now includes elements of the chemist's world of reactive chemical compounds. Joint efforts between composite suppliers, fabricators, labor, trade associations, and governmental agencies have been initiated to address the issue of 'chemical hazard awareness' in the work place. A priority program for addressing the chemical exposure problem in the aerospace industry is vital in assuring worker understanding and respect for the chemicals they are exposed to, while at the same time insuring that productivity requirements are achieved. Author

A90-50189
SPECTRA COMPOSITE ENHANCES PORTABILITY AND SURVIVABILITY OF ELECTRONIC EQUIPMENT
BERNARD P. GOLLOMP (Allied-Signal Aerospace Co., Test Systems Div., Tetersboro, NJ) and HUY X. NGUYEN (Allied-Signal, Inc., Fibers Div., Petersburg, VA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1772-1782. refs
Copyright

An account is given of the development status and capabilities of Spectra extended-chain polyethylene fiber-reinforced composites for man-portable military electronics equipment enclosures. Such enclosures' weights have been reduced by 45 percent relative to their aluminum counterparts; the electronics thus enclosed experience 40 percent lower acceleration forces due to shock. The case designed on the basis of Spectra-reinforced composites does not require corner-impact guards, and will withstand 48-inch drops on those corners. O.C.

A90-50190
FLAMMABILITY REGULATIONS AFFECTING ADVANCED COMPOSITE MATERIALS
DENNIS A. NOLLEN (Suppliers of Advanced Composite Materials Association, Arlington, VA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1783-1795. refs
Copyright

FAA regulations have recently been promulgated on the flammability of commercial aircraft interior panels, and emerging naval requirements for submarine interiors have been formulated by the Naval Research Laboratory. An evaluation is presently made of the consequences and opportunities which emerge from these regulatory trends for the advanced composites industry. Pursuant to these considerations, the Suppliers of Advanced Composite Materials Association has formed a regulatory initiatives-monitoring task force. A tabulation is presented of the flammability characteristics of the composite systems most apposite to meeting new regulatory specifications. O.C.

A90-50199
EFFECT OF MOLECULAR WEIGHT AND END GROUP CONTROL ON THE ADHESION BEHAVIOR OF THERMOPLASTIC POLYIMIDES AND POLY(IMIDE SILOXANE) SEGMENTED COPOLYMERS
T. H. YOON, J. E. MCGRATH (NSF; Virginia Polytechnic Institute and State University, Blacksburg), and C. A. ARNOLD (ICI Fiberite, Inc., Tempe, AZ) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1892-1904. Research supported by Virginia Polytechnic Institute and State University and NSF. refs
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A90-50205
FRACTURE MORPHOLOGY OF TOUGHENED BISMALEIMIDE/CARBON FIBER COMPOSITES
XUANZHANG WU (Institute of Aeronautical Materials, Beijing, People's Republic of China), QUSEN ZHAO (Aero-manufacturing Technology Research Institute, Beijing, People's Republic of China), ZONGNENG QI (Chinese Academy of Sciences, Institute of Chemistry, Beijing, People's Republic of China), and DENGGAO ZHANG (Chinese Aeronautics and Astronautics Establishment, Beijing, People's Republic of China) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1997-2006. refs

The fracture surfaces of toughened bismaleimide resin QY8911 casts and QY8911/carbon fiber (T300) composite samples were examined using SEM in order to investigate the correlation between the fracture surface morphology and toughening agent, as well as the water absorption of the composites. The toughening agent can remarkably increase the toughness of QY8911 cast samples. The SEM results reveal second phase particles with 2-3 micron diameter. The texture structure appearance around the particles is an indication of a toughening resin. Results also show that the large amount of resin adhering to the fiber and the small amount of fibers pulled out are the characteristics of a good resin/fiber interface and good interlaminar strength. However, after absorption water, the resin/fiber interface became weakness. Author

A90-50212
NOVEL COMPOSITE SURFACING FILM
CALVIN CEDARLEAF (Dexter Corp., Adhesive and Structural Materials Div., Pittsburg, CA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 2064-2071.

The proprietary film, 'SynSkin', has been optimized for production of a high-quality composite material surface that is resistant to environmental degradation, and which will eliminate cocured, composite honeycomb sandwich panel cores' imprints and porosity, while minimizing core crush. The reduction in surface irregularities obtained by means of SynSkin application leads to production cost reductions, through obviation of filling and sanding. SynSkin's formulation is also such as to improve fire, smoke, and toxicity characteristics. O.C.

A90-50214* Tennessee Univ., Knoxville.
FREEZE DRYING FOR MORPHOLOGICAL CONTROL OF INTER-PENETRATING POLYMER NETWORKS
MARION G. HANSEN (Tennessee, University, Knoxville) and RUTH H. PATER (NASA, Langley Research Center, Hampton, VA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 2080-2085.

The intrinsic brittleness of BMI resins can be reduced through the creation of an interpenetrating network (IPN) of BMI with a reactive-encapped thermoplastic, such as the presently considered polyimidesulfone, PISO2. The PISO2 and BMI were dissolved in a common solvent, which was then removed from the constituents by freeze drying; in an alternative method, an IPN was formed through dissolution of the constituent in a common solvent with either high or low melting point, followed by evaporative removal of the solvent. The effectiveness of the freeze-drying approach for morphological control is evaluated. O.C.

A90-50215*
ELECTROSTATIC DRY POWDER PREPREGGING OF CARBON FIBER
JAMES L. THRONE (Sherwood Technologies, Inc., Akron, OH) and MIN-SEOK SOHN IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 2086-2101. refs
(Contract NAG1-779)

Ultrafine, 5-10 micron polymer-matrix resin powders are directly applied to carbon fiber tows by passing then in an air or nitrogen stream through an electrostatic potential; the particles thus charged will strongly adhere to grounded carbon fibers, and can be subsequently fused to the fiber in a continuously-fed radiant oven. This electrostatic technique derived significant end-use mechanical property advantages from the obviation of solvents, binders, and other adulterants. Additional matrix resins used to produce prepregs to date have been PMR-15, Torlon 40000, and LaRC TPI. O.C.

A90-50217* Case Western Reserve Univ., Cleveland, OH.
USE OF UNBALANCED LAMINATES AS A SCREENING METHOD FOR MICROCRACKING
DEMETRIOS S. PAPADOPOULOS (Case Western University, Cleveland, OH) and KENNETH J. BOWLES (NASA, Lewis Research Center, Cleveland, OH) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 2127-2141. Previously announced in STAR as N90-21124. refs

State-of-the-art, high temperature polyimide matrix composites, reinforced with continuous graphite fibers are known to be susceptible to intraply cracking when thermally cycled over their useful service temperature range. It is believed that the transply cracking, in part, results from residual stresses caused by differences in coefficients of thermal expansion (CTE) between the polymer matrix and the reinforcement. Thermal cycling tests to investigate this phenomenon involve expensive time and energy consuming programs which are not economically feasible for use as a part of a materials screening process. As an alternative to thermal cycling studies, a study of unbalanced crossply graphite fiber reinforcement composites was conducted to assess the effect of the composite ply layup and surface condition on the residual stresses that remain after the processing of these materials. The residual stresses were assessed by measuring the radii of curvature of the types of laminates that were studied. The temperature at which stress-free conditions existed were determined and a dye penetrant method was used to observe surface damage resulting from excessive residual stress buildup. These results are compared with some published results of thermal cycling tests that were previously conducted on balanced polyimide composites. Author

A90-50218
A STUDY OF FILAMENT WOUND HIGH MODULUS CARBON FIBER REINFORCED CYLINDERS
H. TAMAKI, K. KUBOMURA, and T. HERAI (Nippon Steel Corp., Chemical Research Laboratory, Kawasaki, Japan) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 2142-2152.

A90-50225
MATERIAL DEVELOPMENT AND SECOND SOURCE QUALIFICATION OF CARBON FIBER/EPOXY PREPREGS FOR PRIMARY AND SECONDARY AIRBUS STRUCTURES
R. W. LANG, G. HERRMANN (BASF AG, Ludwigshafen, Federal Republic of Germany), and K. SCHNEIDER (MBB GmbH, Bremen, Federal Republic of Germany) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 2245-2259. refs

A second-source qualification program was conducted for such Airbus structures as vertical finboxes, spoilers, rudders and horizontal tail plane fairings. While the qualification of second-source prepregs offers several advantages, the benefits

may be offset by high qualification costs and the lack of an approved procedure for a low cost qualification program. The key elements of the second-source qualification procedure are given. The cost of the second-source qualification is only a fraction of the cost for the original qualification procedure, compared to the first source product forms, a material cost reduction could be achieved by changing the filament count in both unidirectional tape and fabric prepregs. Author

A90-50226
MEASUREMENT AND CHARACTERIZATION OF PREPREG PERMEABILITY WITH A MODIFIED BAGGING TECHNIQUE
K. J. AHN, J. C. SEFERIS (Washington, University, Seattle), J. O. PRICE, and A. J. BERG (Heath Tecna Aerospace Co., Kent, WA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 2260-2271. Research supported by Heath Tecna Aerospace Co. refs
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A simple technique of air permeation measurements was developed that was capable of quantitatively describing the ability of a prepreg laminate to vent off volatiles during the consolidation process. Two types of commercially available prepregs were examined with this technique. Optical microscopic study showed that one type of prepreg was porous with approximately 30 percent voids inside and a resin-poor surface, while the other type of prepreg had no internal voids and had a resin-rich surface. Both the intralaminar and the interlaminar air permeations were measured for prepreg laminate stacks. Most of the air permeation took place through the interfaces between the prepregs (interlaminar). On a relative basis, 79 percent of the permeation of the porous prepreg and more than 99 percent of the fully resin-impregnated prepreg took place in the interlaminar region. Under the same operating conditions, the prepregs of higher air permeation consistently resulted in the production of void-free composites. This observation implied that air permeation through the prepreg laminate could be one of the factors affecting the void content in composites. Author

A90-50227
MECHANICAL INFLUENCES ON CRYSTALLIZATION IN PEEK MATRIX/CARBON FIBER REINFORCED COMPOSITES
A. KITANO and J. C. SEFERIS (Washington, University, Seattle) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 2272-2279. Research supported by Toray Industry of Japan and Boeing Commercial Airplanes. refs
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Three isothermal crystallization processes of PEEK (poly-etheretherketone) composite (APC-2) were observed in DMA (dynamic mechanical analysis) experiments and further supported by careful analysis of DSC (differential scanning calorimetry) data. These three processes may be actually viewed as separate dominating regions of two different crystallization mechanisms that have been described by the Velisaris-Seferis Avrami type equation, which established a dual composite type mechanism with Avrami exponents of 2.5 and 1.5. DMA results of frequency dependent upon isothermal experiments demonstrated that the initial crystallization process can be induced by stress. Examination of neat and composite PEEK data generated in this laboratory, as well as by several others, since our first report of the dual mechanism, not only confirmed this new finding, but provided a rational explanation for apparent discrepancies that have been reported in the literature concerning PEEK crystallization. Author

A90-50230
THE APPLICATION OF 'PT' RESINS TO HIGH TEMPERATURE AEROSPACE STRUCTURES
BRIAN P. COUCH and LAWRENCE E. MCALLISTER (Allied-Signal Aerospace Co., South Bend, IN) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 2298-2310.
Copyright

The 'PT' resins presently investigated are members of a modified phenolic system formulated with a view to high temperature/high mechanical strength structural composite applications. PTs generate no volatile byproducts during cure. Attention is presently given to the results of carbon-reinforced PT composites mechanical-property tests conducted over the room temperature-316 C range, including tests of samples after 500 hrs of 260 C exposure. Laminate property results indicate the effects of carbon fiber surface conditions and finishes on high temperature mechanical properties; thick-walled filament-wound cylindrical structure results are also noted. O.C.

A90-50551
QUANTITATIVE METHODS IN FRACTOGRAPHY; PROCEEDINGS OF THE SYMPOSIUM ON EVALUATION AND TECHNIQUES IN FRACTOGRAPHY, ATLANTA, GA, NOV. 10, 1988
BERNARD M. STRAUSS, ED. (Teledyne Engineering Services, Waltham, MA) and SUSIL K. PUTATUNDA, ED. (Wayne State University, Detroit, MI) Symposium sponsored by ASTM. Philadelphia, PA, American Society for Testing and Materials, 1990, 173 p. For individual items see A90-50552 to A90-50557.
(ASTM STP-1085) Copyright

Papers are presented on the application of quantitative fractography and computed tomography to fracture processes in materials, the relationships between fractographic features and material toughness, the quantitative analysis of fracture surfaces using fractals, and the analysis and interpretation of aircraft component defects by means of quantitative fractography. Also discussed are the characteristics of hydrogen-assisted cracking measured by the holding-load and fractographic method, a fractographic study of isolated cleavage regions in nuclear pressure vessel steels and their weld metals, a fractographic and metallographic study of the initiation of brittle fracture in weldments, cracking mechanisms for mean stress/strain low-cycle multiaxial fatigue loadings, and corrosion fatigue crack arrest in Al alloys. O.C.

A90-50645*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CRITICAL EVALUATION OF JET-A SPRAY COMBUSTION USING PROPANE CHEMICAL KINETICS IN GAS TURBINE COMBUSTION SIMULATED BY KIVA-II
H. L. NGUYEN (NASA, Lewis Research Center, Cleveland, OH) and S.-J. YING (South Florida, University, Tampa, FL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, July 16-18, 1990. 20 p. refs
(Contract NAG3-1112)
(AIAA PAPER 90-2439) Copyright

Numerical solutions of the Jet-A spray combustion were obtained by means of the KIVA-II computer code after Jet-A properties were added to the 12 chemical species the program had initially contained. Three different reaction mechanism models are considered. The first model consists of 131 reactions and 45 species; it is evaluated by comparing calculated ignition delay times with available shock tube data, and it is used in the evaluation of the other two simplified models. The simplified mechanisms consider 45 reactions and 27 species and 5 reactions and 12 species, respectively. In the prediction of pollutants NOx and CO, the full mechanism of 131 reactions is considered to be more reliable. The numerical results indicate that the variation of the maximum flame temperature is within 20 percent as compared with that of the full mechanism of 131 reactions. The chemical compositions of major components such as C3H8, H2O, O2, CO2, and N2 are of the same order of magnitude. However, the concentrations of pollutants are quite different. B.P.

A90-51198
INVESTMENT-CAST SUPERALLOYS A GOOD INVESTMENT
W. J. MOLLOY (Nickel Development Institute, London, England)

Advanced Materials and Processes (ISSN 0882-7958), vol. 138, Oct. 1990, p. 23-25, 28-30.
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Since their emergence in the 1950s, cast superalloys have almost completely replaced their wrought counterparts in high-performance gas-turbine engines. This steady market penetration is due to the rapid pace of casting-alloy development, as well as to the accompanying improvement in melting and casting practices. Some high-strength superalloys can possibly be developed further before their upper strength limit is reached; however, additional increases in use-temperature of nickel-base turbine-blade alloys appear to be unlikely. For this application, intermetallic compounds, such as nickel aluminides, have the potential to continue the upward trend in performance before metallic materials must give way to other high-temperature materials, such as ceramics. B.P.

A90-51200
MECHANICAL ALLOYING SPREADS ITS WINGS
JOHN J. FISCHER and JOHN H. WEBER (Inco Alloys International, Inc., Huntington, WV) Advanced Materials and Processes (ISSN 0882-7958), vol. 138, Oct. 1990, p. 43-45, 48-50.
Copyright

Mechanical alloying (MA) was developed as a means of raising the maximum service temperatures of the conventionally produced superalloys used in aircraft gas-turbine applications. The solid-state MA process avoids many of the problems associated with a conventional melting and solidification, and is now used to make a variety of oxide-dispersion-strengthened (ODS) Fe-Cr, Ni-Cr, and Ni-Cr-gamma prime superalloys for both turbine-engine and industrial applications, as well as aluminum alloys for aircraft structural components. MA may play a key role in the development of future aerospace systems by enabling the production of even higher performance materials that are difficult or impossible to make by other methods. Examples include metastable phases, amorphous materials, aluminides and other intermetallics, and even cermets and organic/ceramic/metallic systems. B.P.

A90-51616
FUTURE FUELS FOR GENERAL AVIATION; PROCEEDINGS OF THE SYMPOSIUM ON FUTURE FUELS FOR GENERAL AVIATION INTERMITTENT COMBUSTION, BALTIMORE, MD, JUNE 29, 1988
KURT H. STRAUSS, ED. and CESAR GONZALEZ, ED. Symposium sponsored by ASTM. Philadelphia, PA, American Society for Testing and Materials, 1989, 171 p. For individual items see A90-51617 to A90-51625.
(ASTM STP-1048) Copyright

The conference presents papers on motor gasoline use in aircraft, alternative fuel use in aircraft, and future fuel requirements. Aircraft field experience with automotive gasoline in the U.S. is considered as well as field experience with type certified civil aircraft operated on motor gasolines and a worldwide survey of motor gasoline characteristics. Attention is also given to the performance of alternative fuels in general aviation aircraft, ethanol and methanol in intermittent combustion engines, and investigations into gasoline/alcohol blends for use in general aviation. K.K.

A90-51617
MANUFACTURING AVIATION GASOLINE
ROBERT J. CREEK (Chevron U.S.A., Inc., Richmond, CA) IN: Future fuels for general aviation; Proceedings of the Symposium on Future Fuels for General Aviation Intermittent Combustion, Baltimore, MD, June 29, 1988. Philadelphia, PA, American Society for Testing and Materials, 1989, p. 5-15; Discussion, p. 15.
Copyright

The most significant processing unit for aviation gasoline (avgas) manufacture is the alkylation plant. To understand the alkylation process, a brief description is presented of crude oil distillation and further refinery processing to make alkylation feedstocks. The alkylation process and aviation alkylate recovery is reviewed. Typical aviation alkylate composition requires blending other components into avgas including light naphtha, toluene, and other blend stocks. Constraining elements of the specification that determines blend components for finished avgas are discussed. The refinery method for determining the proper ratio of component addition, blending, and testing to meet specifications are presented. Author

A90-51620
AUTOMOTIVE GASOLINE - A FUEL FOR MODERN AIRCRAFT PISTON ENGINES
JOACHIM SCHMAUDER (Porsche AG, Stuttgart, Federal Republic of Germany) IN: Future fuels for general aviation; Proceedings of the Symposium on Future Fuels for General Aviation Intermittent Combustion, Baltimore, MD, June 29, 1988. Philadelphia, PA, American Society for Testing and Materials, 1989, p. 56-76. refs
Copyright

The use of automotive gasoline as a fuel for aircraft power engines is discussed. It is noted that, while automotive gas seems to be the most feasible alternative to aviation gas, the type of automotive gas should be carefully chosen. The advantages of unleaded premium gasoline are pointed out. K.K.

A90-51621
THE PERFORMANCE OF ALTERNATE FUELS IN GENERAL AVIATION AIRCRAFT
RICHARD WARES (National Institute for Petroleum and Energy Research, Bartlesville, OK) and AUGUSTO M. FERRARA (FAA, Technical Center, Atlantic City, NJ) IN: Future fuels for general aviation; Proceedings of the Symposium on Future Fuels for General Aviation Intermittent Combustion, Baltimore, MD, June 29, 1988. Philadelphia, PA, American Society for Testing and Materials, 1989, p. 79-102. Previously announced in STAR as N89-10175. refs
Copyright

The results of a study which measured the effects of pressure altitude on fuel weathering are described. Samples of unleaded automobile gasoline were exposed to varying pressure altitudes, and the effects of this exposure on aircraft performance and volatility were measured. The composition of the fuel, aircraft configuration, and the initial temperature of the fuel when transferred to the tank were varied to determine the extent these variables affected the aircraft performance. Experiments were conducted which demonstrated that the use of 100 F fuel during aircraft certification will provide the greatest margin of safety. In addition, the suitability of methyl-tertiary-butyl ether as an acceptable fuel for use in general aviation aircraft was demonstrated. Several different oxygenated fuels (including gasolines containing alcohols) were aged in ground-based tests. The results are presented. Author

A90-51622
ETHANOL AND METHANOL IN INTERMITTENT COMBUSTION ENGINES
EDMUND L. EVELETH (Alabama Aviation and Technical College, Ozark) IN: Future fuels for general aviation; Proceedings of the Symposium on Future Fuels for General Aviation Intermittent Combustion, Baltimore, MD, June 29, 1988. Philadelphia, PA, American Society for Testing and Materials, 1989, p. 103-115.
Copyright

Research attesting to the superiority of alcohol as a fuel for aviation is presented. It is noted that ethanol is preferable to methanol because methanol is highly corrosive and requires special additives, whereas, in the present study, ethanol did not cause any problems in the piston engines, parts, and accessories. An aircraft turbine running on 10 percent ethanol and 90 percent Jet A fuel is described. K.K.

A90-51623
INVESTIGATIONS INTO GASOLINE/ALCOHOL BLENDS FOR USE IN GENERAL AVIATION AIRCRAFT
AUGUSTO M. FERRARA (FAA, Technical Center, Atlantic City, NJ) IN: Future fuels for general aviation; Proceedings of the Symposium on Future Fuels for General Aviation Intermittent

Combustion, Baltimore, MD, June 29, 1988. Philadelphia, PA, American Society for Testing and Materials, 1989, p. 116-137.
Copyright

The Federal Aviation Administration has studied the behavior of gasolines containing alcohols using an aircraft fuel system and engine that were installed on a dynamometer. The results of this study identified the worst case for vapor lock testing as: takeoff fuel flow, a fuel temperature in the tank of 38 C, and an alcohol concentration of 15 percent on a weight/weight basis. Several other considerations for using gasoline/alcohol blends in aircraft systems are identified including: material compatibility problems, water absorption and phase separation, and fuel aging, which aggravates the vapor lock behavior. An attempt was made to correlate the vapor pressure of the test fuels with the vapor lock behavior. Author

A90-51624
FUTURE USE OF AUTOMOTIVE GASOLINE IN LIGHT AIRCRAFT
THEODORE O. WAGNER IN: Future fuels for general aviation; Proceedings of the Symposium on Future Fuels for General Aviation Intermittent Combustion, Baltimore, MD, June 29, 1988. Philadelphia, PA, American Society for Testing and Materials, 1989, p. 144-152.
Copyright

It is proposed that the use of automotive gasoline in light aircraft originally certified on Grade 80 aviation gasoline is attractive because automotive gasoline is more accessible and less expensive than Grade 80 aviation gasoline. Due to the fact that automotive gasolines are more volatile than aviation gasoline, the fuel supply systems on the aircraft involved must be capable of handling the additional volumes of vapor generated at high altitudes or elevated ambient temperatures or both. It is suggested that new aircraft should be certified for year-round use on gasoline of the most-volatile ASTM class. K.K.

A90-51625
A PROPOSAL FOR FUEL SPECIFICATION ACTIVITIES RELATING TO GENERAL AVIATION INTERMITTENT COMBUSTION ENGINES
CESAR GONZALES (Cessna Aircraft Co., Aircraft Div., Wichita, KS) IN: Future fuels for general aviation; Proceedings of the Symposium on Future Fuels for General Aviation Intermittent Combustion, Baltimore, MD, June 29, 1988. Philadelphia, PA, American Society for Testing and Materials, 1989, p. 153-165. refs
Copyright

The potential impact of various aviation and currently nonaviation fuels on future power-plant development activities is discussed. Conclusions pertaining to typical general aviation reciprocating power plants and power plants envisioned for the near and midrange future are presented. Proposed ASTM specification activities are discussed. K.K.

A90-51966
PROCESSING AND MECHANICAL PROPERTIES OF AL2O3/Y3AL5O12 (YAG) EUTECTIC COMPOSITE
T. MAH, T. A. PARTHASARATHY (Universal Energy Systems, Inc., Dayton, OH), and L. E. MATSON (USAF, Materials Laboratory, Wright-Patterson AFB, OH) Ceramic Engineering and Science Proceedings (ISSN 0196-6219), vol. 11, Sept.-Oct. 1990, p. 1617-1627. refs
(Contract F33615-78-C-5346; F33615-89-C-5604)
Copyright

A modified Bridgman-type crystal-growing technique was used to fabricate a directionally solidified eutectic composite of Al2O3 and Y3Al5O12 (YAG). The resulting composite did not have a truly directionally solidified microstructure, but the eutectic grains were large, elongated, and aligned with the continuous alumina phase having its a-axis along the solidification direction. This microstructure did not change after heat treatment at 1700 C, 5 h in air. The composite was found to have a flexural strength of 373 MPa and a fracture toughness of 4.3 MPa x sq rt m at room temperature. The strength dropped to 272 MPa at 1375 C and at 1585 C the strength was still 265 MPa. The fracture toughness was retained up to 1585 C. In comparison with sapphire and single-crystal YAG, the composite has a significantly higher fracture toughness at elevated temperatures. Author

A90-52799
MOISTURE ABSORPTION IN GRAPHITE/EPOXY LAMINATES
G. CLARK, D. S. SAUNDERS, T. J. VAN BLARICUM, and M. RICHMOND (Defence Science and Technology Organisation, Aircraft Materials Div., Melbourne, Australia) Composites Science and Technology (ISSN 0266-3538), vol. 39, no. 4, 1990, p. 355-375. refs
Copyright

The moisture-absorption characteristics of XAS-914C and AS4/3501-6 graphite/epoxy composite laminates are investigated under a range of temperature and humidity conditions. Focus is placed on the diffusion coefficients and equilibrium moisture levels in a range of layups and thickness, and the effects of thermal spiking on the moisture-absorption characteristics are examined. It is demonstrated that thermal spiking at temperatures above 100 C has a measurable effect on moisture uptake characteristics only when the laminates contain moisture. The pronounced effects of repeated thermal spiking on moisture uptake indicates a progressive form of spiking damage. A model for predicting moisture uptake of graphite/epoxy materials is offered. V.T.

N90-28674# Atomic Energy of Canada Ltd., Pinawa (Manitoba). Nuclear Research Establishment.
RADIATION-CURABLE PREPREG COMPOSITES
CHRIS B. SAUNDERS, LAWRENCE W. DICKSON, AJIT SINGH, ALISTAIR A. CARMICHAEL, and VINCE J. LOPATA 1988 23 p
(DE90-629740; AECL-9560; ISSN-0067-0367) Avail: NTIS (US Sales Only) HC A03/MF A01

A potential application of electron-beam processing in composite manufacturing is curing carbon-fiber prepregs. These thermally curable prepregs, carbon fibers or fabrics preimpregnated with liquid polymer resin, are commonly used in the aircraft industry. A radiation-curable prepreg was designed to meet the mechanical and physical property specifications of a leading aircraft manufacturing company. Characterization studies showed that the maximum gel fraction in the cured polymer occurred at a dose of about 50 kGy and varied from 91 to 97 percent, depending on the type of atmosphere (air or nitrogen) and the pressure (100 to 1000 kPa) during irradiation. Only the acrylate groups of the resin took a significant part in the curing reactions. Some carbon dioxide was produced during radiation curing. The polymer was amorphous with a softening point of about 235 C and a linear thermal expansion coefficient of 1.3 x 10(exp -4) m/(m x C) between 25 and 150 C (30 to 50 kGy). Preliminary mechanical and physical testing of the prepreg composites was also started. DOE

N90-28698# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
HIGH TEMPERATURE SURFACE INTERACTIONS
Nov. 1989 239 p The 68th meeting was held in Ottawa, Ontario, 23-28 Apr. 1989
(AGARD-CP-461; ISBN-92-835-0533-6; AD-A217461) Copyright Avail: NTIS HC A11/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

In today's climate of life extension for military aircraft, the topic of corrosion control assumes a role of greater importance. Controlling the degradative effects of flight environments on aircraft engine materials was emphasized. The chemical and mechanical mechanisms involved in degradative processes were reviewed and some state-of-the-art solutions considered. Emphasis in discussions centered on hot-salt corrosion topics but wear and erosion problems were also considered.

N90-28701# National Research Council of Canada, Ottawa (Ontario).
THE EFFECTS OF A COMPRESSOR REBUILD ON GAS TURBINE ENGINE PERFORMANCE: FINAL RESULTS
J. D. MACLEOD and J. C. G. LAFLAMME (Canadian Forces Base, Baden-Soellingen, Germany, F.R.) *In* AGARD, High Temperature Surface Interactions 13 p Nov. 1989
Copyright Avail: NTIS HC A11/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The Canadian Department of National Defence, in conjunction with the Engine Laboratory of the National Research Council Canada (NRCC), initiated a project for the evaluation of gas path coatings on the Allison T56 engine. The objective was to evaluate blade coatings in terms of engine performance effects and material durability. The project included a study of the influence of rebuilding the compressor on performance, since dismantling and rebuilding was required for the coating process. The compressor rebuild study, including the overall objectives, the test set-up, the performance effects, and the uncertainty of the measured results are described. The impact of this work on the coatings project is also documented. Author

N90-28704# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Dept. of Materials Science.
MOLTEN SALT INDUCED HIGH TEMPERATURE DEGRADATION OF THERMAL BARRIER COATINGS
SERGE ALPERINE *In* AGARD, High Temperature Surface Interactions 18 p Nov. 1989 Previously announced in IAA as A89-48745
Copyright Avail: NTIS HC A11/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Thermal barriers are now fairly well known as a new generation of protective coatings for components of the hot sections of conventional, diesel and turbine engines. The more performing system is a duplex coating consisting of a stabilized zirconia top coat generally air plasma sprayed on a approximately 100 micron thick MCrAlY bond coat. The service degradation modes of such coatings have been extensively studied during the past ten years. Their failure mechanisms are generally thought of in terms of thermomechanical stress, thermal expansion coefficient mismatch and bond coat high temperature oxidation. Efforts are thus made to design ceramic and bond coat composition, microstructure and processing parameters, according to these requirements. However, degradation of thermal barrier coatings by hot corrosion processes and, more generally, by fused salt thin films related phenomena, should also be taken into account. A review is given of the degradation modes that can be encountered when partially stabilized zirconia coatings are exposed to intermediate temperature range and sulphur and/or vanadium containing atmosphere. The interaction of the salt film with the coating is threefold: a chemical acidic or alkaline dissolution of the zirconia stabilizing oxide may occur, provoking zirconia tetragonal to monoclinic phase transformation and subsequent coating spallation on cooling. Fused salt may diffuse inside the ceramic microcracks network and solidify on cooling with a generation of extra stress inside the coating. Fused salt diffused throughout the microcracks network down to the ceramic/bond coat interface may also affect the MCrAlY bond coat. Careful distinction should be made between the working conditions encountered in diesel engines and marine turbines and those involved in aircraft turboengines. An illustration of the hot corrosion resistance of a ZrO2-8wt percent Y2O3/NiCrAlY thermal barrier coating, plasma sprayed on a single crystal superalloy substrate, in a typical aircraft turbine environment is given. Author

N90-28707# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Dept. of Materials Science.
EFFECT OF PROTECTIVE COATINGS ON MECHANICAL PROPERTIES OF SUPERALLOYS
REMY MEVREL and JEAN-MARIE VEYS (Service Technique des Programmes Aeronautiques, Paris, France) *In* AGARD, High Temperature Surface Interactions 13 p Nov. 1989 Previously announced in IAA as A90-11126
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The influence of protective coatings on the mechanical properties of superalloys employed in hot sections of gas turbine engines is investigated. The most used coatings are aluminide-based such as MCrAlY overlays and zirconia-based thermal barrier coatings, which may affect the mechanical properties of the superalloy substrates in several ways. Interdiffusion phenomena taking place between coating and substrate at high temperature during service may decrease the load bearing section of the superalloy and, as a consequence, may degrade its creep lifetime. Examples of possible effects of coating/substrate interdiffusion on the creep life of single crystal CMSX2 (no effect) and in the case of a directionally solidified eutectics superalloy (significant degradation) are considered. In the long run, the presence of a coating can enhance the creep life of a substrate due to its protective effect against high temperature corrosion. After considering different factors which can affect the mechanical behavior of the coated systems, a review of recent experimental results is presented. Author

N90-28709# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (Germany, F.R.).
FRETTING FATIGUE STRENGTH OF TI-6AL-4V AT ROOM AND ELEVATED TEMPERATURES AND WAYS OF IMPROVING IT
RAINER SCHAEFER and WALTER SCHUETZ *In* AGARD, High Temperature Surface Interactions 15 p Nov. 1989 Sponsored by BMFT, Fed. Republic of Germany
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The high sensitivity of titanium alloys to fretting fatigue has to be taken into account when oscillatory relative motion occurs in joints of fatigue loaded components, e.g., in the connection of the disc with the blades in compressors of aircraft engines. Against this background fretting fatigue behavior of Ti-6Al-4V was investigated at room temperature and service temperature (350 C) as well by testing flat specimens under fatigue loading and simultaneous fretting applied by a special fretting apparatus. The results show a complex system of parameters affecting fretting fatigue resistance: Fretting fatigue resistance decreases with increasing contact pressure and increasing amplitude of slip, down to a certain limit value for each. Other parameters investigated here are surface finish and stress ratios. The lowest value of fretting fatigue limit found was about 20 percent of the original fatigue limit of the unfretted material. Elevated temperature (350 C), however, had little additional detrimental effect. Among several methods to improve fretting fatigue resistance, shot peening and coating are also employed in compressor components. By shot peening the fretting fatigue limit could be increased by more than a factor of two, by coating with PVD systems by nearly a factor of two. Author

N90-28712# National Aeronautical Establishment, Ottawa (Ontario).
EVALUATION OF HIGH TEMPERATURE PROTECTIVE COATINGS FOR GAS TURBINE ENGINES UNDER SIMULATED SERVICE CONDITIONS
A. K. GUPTA, T. TERADA, P. C. PATNAIK (Hawker Siddeley Canada Ltd., Toronto, Ontario), and J.-P. IMMARIGEON *In* AGARD, High Temperature Surface Interactions 31 p Nov. 1989 Sponsored by Department of National Defence, Ottawa, Ontario
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The surface degradation of turbine hot section components, due to oxidation, hot corrosion, erosion, and thermal fatigue, is discussed. The mechanisms of each mode of attack are

summarized and the state-of-the-art in protective coatings for gas path components is reviewed. Durability evaluations of coatings under simulated service conditions are discussed, including evaluations conducted in high velocity burner rigs. Inconsistencies in the ranking of coatings in rigs is attributed to laboratory-to-laboratory variations in test procedures and/or test conditions. Finally, the important parameters for durability testing in rigs are discussed in terms of the environmental and operational factors that control hot gas chemistry and the extent of surface damage of hot parts. A description of commonly used burner rigs and test procedures employed is also provided to complete the paper. Author

N90-28713# Hawker Siddeley Canada Ltd., Toronto (Ontario). Research and Technology Development Group.
SURFACE PROPERTY IMPROVEMENT IN TITANIUM ALLOY GAS TURBINE COMPONENTS THROUGH ION IMPLANTATION
J. E. ELDER, M. R. PISHVA, N. C. BELLINGER, P. C. PATNAIK, and R. THAMBURAJ *In* AGARD, High Temperature Surface Interactions 11 p Nov. 1989 Sponsored by Department of National Defence, Ottawa, Ontario
Copyright Avail: NTIS HC A11/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The feasibility of applying ion implantation to produce substantial improvement in the wear/fretting fatigue resistance of titanium alloys used as gas turbine fan and compressor blade material was studied. Detailed/microscopy and mechanical test results were used to analyze the various mechanisms contributing to wear and fretting fatigue damage in titanium alloys at room and elevated temperatures. The manner in which ion implantation might modify the normal wear/fretting fatigue response of these alloys is discussed in detail, along with the factors to be considered in choosing optimum ion implantation parameters. Author

N90-28714# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Cologne (Germany, F.R.). Inst. for Materials Research.
OVERVIEW ON HOT GAS TESTS AND MOLTEN SALT CORROSION EXPERIMENTS AT THE DLR
H.-J. RAETZER-SCHEIBE *In* AGARD, High Temperature Surface Interactions 14 p Nov. 1989
Copyright Avail: NTIS HC A11/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The use of more corrosive low-grade fuels in combination with increasing combustion gas temperatures are major challenges in the present and future operation of heat engines. Improved thermal efficiency under practical operating conditions can only be accomplished by improved materials and/or coatings. This development motivated in 1982, the procurement of a high-velocity burner rig for simulation of the operation of gas turbines under service conditions. As an aircraft research and development establishment, corrosion and oxidation of aircraft gas turbines were the main interest. Working in this new field of research yielded a review on hot corrosion in aircraft engines. For an overview of the work, to date, in the field of hot corrosion and high temperature oxidation some topics are selected. Burner rig tests were started with investigations on the hot corrosion resistance of protective coating systems to evaluate coating alloys for use in highly contaminated combustion gases. Thermocyclic oxidation tests of coated aircraft turbine glade materials in hot gases of JP4 up to temperatures of 1100 C, followed later. Since hot corrosion is induced by molten salts or low-melting oxides deposited from the hot gas on the material surface the necessity is seen for fundamental investigations of molten salt corrosion. Therefore a device was developed for electrochemical experiments in molten salts. Another motivation for developing molten salt experimentation was to have an alternative test procedure to the high-cost burner rig tests. Author

N90-28722# Aerospatiale, Suresnes (France).
STATIC AND DYNAMIC CHARACTERIZATION OF THE ATR 72 RODS MADE OF TI 10.2.3 TITANIUM ALLOY [CARACTERISATION STATIQUE ET DYNAMIQUE DE BIELLES ATR 72 EN ALLIAGE DU TITANE TI 10.2.3]
R. SENGER and M. H. CAMPAGNAC 10 Aug. 1989 40 p In FRENCH
(Contract STPA-86-91-021-00-471-75-86)
(REPT-49-238; ETN-90-97484) Copyright Avail: NTIS HC A03/MF A01

The mechanical properties of the airfoil-fuselage rods of the ATR 72 are investigated. The control rods are made of beta metastable Ti 10.2.3 titanium alloy. The static mechanical characteristics, for loads of about 1100 and 1200 MPa, concerning tensile tests and toughness are higher than those obtained for the annealed TA6V alloy. Optimal characteristics are obtained for R equal to 1100 MPa. The Ti 10.2.3 characteristics measured under fatigue notch tests are not satisfactory. ESA

N90-29442# Naval Air Development Center, Warminster, PA. Dept. of Air Vehicle and Crew Systems Technology.
A LOW COST SHADOW MOIRE DEVICE FOR THE NONDESTRUCTIVE EVALUATION OF IMPACT DAMAGE IN COMPOSITE LAMINATES Final Report, Oct. 1987 - Sep. 1988
ARTHUR E. SCOTESE 1 Mar. 1990 62 p
(AD-A223451; NADC-90011-60) Avail: NTIS HC A04/MF A01 CSCL 20/6

Studies conducted under this Independent Exploratory Development (IED) project have concentrated on developing a field inspection instrument for the detection of low-velocity impact damage and delaminations in laminated composites and honeycomb sandwich structures. A low cost, hand-held battery-powered damage detector was developed which can be operated under field conditions. This device can be used to detect minute surface perturbations resulting from foreign object impact that can cause disbond and/or delamination in aircraft structures. Since the operation of the device is simple and its detecting capability is not affected by temperature, humidity or vibration, it can be used under field operational conditions with minimum training. The entire detector system, including the power pack, weighs less than 3.5 lbs. GRA

N90-29480# Naval Postgraduate School, Monterey, CA. Dept. of Mechanical Engineering.
THE STRESS AND TEMPERATURE DEPENDENCE OF CREEP IN AN AL-2.0 WT PERCENT LI ALLOY M.S. Thesis
EARL F. GOODSON, SR. Dec. 1989 130 p
(AD-A223676) Avail: NTIS HC A07/MF A01 CSCL 11/6

The effect of stress and temperature on the creep behavior of an Aluminum-2.0 wt percent Lithium alloy was investigated in the temperature range from 300 to 500 C. This temperature interval corresponds to a solid solution of Li in Al. Experimental results indicate that Al-2.0 wt percent Li behaves as a pure metal class alloy (class II). This is demonstrated by several creep characteristics including the value of the stress exponent (n approx. 5), the shape of the creep curve, and the nature of the creep transient after a temperature change. However, anomalous behavior of the activation energy was observed. Activation energies up to 55 kilocalories per mole, decreasing to approximately 33 kcal/mole at higher temperatures, were observed by the temperature cycling technique. GRA

N90-29499# National Aerospace Lab., Tokyo (Japan).
EVALUATION OF STATIC AND FATIGUE PROPERTIES OF THIN SHEETS OF 8090-T8 ALUMINUM-LITHIUM ALLOY AND OBSERVATION OF ITS FRACTURE SURFACES
TOSHIYUKI SHIMOKAWA, YOSHIAKI KAKUTA, and YASUMASA HAMAGUCHI Nov. 1989 16 p In JAPANESE; ENGLISH summary
(NAL-TR-1039; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

The static and fatigue properties of thin sheets of 8090-T8 aluminum-lithium alloy, which was developed for aircraft structures are evaluated. Systematical tests of this material and conventional

2024-T4 and 7075-T6 aluminum alloys were conducted. Static tests provided data on mechanical properties such as tensile strength, yield strength, elongation, and Young's modulus. Hardness tests gave data on Vickers hardness. Fatigue tests yielded data on S-N relationships of circular hole notched specimens, crack growth behavior, and fatigue crack growth rates as a function of stress intensity factor range. The fracture surfaces formed by static and fatigue tests were observed by a SEM. The obtained results are analyzed and compared with each other. The various distinctive properties of this material are clarified in comparison with those of the conventional aluminum alloys. Author

N90-29527# IIT Research Inst., Bartlesville, OK.
PRODUCTION OF JET FUELS FROM COAL-DERIVED LIQUIDS. VOLUME 13: EVALUATION OF STORAGE AND THERMAL STABILITY OF JET FUELS DERIVED FROM COAL LIQUIDS Interim Report, Aug. 1988 - Dec. 1989
G. P. STURM, JR., R. D. GRIGSBY, J. W. GOETZINGER, J. B. GREEN, and R. P. ANDERSON May 1990 69 p
(Contract DE-FC22-83FE-60149; MIPR-FY1455-86-N0657; AF PROJ. 2480)
(AD-A224576; AFWAL-TR-87-2042-VOL-13) Avail: NTIS HC A04/MF A01 CSCL 21/4

An investigation of the potential of the production of jet fuel from the liquid by-products streams produced by the gasification of lignite at the Great Plains Gasification Plant (GPGP) in Beulah, North Dakota is discussed. Funding was provided to the Department of Energy, Pittsburgh Energy Technology Center, to administer the experimental portion of this effort. This report details the program with the National Institute for Petroleum and Energy Research of the IIT Research Institute to study the storage and thermal stability of a JP-8 fuel produced from the GPGP liquid by-products streams. Sediments and deposits from stability tests were analyzed by IR and probe microdistillation/high resolution mass spectroscopy. Results were compared with corresponding results from a conventional petroleum-derived JP-8 fuel. GRA

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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.

A90-49884
A RATE THEORY INVESTIGATION OF CYCLIC LOADING AND PLASTIC DEFORMATION IN THE HIGH STRESS AND AMBIENT TEMPERATURE RANGE
A. S. KRAUSZ (Ottawa, University, Canada), Z. W. LIAN, J. S. MSHANA, and K. KRAUSZ IN: Aeronautical fatigue in the electronic era; Proceedings of the Fifteenth ICAF Symposium, Jerusalem, Israel, June 21-23, 1989. Warley, England, Engineering Materials Advisory Services, Ltd., 1989, p. 185-197. Research supported by NSERC. refs
Copyright

Plastic deformation is a thermally activated process controlled by a system of energy barriers, each of which represents a deformation mechanism. Constitutive equations derived from this rigorous physical theory describe accurately the deformation behavior of materials during stress relaxation, creep and cyclic softening in the high stress and ambient temperature range. The application of these constitutive equations is further extended to determine the stress-strain response of materials under random cyclic loading. Author

A90-49885
FRACTOGRAPHIC TECHNIQUES FOR THE ASSESSMENT OF AIRCRAFT COMPONENT CRACKING
N. T. GOLDSMITH and G. CLARK (Defence Science and Technology Organization, Aeronautical Research Laboratories, Melbourne, Australia) IN: Aeronautical fatigue in the electronic era; Proceedings of the Fifteenth ICAF Symposium, Jerusalem, Israel, June 21-23, 1989. Warley, England, Engineering Materials Advisory Services, Ltd., 1989, p. 199-214. refs
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An overview of the methods and equipment used for quantitative fractography and procedures for the objective assessment of fractographic data is presented. The results obtainable are illustrated by reference to case histories of defects observed in components from aircraft in service, in full-scale components tests and in laboratory test samples. Procedures for minimizing or overcoming some of the difficulties encountered in interpreting fracture surface markings are discussed. The paper also describes the way in which fracture mechanics concepts should be used in conjunction with fracture surface analysis to achieve a correct understanding of the crack growth history. In particular, some empirically-based approaches developed for interpolation and extrapolation of incomplete crack growth histories may now be understood by reference to fracture mechanics concepts. Finally, current and future developments in fracture surface analysis are discussed. Author

A90-49886
ACOUSTIC FATIGUE ANALYSIS BY THE FINITE ELEMENT METHOD
Z. H. GRANOT (Israel Aircraft Industries, Ltd., Fatigue Dept., Lod) IN: Aeronautical fatigue in the electronic era; Proceedings of the Fifteenth ICAF Symposium, Jerusalem, Israel, June 21-23, 1989. Warley, England, Engineering Materials Advisory Services, Ltd., 1989, p. 215-242. refs
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The solution to acoustic fatigue problems is considered through finite element modeling of the dynamic behavior of the structure under impinging sound. A general linear elastic finite element procedure is presented for modeling wide frequency band sound with arbitrary correlation properties. The procedure is checked by modeling three different types of panels which have been previously tested in a progressive wave tube. Relatively good agreement is obtained between the analysis and experiment, better than conventional approximate techniques. Author

A90-50111
FABRICATION OF COMPLEX COMPOSITE STRUCTURES USING ADVANCED FIBER PLACEMENT TECHNOLOGY
JAMES R. BARTH (Hercules, Inc., Magna, UT) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 710-720. Research supported by Hercules, Inc.
Copyright

A new process for fabricating complex composite structures using advanced fiber placement technology has been developed. The computer-controlled, automated process allows the material to be placed with zero tension into complex, concave surfaces and in the 0 deg orientation. The technology of dropping and adding single prepreg tows makes it possible to fabricate parts with varying cross sections and constant part thicknesses. A data base with the material properties of specimens fabricated by means of the fiber placement process is being generated. B.P.

A90-50113
AUTOMATED PREPREG TOW PLACEMENT FOR COMPOSITE STRUCTURES
F. BULLOCK, S. KOWALSKI, and R. YOUNG (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and

Process Engineering, 1990, p. 734-745.
Copyright

An automated method of placing prepreg tows on complex-shaped tools, while maintaining the design fiber orientations in the various plies of the parts, is described. The method is considered to be cost-effective for fabricating thermoset matrix composite structures with complex contours. Integrated with a mainframe database, it provides a high degree of automation in the above-the-floor information flow as well as reduction of direct labor on the floor. It is suggested that the automated fiber placement satisfies the manufacturing requirements of the next-generation aircraft. B.P.

A90-50126
DEVELOPMENT OF A HIGH TOUGHNESS HEAT RESISTANT 177 C (350 F) CURING FILM ADHESIVE FOR AEROSPACE BONDING APPLICATIONS - FM 377 ADHESIVE
DALIP K. KOHLI (American Cyanamid Co., Havre de Grace, MD) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 907-921. refs
Copyright

Development of a new state-of-the-art 177 C curing epoxy based film adhesive for aerospace bonding applications is described. The FM 377 adhesive has excellent toughness and offers continuous service at 177 C for greater than 1000 hours. This new adhesive is designed for bonding both metallic and nonmetallic structures as well as structures fabricated from aluminum, fiber glass and Nomex, a fabric or fiber honeycomb. Because of its reticulating properties, this adhesive is especially suited for nacelle bonding applications. This paper discusses the performance of FM 377 and FM 377 interleaf adhesives in various bonding applications. Author

A90-50136
MONOLITHIC CFC-MAIN LANDING GEAR DOOR FOR TORNADO
W. HARTMANN, M. MICHALAK, and W. PITZL (MBB GmbH, Ottobrunn and Augsburg, Federal Republic of Germany) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 1. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1057-1068.
Copyright

The design and manufacture of the monolithic CFC-Main Landing Gear Door (MLGD) for the Tornado aircraft are examined. The CFC-MLGD is designed with an internal spar-stringer structure covered by two skins, with all of these structural elements made of Narmco 5245C/T800. The fabrication process includes a combination of hot-forming processes with direct lay-up procedures and a single curing process for the assembly of the preformed elements. The test program for CFC-MLGD considers static and dynamic loads at high temperature and structural moisture equilibrium to fulfil the airworthiness requirements. V.L.

A90-50159
CHEMICAL VAPOR DEPOSITION OF HF/SI COMPOUNDS AS A HIGH TEMPERATURE COATING FOR CARBON/CARBON COMPOSITES
BEHZAD BAVARIAN, VICTOR ARRIETA (California State University, Northridge), and MEHROUZ ZAMANZADEH (Pittsburg Testing Laboratory, PA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1348-1362. Research supported by California State University. refs
Copyright

A reliable antioxidation coating system is required for maintaining the integrity of C/C composites in high temperature applications; attention is presently given to the CVD application of ternary Hf-Si-C system coatings to C/C surfaces. The coating's HfO2 component is an extremely stable oxide at high temperatures, while the SiC component provides a diffusion barrier over the substrate. Extensive testing has verified the coating's achievement of high oxidation resistance up to 1900 C under cyclic cooling/heating in air. EDAX, AES, XRD, and XPS are used to characterize the coatings and to modify the deposition parameters accordingly. O.C.

A90-50164
INDUCTION HEATING DEVELOPMENT FOR AIRCRAFT REPAIR
JOHN BORDER, RIK SALAS, and MARC BLACK (PDA Engineering, Materials Development Dept., Albuquerque, NM) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1411-1419. Research supported by the U.S. Army. refs
Copyright

Induction heating is a technique for providing fast heating. Portable power units have been constructed that make induction heating well-suited for aircraft repair. The limitations on induction heating have been its inability to heat a large area and a lack of control. PDA has been conducting considerable research into increasing the usability of induction heating for repair. Research into coil design shows that a flexible coil can be constructed which will provide a striped heat zone. By bending the coil to fit the repair patch, the coil can be used on any type of repair without the need for skilled scanning of the patch. This coil represents a significant step forward in induction heating technology as complex curves and large areas can be repaired with this coil. By eliminating the need for scanning of the surface, control is also enhanced. The coil design is discussed and results are presented. Author

A90-50173
HIGH PERFORMANCE NEEDLED STRUCTURES IN COMPOSITES
EDWARD J. BURNETT and JANE A. HARRIS (Tex-Tech Industries, Inc., North Monmouth, ME) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1533-1543.
Copyright

Needlefelts containing high-performance fibers are used to meet the needs of many demanding applications including the Space Shuttle, aircraft seat/bus seat fire blocking, and aircraft cabin acoustic insulation. Needled structures possess properties not achievable with other fabric formation methods such as weaving and knitting. Needlefelts offer unique design possibilities for composite material manufacture by providing a simple process for controlling fiber orientation. A description of the needle-punching process is presented here so that an appreciation of the sources of the needlefelt properties can be derived. The range of design possibilities achievable with needled structures is then explored. Details of selected applications are presented. Author

A90-50183
THE EFFECT OF MATRIX TOUGHNESS IN THE DEVELOPMENT OF IMPROVED STRUCTURAL ADHESIVES
J. PRANDY, H. SITT (BASF Narmco, Anaheim, CA), V. ALTSTAEDT, U. DITTRICH, and D. W. SANNE (BASF AG, Ludwigshafen, Federal Republic of Germany) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1671-1683. refs
Copyright

An experimental investigation was undertaken to study the effect of the structural adhesive neat resin fracture toughness on the performance of their corresponding adhesive joints. Classical empirical tests such as lap shear and Bell peel test along with fracture mechanics tests and the 'KGR-1 shear stress-strain' response were used to gain a fundamental understanding of the correlation within these tests and the influence of the neat resin fracture toughness. A direct transformation of neat resin fracture toughness into adhesive Mode I and Mode II fracture toughness

was seen. Also, a direct correlation between adhesive Mode II fracture toughness and the energy absorbed during the shear stress/strain test was observed. However, a nonlinear correlation was discovered for Bell peel and lap shear with adhesive Mode I and Mode II fracture toughness as well as neat resin fracture toughness. Author

A90-50187
EFFECTS ON AEROSPACE ALLOYS OF RESIDUAL CHLORINE IN CHLORINATED-SOLVENT PRIMERS
JOHN H. JONES (Boeing Commercial Airplanes, Seattle, WA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1735-1746.
Copyright

The potential of chlorinated-solvent primers for causing stress corrosion cracks, pits, and general corrosion in typical high-strength aerospace alloys was studied. Specimens made from 7075-T651 aluminum alloy plate, Ti-6Al-4V plate, and 4340M steel plate were primed with chlorinated-solvent primers, stressed, and exposed to condensing humidity conditions at 60 C (140 F). The primers were tested under conditions in which they had been allowed to freely evaporate before environmental exposure and also under conditions in which they were trapped, as in wet-installation applications. Results indicated no cracking in any of the specimens under any of the conditions. Pitting and general corrosion developed only on 7075-T651 aluminum specimens under conditions of primer trapped during wet-installation applications. Author

A90-50200
INTEGRALLY HEATED TOOLING FOR ECONOMICAL, NONAUTOCLAVE PRODUCTION OF THERMOPLASTIC PARTS
ANDY KERR and STEVEN EVERDING (Lockheed Aeronautical Sytems Co., Burbank, CA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1917-1927.
Copyright

A pressure vessel has been devised for the accommodation of integrally heated tools used to shape graphite-reinforced thermoplastic composite laminates with complex contours. The 6 x 11-ft vessel has a pressure rating of 500 psi, and the tool designs in question are from generic aircraft structural components, such as fuselage skins and side panels. Formation temperatures are of the order of 650-730 F; dramatic cost reductions have been obtained through lower capital investment, lower skilled labor requirements, and lower energy consumption, relative to the conventionally employed autoclaving operations. O.C.

A90-50213
DEVELOPMENT OF A WATER-BORNE NON-CHROMATED PRIMER AND TOPCOAT FOR AEROSPACE APPLICATIONS
CYNTHIA C. GILBRETH, RON S. MEIER (Northrop Corp., B-2 Div., Pico Rivera, CA), and DONALD R. BANGLE (Aztec Chemical, Inc., El Monte, CA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 2072-2079.
Copyright

With the escalating controls on the emissions of volatile organic compounds (VOC), the need for reduced levels in coatings has increased dramatically. This has led to the development of two water borne surface coatings. One is a chromate free, corrosion inhibiting, water-borne primer. The other is a water-borne topcoat. Either coating can be applied with equipment that is currently in use for solvent based systems, thereby minimizing capital expenditure and operator retraining. This paper discusses the research and development of these coatings, and will show some typical test results pertinent to aerospace coating application. Author

A90-50216
CHROME FREE ELECTROLYTIC DEOXIDIZER FOR ALUMINUM
LARRY E. TARR and HOWARD H. HOLMQUIST (Boeing Commercial Airplanes, Seattle, WA) IN: International SAMPE Symposium and Exhibition, 35th, Anaheim, CA, Apr. 2-5, 1990, Proceedings. Book 2. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 2102-2111.
Copyright

The application of low-voltage dc current to Al surfaces immersed in a phosphoric acid electrolyte has been found to yield an effective deoxidizing treatment for the metal surfaces prior to adhesive bonding. Bath parameters of about 20-percent H3PO4 concentration, about 30 C temperature, 7 V rectifier voltage, and about 10-min immersion time, have been established to result in the dissolution of the surface aluminum oxide. The process is also noted to furnish a predictable etch rate without intergranular attack, as well as the removal of a wide variety of surface contaminants. The process itself possesses low toxicity and long bath life. O.C.

A90-50555
ANALYSIS AND INTERPRETATION OF AIRCRAFT COMPONENT DEFECTS USING QUANTITATIVE FRACTOGRAPHY
N. T. GOLDSMITH and G. CLARK (Defence Science and Technology Organisation, Aeronautical Research Laboratories, Melbourne, Australia) IN: Quantitative methods in fractography; Proceedings of the Symposium on Evaluation and Techniques in Fractography, Atlanta, GA, Nov. 10, 1988. Philadelphia, PA, American Society for Testing and Materials, 1990, p. 52-68. refs
Copyright

Quantitative fractography methods have been developed for 15 years in order to derive crack growth histories from fracture surfaces; this capability has been used in pioneering service life-extension programs. Attention is presently given to current computer-based semiautomatic data acquisition and processing facilities for fractographic analysis, as well as to the specialized facilities used in deriving and processing data from optical microscopy and SEM fracture-surface observations. Empirically based approaches for the interpolation and extrapolation of incomplete crack-growth histories can now be understood by reference to fracture-mechanics concepts. O.C.

A90-50636*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THERMAL INTERACTION BETWEEN AN IMPINGING HOT JET AND A CONDUCTING SOLID SURFACE
P. A. ABELOFF, F. C. DOUGHERTY (NASA, Ames Research Center, Moffett Field, CA; Colorado, University, Boulder), and W. R. VAN DALSEM (NASA, Ames Research Center, Moffett Field, CA) AIAA, Applied Aerodynamics Conference, 8th, Portland, OR, Aug. 20-22, 1990. 12 p. refs
(AIAA PAPER 90-3010)

Powered-lift aircraft may produce severe high-temperature environments which are potentially damaging to a landing surface or the aircraft. The interaction betweean the high temperature flow field and a nonadiabatic landing surface is analyzed with a coupled computational fluid dynamics/solid thermal conduction computer code, HOTJET. The HOTJET code couples time-accurate, implicit, factored solution schemes for the governing fluid dynamics equations (Reynolds-averaged Navier-Stokes equations) to the unsteady thermal conduction equation, which governs heat flux within a solid. HOTJET is validated against exact solutions to the thermal conduction and Navier-Stokes equations. First-of-a-kind results are included which show the impact of surface material properties on the fluid physics and the coupled fluid/material thermal fields. Author

A90-50644*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EFFICIENCY STUDY COMPARING TWO HELICOPTER PLANETARY REDUCTION STAGES

TIMOTHY L. KRANTZ and ROBERT F. HANDSCHUH (NASA, Lewis Research Center; U.S. Army, Propulsion Directorate, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 26th, July 16-18, 1990. 10 p. Previously announced in STAR as N90-26334. refs
(AIAA PAPER 90-2156)

A study was conducted to compare the efficiency of two helicopter transmission planetary reduction stages. Experimental measurements and analytical predictions were made. The analysis predicted and experiments verified that one planetary stage was a more efficient design due to the type of planet bearing used in the stage. The effects of torque, speed, lubricant type, and lubricant temperature on planetary efficiency are discussed. Author

A90-50649
SECURITY AUDIT FOR EMBEDDED AVIONICS SYSTEMS

K. N. RAO (Hughes Aircraft Co., Radar Systems Group, Los Angeles, CA) IN: Annual Computer Security Applications Conference, 5th, Tucson, AZ, Dec. 4-8, 1989, Proceedings. Los Alamitos, CA, IEEE Computer Society Press, 1990, p. 78-84.
Copyright

The design of security audit subsystems for real-time embedded avionics systems is described. The selection criteria of auditable events and the design of the audit functions are described. The data storage requirements and the data compression features of embedded avionics systems are analyzed. Two data compression algorithms applicable to avionics systems are described. Huffman encoding is optimal, but Fibonacci encoding is shown to be nearly optimal and better suited for airborne avionics systems. The memory capacity needed for audit data storage is computed for typical avionics missions. I.E.

A90-50773
OPTIMIZATION OF THE SHAPE OF A SEALED SHELL AND OF THE SIZE AND LOCATION OF ITS REINFORCEMENTS [OPTIMIZATSIIA FORMY GERMOOBOLOCHKI, RAZMEROV I MESTORASPOLOZHENIIA EE PODKREPLENII]

V. G. LAGUTIN and V. G. MARKOV (Tsentral'nyi Aerogidrodinamicheskii Institut, Zhukovsky, USSR) Problemy Prochnosti (ISSN 0556-171X), July 1990, p. 102-107. In Russian. refs
Copyright

A solution is presented for the problem of sealed shell design optimization. The shell mass is minimized with allowance for fracture mechanics constraints (for possible fatigue cracks in the shell), static strength limits, design and dimensional constraints, and constraints on the stiffness characteristics of the shell under lateral bending and twisting. The optimization procedure is carried out using the method of penalty functions and coordinate descent with a variable Fibonacci step. The procedure is illustrated by an example. V.L.

A90-50843
WAYS OF PROVIDING FOR THE STRENGTH AND SERVICE LIFE OF AIRCRAFT STRUCTURES MADE OF POLYMER COMPOSITES WITH ALLOWANCE FOR DAMAGE [OSOBENNOSTI OBESPECHENIIA PROCHNOSTI I RESURSA AVIAKONSTRUKTSII, VYPOLNENNYKH IZ POLIMERNYKGH KOMPOZITNYKH MATERIALOV, S UCHETOM IKH POVREZHDAEMOSTI]

A. F. SELIKHOV, V. F. KUT'INOV, and A. E. USHAKOV (Tsentral'nyi Aerogidrodinamicheskii Institut, Moscow, USSR) Mekhanika Kompozitnykh Materialov (ISSN 0203-1272), May-June 1990, p. 469-479. In Russian. refs
Copyright

The objective of ensuring the required strength and service life of aircraft structures made of polymer composites is treated as a totality of provisions during the manufacture and operation of aircraft. Particular attention is given to the characteristics of damage evolution in composite materials, evaluation of the susceptibility of composite structures to damage during production and operation, attainment of the required fracture toughness characteristics, and design and technological methods of improving reliability and survivability. V.L.

A90-51261#
AN EXPERIMENTAL CONVECTIVE HEAT TRANSFER INVESTIGATION AROUND A FILM-COOLED GAS TURBINE BLADE

C. CAMCI (Pennsylvania State University, University Park) and T. ARTS (Institut von Karman de Dynamique des Fluides, Rhode-Saint-Genese, Belgium) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 112, July 1990, p. 497-503. refs
Copyright

The present paper deals with an experimental convective heat transfer investigation around a film-cooled, high-pressure gas turbine rotor blade mounted in a stationary, linear cascade arrangement. The measurements were performed in the von Karman Institute Isentropic Light Piston Compression Tube facility. The test blade was made of Macor glass ceramic and was instrumented with thin film gages. The coolant flow was ejected simultaneously through the leading edge (three rows of holes), the suction side (two rows of holes), and the pressure side (one row of holes). The effects of overall mass weight ratio, coolant to free-stream temperature ratio, and free-stream turbulence were successively investigated. Author

A90-51525
MODELING OF THE OIL QUENCH FOR NI-BASED SUPERALLOY TURBINE DISKS [MODELISATION DE LA TREMPE A L'HUILE DE DISQUES DE TURBOREACTEURS EN SUPERALLIAGE BASE NICKEL]

F. DEVY, A. BENALLAL, D. MARQUIS (*Ecole Normale Superieure* de l'Enseignement Technique, Cachan, France), A. BOUCHERIT (SNECMA, Centre d'Activite de Villaroche, Moissy-Cramayel, France), and P.-E. MOSSER (SNECMA, Laboratoire Materiaux et Procedes, Gennevilliers, France) Revue Francaise de Mecanique (ISSN 0373-6601), no. 2, 1990, p. 143-157. In French. refs
(Contract DRET-88-34432)
Copyright

Jet engine disks are designed to sustain low-cycle fatigue and creep at temperatures up to 650 C and stresses up to 1000 MPa. They are made of PM-processed nickel alloys. The mechanical properties of these alloys are strongly dependent on the quenching process. For the most massive parts the quench medium is oil. This severe heat extraction would induce mechanical stresses during cooling, followed in the worst cases by quench cracking; since the material is viscoplastic at the beginning of the quench, residual stresses are left within the part when it is back at room temperature. A quench-modeling method has been developed to predict local temperature rate and residual stresses. Author

A90-52037
STRAIN-GAGE APPLICATIONS IN WIND TUNNEL BALANCES

P. J. MOLE (General Dynamics Corp., San Diego, CA) Experimental Techniques (ISSN 0732-8818), vol. 14, Sept.-Oct. 1990, p. 39-42.
Copyright

Six-component balances used in wind tunnels for precision measurements of air loads on scale models of aircraft and missiles are reviewed. A beam moment-type balance, two-shell balance consisting of an outer shell and inner rod, and air-flow balances used in STOL aircraft configurations are described. The design process, fabrication, gaging, single-gage procedure, and calibration of balances are outlined, and emphasis is placed on computer stress programs and data-reduction computer programs. It is pointed out that these wind-tunnel balances are used in applications for full-scale flight vehicles. Attention is given to a standard two-shell booster balance and an adaptation of a wind-tunnel balance employed to measure the simulated distributed launch loads of a payload in the Space Shuttle. V.T.

A90-52044* Virginia Polytechnic Inst. and State Univ., Blacksburg.
DESIGN OF AIRCRAFT WINGS SUBJECTED TO GUST LOADS - A SYSTEM RELIABILITY APPROACH
J. S. YANG, E. NIKOLAIDIS, and R. T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg) Computers and Structures (ISSN 0045-7949), vol. 36, no. 6, 1990, p. 1057-1066. refs
(Contract NAG1-168)
Copyright

A method for system reliability-based design of aircraft wing structures is presented. A wing of a light commuter aircraft designed for gust loads according to the FAA regulations is compared with one designed by system reliability optimization. It is shown that system reliability optimization has the potential of improving dramatically the safety and efficiency of new designs. The reasons for the differences between the deterministic and reliability-based designs are explained. Author

A90-52356
ESTIMATION OF THE SAFETY FACTOR OF TURBINE BLADES UNDER THERMAL CYCLING AND VIBRATION LOADING [OTSENKA ZAPASA PROCHNOSTI LOPATOK TURBINY PRI DEISTVII TERMOTSIKLICHESKIKH I VIBRATSIONNYKH NAGRUZOK]
M. E. KOLOTNIKOV, K. G. SVIATYSHEV, and V. A. SOLIANNIKOV Problemy Prochnosti (ISSN 0556-171X), Aug. 1990, p. 97-100. In Russian. refs
Copyright

Results of an analytical and experimental study of the low-cycle fatigue of the blades of a gas turbine engine under multiple-factor loading are examined. Equations are obtained for the limiting state under combined thermal cycling and vibration loading and thermal cycling with isothermal holds. A method is proposed for evaluating the safety factor of the blades under multiple-factor loading. V.L.

A90-52954
A MODULAR 550 WATT, 25 WATTS PER CUBIC INCH POWER SUPPLY FOR NEXT GENERATION AIRCRAFT
O. M. HOLLEY (Texas Instruments, Inc., Defense Systems and Electronics Group, Dallas) and BOB BIESCHKE (Texas Instruments, Inc., Defense Systems and Electronics Group, Plano) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 5, Sept. 1990, p. 11-16.
Copyright

The development of the HVS-550 high-performance power supply is described. The HVS-550 was designed and built utilizing state-of-the-art surface-mount construction, low-profile magnetics, and aggressive thermal management techniques. This combination allowed the module height to be only 0.58 inches. The unique requirements of the military system that bounded the power-supply parameters are discussed. Cooling is provided either by liquid circulating through the chassis or by conduction through the card edges. The measured power-supply efficiency is in excess of 85 percent, with 11-V output. The output noise spectrum is excellent because of noise-cancelling techniques utilized to achieve the level of performance required by the system. I.E.

N90-28759 Council for National Academic Awards (England).
STUDIES IN AUTOMATIC SPEECH RECOGNITION AND ITS APPLICATION IN AEROSPACE Ph.D. Thesis
MICHAEL ROBINSON TAYLOR 1989 1989 p
Avail: Univ. Microfilms Order No. BRDX88064

Human communication is characterized in terms of the spectral and temporal dimensions of speech waveforms. Electronic speech recognition strategies based on Dynamic Time Warping and Markov Model algorithms are described and typical digit recognition error rates are tabulated. The application of Direct Voice Input (DVI) as an interface between man and machine is explored within the context of civil and military aerospace programmes. Sources of physical and emotional stress affecting speech production within military high performance aircraft are identified. Experimental results are reported which quantify fundamental frequency and coarse temporal dimensions of male speech as a function of the vibration, linear acceleration and noise levels typical of aerospace environments; preliminary indications of acoustic phonetic variability reported by other researchers are summarized. Connected whole-word pattern recognition error rates are presented for digits spoken under controlled Gz sinusoidal whole-body vibration. Correlations are made between significant increases in recognition error rate and resonance of the abdomen-thorax and head subsystems of the body. The phenomenon of vibrato style speech produced under low frequency whole-body Gz vibration is also examined. Interactive DVI system architectures and avionic data bus integration concepts are outlined together with design procedures for the efficient development of pilot-vehicle command and control protocols. Dissert. Abstr.

N90-28762# Federal Aviation Administration, Atlantic City, NJ.
COMMUNICATIONS INTERFACE DRIVER (CID) TEST PLAN
THOMAS BRATTON, JAMES DAVIS, CHARLES DUDAS, JEFFREY G. LIVINGS, and MARK SCHOENTHAL Sep. 1990 124 p
(DOT/FAA/CT-TN89/35) Avail: NTIS HC A06/MF A01

This test plan for the Communications Interface Driver (CID) systems will be used to evaluate and accept the CID. The CID system is a test tool whose purpose is to supply or receive a capacity level of communication (comm) messages to and from the air traffic control (ATC) and non-ATC ports of the Mode Select (Mode S) sensor. The primary concern of the CID test plan is written to establish the detailed test requirements, criteria, and methods to achieve the evaluation of the CID against the requirements set forth in the report, Functional Requirements of the Communications Interface Driver (CID), DOT/FAA/CT-TN87/41. Author

N90-28800# Royal Aerospace Establishment, Farnborough (England).
USE OF LIQUID CRYSTALS FOR QUALITATIVE AND QUANTITATIVE 2-D STUDIES OF TRANSITION AND SKIN FRICTION
L. GAUDET and T. G. GELL 15 Jun. 1989 35 p Presented at the ICIASF 1989, Goettingen, Fed. Republic of Germany, 18-21 Sep. 1989 Previously announced in IAA as A90-28259 Original contains color illustrations
(RAE-TM-AERO-2159; BR112416; ETN-90-97063; AD-A218227)
Copyright Avail: NTIS HC A03/MF A01

The exploitation of the properties of liquid crystals to visualize transition and to measure skin friction is described. The effectiveness of a transition band to trip the laminar boundary layer on a swept wing is demonstrated by the growth of turbulent wedges with Reynolds number. The ability of liquid crystals to reveal intricate surface flow structure is clearly shown by subtle changes of color on an unswept rectangular wing when subjected to the combined effects of transition, separation, reattachment, and a normal shock. The time response of the liquid crystals to changes in shear stress is illustrated by the shock pattern on the model surface which was seen to be oscillating. A method involving the digitization of the video image into its three components colors has the potential for measuring skin friction in great detail. This involves using relationships firstly correlating the components colors with wavelength and secondly correlating shear stress with wavelength. ESA

N90-28810# Institut de Mecanique des Fluides de Toulouse (France). Equipe Transferts en Ecoulements Laminaires et Turbulents.
DEVELOPMENT OF TURBULENCE MODELS FOR THE ANALYSIS OF COMPRESSIBLE OR INCOMPRESSIBLE UNSTEADY FLOW Final Report [LE DEVELOPPEMENT DE MODELES DE TURBULENCE ADAPTES AUX ECOULEMENTS INSTATIONNAIRES INCOMPRESSIBLES OU COMPRESSIBLES, RAPPORT DE SYNTHESE]
H. C. BOISSON, M. BRAZA, P. CHASSAING, H. HAMINH, A. KOURTA, J. MEYER, and A. SEVRAIN Jun. 1989 161 p In FRENCH

(Contract DRET-87-131)
(ETN-90-97486) Avail: NTIS HC A08/MF A01

The results of the investigations performed on the project for the development of turbulence models are summarized. Classical models of turbulence were developed and adapted to complex flow configurations. Models based on one-point schemes, numerical simulation of the aerodynamics around airfoils and a three dimensional analysis of the interaction of the turbulent flow shock and boundary layers are established. The characteristics of the flow transitions around a cylinder and in the layer in the planar neighborhood of a planar jet are analyzed. ESA

N90-28812# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Abt. fuer Numerische Stroemungsmechanik.

DESIGN OF AN AXISYMMETRIC, CONTOURED NOZZLE FOR THE HEG

KLAUS HANNEMANN 1990 73 p
(DLR-FB-90-04; ISSN-0171-1342; ETN-90-97543) Avail: NTIS HC A04/MF A01; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, HC 28 DM

An axisymmetric contoured nozzle is designed for the High Entalpy wind tunnel Gottingen (HEG), Germany, Fed. Republic of Germany. In the first, conical part of the expansion, the flow is calculated using a quasi one dimensional approximation, taking into account finite rate chemical kinetics. Assuming a source flow and species freezing at the end of the conical section, the contoured part of the nozzle contour is subsequently determined using the method of characteristics for a perfect gas. The physical nozzle contour is finally obtained by adding the boundary layer displacement thickness, calculated by using an empirical correlation, to the inviscid contour. In addition to the discussion of the performance at off-design conditions, different chemical models and rate constants are used in the quasi one dimensional calculations in order to investigate the influence on the flow properties. ESA

N90-28815*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.

REAL-TIME AERODYNAMIC HEATING AND SURFACE TEMPERATURE CALCULATIONS FOR HYPERSONIC FLIGHT SIMULATION

ROBERT D. QUINN and LESLIE GONG Washington Aug. 1990 44 p
(NASA-TM-4222; H-1602; NAS 1.15:4222) Avail: NTIS HC A03/MF A01 CSCL 20/4

A real-time heating algorithm was derived and installed on the Ames Research Center Dryden Flight Research Facility real-time flight simulator. This program can calculate two- and three-dimensional stagnation point surface heating rates and surface temperatures. The two-dimensional calculations can be made with or without leading-edge sweep. In addition, upper and lower surface heating rates and surface temperatures for flat plates, wedges, and cones can be calculated. Laminar or turbulent heating can be calculated, with boundary-layer transition made a function of free-stream Reynolds number and free-stream Mach number. Real-time heating rates and surface temperatures calculated for a generic hypersonic vehicle are presented and compared with more exact values computed by a batch aeroheating program. As these comparisons show, the heating algorithm used on the flight simulator calculates surface heating rates and temperatures well within the accuracy required to evaluate flight profiles for acceptable heating trajectories. Author

N90-28828# Kopin Corp., Taunton, MA.

SMART MICROSENSORS FOR HIGH TEMPERATURE APPLICATIONS, PHASE 1 Final Report, Aug. 1989 - Feb. 1990

PAUL M. ZAVRACKY 28 Jun. 1990 30 p
(Contract DAAL03-89-C-0024)
(AD-A224151; ARO-27323.1-SBI) Avail: NTIS HC A03/MF A01 CSCL 09/1

Microsensors find applications in many important areas of U.S. military hardware. Advances in aircraft and internal combustion engines are placing increasing demands on the electronics which play an increasingly important role in engine control. Complexity of control circuits has demanded increases in the scale of integration and in reliability, and have suggested the placement of high levels of functionality near the point of use. Engine performance must be evaluated with sensors and used intelligently to maintain optimum efficiency. Recent advances in microsensor technology have provided smaller, more economical sensors for these applications. With smaller sensors the need for signal conditioning electronics in close proximity to the sensor has become an increasingly important issue. The proposed three-phase project addresses the development of smart sensors for applications under high temperature ambients (up to 350 C). The approach proposed here is the demonstration of the usefulness of the SOI material obtained by the Isolated Silicon Epitaxy (ISE) process for high temperature sensor applications. This would couple with process development of sensor elements. GRA

N90-28862*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Center for Composite Materials and Structures.

STRUCTURAL ANALYSIS AND OPTIMUM DESIGN OF GEODESICALLY STIFFENED COMPOSITE PANELS

JOHN L. PHILLIPS and ZAFER GUERDAL Jul. 1990 263 p
(Contract NAG1-643)
(NASA-CR-186944; NAS 1.26:186944; CCMS-90-05; VPI-E-90-08) Avail: NTIS HC A12/MF A02 CSCL 20/11

A computationally efficient analyses approach is developed to predict the buckling of geodesically stiffened composite panels under in-plane loads. This procedure accounts for the discrete flexural contribution of each stiffener through the use of Lagrange multipliers in an energy method solution. An analysis is also implemented for the buckling of simply supported anisotropic rhombic plates. Analysis routines are coupled with the numerical optimizer ADS to create a package for the design of minimum-mass stiffened panels, subject to constraints on buckling of the panel assembly, local buckling of the stiffeners, and material strength failure. The design code is used to conduct a preliminary design study of structurally efficient stiffened aircraft wing rib panels. Design variables include thickness of the skin laminates, stiffener thickness, and stiffener height. Applied loads are uniaxial compression, pure shear, and combined compression-shear. Two different geodesically stiffened wing rib configurations with increasing numbers of stiffeners are considered. Results are presented in the form of structural efficiency charts and are compared with those for minimum-weight longitudinally stiffened panels and unstiffened flat plates. Trends in design parameters, including skin thickness, stiffener height, stiffener thickness, stiffener aspect ratio, stiffener load fraction, and stiffener mass fraction, are also examined for the panels under compression and shear. The effect of skin laminate geometry and anisotropy on the local buckling behavior of cross-stiffened geodesic panels are examined using the rhombic plate analysis. Author

N90-28865*# McDonnell-Douglas Helicopter Co., Mesa, AZ.

CORRELATION OF AH-1G AIRFRAME FLIGHT VIBRATION DATA WITH A COUPLED ROTOR-FUSELAGE ANALYSIS

K. SANGHA and J. SHAMIE Aug. 1990 172 p
(Contract NAS1-17498)
(NASA-CR-181974; NAS 1.26:181974) Avail: NTIS HC A08/MF A01 CSCL 20/12

The formulation and features of the Rotor-Airframe Comprehensive Analysis Program (RACAP) is described. The analysis employs a frequency domain, transfer matrix approach for the blade structural model, a time domain wake or momentum theory aerodynamic model, and impedance matching for rotor-fuselage coupling. The analysis is applied to the AH-1G helicopter, and a correlation study is conducted on fuselage vibration predictions. The purpose of the study is to evaluate the state-of-the-art in helicopter fuselage vibration prediction technology. The fuselage vibration predicted using RACAP are fairly good in the vertical direction and somewhat deficient in the lateral/longitudinal directions. Some of these deficiencies are traced to the fuselage finite element model. Author

N90-28866*# McDonnell-Douglas Helicopter Co., Mesa, AZ.
PLAN, EXECUTE, AND DISCUSS VIBRATION MEASUREMENTS AND CORRELATIONS TO EVALUATE A NASTRAN FINITE ELEMENT MODEL OF THE AH-64 HELICOPTER AIRFRAME
D. FERG, L. FOOTE, G. KORKOSZ, F. STRAUB, M. TOOSSI, and R. WEISENBURGER Jan. 1990 215 p
(Contract NAS1-17498)
(NASA-CR-181973; NAS 1.26:181973) Avail: NTIS HC A10/MF A02 CSCL 20/11

A ground vibration test was performed on the AH-64 (Apache) helicopter to determine the frequency response of the airframe. The structure was excited at both the main and tail rotor hubs, separately, and response measurements were taken at 102 locations throughout the fuselage structure. Frequency responses were compared and correlated with results from a NASTRAN finite element model of AH-64. In addition, natural frequencies and mode shapes were estimated from the frequency response data and were correlated with analytical results. Author

N90-29161# European Space Agency, Paris (France).
NUMERIC FLUID MECHANICS
HERBERT OERTEL (Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Cologne, Germany, F.R.) *In its* Scientific Colloquium in Honor of Prof. Dr. Rer. Nat. Hermann L. Jordan p 45-68 May 1990 Transl. into ENGLISH from Wissenschaftliches Kolloquim Gewidmet Herrn Professor Dr. Rer. Nat. Hermann L. Jordan zum 65 Geburtstag (Cologne, Fed. Republic of Germany, DFVLR), Jun. 1987 p 37-55 Original language document was announced as N88-17434
Avail: NTIS HC A06/MF A01

An introduction into the variety of solutions of the fluid-mechanical model equations is presented. The question of whether the nonlinear interactions of a few modes can describe the transition to turbulent flows and thus open an access to transition and turbulence modeling is discussed. The utilization of numeric methods for practical application in the calculation of transonic wings of commercial aircraft and for the aerodynamic design of re-entry vehicles is presented. ESA

N90-29565# Rockwell International Corp., Cedar Rapids, IA. Government Avionics Div.
HIGH SPEED BUS TECHNOLOGY DEVELOPMENT Final Report, Sep. 1983 - Aug. 1988
MARLAN B. MODROW and DONALD W. HATFIELD Sep. 1989 175 p
(Contract F33615-83-C-1036; AF PROJ. 2734)
(AD-A224486; WRDC-TR-89-1040) Avail: NTIS HC A08/MF A01 CSCL 25/3

The development and demonstration of the High Speed Data Bus system, a 50 Million bits per second (Mbps) local data network intended for avionics applications in advanced military aircraft is described. The Advanced System Avionics (ASA)/PAVE PILLAR program provided the avionics architecture concept and basic requirements. Designs for wire and fiber optic media were produced and hardware demonstrations were performed. An efficient, robust token-passing protocol was developed and partially demonstrated. The requirements specifications, the trade-offs made, and the resulting designs for both a coaxial wire media system and a fiber optics design are examined. Also, the development of a message-oriented media access protocol is described, from requirements definition through analysis, simulation and experimentation. Finally, the testing and demonstrations conducted on the breadboard and brassboard hardware is presented. GRA

N90-29587# Naval Research Lab., Washington, DC. Lab. for Computational Physics and Fluid Dynamics.
NUMERICAL SIMULATIONS OF THE STRUCTURE OF SUPERSONIC SHEAR LAYERS Memorandum Report
B. FAROUK (Drexel Univ., Philadelphia, PA.), E. S. ORAN, and K. KAILASANATH 20 Jul. 1990 42 p Sponsored by ONR, Arlington, VA
(AD-A224164; NRL-MR-6667) Avail: NTIS HC A03/MF A01 CSCL 20/4

Time-dependent two-dimensional numerical calculations were performed to study the mixing characteristics of unforced, planar, confined shear layers formed by two parallel streams of air that come into contact after passing over a splitter plate. The evolution of the shear layer was examined by systematically varying the velocities, densities, and the static pressures of the two streams that come into contact at the trailing edge of the plate. At least one of the streams was always supersonic. For the range of the parameters studied, the supersonic shear layers show some organization, albeit less coherent than their subsonic counterparts. The most amplified frequency, obtained by Fourier analysis of the velocity and pressure fluctuations, depends on the effective inlet momentum thickness. Convective Mach numbers of the streams corresponding to each side of the shear layer were found to be quite different. The simulations indicate that the single convective Mach number as derived from an isentropic model is not sufficient to characterize the mixing behavior when the velocity, pressure, and density ratios are changed independently. GRA

N90-29593# Naval Postgraduate School, Monterey, CA. Dept. of Mechanical Engineering.
FURTHER STUDIES OF TURBULENCE STRUCTURE RESULTING FROM INTERACTIONS BETWEEN EMBEDDED VORTICES AND WALL JETS AT HIGH BLOWING RATIOS M.S. Thesis
WILLIAM D. DONER Dec. 1989 291 p
(AD-A223296) Avail: NTIS HC A13/MF A02 CSCL 20/4

Interactions of wall jets and vortices embedded in turbulent layers commonly occur near gas turbine blades and endwalls where film cooling is employed. These interactions frequently result in undesirable heat transfer effects at blade and endwall surfaces. In this thesis, a crossed hot-wire probe is used to measure the turbulence structure resulting from this type of interaction. The vortex is generated using a half delta-wing vortex generator mounted 12 deg with respect to a 10 m/s mean velocity flow over a flat plate. A single injection hole, 0.95 cm in diameter, inclined 30 deg to the horizontal, is positioned 59.3 cm downstream of the vortex generator. The vortex generator is positioned so that vortex upwash and downwash could be located over the injection hole. Streamwise development of the turbulent boundary layer was investigated for the following cases: (1) boundary layer with jet only (m = 1.5), and (2) boundary layer with vortex only. Measurement of interaction between the boundary layer, vortex upwash, and the wall jet was made at one station with various blowing ratios. At low blowing ratios (m = 0.5 and 1.5) the vortex dominates the flow. Significant alterations to the turbulent structure are seen in the Reynolds stress components, vorticity distributions and mean velocities. At higher blowing ratios (m = 2.5 and 3.5) the jet dominates the flow, the vortex is blown away from the wall, and its turbulence effects are dispersed over a larger area. GRA

N90-29597# Royal Aircraft Establishment, Farnborough (England).
THE EXPERIMENTAL INVESTIGATION OF FLOW IN THE CORE OF A VORTEX STRUCTURE
V. L. BAKULIN and A. M. GAIFULLIN Jan. 1990 8 p Original language document was announced in IAA as A88-52094
(BR114893; RAE-TRANS-2176) Avail: NTIS HC A02/MF A01

An experimental study is presented for quasi-conical flow for a parabolically curved wing with a parabolic planform. Two closed recirculation regions not touching the wing were observed at the wing's leading edge. An analysis is made of the effect of nonself-similar factors on the structure of the quasi-conical flow. Author

N90-29664# Wright Research Development Center, Wright-Patterson AFB, OH.
PROCEEDINGS OF DAMPING '89. VOLUME 1: PAGES AAB-1 THROUGH DCD-11 Final Report, Feb. 1986 - Feb. 1989
Nov. 1989 511 p Proceedings held in West Palm Beach, FL,

8-10 Feb. 1989
(Contract AF PROJ. 486U)
(AD-A223431; WRDC-TR-89-3116-VOL-1) Avail: NTIS HC A22/MF A03 CSCL 20/11

Session topics in this volume include: complex modules; aircraft applications; composite materials/structures; electro-rheological fluids; hydraulic dampers; damping identification and analysis; fractional derivatives; and space applications. GRA

N90-29680# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
FRACTOGRAPHIC ANALYSIS OF FATIGUE CRACK GROWTH UNDER TWO-BLOCKS LOADING ON 2024-T351 SHEET SPECIMENS
M. R. LING and J. SCHIJVE Apr. 1990 25 p
(LR-628; ETN-90-97639) Avail: NTIS HC A03/MF A01

Fatigue crack growth in 2024-T351 sheet material (6.35 mm) under load sequences with periodic overload blocks are analyzed nearly cycle by cycle in the electron microscope. The purpose is to study the interaction effects between the load cycles with different amplitudes. The crack increment of the first overload cycle in an overload block is significantly larger (giant striation) than that of the direct following overload cycles and it increases systematically with the number of the small amplitude cycle applied before the overload block. It is probably a result of more primary plastic deformation around the crack tip. The crack growth situation after the first overload becomes approximately the same as in constant amplitude tests. The crack growth in the small amplitude blocks are retarded immediately after applying the overloads. The crack growth rates decrease subsequently (delayed retardation) to a minimum value following a similar trend. ESA

N90-29681# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
EFFECTS OF BLOCKS OF OVERLOADS AND UNDERLOADS ON FATIGUE CRACK GROWTH IN 2024-T351 SHEET SPECIMENS: FRACTOGRAPHIC ANALYSIS AND CRACK CLOSURE PREDICTIONS
M. R. LING and J. SCHIJVE Apr. 1990 27 p
(LR-629; ETN-90-97640) Avail: NTIS HC A03/MF A01

Fatigue crack growth in 2024-T351 sheet material under load sequences with underload-overload combinations is analyzed nearly cycle by cycle in the electron microscope. The purpose is to study the interaction effects between underloads, overloads and load cycles with a smaller amplitude. The overload block causes significant crack growth retardation in both the underload block and the small amplitude block as expected in view of the crack closure concept. The extent of the retardation in the small cycles reduces after applying underloads which is supposed to erase the retardation completely according to the crack closure concept. However, some retardation is still found. In the overload block itself only the first cycle shows a significantly larger crack increment. It is probably a result of more primary plastic deformation around the crack tip and a lower strain hardening level. The other overload cycles induce crack increments similar to those in constant amplitude tests, independent of the underload level. ESA

N90-29682# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
FATIGUE, STATIC TENSILE STRENGTH AND STRESS CORROSION OF AIRCRAFT MATERIALS AND STRUCTURES. PART 1: TEXT
J. SCHIJVE Mar. 1990 229 p Revised
(LR-630-PT-1-REV; ETN-90-97641) Avail: NTIS HC A11/MF A02

A book used as a text for an aircraft materials course is presented. Stress concentrations, the stress intensity at crack tips, and residual stresses are discussed. Knowledge about these subjects is essential for further discussion on static tensile strength, stress corrosion and fatigue. Failure in tension is addressed, covering the material tensile strength, the blunt notch strength (strength of notched elements), fracture toughness and the residual strength of cracked parts. Aspects of stress corrosion are discussed. The main emphasis is on fatigue of materials and structures. The fatigue life is divided in two periods: the crack initiation period and the crack growth period. The significance of the two periods for practical problems is emphasized and used in the discussion of several effects on fatigue. Fatigue under constant-amplitude loading, fatigue under variable-amplitude loading, fatigue of joints, fatigue loads on aircraft structures and fatigue of aircraft structures, are presented. ESA

N90-29683# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
FATIGUE, STATIC TENSILE STRENGTH AND STRESS CORROSION OF AIRCRAFT MATERIALS AND STRUCTURES. PART 2: FIGURES
J. SCHIJVE Mar. 1990 121 p
(LR-630-PT-2; ETN-90-97642) Avail: NTIS HC A06/MF A01

A book used as a text for an aircraft materials course is presented. Stress concentrations, the stress intensity at crack tips, and residual stresses are discussed. Knowledge about these subjects is essential for further discussion on static tensile strength, stress corrosion and fatigue. Failure in tension is addressed, covering the material tensile strength, the blunt notch strength (strength of notch elements), fracture toughness and the residual strength of cracked parts. Aspects of stress corrosion are discussed. The main emphasis is on fatigue of materials and structures. The fatigue life is divided in two periods: the crack initiation period and the crack growth period. The significance of the two periods for practical problems is emphasized and used in the discussion of several effects on fatigue. Fatigue under constant-amplitude loading, fatigue under variable-amplitude loading, fatigue of joints, fatigue loads on aircraft structures and fatigue of aircraft structures, are presented separately. ESA

N90-29684# Technische Univ., Delft (Netherlands). Faculty of Aerospace Engineering.
FRACTOGRAPHIC OBSERVATIONS ON FATIGUE CRACK GROWTH UNDER MINITWIST FLIGHT-SIMULATION LOADING (2024-T3 MATERIAL)
J. SIEGL (Technical Univ. of Prague, Czechoslovakia) and J. SCHIJVE May 1990 65 p
(LR-631; ETN-90-97643) Avail: NTIS HC A04/MF A01

Fractographic observations were performed to determine fatigue crack growth increments corresponding to the most severe flights of the miniTWIST flight simulation. Specimens were tested under two miniTWIST load histories and three special load sequences based on the most severe flights of the miniTWIST. Bands caused by the severe flights could be distinguished on the fracture surface and an accurate reconstitution of the crack growth curve could be made. Crack increments occurring in the most severe flights were measured and compared with values predicted by the modified CORPUS model. Observations on accelerations and retardations are presented. ESA

N90-29686# National Aerospace Lab., Tokyo (Japan).
FRACTOGRAPHIC ANALYSIS OF FATIGUE FAILURES OF AIRFRAME EQUIPMENT PARTS: EXAMPLES OF A ROD END HOUSING AND A ROD END CAP
YOSHIAKI KAKUTA and TOSHIYUKI SHIMOKAWA Dec. 1989 14 p In JAPANESE; ENGLISH summary
(NAL-TR-1047; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

Fatigue failure surfaces of a rod end housing and a rod end cap of airframe equipment used in transport airplanes were observed by a scanning electron microscope (SEM). Obtained fractographs were analyzed and fatigue crack initiation and propagation periods were estimated. Basic technical data were provided to determine proper inspection and replacement periods and intervals for the identical parts potentially fatigue damaged. The inspection and replacement periods and intervals for these parts were discussed. Author

N90-29687# National Aerospace Lab., Tokyo (Japan).
NONCONTACT MEASUREMENT OF ROTATING BLADE VIBRATIONS

YUKIO MATSUDA, MASANORI ENDOH, NANAHISA SUGIYAMA, and TAKESHI KOSHINUMA Aug. 1989 51 p In JAPANESE; ENGLISH summary
(NAL-TR-1033; ISSN-0389-4010) Avail: NTIS HC A04/MF A01

A new noncontact measuring system for rotating blades vibrations of fans, compressors, and turbines was developed and successfully applied in the research and development project of turbofan engines and industrial gas turbines. It is a powerful measurement system which can simultaneously measure the vibration of all blades without the need of such processing of blades and rotor as in traditional strain gage measurement. The system consists of optical fiber blade-tip detectors on the peripheral of the engine casing, signal processing/data acquisition subsystem and control/calculation/display subsystem. Software is devised to insure valid data and high handling qualities of the system. Results of measurement are displayed on a sub-realtime basis in the on-line monitoring mode as vibration wave forms of a few blades and bar-graphs for the maximum vibration amplitudes of all the blades. Also an off-line data processing mode is available for later analysis and review. The measuring principle, the system performance, and the hard- and software, and in addition, some results of application and calibration which show good agreement with those of strain gage measurement, are described. Author

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GEOSCIENCES

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

A90-50777
REQUIREMENTS FOR METEOROLOGICAL EQUIPMENT DESIGNED FOR THE ACQUISITION OF METEOROLOGICAL DATA ESSENTIAL FOR THE TAKEOFF AND LANDING OF AIRCRAFT AT CIVIL AIRPORTS [TREBOVANIIA K METEOOBORUDOVANIIU, PREDNAZNACHENNOMU DLIA POLUCHENIIA METEOINFORMATSII, NEOBKHODIMOI PRI OBESPECHENII VZLETA I POSADKI VOZDUSHNYKH SUDOV NA AERODROMAKH GA]
P. IA. NIKISHKOV IN: Methodology and tools for meteorological observations. Leningrad, Gidrometeoizdat, 1989, p. 3-25. In Russian. refs
Copyright

The principal criteria for the contents and quality of meteorological data that would provide for the safe takeoff and landing of civil aircraft are briefly reviewed. It is then shown that these criteria can be satisfied only if the meteorological equipment meets certain requirements. In particular, attention is given to the requirements for visibility range meters, detectors of the lower cloud boundary, detectors of wind parameters, and atmospheric pressure detectors. The discussion also covers requirements for air humidity and temperature monitors, instrumentation for the detection of hazardous meteorological conditions, and automated meteorological systems, as well as general requirements for the meteorological equipment of airports. V.L.

A90-50780
MEASUREMENT OF WIND CHARACTERISTICS AT AIRPORTS [OB IZMERENII KHARAKTERISTIK VETRA NA AERODROMAKH]
S. M. PERSIN and L. V. ANISKIN IN: Methodology and tools for meteorological observations. Leningrad, Gidrometeoizdat, 1989, p. 40-50. In Russian. refs
Copyright

Requirements for wind parameter measurements as part of the meteorological support of flight operations are discussed. In particular, results of theoretical and experimental studies of wind variability characteristics are reported, and recommendations are given concerning the selection of observation intervals when determining the mean and extreme wind velocity parameters. Attention is also given to the consideration of errors associated with the discrete nature of measurements and with the effect of the frequency characteristics of the transducers. V.L.

A90-50783
SEMIAUTOMATIC CODING OF WEATHER PHENOMENON GROUPS IN THE METEOROLOGICAL REPORTS OF AUTOMATIC AIRPORT STATIONS [POLUAVTOMATICHESKOE KODIROVANIE GRUPP IAVLENII POGODY V METEOSOOBSHCHENIIAKH AVTOMATICHESKIKH AERODROMNYKH STANTSII]
A. A. AFANAS'EV and E. V. ROMANOV IN: Methodology and tools for meteorological observations. Leningrad, Gidrometeoizdat, 1989, p. 62-70. In Russian. refs
Copyright

A unified table of weather phenomena, which also contains recent weather and weather between forecast periods, is proposed for coding during the preparation of meteorological reports using common meteorological codes. Urgent reports are also produced to warn about hazardous weather phenomena and to inform airport dispatchers of approaching storms. An algorithm for automatic report generation with manual input of data on the current weather phenomena is presented which uses the table of weather phenomena. V.L.

A90-50784
VARIABILITY CHARACTERISTICS OF THE METEOROLOGICAL OPTICAL RANGE FIELD IN AN OPTICALLY INHOMOGENEOUS ATMOSPHERE [KHARAKTERISTIKI IZMENCHIVOSTI POLIA METEOROLOGICHESKOI OPTICHESKOI DAL'NOSTI /MOD/ V *OPTICHESKI NEODNORODNOI ATMOSFERE*]
S. M. PERSIN and V. I. LAIKHTMAN IN: Methodology and tools for meteorological observations. Leningrad, Gidrometeoizdat, 1989, p. 71-84. In Russian. refs
Copyright

Analytical expressions are obtained which relate the three-dimensional structural characteristics of the meteorological optical range field and those of the attenuation field. The results obtained provide a way to evaluate the methodological errors arising during the determination of the visibility range characteristics from instrumental measurements of the attenuation factor. V.L.

A90-52051
INVERSIONS AND ASSOCIATED WIND-SHEAR WARNINGS MUST BE RELATED TO AIRPORT CHARACTERISTICS
K. H. HACK (Zurich Airport, Meteorological Office, Switzerland) ICAO Journal (ISSN 0018-8778), vol. 45, April 1990, p. 9-12.
Copyright

The problem of potentially dangerous wind shear temperature inversions in the air layers close to the ground around airports is discussed. Measuring equipment to provide warnings of wind shear, already installed in many countries, has shown that each airport must develop a made-to-measure concept to comply with the airport's characteristics including topogrphy and runway configrations. The usefulness of Doppler radar in providing sufficiently precise measurements of wind shears is considered and it is noted that with the occurrence of strong gradient wind, hills around an airport give rise to vortices which are carried over the wind and constitute a source of dangerous wind shear. Due to rapid changes, precise measurement of wind shear is not yet possible with current instruments; however, a correlation between the measured values from selected wind measuring points and the degree of wind shear may be found. Finally, the Aeronautical Meteorological Information System project and its findings are described. L.K.S.

A90-52052
MAXIMUM EXPECTED CONCENTRATIONS OF HAIL IN THUNDERSTORM PRECIPITATION
J. F. MEZEIX, D. HUSSON (Groupement National d'Etudes des

Fleaux Atmospheriques, Grenoble, France), and J. P. CAMMAS (Clermont-Ferrand, Observatoire de Physique du Globe, France) ICAO Journal (ISSN 0018-8778), vol. 45, April 1990, p. 13-19. Copyright

Data recorded since 1972 in the course of four experimetal programs in France and Switzerland (614 hailfalls and 253 thunderstorm cells) have been used to estimate maximum hail concentration in thunderstorm precipitation. Radar measurements of the reflectivity factor (Z) provide an indirect estimate of the concentration (M) in a thunderstorm through a Z-M relationship. Four possibilities for Z-M relationships (based upon assumptions concerning the Mie or Rayleigh scattering field, and the structure and the shape of the dimensional hailstone spectra were selected and tested on data from actual hailfalls. Equipment used to measure hailfall is discussed and estimation of maximum hail concentration is illustrated. It is noted that, due to the disperse nature of hail, the phenomenon cannot be explained by a single model, nor is there a single answer to estimating the maximum hail concentration by a Z-M relationship. L.K.S.

N90-28887 Physics and Electronics Lab. TNO, The Hague (Netherlands).
DESCRIPTION OF THE MARC MEASURING SYSTEM Final Report
A. N. DEJONG, J. WINKEL, and R. A. W. KEMP Nov. 1989 69 p In DUTCH; ENGLISH summary
(FEL-89-B170; TD-89-3873; ETN-90-97408) Copyright Avail: Physics and Electronics Lab. TNO, P.O. Box 96864, 2509 JG The Hague, Netherlands

The MARC (Multispectral Airborne Reference-aided Calibrated scanner) measuring system is presented. The MARC system for gathering multispectral reflection data of terrain elements contains 16 spectral bands from the UV to the IR range. Special attention was paid to the data collection and gathering system with a view to different applications. The system can either measure in the field or from an airplane. In the latter case the required accuracy cannot be obtained in all spectral bands. Some measurement results are discussed. ESA

N90-29692# European Space Agency, Paris (France).
THE SIGNALS OF AN ICE WARNING DEVICE IN DEPENDENCE ON TOTAL WATER CONTENT AND NORMALIZED ICING DEGREE
HANS-EBERHARD HOFFMANN, JOHANN DEMMEL, and JOACHIM SCHUSTER (Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen, Germany, F.R.) Jun. 1990 64 p Transl. into ENGLISH of Die Signale eines Eiswarngebers in Abhaengigkeit vom Gesamtwassergehalt in Wolken und vom normierten Vereisungsgrad Original report in GERMAN previously announced as ETN-90-96279
(ESA-TT-1207; DFVLR-FB-89-52; ETN-90-97598) Avail: NTIS HC A04/MF A01

The equipment on an icing research aircraft is described. It includes an icing rate indicator, which has operated perfectly on all icing flights performed to date (approx. 70 hours). Its three output signals, icing rate on sensor, sensor defrost frequency, and weight of ice accretion on sensor, were recorded during these flights. In some special flights, photographs were taken of ice accretion on a metal rod of the same diameter as the sensor of the icing rate indicator. Some of the conclusions reached were as follows: even at temperatures of approx. -4.5 C, only a proportion of the water in incoming supercooled cloud particles remained attached in the form of ice to the sensor rod. The sensitivity of the output signal ice accretion rate as an index for short term total water content, where short term means for approx. 2 seconds flight through cloud, decreased as cloud inhomogeneity increased. In strong inhomogeneous clouds, this output signal was not found to exhibit a clear dependency on total water content. ESA

N90-29745 Rice Univ., Houston, TX.
WINDSHEAR ESTIMATION ALONG THE TRAJECTORY OF AN AIRCRAFT Ph.D. Thesis
CHING-YAW TZENG 1989 105 p
Avail: Univ. Microfilms Order No. DA9012879

The application of the sequential gradient restoration algorithm (SGRA) to the estimation of the windshear along the trajectory of an aircraft is studied. Based on the measured trajectory data obtained from the digital flight data recorder (DFDR) of Flight Delta 191 (August 2, 1985, Dallas-Fort Worth International Airport), a nonlinear least-square problem is formulated. The performance index being minimized measures the deviation of the experimental trajectory (the altitude, the relative velocity, and the pitch attitude angle) from the computed trajectory, obtained by integrating the equations of motion of an aircraft in a vertical plane. Since the thrust and the aerodynamic forces enter directly in this dynamic formulation, a clear picture of the forces acting on the aircraft can be seen. The angle of attack is treated as a control, and the power setting is regarded as a known input. By assuming that the manufacturer-supplied aerodynamic and thrust data are dependable, the dynamically estimated vertical wind shows reasonable agreement with that obtained with the kinematic approach. However, the results obtained for the horizontal wind are less satisfactory. Upon modifying the manufacturer-supplied thrust and aerodynamic data with unknown multiplicative factors, a better agreement between the measured and computed trajectory can be achieved. Upon employing different combinations of the measured trajectory data, the relative importance of each data can be established. The horizontal distance data and the relative velocity data are found to have minor effect on the estimation results. The altitude data affect mostly the vertical wind, and the pitch attitude angle data are crucial to the estimation of both the horizontal and vertical winds. Dissert. Abstr.

N90-29746 Texas A&M Univ., College Station.
THREE-DIMENSIONAL NUMERICAL STUDY OF THUNDERSTORM DOWNDRAFTS AND ASSOCIATED OUTFLOW BOUNDARIES Ph.D. Thesis
DANNY RAYMOND POPHIN 1989 172 p
Avail: Univ. Microfilms Order No. DA9015566

Thunderstorm downdrafts and their associated outflow boundaries are numerically simulated using a high-resolution, time-dependent, three-dimensional model. The initial downdraft is initiated by specifying a distribution of precipitation at the top of the domain which initially has no vertical motion. Two initial thermodynamic profiles are used to represent the pre-environmental conditions for a Mesoscale Convective Complex (MCC). Several different initial and ambient conditions are used to simulate the effects of vertical shear, the type of precipitation falling through the storm and the radius of the precipitation core. The simulations indicate that the outflows and downdrafts are sensitive to the vertical profile of temperature and humidity, vertical wind shear, low-level inflow speeds, the type of precipitation and the radius of the precipitation shaft. One interesting result of the study relates to the formation and life cycle of the ring vortex associated with the downdraft. When a low-level shear is imposed against the forward outflow boundary the vortex in this region dissipates while the vortex on the rear flank of the storm is enhanced. As the shear in the lower levels is increased, the ring vortex on the front flank of the storm is slower in its downward propagation to the surface from its initiation point. The ring vortex in these simulations always formed in the region where the temperature profile first becomes adiabatic. In the simulations where the radius of the precipitation core is varied it is found that the buoyancy term in the vertical equation of motion is always the key in the calculations of the vertical motion. The results show that the growth rate of the downdraft is slow for large radius and fast for small radius. This is consistent with the theory of scale dependence.
Dissert. Abstr.

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LIFE SCIENCES

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

N90-28982# Human Engineering Labs., Aberdeen Proving Ground, MD.
COUNTERAIR SITUATION AWARENESS DISPLAY FOR ARMY AVIATION
CHRISTOPHER C. SMYTH, FRANK J. MALKIN, and WILLIAM B. DEBELLIS *In* AGARD, Situational Awareness in Aerospace Operations 10 p Apr. 1990
Copyright Avail: NTIS HC A09/MF A02; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

An air combat display concept is proposed for Army aviation helicopter cockpits. The effects of the choice of the display size, the display symbol size, and the area of coverage as a counterair situation awareness display are discussed. The display shows the tracks of aircraft about the host helicopter on a Planar Position Indicator (PPI) graph via the open broadcast radio net of the division-wide air defense radar coverage. The display is used to alert the aircrew to the presence of aircraft in the area and cue to the location of enemy threats for the counterair role. It is concluded that with the relatively small display sizes used in helicopters, an accurate determination of the position of enemy threats during air-to-air combat cannot be made by an aviator from the PPI alone. It must be interactive allowing access to detailed information about a track of interest to be useful. Author

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MATHEMATICAL AND COMPUTER SCIENCES

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

A90-52877
LQG/LTR CONTROLLER DESIGN USING A REDUCED ORDER MODEL
RAJIVA PRAKASH and S. VITTAL RAO (Missouri-Rolla, University, Rolla) IN: IEEE International Conference on Systems Engineering, Dayton, OH, Aug. 24-26, 1989, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 343-346. refs
Copyright

A specific robust controller design procedure, linear quadratic Gaussian with loop transfer recovery (LQG/LTR), is studied. LQG/LTR design using a reduced-order model is performed. The error due to the use of the reduced model is accounted for by computing multiplicative error. All closed right half plane modes of the given system are included in the reduced-order model. The reduced-order LQG/LTR controller design procedure is applied to the problem of lateral attitude control of a drone aircraft. The case study demonstrates the reduction/design steps for a practical problem. I.E.

A90-52881* Akron Univ., OH.
THE DETERMINATION OF THIRD ORDER LINEAR MODELS FROM A SEVENTH ORDER NONLINEAR JET ENGINE MODEL
RICK J. LALONDE, TOM T. HARTLEY, and J. ALEX DE ABREU-GARCIA (Akron, University, OH) IN: IEEE International Conference on Systems Engineering, Dayton, OH, Aug. 24-26, 1989, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1989, p. 467-470. refs
(Contract NAG3-778)
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Results are presented that demonstrate how good reduced-order models can be obtained directly by recursive parameter identification using input/output (I/O) data of high-order nonlinear systems. Three different methods of obtaining a third-order linear model from a seventh-order nonlinear turbojet engine model are compared. The first method is to obtain a linear model from the original model and then reduce the linear model by standard reduction techniques such as residualization and balancing. The second method is to identify directly a third-order linear model by recursive least-squares parameter estimation using I/O data of the original model. The third method is to obtain a reduced-order model from the original model and then linearize the reduced model. Frequency responses are used as the performance measure to evaluate the reduced models. The reduced-order models along with their Bode plots are presented for comparison purposes. I.E.

N90-29121*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AN EXPERT SYSTEM TO PERFORM ON-LINE CONTROLLER RESTRUCTURING FOR ABRUPT MODEL CHANGES
JONATHAN S. LITT 1990 12 p Prepared for presentation at the Rotary Wing Propulsion Specialists' Meeting, Williamsburg, VA, 13-15 Nov. 1990; sponsored in part by the Hampton Roads Chapter of the Southeast Region of the American Helicopter Society Prepared in cooperation with Army Aviation Systems Command, Cleveland, OH
(Contract DA PROJ. 1L1-61102-AH-45)
(NASA-TM-103609; E-5761; NAS 1.15:103609; AVSCOM-TR-90-C-018) Avail: NTIS HC A03/MF A01 CSCL 09/2

Work in progress on an expert system used to reconfigure and tune airframe/engine control systems on-line in real time in response to battle damage or structural failures is presented. The closed loop system is monitored constantly for changes in structure and performance, the detection of which prompts the expert system to choose and apply a particular control restructuring algorithm based on the type and severity of the damage. Each algorithm is designed to handle specific types of failures and each is applicable only in certain situations. The expert system uses information about the system model to identify the failure and to select the technique best suited to compensate for it. A depth-first search is used to find a solution. Once a new controller is designed and implemented it must be tuned to recover the original closed-loop handling qualities and responsiveness from the degraded system. Ideally, the pilot should not be able to tell the difference between the original and redesigned systems. The key is that the system must have inherent redundancy so that degraded or missing capabilities can be restored by creative use of alternate functionalities. With enough redundancy in the control system, minor battle damage affecting individual control surfaces or actuators, compressor efficiency, etc., can be compensated for such that the closed-loop performance in not noticeably altered. The work is applied to a Black Hawk/T700 system. Author

N90-29142*# Draper (Charles Stark) Lab., Inc., Cambridge, MA.
MODEL AUTHORING SYSTEM FOR FAIL SAFE ANALYSIS
SCOTT E. SIKORA Washington NASA Aug. 1990 65 p
(Contract NAS2-12451)
(NASA-CR-4317; H-1620; NAS 1.26:4317) Avail: NTIS HC A04/MF A01 CSCL 12/2

The Model Authoring System is a prototype software application for generating fault tree analyses and failure mode and effects analyses for circuit designs. Utilizing established artificial intelligence and expert system techniques, the circuits are modeled as a frame-based knowledge base in an expert system shell, which allows the use of object oriented programming and an inference engine. The behavior of the circuit is then captured through IF-THEN rules, which then are searched to generate either a

graphical fault tree analysis or failure modes and effects analysis. Sophisticated authoring techniques allow the circuit to be easily modeled, permit its behavior to be quickly defined, and provide abstraction features to deal with complexity. Author

N90-29143*# Draper (Charles Stark) Lab., Inc., Cambridge, MA.
A KNOWLEDGE-BASED SYSTEM DESIGN/INFORMATION TOOL
JAMES G. ALLEN and SCOTT E. SIKORA Washington NASA Aug. 1990 192 p
(Contract NAS2-12451)
(NASA-CR-4316; H-1621; NAS 1.26:4316) Avail: NTIS HC A09/MF A01 CSCL 12/2

The objective of this effort was to develop a Knowledge Capture System (KCS) for the Integrated Test Facility (ITF) at the Dryden Flight Research Facility (DFRF). The DFRF is a NASA Ames Research Center (ARC) facility. This system was used to capture the design and implementation information for NASA's high angle-of-attack research vehicle (HARV), a modified F/A-18A. In particular, the KCS was used to capture specific characteristics of the design of the HARV fly-by-wire (FBW) flight control system (FCS). The KCS utilizes artificial intelligence (AI) knowledge-based system (KBS) technology. The KCS enables the user to capture the following characteristics of automated systems: the system design; the hardware (H/W) design and implementation; the software (S/W) design and implementation; and the utilities (electrical and hydraulic) design and implementation. A generic version of the KCS was developed which can be used to capture the design information for any automated system. The deliverable items for this project consist of the prototype generic KCS and an application, which captures selected design characteristics of the HARV FCS. Author

N90-29919*# Wyle Labs., Inc., Hampton, VA.
REALTIME MULTI-PLOT GRAPHICS SYSTEM
MICHAEL S. SHIPKOWSKI Washington Sep. 1990 47 p
(Contract NAS1-18304)
(NASA-CR-4304; NAS 1.26:4304) Avail: NTIS HC A03/MF A01 CSCL 09/2

The increased complexity of test operations and customer requirements at Langley Research Center's National Transonic Facility (NTF) surpassed the capabilities of the initial realtime graphics system. The analysis of existing hardware and software and the enhancements made to develop a new realtime graphics system are described. The result of this effort is a cost effective system, based on hardware already in place, that support high speed, high resolution, generation and display of multiple realtime plots. The enhanced graphics system (EGS) meets the current and foreseeable future realtime graphics requirements of the NTF. While this system was developed to support wind tunnel operations, the overall design and capability of the system is applicable to other realtime data acquisition systems that have realtime plot requirements. Author

N90-29926# National Aeronautical Lab., Bangalore (India). Propulsion Div.
DEVELOPMENT OF A SOFTWARE PACKAGE FOR AUTOMATIC DATA ACQUISITION, ANALYSIS, AND CONTROLS IN AN AXIAL FLOW COMPRESSOR TEST RIG
Q. H. NAGPURWALA and K. RAMMOHAN (Regional Engineering Coll., Tiruchirapalli, India) Nov. 1989 18 p
(PD-PR-8910) Avail: NTIS HC A03/MF A01

A comprehensive multitasking software was developed for AUTOmatic Data Acquisition, Analysis, and Controls (AUTODAAC) in a high speed Axial Flow Compressor Research Rig. The software, written in BASIC, runs on a MACSYM 150 high speed desk-top computer which forms the heart of the instrumentation system attached to this test facility. The salient features and capabilities of AUTODAAC are discussed. Typical graphical outputs are also presented. Author

N90-29965*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FORMAL DESIGN AND VERIFICATION OF A RELIABLE COMPUTING PLATFORM FOR REAL-TIME CONTROL. PHASE 1: RESULTS
BEN L. DIVITO (Vigyan Research Associates, Inc., Hampton, VA.), RICKY W. BUTLER, and JAMES L. CALDWELL Oct. 1990 69 p
(NASA-TM-102716; NAS 1.15:102716) Avail: NTIS HC A04/MF A01 CSCL 09/2

A high-level design is presented for a reliable computing platform for real-time control applications. Design tradeoffs and analyses related to the development of the fault-tolerant computing platform are discussed. The architecture is formalized and shown to satisfy a key correctness property. The reliable computing platform uses replicated processors and majority voting to achieve fault tolerance. Under the assumption of a majority of processors working in each frame, it is shown that the replicated system computes the same results as a single processor system not subject to failures. Sufficient conditions are obtained to establish that the replicated system recovers from transient faults within a bounded amount of time. Three different voting schemes are examined and proved to satisfy the bounded recovery time conditions. Author

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PHYSICS

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

A90-51994
THE ABSORPTION OF SOUND BY PERFORATED LININGS
I. J. HUGHES (Topexpress, Ltd., Cambridge, England) and A. P. DOWLING (Cambridge, University, England) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 218, Sept. 1990, p. 299-335. refs
Copyright

This paper describes a practical application for sound-absorbent perforated screen with a bias flow through the screen. It is postulated that, if a perforated liner with a bias flow of cooling air through the liner is inserted in the afterburner section of a jet engine, all the incident sound may be absorbed at a particular frequency. Experimental results are presented on the absorptive properties of plane liners with circular apertures, showing an agreement with the theoretical model. I.S.

A90-52289
ACOUSTIC WAVE EXCITATION DURING THE AERODYNAMIC INTERACTION BETWEEN A FAN BLADE AND A BLUFF OBSTACLE [VOZBUZHDENIE ZVUKOVYKH VOLN PRI AERODINAMICHESKOM VZAIMODEISTVII LOPASTI VENTILIATORA S PLOKHO OBTEKAEMYM PREPIATSTVIEM]
S. G. CHUKHLANTSEV (AN SSSR, Akusticheskii Institut, Moscow, USSR) Akusticheskii Zhurnal (ISSN 0320-7919), vol. 36, July-Aug. 1990, p. 753-759. In Russian. refs
Copyright

The forces generated by flow over the surface of a fan blade and a bluff obstacle are calculated using the discrete vortex method. The results are then used to determine the sound source and the acoustic field formed. Results of an experimental verification of the analytical relations are presented. V.L.

N90-29166* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ANNOYANCE CAUSED BY ADVANCED TURBOPROP AIRCRAFT FLYOVER NOISE: COUNTER-ROTATING-PROPELLER CONFIGURATION

DAVID A. MCCURDY Washington Sep. 1990 88 p
(NASA-TP-3027; L-16780; NAS 1.60:3027) Avail: NTIS HC A05/MF A01 CSCL 20/1

Two experiments were conducted to quantify the annoyance of people to flyover noise of advanced turboprop aircraft with counter rotating propellers. The first experiment examined configurations having an equal number of blades on each rotor and the second experiment examined configurations having an unequal number of blades on each rotor. The objectives were to determine the effects on annoyance of various tonal characteristics, and to compare annoyance to advanced turboprops with annoyance to conventional turboprops and turbofans. A computer was used to synthesize realistic, time-varying simulations of advanced turboprop aircraft takeoff noise. The simulations represented different combinations fundamental frequency and tone-to-broadband noise ratio. Also included in each experiment were recordings of 10 conventional turboprop and turbofan takeoffs. Each noise was presented at three sound pressure levels in an anechoic chamber. In each experiment, 64 subjects judged the annoyance of each noise stimulus. Analyses indicated that annoyance was significantly affected by the interaction of fundamental frequency with tone-to-broadband noise ratio. No significant differences in annoyance between the advanced turboprop aircraft and the conventional turbofans were found. The use of a duration correction and a modified tone correction improved the annoyance prediction for the stimuli. Author

N90-29169*# Lockheed Engineering and Sciences Co., Hampton, VA.
VIBRATION RESPONSES OF TWO HOUSE STRUCTURES DURING THE EDWARDS AIR FORCE BASE PHASE OF THE NATIONAL SONIC BOOM PROGRAM
HARVEY H. HUBBARD Aug. 1990 58 p
(Contract NAS1-19000)
(NASA-CR-182089; NAS 1.26:182089) Avail: NTIS HC A04/MF A01 CSCL 20/1

The data are reproduced from NSBEO-1-67, which contains some preliminary results of the test program, and from NASA-Langley working papers 259 and 288 which are now out of print. Included are sample acceleration and strain recordings from F-104, B-58, and XB-70 sonic boom exposures, along with tabulations of the maximum acceleration and strain values measured for each one of about 130 flight tests. These data are compared with similar measurements for engine noise exposures of the building during simulated landing approaches and takeoffs of KC-135 aircraft. Author

N90-30030# National Aerospace Lab., Tokyo (Japan).
PARAMETRIC STUDIES OF ACOUSTIC DUCT ATTENUATION OFPERFORATED-PLATE-ON-HONEYCOMB ABSORBER
MINORU WATANABE, KATSUMI TAKEDA, and TADAO TORISAKI Feb. 1989 43 p In JAPANESE; ENGLISH summary
(NAL-TM-603; ISSN-0452-2982; JTN-90-80190) Avail: NTIS HC A03/MF A01

Parametric studies of acoustic duct attenuation of perforated-plate-on-honeycomb absorbers were conducted using a flow duct facility with duct air flow Mach number from -0.6 to 0.6. Open area ratio of face sheets from 0.01 to 0.09 and core depth from 10 to 40 mm were tested with constant duct size of 200 mm. The influence of these parameters as well as duct air flow Mach number was discussed. NASDA

N90-30031 Stanford Univ., CA.
THE COMPUTATION AND ANALYSIS OF ACOUSTIC WAVES IN TRANSONIC AIRFOIL-VORTEX INTERACTIONS Ph.D. Thesis
JAMES DOUGLAS BAEDER 1989 159 p
Avail: Univ. Microfilms Order No. DA9011450

The propagation characteristics of acoustic waves due to the interaction between a vortex and a helicopter airfoil were computed for a wide variety of methods, ranging from linearized transonic small disturbance to thin-layer Navier-Stokes. The analysis of the data from these methods showed that the accurate calculation of the acoustics required a computational method that not only accurately calculated the aerodynamics on the airfoil, but also properly preserved and propagated the wave as it left the surface. This resulted in improvements to the transonic small disturbance formulation for transonic airfoil-vortex interactions. Several post-processing techniques were developed to display the most important information from the computations. The Euler equations were found to be the most effective for calculating typical transonic airfoil-vortex interactions. Thus, they were utilized to study the effect of transonic flow on the formation process of the acoustic wave, resulting in significant new insight. Next, various parameters were studied. It was shown that in the linear subsonic regime the strength of the propagating wave varies with the sixth power of the Mach number; while, in the nonlinear transonic regime this power is smaller. It was also shown that in the transonic regime, the sign of the vortex was very important; suggesting that in the transonic regime one should avoid situations which results in clockwise vortices passing above the airfoil. The most important parameters governing transonic airfoil-vortex interaction noise were the Mach number, the vortex miss-distance, vortex strength and the sign of the vortex. Surprisingly, the airfoil shape and shock wave motions had relatively little effect on the transonic airfoil-vortex interaction noise. Dissert. Abstr.

N90-30035# BBN Systems and Technologies Corp., Canoga Park, CA.
AUDIBILITY AND ANNOYANCE OF EN ROUTE NOISE OF UNDUCTED FAN ENGINES Final Report
S. A. FIDELL, L. A. HUTCHINGS, M. HELWEG-LARSEN, and L. A. SIVATI Apr. 1990 57 p
(Contract F33615-86-C-0530)
(AD-A223687; BBN-7212; DOT/FAA/EE-90-03) Avail: NTIS HC A04/MF A01 CSCL 20/1

Aircraft flyovers heard in high ambient noise urban environments are composed in large part of high absolute level, broadband noise. In contrast, noise exposure created en route by aircraft powered by unducted fan engines is expected to be relatively low in level, but to contain prominent low frequency tonal energy. These tones may be readily audible in low ambient noise rural environments. The annoyance of noise intrusions of low absolute level has been shown to be closely related to their audibility. Thus, one way to predict the annoyance of high altitude overflights by aircraft equipped with unducted fan engines is to estimate their audibility relative to that of conventionally powered aircraft in various ambient noise conditions. These predictions may be converted into estimates of the probability of high annoyance by means of a dosage-response relationship derived from laboratory data about the annoyance of individual noise intrusions. The latter estimates may in turn be applied to populations exposed to unducted fan engine noise over a range of assumed exposure levels. Application of these procedures to several assumed exposure cases suggests that millions of people in rural areas of the United States would be likely to be highly annoyed by the noise of aircraft powered by unducted fan engines. GRA

N90-30036# BBN Systems and Technologies Corp., Canoga Park, CA.
ASSESSMENT SYSTEM FOR AIRCRAFT NOISE (ASAN): DEVELOPMENT OF ALPHA-TEST PROTOTYPE SYSTEM SOFTWARE Final Report, Oct. 1988 - Nov. 1989
NICHOLAAS H. REDDINGIUS and JOHN S. SMYTH Feb. 1990 22 p
(Contract F33615086-C-0530; AF PROJ. 3037)
(AD-A223770; REPT-7227; HSD-TR-90-005) Avail: NTIS HC A03/MF A01 CSCL 12/5

The Alpha-Test version of the Assessment System for Aircraft Noise (ASAN) is described. ASAN was developed for the United States Air Force's Noise and Sonic Boom Impact Technology Advanced Development Program Office (NSBIT ADPO). The Purpose of ASAN is to provide Air Force route and environment planners with a set of tools for preparing the noise portion of environmental impact statements (EIS), environmental

assessments (EA), and findings of no significant impact (FONSI). ASAN provides a consistent set of procedures and models which represent the current state-of-the-art in noise engineering practice. A brief overview is given of the technical issues of developing the ASAN system. GRA

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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.

N90-29247# Wichita State Univ., KS. National Inst. for Aviation Research.

INTERNATIONAL AIRCRAFT OPERATOR DATA BASE MASTER REQUIREMENTS AND IMPLEMENTATION PLAN Final Report, Sep. 1989 - Jul. 1990

GARY OTT, JOHN ELLIS, RAJ SUNDERRAMAN, JOHN J. HUTCHINSON, and FRANK H. MACHEERS Aug. 1990 45 p (Contract DTFA03-89-C-00057)

(DOT/FAA/CT-90/17) Avail: NTIS HC A03/MF A01

This International Aircraft Operator Data Base Master Requirements and Implementation Plan describes the Federal Aviation Administration's (FAA) requirements for aircraft operator information as well as a plan for addressing these requirements. In order to carry out this responsibility the FAA requirements include a unique description of each aircraft along with the name, address, telephone number, and a fax number of the aircraft operator. It was determined that the FAA has other ad hoc requirements for aircraft operator related information. It was also determined that information needed by the FAA to carry out this responsibility is available through the private sector. The software and computer networking capability is developed to make effective use of this information. The main task of this program is to create an information system which will facilitate and enhance communication between the FAA and the aircraft operator data base suppliers. The plan is presented to make use of these commercial data suppliers to create an aircraft operator information system. Author

N90-29249# Federal Aviation Administration, Atlantic City, NJ.

A GLOSSARY OF TERMS, DEFINITIONS, ACRONYMS, AND ABBREVIATIONS RELATED TO THE NATIONAL AIRSPACE SYSTEM

JOHN M. FABRY Jun. 1990 848 p

(DOT/FAA/CT-TN89/53) Avail: NTIS HC A99/MF E06

The following terms, definitions, acronyms, and abbreviations are defined for the purpose of clarifying their meaning. This unofficial glossary was compiled to provide a common understanding of terms related to the National Airspace System (NAS). The terms contained in this glossary are primarily defined in an operational sense, and are applicable to users, operators, and maintainers of the NAS. This document is not intended to be a arbiter of the official definition. Rather, it is intended to be a general listing of terms, definitions, acronyms, and abbreviations related to NAS projects, system programming, to contractors' documents, and to miscellaneous topics. Author

N90-30134# Sandia National Labs., Albuquerque, NM.

SMALL MULTIPURPOSE STORED DATA ACQUISITION SYSTEM

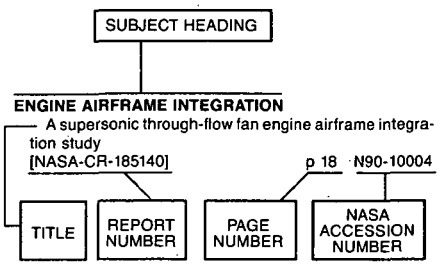
G. C. HAUSER and D. E. RYERSON 1990 5 p Presented at the International Telemetering Conference, Las Vegas, NV, 29 Oct. 1990

(Contract DE-AC04-76DP-00789)

(DE90-010823; SAND-90-0985C; CONF-901074-1) Avail: NTIS HC A01/MF A01

Sandia National Laboratories Telemetry Department has designed and is fielding a small, inexpensive multipurpose stored data acquisition system in tests ranging from 6000 meters below the ocean surface in seafloor penetrators to 40,000 meters above sea level in gamma ray telescope balloons. The system consists of a simple microprocessor-controlled unit which digitizes analog data and stores the data in memory for readout after the test by a portable personal computer. The system has been used in over ninety tests consisting of parachute drops, water entry test, vehicle environmental monitoring, and seafloor penetration tests. Data typically recorded with the system are acceleration, strain, temperature, pressure, and angular velocity. The system is also capable of generating control functions such as parachute release. DOE

Typical Subject Index Listing



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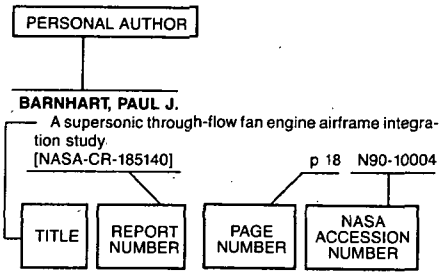
Typical Personal Author Index Listing



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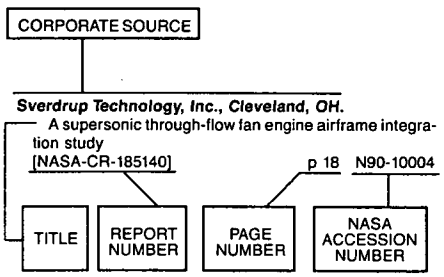
Typical Corporate Source Index Listing



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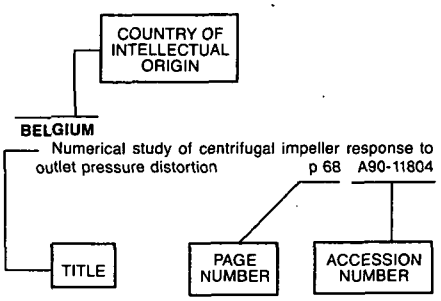

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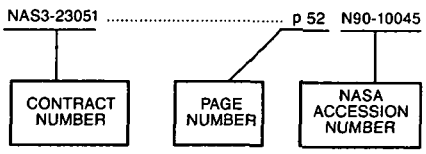
Typical Contract Number Index Listing



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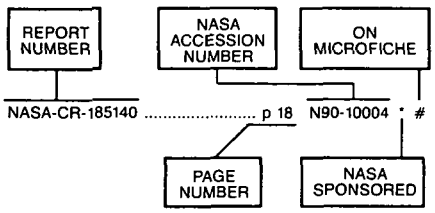
Typical Report Number Index Listing



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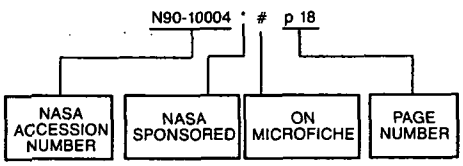

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