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A CONTINUING BIBLIOGRAPHY WITH INDEXES

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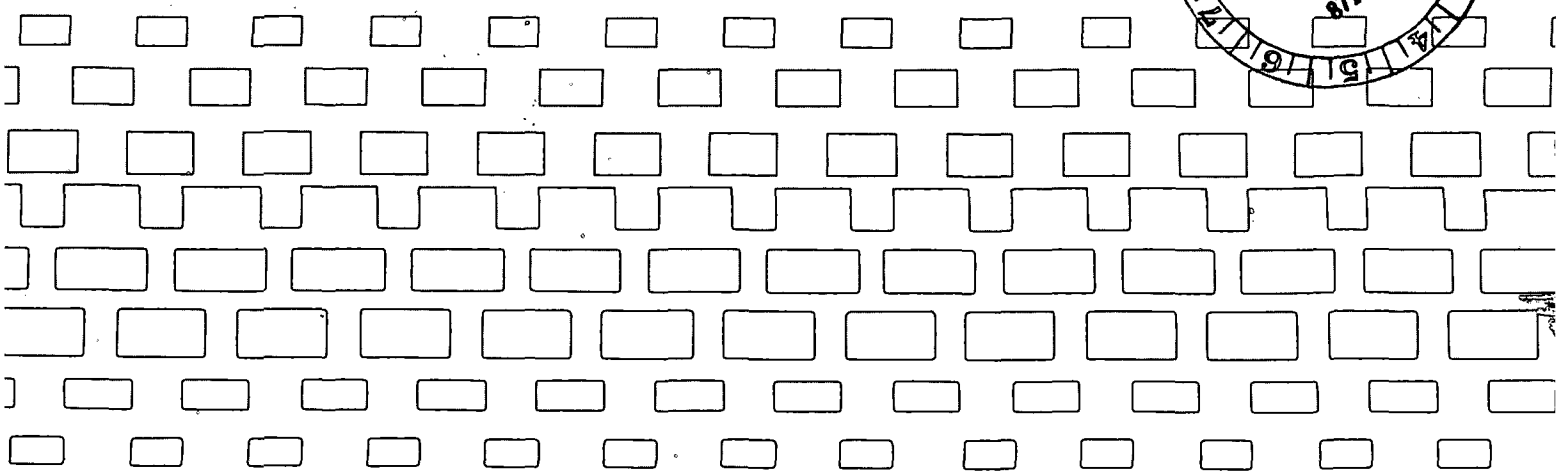

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INTRODUCTION

This issue of *Aeronautical Engineering—A Continuing Bibliography* (NASA SP-7037) lists 645 reports, journal articles, and other documents originally announced in May 1991 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

Accession numbers cited in this issue are:

STAR (N-10000 Series)	N91-16988 — N91-19023
IAA (A-10000 Series)	A91-24169 — A91-28400

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

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

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

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

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

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Includes aircraft simulation technology.

Category 06 Aircraft Instrumentation 393
Includes cockpit and cabin display devices; and flight instruments.

Category 07 Aircraft Propulsion and Power 396
Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and onboard auxiliary power plants for aircraft.

Category 08 Aircraft Stability and Control 401
Includes aircraft handling qualities; piloting; flight controls; and autopilots.

Category 09 Research and Support Facilities (Air) 407
Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tubes; and aircraft engine test stands.

Category 10 Astronautics 410
Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; space communications, spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

Category 11 Chemistry and Materials 412
Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; propellants and fuels; and materials processing.

Category 12 Engineering 415
Includes engineering (general); communications and radar; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

Category 13 Geosciences 423
Includes geosciences (general); earth resources and remote sensing; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

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

Category 15 Mathematical and Computer Sciences 427
Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

Category 16 Physics 429
Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

Category 17 Social Sciences 432
Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law, political science, and space policy; and urban technology and transportation.

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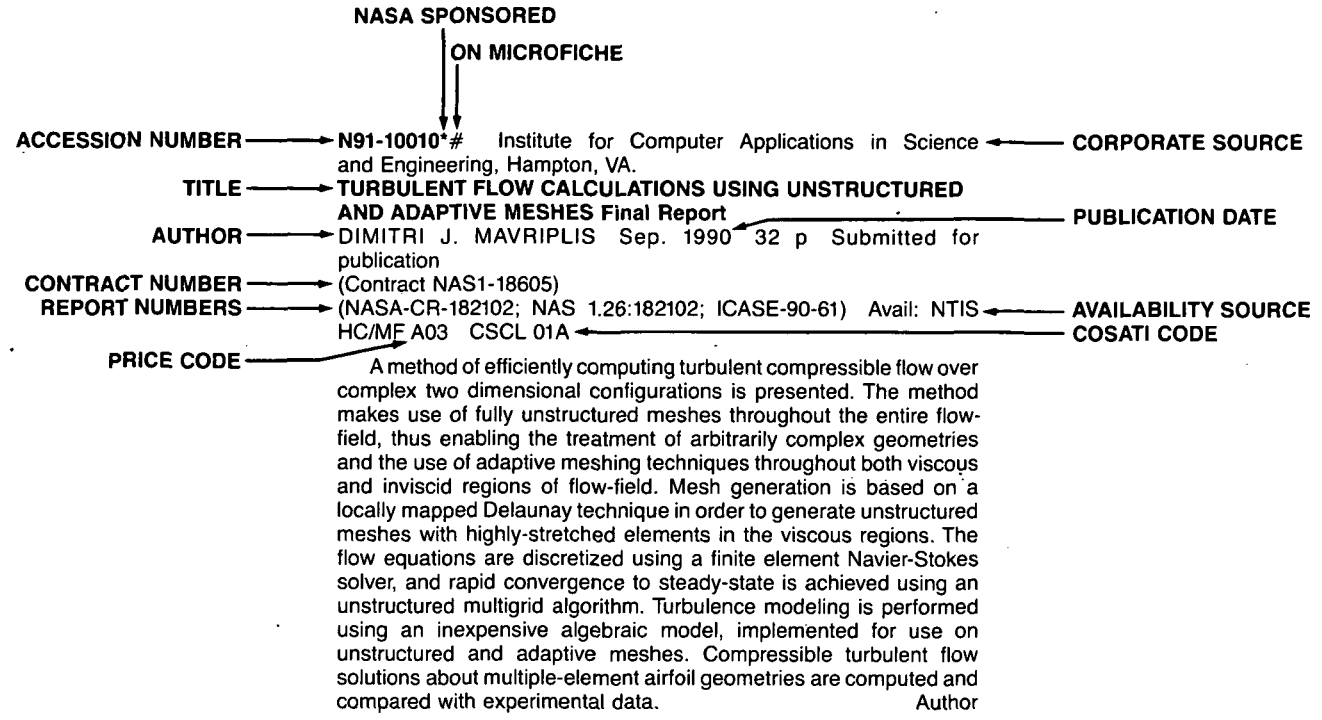
TYPICAL REPORT CITATION AND ABSTRACT



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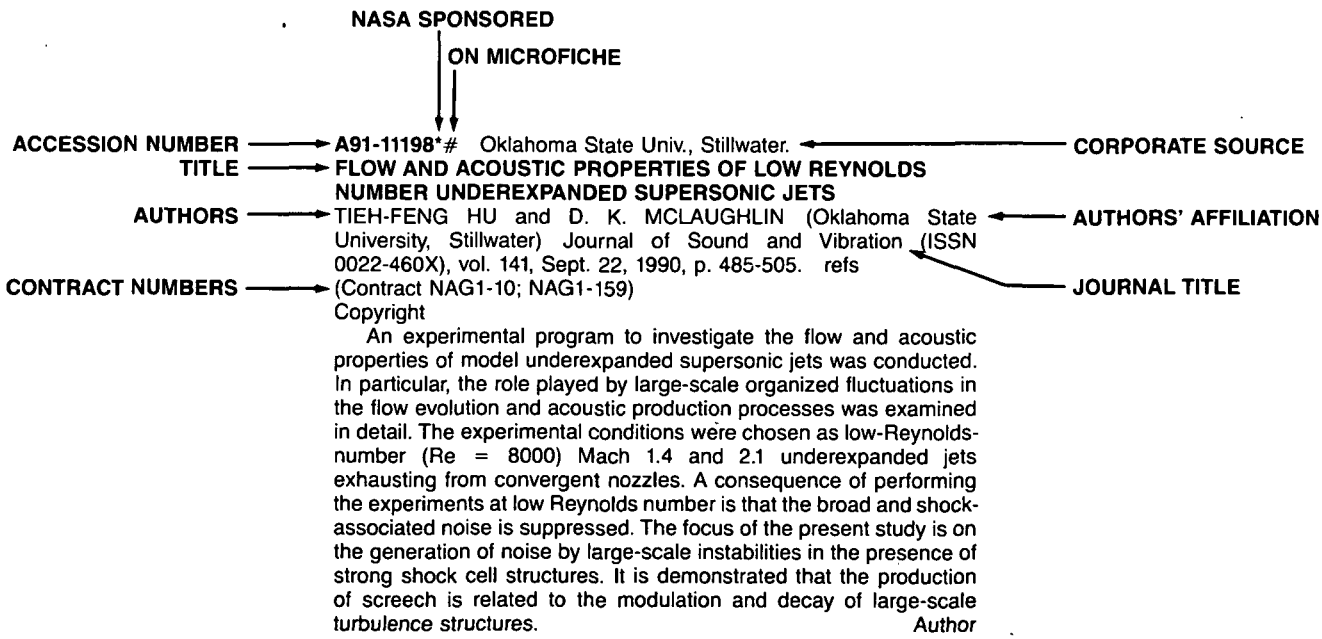

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 266)

JUNE 1991

01

AERONAUTICS (GENERAL)

A91-24301
ICAS, CONGRESS, 17TH, STOCKHOLM, SWEDEN, SEPT. 9-14, 1990, PROCEEDINGS. VOLS. 1 & 2
Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. Vol. 1, 1279 p.; vol. 2, 1203 p. For individual items see A91-24302 to A91-24534.
Copyright

The present conference discusses issues in the fields of aeroelasticity, multidisciplinary design integration, slipstreams and jet interference, the aeroacoustics of advanced propellers, simulation technologies for human factors, boundary-layer testing, aircraft sensors and subsystems, high-alpha and vortex flows, rotorcraft design, novel test facilities, high-alpha flow over wings, buckling and postbuckling structural behavior, inlet and nozzle design, simulation and flighttesting, aeroelastic response, systems architecture and integration, unsteady aerodynamics, fatigue and fracture mechanics, and propulsion-system integration. Also discussed are CFD configurations, trajectory optimization and guidance, high-alpha dynamics, combustion phenomena, experimental techniques, structural dynamics and impact effects, computational aids for transport aircraft, drag reduction methods, high-temperature materials, aircraft control methods, impact and crash resistance, transport aircraft design integration, subsonic wings, hypersonic propulsion, structural testing, ATC, high-temperature structures, airworthiness and reliability, military aircraft, composite materials fabrication, nonlinear flight dynamics, and mathematical modeling. O.C.

A91-24304#
THE X-31A AND ADVANCED HIGHLY MANEUVERABLE AIRCRAFT
M. R. ROBINSON (Rockwell International Corp., El Segundo, CA) and W. B. HERBST (MBB GmbH, Munich, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. LV-LXIV.
Copyright

The Enhanced Fighter Maneuverability (EFM) program which has developed the X-31A poststall-maneuverability technology demonstration aircraft is a joint U.S.-German effort exploring the tactical advantages of enhanced agility. The X-31A is unique in its use of thrust vector control in pitch and in yaw; these propulsion-based control capabilities are blended with conventional aerodynamic control in such a way that the thrust vectoring component is entirely transparent to the pilot. EFM managers hope that the X-31A will demonstrate superior close-in air combat capability without sacrificing supersonic-regime performance. O.C.

A91-24379#
MONITORING LOAD EXPERIENCE OF INDIVIDUAL AIRCRAFT
J. B. DE JONGE (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 702-708.
Copyright

The actual service load experience of aircraft may differ appreciably from design assumptions. The necessity to monitor service loads is generally recognized now for military aircraft. This paper starts with a general review of the overall life management procedure commonly used today. Specific elements in this procedure are discussed in some detail. Specific attention is paid to the amount of scatter in severity between different flights and the required sample sizes of flight load measurements for obtaining reliable average load spectrum data. Possible causes for variation in load experience between different aircraft flying the same duty are analyzed. It is concluded that Individual Aircraft Tracking (IAT), if necessary at all, can usually be adequately accomplished by administrative means, indicated as Usage Monitoring. Author

A91-24457*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ADVANCED FABRICATION TECHNOLOGY FOR HIGH SPEED AIRCRAFT STRUCTURES
T. T. BALES, E. K. HOFFMAN, and R. K. BIRD (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1519-1528. refs
Copyright

An overview of the development of the weld-brazing process for fabricating Ti-6Al-4V skin-stiffened panels, a brazing process for fabricating Bsc/Al titanium honeycomb core panels, and the enhanced diffusion bonding (EDB) process for fabricating Ti-14Al-21Nb titanium aluminide structural elements are presented. Data presented include the shear strengths of full-scale weldbrazed Ti-6Al-4V skin stiffened and Bsc/Al titanium honeycomb core sandwich panels designed to meet the requirements of an upper wing panel on the NASA YF-12. These results verified that the materials, fabrication processes, and structural concepts were qualified for Mach 3 flight. Shear strengths of each of the panel concepts following flight service evaluation are also reported. Comparisons made with the cost and weight of the original wing panel indicated that the weldbrazed titanium panels resulted in a 15-20 percent cost savings and the brazed Bsc/Al panel showed a 30 percent weight savings. It was also shown that the strengths of the EDB joints were sufficient to develop stresses in the Ti-14Al-21Nb face sheets of the sandwich structure which were above the yield strength of the material. Author

A91-24487#
CONTINUING AIRWORTHINESS - REQUIREMENTS AND SUBSTANTIATION
F. C. FICKEISEN (Boeing Commercial Airplanes, Seattle, WA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1844-1848.
Copyright

Requirements to show that airplane systems continue to operate with levels of safety demonstrated during initial certification processes have been established. These requirements take two

forms: (1) Follow approved maintenance procedures and schedules to assure continuation of design reliability levels, and (2) measure reliability levels by use of in-service data and take action when measured values approach levels shown to be necessary by certification analyses. Both processes are used successfully, and each has some inherent limitations. The second process requires in-service data sources, data reduction and analysis, and a method to compare in-service results to predictions. Though the second process is generally more complicated, it has the advantage of providing some insight into corrective actions that may enhance system reliabilities. Author

A91-24488#
DIAGNOSIS ON NEW CIVIL AIRPLANES - ECONOMIC ASPECTS
PAUL CAMUS (Airbus Industrie, Blagnac, France) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1849-1851.
Copyright

The characteristics of the Centralized Fault Display System (CFDS) on the A320 Airbus are described. Centralized onboard maintenance data processing features the advantages of a reduced training requirement, improved MTBUR, and shorter times to repair. Problems encountered over the life of an aircraft are examined, and the issue of spares supply is discussed in detail. B.J.

A91-24489#
COMPOSITE REPAIR - AN AIRLINES POINT OF VIEW
ERIK MOYSON (Sabena Technics, Brussels, Belgium) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1852-1857. refs
Copyright

To standardize repair as much as possible and to minimize the cost of repair and maintenance; IATA has formed the Compositie Repair Task Force. Various aspects of composite repair for aircraft structures are discussed here, including maintainability, damage assessment, surface preparation, repair types and materials, taper ratio and overlap length, and sequence of path overlay. B.J.

A91-24493#
ADAPTING COMMERCIAL AIRCRAFT DESIGNS TO MEET EXISTING AND FUTURE MILITARY AIRCRAFT REQUIREMENTS - A COST-EFFECTIVE DESIGN APPROACH TO MEET MILITARY AIRCRAFT REQUIREMENTS IN AN AUSTERE FISCAL ENVIRONMENT
L. LADDIE COBURN (System Planning Corp., Arlington, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1891-1898.
Copyright

This paper discusses the decision process relating to and the impacts of military jet aircraft design and development versus procurement and modification of existing commercial aircraft. The military acquisition process and approach to aircraft design requirements, modifications, mission system integration, and certification and testing are addressed. Consideration is given to compliance with specifications and federal regulations to achieve successful aircraft design, modifications, and flight certification through either the military or civil aircraft certification process. Examples are provided of successful military programs which have adapted commercial designs. A list of current or future medium- and long-range commercial jet aircraft which offer potential for military mission application is also provided. Author

A91-24530#
COMMERCIAL AIRCRAFT COMPOSITE THRUST REVERSER BLOCKER DOOR MANUFACTURED USING THE RESIN TRANSFER MOLDING TECHNIQUE
KURT R. KRAFT (Boeing Commercial Airplanes, Seattle, WA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2231-2236.
Copyright

The design and fabrication of a CFRP blocker door for the thrust reverser of the B747 and B767 aircraft by the resin transfer molding (RTM) technique are described and illustrated with extensive diagrams, drawings, photographs, and tables of numerical data. The operation of the blocker doors and the stringent design limitations imposed are reviewed; the existing Al-alloy honeycomb design is discussed; the steps in the RTM process are outlined; and the CFRP design is presented. The latter comprises three main parts, an acoustic face plate, a fiberglass honeycomb core, and a backpan assembly. Data from coupon tests on the RTM materials and initial results from flight testing of a complete set of blocker doors on a B767 confirm that the lighter and less expensive composite doors perform at least as well as the metallic doors. D.G.

A91-24775
DLR, ANNUAL REPORT 1989/90 [DLR, JAHRESBERICHT 1989/90]
Cologne, Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, 1990, 85 p. In German. No individual items are abstracted in this volume.
Copyright

The activities of the German aerospace agency DLR during the 1989 fiscal year are surveyed and illustrated with extensive graphs, diagrams, drawings, photographs, and tables of numerical data. Sections are devoted to the financial, organizational, and personnel structure of DLR; aeronautics programs; astronautics programs; energy programs; and DLR facilities. Particular attention is given to research on the future development of air traffic in the FRG, psychological factors in the selection of aircrew, dynamic testing of space structures, rapid positioning of two communication satellites, tropospheric ozone monitoring, and laser cutting tools for industrial applications. T.K.

A91-26087#
THE DESIGN OF CIVIL TRANSPORT AIRCRAFT - WHAT EVOLUTION FACTORS SHOULD BE CONSIDERED AND WHAT APPROACH SHOULD BE TAKEN [LA CONCEPTION DES AVIONS DE TRANSPORT CIVIL - QUELS FACTEURS D'EVOLUTION ET QUELLE DEMARCHE?]
JEAN-PIERRE MAREC (ONERA, Chatillon, France) ONERA, TP no. 1990-186, 1990, 46 p. In French.
(ONERA, TP NO. 1990-186)

An overview is presented of trends in civil aviation with reference to the main conclusions of the Aeropropulsion 90 colloquium held in Paris on March 20-21, 1990. Areas that are explored include the constraints imposed by environmental conditions in the face of the large growth foreseen in the civil aircraft market; the best technological approach to follow in the fields of aerodynamics, propulsion and materials; and whether additional development should be continued for current aircraft types or whether the time is now right for going to the second generation SST or possibly the hypersonic transport. Discussions also cover the supersonic transport, large commercial aircraft operations, trends in regional transport aircraft development, and business aircraft and their future available propulsion systems. R.E.P.

A91-26177
WILL AIRCRAFT FEEL PAIN?
PETER DONALDSON Aerospace Composites and Materials (ISSN 0954-5832), vol. 3, Jan.-Feb. 1991, p. 21-23.
Copyright

The application of distributed sensing embedded in aircraft structures will permit an aircraft to be flown to the very edge of its performance envelope and to its structral limits without exceeding either. An intelligent structure utilizing the embedded sensors supplying the aircraft's central maintainance computer could detect, identify, and classify delaminations or cracks for later notification to maintainance personnel, or advise the pilot to avoid certain maneuvers or to land as soon as possible. Some of the

new materials being researched in this field include ceramics and polymers with piezoelectric properties, electrorheological fluids, and shape memory alloys. A principal concern in this research effort is electromagnetic interference that would make shielding of electronic systems difficult in airframes that are largely composite as they do not provide a convenient ground for stray electric current. R.E.P.

A91-26226
THE IMPACT OF SUPERCOMPUTERS ON CFD
P. E. RUBBERT (Boeing Commercial Airplanes, Seattle, WA) Computing Systems in Engineering (ISSN 0956-0521), vol. 1, no. 1, 1990, p. 1-6.
Copyright

The application of computational fluid dynamics (CFD) to the design of commercial transport aircraft is compared with the wind tunnel in terms of importance. The strengths and limitations of both the wind tunnel and CFD are discussed. It is noted that the combination of these elements enables the achievement of aerodynamic design objectives that previously were not achievable. The current role of CFD design is described and a number of specific examples that illustrate the contribution of CFD are given. It is concluded that further development in algorithm technology should include grids that properly resolve all important length scales; problem setup and solution times measured in hours or days, rather than weeks or months for complex geometry; and reliably accurate codes, with minimum risk of introducing inaccuracies either through user ineptitude or any other source. Also recommended for further development are validation experiments and turbulence and turbulence modeling. L.K.S.

A91-26438
MODELING AND OPTIMIZATION OF FLIGHT VEHICLE ASSEMBLY [MODELIROVANIE I OPTIMIZATSIIA SBORKI LETATEL'NYKH APPARATOV]
ANATOLII I. BABUSHKIN Moscow, Izdatel'stvo Mashinostroenie, 1990, 240 p. In Russian.
Copyright

The theory of the computerized production of technical documentation for the line assembly of flight vehicles is examined, and computer algorithms implementing the production objectives are described. The discussion covers the principal characteristics of assembly-line production, development of assembly models and their optimization, and optimization of the assembly process with and without constraints on the available resources. The general design of CAD/CAM systems for flight vehicle production is examined, and some of the existing computer-controlled flight vehicle assembly lines are described. V.L.

A91-26913
V-22 MECHANICAL DIAGNOSTIC DESIGN APPROACH
ROD W. BALKE (Bell Helicopter Textron, Inc., Fort Worth, TX) (IEEE, Automatic Test Conference, 26th, San Antonio, TX, Sept. 17-20, 1990) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 6, Jan. 1991, p. 21-27.
Copyright

The requirements and diagnostic applications for the V-22 tiltrotor aircraft are used to demonstrate the unique requirements of mechanical system diagnostic design. The rationale for the approach selected is explored, and it is shown how the mechanical system diagnostic requirements affect the avionics architecture and performance requirements. It is concluded that, in light of the underdeveloped nature of mechanical diagnostics technology and the extended time required for a given mechanical diagnostic design to mature, future avionics system designs need architecture that is adaptable enough to accommodate the evolving mechanical diagnostics. I.E.

A91-27520
SECTION 41 - STRAINING THE SYSTEM
IAN GOOLD Flight International (ISSN 0015-3710), vol. 139, Feb. 12, 1991, p. 43, 44, 47, 48.
Copyright

As the aging fleet of 747-100/200/SP/SR aircraft begin to go through mandatory modification programs, operators are becoming increasingly concerned about the industry's capacity to handle the work as well as fatigue- and corrosion-control programs being mandated as a result of ongoing aging-aircraft studies. The airworthiness directives issued cover mandatory inspection of the 747's fuselage between the forward pressure bulkhead and frame station 520 aft of the number 1 main passenger door (section 41). Details are provided for the various 747 operators including the average age within the fleet, the mandatory modifications, where the fleets are being modified, and modification overhaul times based on the experience gained with the number of aircraft going through modification. Available capacity of overhaul agencies to handle these modifications is considered to be critical and some of these concerns are addressed. R.E.P.

N91-16988# Transportation Research Board, Washington, DC.
PUBLIC-SECTOR AVIATION ISSUES: GRADUATE RESEARCH AWARD PAPERS Transportation Research Record, 1988 - 1989
1990 66 p Sponsored by FAA
(PB91-108415; TRB/TRR-1257; LC-90-41736;
ISBN-0-309-05012-X) Avail: NTIS HC/MF A04 CSCL 01B

The main subject areas covered are: land use control and policy for airport development; general aviation safety; where can safety improvements be made; cockpit-crew crisis decision making; robust tracking and control strategies for automatic landing systems; and empirical analysis of runway occupancy with applications to exit taxiway location and automated exit guidance. Author

N91-16989# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Systems and Logistics.
PRODUCTIVITY MEASUREMENT IN AIRCRAFT MAINTENANCE ORGANIZATIONS M.S. Thesis
BILLY J. GILILLAND Sep. 1990 224 p
(AD-A229239; AFIT/GLM/LSM/90S-20) Avail: NTIS HC/MF A10 CSCL 15/5

This research was undertaken to explore productivity measurement in aircraft maintenance units and to examine the relationships of the measures used to evaluate a unit's productivity. Review of current literature and regulatory guidance concerning productivity measurement provided the basis for the development of an interview questionnaire. A questionnaire was administered to Deputy Commanders for Maintenance (DCMs) and chiefs of analysis at ten Military Airlift Command (MAC) wings. Additionally, managers in the maintenance management, cost and manpower divisions at Headquarters MAC were interviewed. From these interviews, information concerning current productivity measurement methodology was gathered and thirteen measures were identified for analysis. Of the thirteen measures evaluated, eight produced the strongest explainable model reflecting maintenance productivity. Manhours per flying hour was the predominant output when viewed as a result of the influence of mission capable rates and maintenance scheduling effectiveness. Cannibalization rates, delayed discrepancies (both awaiting parts and awaiting maintenance) and the average number of aircraft possessed were the inputs which appeared to contribute most significantly to mission capable rates and maintenance scheduling effectiveness. GRA

N91-18004# Wichita State Univ., KS. National Inst. for Aviation Research.
PROCEEDINGS: TECHFEST 17
NEAL J. PFEIFFER, ed. (Beech Aircraft Corp., Wichita, KS.) 1991 39 p Conference held in Wichita, KS, 16-17 Nov. 1990; sponsored by AIAA and Wichita State Univ.
(NIAR-91-1) Avail: NTIS HC/MF A03

Papers presented at the Wichita Section of the American Institute of Aeronautics and Astronautics Techfest 17 are compiled. The following subject areas are covered: NASA research; certification and aging aircraft; structures and material studies;

aviation safety; aerodynamics topics; and aircraft design and sport aviation.

N91-18005*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CHALLENGES IN AERONAUTICAL RESEARCH FOR THE 1990'S Abstract Only
BRUCE HOLMES *In* Wichita State Univ., Proceedings: Techfest 17 p 1 1991
Avail: NTIS HC/MF A03 CSCL 01/2

Three areas of the specific NASA aeronautical research are discussed: (1) advanced subsonic transport airplanes; (2) next generation high speed civil transport aircraft (SST's); and (3) next century hypersonic vehicles. The research planning reflects an awareness of and sensitivity to modern, stringent environmental constraints, changing marketplace demands, and advanced technology driven opportunities. The technical foundations of those future systems are described. Y.S.

N91-18008# Beech Aircraft Corp., Wichita, KS. Technical Services Div.
AGING AIRCRAFT: ISSUES AND PARTIAL ANSWERS Abstract Only
BILL SCHULTZ *In* Wichita State Univ., Proceedings: Techfest 17 p 5 1991
Avail: NTIS HC/MF A03

The spectrum of factors affecting the airplane aging process are reviewed. Discussion emphasis is given to airframe strength, durability and life to show the complex nature of several aging influencing factors. The status of industry and regular activities and plans are also presented. Y.S.

N91-18009# Wichita State Univ., KS. Dept. of Mechanical Engineering.
AUTOMATED INSPECTION SYSTEM FOR AGING AIRCRAFT Abstract Only
BEHNAM BAHR *In its* Proceedings: Techfest 17 p 6 1991
Avail: NTIS HC/MF A03

The state-of-the-art automation techniques and the robotics developments for inspection of aircraft are reviewed. The advantages and disadvantages of different systems in terms of cost, ease of usage, required training, and portability are analyzed so that one can make an intelligent decision about selection of the appropriate system for the inspection process. These systems include the gantry system at the Air Logistic Center at the Air Force Base in Sacramento, California, the proposed fork-lift-type system by United Technologies and Lockheed, the Japanese car wash type approach, and other conventional six-degree of freedom robots. Author

N91-18010# Wichita State Univ., KS. Dept. of Mechanical Engineering.
FOUR-LEGGED SURFACE-CLIMBING ROBOT FOR THE INSPECTION OF AGING AIRCRAFT Abstract Only
BEHNAM BAHR and SAMI MAARI *In its* Proceedings: Techfest 17 p 7 1991
Avail: NTIS HC/MF A03

The development of a small, spider-like robot which can carry a variety of nondestructive testing devices is discussed. This robot can be guided from the ground and its signals can be processed in a personal computer. The device can be used for inspection of a wide variety of commercial aircrafts. Its size and cost permit inspection to be done in many locations along with regularly scheduled maintenance. This is a timely, cost-effective, reliable approach to a continuing problem of aging aircraft. Y.S.

02

AERODYNAMICS

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

A91-24307#
DEVELOPMENT OF A THREE DIMENSIONAL UNSTEADY TRANSONIC AERODYNAMICS COMPUTER CODE FOR FLUTTER ANALYSIS
Y. S. WONG (Alberta, University, Edmonton, Canada) and B. H. K. LEE (National Aeronautical Establishment, Ottawa, Canada) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 19-29. Research supported by DND. refs
Copyright

This paper presents the development and applications of a three-dimensional unsteady transonic aerodynamics computer code designed primarily for flutter analysis. The mathematical formulation is based on a transonic small disturbance equation, and the numerical technique employs a time-linearization approach in which the flow potentials consist of (nonlinear) steady and (linear) unsteady components. The numerical procedure has been implemented in a computer program called UST3D (UnSteady Transonic code for a three-dimensional isolated wing), whose features are discussed. Transonic flutter results for a fighter type aircraft are presented. Author

A91-24312#
MEASUREMENT OF UNSTEADY PRESSURES AND FORCES ON AN ENGINE AND A WING/ENGINE COMBINATION INCLUDING JET SIMULATION
H. TRIEBSTEIN, G. SCHEWE (DLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany), H. ZINGEL, and S. VOGEL (Deutsche Airbus GmbH, Bremen, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 51-61. Research supported by Bundesministerium fuer Verkehr. refs
Copyright

The experimental results obtained for the unsteady aerodynamic forces of ejector-engine and a wing-engine combination wind tunnel models in the sub- and transonic regimes are presently compared with theoretical results, in order to ascertain how commonly employed mathematical aerodynamic models for flutter calculations correspond to observed model engines. The ejector engine data indicate that linear lifting surface theory furnishes accurate unsteady aerodynamic forces; in the wing-engine combination, the unsteady interference effect for engine oscillation on the wing lower surface is strongly affected by flow separation at the wing/pylon interface. The unsteady aerodynamic forces of the wing can be calculated with linear lifting surface theory. O.C.

A91-24313#
GROUND VORTEX FORMATION WITH TWIN JETS AND MOVING GROUND PLANE
K. KNOWLES and D. BRAY (Royal Military College of Science, Shrivenham, England) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 62-70. Research supported by British Aerospace, PLC. refs
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The present numerical and experimental investigation of the flow-fields associated with the single and twin jets impinging in a cross-flow gives attention to parameters affecting the position and strength of the ground vortex. These parameters encompass nozzle height and pressure ratio, cross-flow/jet velocity ratio, vector angle, and nozzle splay. While experimental results show the ground vortex moving away from the nozzle center-line, as cross-flow/jet

velocity ratio is decreased, the position rate-of-change depends on other parameters. The effect of the moving ground-plane is to reduce the vortex penetration by about 24 percent, on average, suggesting that a moving ground plane simulation is essential when wind tunnel-testing configurations in ground effect. O.C.

A91-24314#
EXPERIMENTAL INVESTIGATION OF LOW SPEED MODEL PROPELLER SLIPSTREAM AERODYNAMIC CHARACTERISTICS INCLUDING FLOW FIELD SURVEYS AND NACELLE/WING STATIC PRESSURE MEASUREMENTS
INGEMAR SAMUELSSON (Flygtekniska Forsoksanstalten, Bromma, Sweden) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 71-84.
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A low speed wind tunnel investigation has been conducted to ascertain the propeller slipstream aerodynamics of different nacelle/wing combinations, using five-hole pressure-probe slipstream flow field surveys and static pressure measurements on the slipstream-washed nacelle and wing surfaces. The results obtained indicate that the distributions of slipstream static and total pressures and velocities are substantially influenced by the mutual interaction between the slipstream flow and adjacent nacelle and wing surfaces. The near-propeller shape is found to be very influential in the development of slipstream-induced nacelle lateral loads. There is considerable azimuthal variation of slipstream characteristics due to the nonaxisymmetric nacelle shapes. O.C.

A91-24315#
MASS FLOW EFFECTS ON THE LOW SPEED CHARACTERISTICS OF AN ADVANCED COMBAT AIRCRAFT
A. GATTI and A. FERRETTI (Aeritalia S.p.A., Turin, Italy) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 85-91. refs
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The ways in which aircraft near-field distortions induced by air-intake operating conditions can modify aircraft aerodynamic behavior, in terms of stability characteristics and foreplane control effectiveness, are presently defined in view of experimental results obtained on a low-speed, six-component wind tunnel model featuring an internal flow-augmentation system. Attention is given to the data-correction procedure used, the mass-flow ratio effect on stability and control characteristics, and foreplane effectiveness at various angles of attack up to, and beyond, 25 deg. O.C.

A91-24316#
RECENT WIND TUNNEL TESTING EXPERIENCE OF CONTRA-ROTATING PROPELLERS
A. E. HARRIS, P. M. RENDER, O. M. POZNIAK, and M. E. WOOD (Aircraft Research Association, Ltd., Bedford, England) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 92-107. Sponsorship: Ministry of Defence of England. refs
(Contract MOD-AE/12A/89)
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Experimental apparatus design advancements have facilitated research concerning small-scale isolated and installed contrarotating propeller (CRP) tests, using compressed air-driven turbine motors, for propellers of 0.4-m diameter. Larger-scale isolated testing can also be conducted via electrically driven CRP models of about 0.8-m diameter. Noise-field studies can be conducted in acoustically lined wind tunnels, in parallel with CRP performance measurements and flowfield surveys supported by laser and conventional measurements. O.C.

A91-24325#
FLIGHT INVESTIGATIONS OF TOLLMIEN-SCHLICHTING WAVES ON AN AIRCRAFT WING
K. H. HORSTMANN, G. REDEKER (DLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany), and S. J. MILEY (Royal Melbourne Institute of Technology, Australia) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 186-192. refs
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Hot-wire anemometer measurements have been carried out in flight to investigate, in detail, laminar boundary layer instability on a special wing glove. Tollmien-Schlichting (TS) waves are easily identifiable, and specific measurements of amplitude, frequency and wavelength have been made. The measured values compare well with results from linear stability analysis utilizing the laminar boundary layer calculated from flight measurements of the wing glove pressure distribtion. Comparisons between the measured distribution of the velocity fluctuations and the calculated eigenfunction show some variation. This may be due to nonlinear behavior of the TS waves. Author

A91-24327#
CONCEPTS AND RESULTS FOR LAMINAR FLOW RESEARCH IN WIND TUNNEL AND FLIGHT EXPERIMENTS
W. NITSCHE (Berlin, Technische Universitaet, Federal Republic of Germany) and J. SZODRUCH (Deutsche Airbus GmbH, Bremen, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 197-209. refs
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The selection, adaptation, and integration of advanced measurement techniques for laminar-flow wing wind tunnel and flight tests are discussed in light of experimental results. While in the case of wind tunnel investigations a number of measurement techniques has been employed for transition-detection, less progress has been made in flight tests, where quantitative rather than qualitative methods are still the exception. A lack of surface sensors yielding quantitative information on details of strongly three-dimensional shear layers, as well as such transition effects as cross-flow instabilities, is noted. O.C.

A91-24335#
FORMATION OF TIP VORTICES AND VORTEX WAKE ALLEVIATION BY TIP DEVICES
R. STAUNFENBIEL and T. VITTING (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 279-291. refs
(Contract DFG-SFB-25)
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Formation and structure of wing tip vortices as well as some methods of vortex wake alleviation are subject of the paper. The formation of vortices is investigated theoretically and experimentally. For calculating the roll-up of vortices, a modified line vortex method is introduced using an amalgamation process which preserves important conservation laws. A comparison of experimental and theoretical data yields good agreement. In the second part of the paper, different ways of tip vortex dissipation have been tested such as destabilization of vortices, stimulation of vortex breakdown and redistribution of the vorticity in tip vortices. Experiments, carried out in a water tunnel, evaluated vortex structure as well as profiles of tangential and axial velocity components using LDV and flow visualization techniques. Author

A91-24338#
A NAVIER-STOKES CALCULATION OF THE FLOW PASSING THROUGH A CASCADE WITH TIP CLEARANCE
TOSHINORI WATANABE (Tokyo University of Agriculture and Technology, Koganei, Japan), OSAMU NOZAKI, and ATSUHIRO TAMURA (National Aerospace Laboratory, Chofu, Japan) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 316-323. refs
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The Navier-Stokes equations have been solved in order to obtain the three-dimensional viscous flow fields through cascades with tip clearances. The computed results are in good agreement with experimental data, clearly describing such detailed flow phenomena around the tip as the formation of separation bubbles on the tip surface. It is found that the normal force acting on the extremity of the blade did not diminish, in the case of small clearances. Further applications of the method to the flow field in a linear turbine cascade and to a rotating fan demonstrated that the influence of wall boundary layers should be taken into account in the computation of inlet flow condition; the complex near-tip flow field clearly appeared on the rotating frame-of-reference.
O.C.

A91-24339#
AERODYNAMIC DESIGN OF A TILT-ROTOR BLADE
B. BENOIT and J. M. BOUSQUET (ONERA, Chatillon, France) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 324-332. Research sponsored by DRET. refs
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The EUROFAR (European Future Advanced Rotorcraft) project is a cooperative program to study an advanced tilt rotor aircraft for a primary civil application. ONERA is in charge of the aerodynamic definition of the rotor. After a preliminary code validation and selection of suitable airfoils, the RC3 rotor has been designed, achieving a good compromise between cruise efficiency (0.83) and hover figure of merit (0.80). In parallel, a higher-performance RC4 rotor with reduced airfoil thickness at the blade root has been designed; the RC4 rotor will be wind-tunnel tested in order to check the ambitious goals of the design, and to ensure the validation of the definition methods. Author

A91-24351*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
SENSITIVITY ANALYSIS OF A WING AEROELASTIC RESPONSE
RAKESH K. KAPANIA (Virginia Polytechnic Institute and State University, Blacksburg) and JEAN-FRANCOIS M. BARTHELEMY (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 450-457. refs
(Contract NAS1-18471)
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The present shape-sensitivity analysis of wing aeroelastic response proceeds from aeroelastic response sensitivities obtained on the basis of the aerodynamic performance valid for high aspect ratio wings in subsonic, subcritical flow. Attention is given to the shape sensitivity of various static aeroelastic responses; the formulation is general, and assumes that, for a given shape and elastic deformation, the aerodynamic analysis will furnish the distribution of the pressure and the pressure sensitivity derivatives with respect to the shape parameters of interest. Wing displacements are obtained by means of an iterative scheme.
O.C.

A91-24353*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NUMERICAL SIMULATION OF HIGH-INCIDENCE FLOW OVER THE F-18 AIRCRAFT
RUSSELL M. CUMMINGS, LEWIS B. SCHIFF, YEHIA M. RIZK, and NEAL M. CHADERJIAN (NASA, Ames Research Center, Moffett Field, CA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 468-485. refs
Copyright

Navier-Stokes solutions have been obtained using the Chimera overset grid scheme for flow over the wing, fuselage, and wing leading-edge extension (LEX) of the F-18 aircraft at high incidence. Solutions are also presented for flow over the fuselage forebody at high angles of attack. The solutions are for turbulent flows at high-Reynolds number flight-test conditions, and are compared with available qualitative and quantitative experimental data. Comparisons of predicted surface flow patterns, off-surface flow visualizations, and surface-pressure distributions are in good agreement with flight-test data. The ability of the numerical method to predict the bursting of the LEX vortex as it encounters the adverse pressure gradient field of the wing is demonstrated.
Author

A91-24354#
NUMERICAL SIMULATION OF VORTICAL FLOW OVER A DELTA WING AT SUBSONIC AND TRANSONIC SPEEDS
H. W. M. HOEIJMAKERS, J. M. J. W. JACOBS, and J. I. VAN DEN BERG (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 486-499. Research supported by Netherlands Agency for Aerospace Programs. refs
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The flow about a 65-deg sharp-edged cropped delta wing is simulated by solving the Euler equations. Solutions are obtained for the wing of a subsonic, free-stream Mach number and high angle of attack, where a strong vortex forms above the wing upper surface as well as for the wing at a transonic free-stream Mach number and high incidence resulting in shocks and strong vortices. For the latter case the development of the flow field with the incidence is studied, while for both cases the formation of the wake downstream of the trailing edge is investigated. The influence of the mesh resolution on the details of the solution is analyzed utilizing a mesh of 0-0 topology with, on its finest level, more than one million grid points in the half-space around the starboard side of the delta wing. Author

A91-24355#
COMPARISON OF EXPERIMENTAL RESULTS WITH THE NON-LINEAR VORTEX LATTICE METHOD CALCULATIONS FOR VARIOUS WING-CANARD CONFIGURATIONS
J. ROM, D. ALMOSNINO (Technion - Israel Institute of Technology, Haifa), and B. MELAMED IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 500-510. refs
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Aerodynamic coefficients, rolled-up vortex trajectories, and pressure distributions calculated for close-coupled wing-canard configurations at moderately high alpha by means of the Nonlinear Vortex Lattice Method (NLVLM) are presently compared with experimental measurements. The wing-canard models encompass various wing and canard geometries; attention is given to the effects of various canard deflections and positions relative to the wing. The canard is found to enhance maneuverability via L/D drag and longitudinal stability coefficient variations as a function of alpha and canard deflection. NLVLM aerodynamic force characteristics are in reasonably good agreement with experiment up to vortex breakdown. O.C.

A91-24358*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
PREDICTION OF INLET DRAG FOR AIRCRAFT CONCEPTUAL DESIGN
P. MALAN and E. F. BROWN (Virginia Polytechnic Institute and State University, Blacksburg) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 528-534. refs
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Recent efforts to upgrade conceptual design program ACSYNT have resulted in a study of methods for inlet drag prediction. These methods enable the drag of four different inlet types (the subsonic pitot, supersonic pitot, supersonic two-dimensional and

supersonic conical inlets) to be predicted over the complete operating range of the inlet. The methods, which have been incorporated into ACSYNT, are presented here, together with sample applications to different inlet geometries. Author

A91-24360*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CONTROL OF FLOW SEPARATION AND MIXING BY AERODYNAMIC EXCITATION
EDWARD J. RICE and JOHN M. ABBOTT (NASA, Lewis Research Center, Cleveland, OH) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 543-553. refs
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The recent research progress in the control of shear flows using unsteady aerodynamic excitation conducted at the NASA Lewis Research Center is reviewed. The program is of fundamental nature concentrating on the physics of the unsteady aerodynamic processes. This field of research is a fairly new development with great promise in the areas of enhanced mixing and flow separation control. Enhanced mixing research reported in this paper include influence of core turbulence, forced pairing of coherent structures, and saturation of mixing enhancement. Separation flow control studies included are for a two-dimensional diffuser, conical diffusers, and single airfoils. Ultimate applications of this research include aircraft engine inlet flow control at high angle of attack, wide angle diffusers, highly loaded airfoils as in turbomachinery, and ejector/suppressor nozzles for the supersonic transport. An argument involving the Coanda Effect is made here that all of the above mentioned application areas really only involve forms of shear layer mixing enhancement. The program also includes the development of practical excitation devices which might be used in aircraft applications. Author

A91-24372#
A REVIEW OF SCALE EFFECTS IN UNSTEADY AERODYNAMICS
D. G. MABEY (Royal Aerospace Establishment, Bedford, England) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 634-645. refs
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The effect of the Reynolds number is reviewed over a wide range of unsteady aerodynamic conditions, with particular attention given to wing flows. The tests discussed include buffet and buffeting, dynamic tests of airfoils and wings, pressure measurements, oscillatory control surface derivatives, and stability derivatives. The available data suggest that scale effects are small for the usual model conditions with fixed transition but become large close to incipient separation. In the case of free transition, scale effects can be large for both attached and separated flows. V.L.

A91-24373#
OBSERVATIONS OF DYNAMIC STALL PHENOMENA ON AN OSCILLATING AIRFOIL WITH SHEAR-STRESS-SENSITIVE LIQUID CRYSTAL COATINGS
DANIEL C. REDA (Sandia National Laboratories, Albuquerque, NM) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 646-652. refs
(Contract DE-AC04-76DP-00789)
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The unsteady fluid physics associated with the dynamic stall process on oscillating airfoils was investigated experimentally using shear-stress-sensitive/temperature-insensitive liquid crystal coatings as well as laser-light-sheet/smoke-particle visualization and surface-mounted microtufts. All observations were recorded using a color video camera. Dynamic boundary layer transition and turbulent separation locations were measured as a function of the geometric angle of attack. The results are presented in comparison with predictions based on the Eppler airfoil design code. V.L.

A91-24374#
EXPERIMENTS ON THE ESTABLISHMENT OF FULLY ATTACHED AEROFOIL FLOW FROM THE FULLY STALLED CONDITION DURING RAMP-DOWN MOTIONS
A. J. NIVEN and R. A. MCD. GALBRAITH (Glasgow, University, Scotland) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 653-662. Research supported by Ministry of Defence Procurement Executive and Department of Energy. refs
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The paper presents data collected, for various aerofoils, during ramp-down tests carried out in the University of Glasgow's dynamic stall test facility. Although a reasonable picture of the boundary-layer behavior has been obtained, the normal force variation with incidence caused concern over the possibility of tunnel interference effects. In order to investigate this phenomenon, tests were conducted which included variations in starting and stopping incidences and aspect ratio. The main purpose of the paper is to present the analysis of this data, provide a description of the overall flow structure within the tunnel, and discuss the validity of utilizing ramp-down tests to study the phenomenon of reattachment. Author

A91-24375#
THE EFFECT OF PERIODICAL FLAP MOTION ON BOUNDARY LAYER AND WAKE
NURCAN ELDEM (Istanbul Technical University, Turkey) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 663-670. refs
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The effect of periodical flap motion on the boundary layer and the wake of the ONERA-RA16SC1 profile was studied experimentally in incompressible two-dimensional turbulent flow using hot wire anemometry for two frequencies and two mean flap angles. The results are presented using the harmonic analysis method. The evolution of the external velocity shows clearly the influence of the perturbation created by the oscillating flap. The mean flow in the boundary layer and the wake is not affected by the periodical motion of the flap for the frequencies studied. The amplitude profiles af the velocity and the turbulence components are influenced mainly by the mean flap angle. V.L.

A91-24382#
A STUDY OF PROPELLER-WING-BODY INTERFERENCE FOR A LOW SPEED TWIN-ENGINED PUSHER CONFIGURATION
MICHAEL GEORGE MAUNSELL (Sao Paulo, Universidade, Brazil) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 725-732. refs
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Results of an experimental and theoretical study of a twin-engined pusher wing-fuselage configuration suitable for general aviation are reported. The effect of wing-body interference on the propeller is found to be much greater in the low power (cruise) case than in the high power case, both in terms of the resultant general nonuniform thrust distribution over the propeller disk and the local effect of the wing wake striking the propeller. Experimental results for both low- and high-power cases show differences from theoretical predictions near the wing root. These are attributed to propeller-induced effects combined with the effects of the boundary layer near the wing root junction. V.L.

A91-24383#
A PROPELLER SLIPSTREAM MODEL IN SUBSONIC LINEARIZED POTENTIAL FLOW
PER LOTSTEDT (Saab-Scania, AB, Linkoping, Sweden) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990,

Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 733-744. refs
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A model for computation of the time-averaged subsonic flow field over a nacelle and a wing induced by a propeller has been developed. The slipstream model is based on classical propeller theory and is included in an existing panel program. The geometry of the slipstream is determined by the nacelle. The influence of the propeller is given by a combined momentum-blade element theory. No experimental data are necessary. The computed pressures and velocities are compared to windtunnel data for two angles of attack and two geometries: an axisymmetric nacelle and a wing and a non-axisymmetric nacelle and a wing. Author

A91-24384#
FLOW SIMULATION AROUND A REALISTIC FIGHTER AIRPLANE CONFIGURATION
TORSTEN BERGLIND (Flygtekniska Forsoksanstalten, Stockholm, Sweden) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 745-754. Research supported by the Defence Material Administration of Sweden. refs
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The concept of patched C1-continuous multiblock grids is applied to the flow region around the new Swedish fighter airplane, JAS 39 Gripen. The volume grid is generated, block by block, using transfinite interpolation. The Euler equations are integrated numerically by a centered finite volume method using an explicit Runge-Kutta scheme. Transonic flow cases are computed and the solutions demonstrate that the grid resolves all relevant flow features. The effect of different mass flux ratios at the air intake on the global solution is investigated. Also, the problem of proper boundary condition on the subsonic outflow boundary at the air intake is addressed. Author

A91-24385*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A TRANSONIC/SUPERSONIC CFD ANALYSIS OF A GENERIC FIGHTER
AGA M. GOODSELL, JOHN E. MELTON, and MICHAEL D. MADSON (NASA, Ames Research Center, Moffett Field, CA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 755-769. refs
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Flow fields about a generic fighter model have been computed using FLO57, a three-dimensional, finite-volume Euler code. Computed pressure coefficients, forces, and moments at several Mach numbers - 0.6, 0.8, 1.2, 1.4, and 1.6 - are compared with wind tunnel data over a wide range of angles of attack in order to determine the applicability of the code for the analysis of fighter configurations. Two configurations were studied, a wing/body and a wing/body/chine. FLO57 predicted pressure distributions, forces, and moments well at low angles of attack, at which the flow was fully attached. The FLO57 predictions were also accurate for some test conditions once the leading-edge vortex became well established. At the subsonic speeds, FLO57 predicted vortex breakdown earlier than that seen in the experimental results. Placing the chine on the forebody delayed the onset of bursting and improved the correlation between numerical and experimental data at the subsonic conditions. Author

A91-24386#
AERODYNAMIC CALCULATION OF COMPLEX THREE-DIMENSIONAL CONFIGURATIONS
F. ROGGERO and R. LARGUIER (ONERA, Chatillon, France) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 770-781. refs
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The three-dimensional ECOPAN code was developed at ONERA to meet a wide variety of demands, including those of the Ariane and Airbus European programs. Typical configurations are a complete launch vehicle in takeoff phase or a complete aircraft with engines operating and high lift devices extended. In these two cases, the ECOPAN code has demonstrated is versatility, its operational status, and its aptitude to perform parametric analyses in subsonic flow with interaction of the Hermes shuttle on the lower part of the Ariane 5 launcher, correctly expressed and the lift increase due to the ground effect for an Airbus in takeoff estimated to within 4 percent. Author

A91-24387#
APPLICATIONS OF MULTIZONE EULER/NAVIER-STOKES AERODYNAMIC METHODS TO AIRCRAFT CONFIGURATIONS
P. RAJ, C. R. OLLING, and S. W. SINGER (Lockheed Aeronautical Systems Co., Burbank, CA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 782-794. Research supported by Lockheed Aeronautical Systems Co. refs
Copyright

Computational methods based on cell-centered finite-volume spatial discretization and explicit time-stepping algorithms for solving the Euler and Navier-Stokes equations are used to simulate inviscid and viscous flow about configurations ranging from simple two-dimensional airfoils to complete aircraft. Solutions are obtained using patched multizone grids with matching and different grid densities across zonal interfaces. Emphasis is placed on evaluating the sensitivity of computed solutions to numerical dissipation associated with the cell-centered finite-volume schemes, and the effects of grid density and turbulence modeling. This is accomplished by correlating computed solutions with experimental data and analytical solutions, whenever possible. The results provide an added measure of confidence in the computational solutions of the Euler and Navier-Stokes equations, and also point out some of the limitations. Author

A91-24403*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A FLIGHT EXPERIMENT TO MEASURE RAREFIED-FLOW AERODYNAMICS
ROBERT C. BLANCHARD (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 963-972. refs
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A flight experiment to measure rarefied-flow aerodynamics of a blunt lifting body is being developed by NASA. This experiment, called the Rarefied-Flow Aerodynamic Measurement Experiment (RAME), is part of the Aeroassist Flight Experiment (AFE) mission, which is a Pathfinder design tool for aeroassisted orbital transfer vehicles. The RAME will use flight measurements from accelerometers, rate gyros, and pressure transducers, combined with knowledge of AFE in-flight mass properties and trajectory, to infer aerodynamic forces and moments in the rarefied-flow environment, including transition into the hypersonic continuum regime. Preflight estimates of the aerodynamic measurements are based upon environment models, existing computer simulations, and ground test results. Planned maneuvers at several altitudes will provide a first-time opportunity to examine gas-surface accommondation effects on aerodynamic coefficients in an environment of changing atmospheric composition. A description is given of the RAME equipment design. Author

A91-24407#
A COMPUTATIONAL AND EXPERIMENTAL ANALYSIS OF JOINED-WING AERODYNAMICS
MASAKATA HASHIMOTO, MASAYUKI ISHIKAWA (Mitsui Engineering and Ship-Building Co., Ltd., Akishima, Japan), NAOKI HIROSE, and TAKESHI OHNUKI (National Aerospace Laboratory, Chofu, Japan) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American

Institute of Aeronautics and Astronautics, Inc., 1990, p. 1017-1027. refs
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The aerodynamic characteristics of a joined-wing were investigated by computational methods and by a low-speed wind tunnel test to show its advantages over the conventional configurations and the feasibility of adapting it for practical application. An initial analysis by the extended lifting-line theory and a second analysis by the three-dimensional potential-flow panel method were performed to clarify the effects of geometrical parameters on the joined-wing aerodynamics, such as solid/planar types, sweep angles, span ratio, and area ratio of the rear and front wings. A third analysis involves finite-difference computation of the three-dimensional Euler equations to obtain the lift and drag characteristics in the high subsonic to transonic regime. It is shown that the three-dimensionally diamond-shaped joined-wing configuration has a higher value of lift-to-drag ratio than the planely joined one. R.E.P.

A91-24408*# Boeing Commercial Airplane Co., Seattle, WA.
DESIGN AND VALIDATION OF ADVANCED TRANSONIC WINGS USING CFD AND VERY HIGH REYNOLDS NUMBER WIND TUNNEL TESTING
MARK I. GOLDHAMMER (Boeing Commercial Airplanes, Seattle, WA) and FRANK W. STEINLE, JR. (NASA, Ames Research Center, Moffett Field, CA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1028-1042. refs
Copyright

A study is presented that opens the possibility for further wing aerodynamic technology advances when the test and design environment is at a significantly higher Reynolds number than that used for previous generations of commercial transports. Early generation wings were based primarily on NACA airfoil sections integrated simply into three-dimensional designs. Recently, designs have been developed with a major influence from CFD and have depended less on iterative wind tunnel testing. It is shown that, coupled with improvements in CFD wing modeling and advances in test techniques, additional improvements in wing technology can be realized at significantly higher Reynolds numbers. R.E.P.

A91-24410#
ONERA ACTIVITIES ON DRAG REDUCTION
J. J. THIBERT, J. RENEAUX, and V. SCHMITT (ONERA, Chatillon, France) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1053-1064. Research supported by Direction Generale de l'Aviation Civile, Aerospatiale, AMDBA, and Airbus Industrie. refs
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A review is presented of recent studies on drag reduction oriented towards the investigation of the potential benefits that can be expected by applying certain new technologies. The various concepts studied include natural laminar flow, riblets, wing tip turbine, hybrid laminar flow control, and shock wave boundary layer control. Theoretical and experimental studies have been performed which serve to demonstrate the potential and also the limits of each of these concepts. Studies on turbulent skin friction drag have mainly been devoted to the riblets. For other drag components, some information is provided concerning the utilization of a wing tip turbine to reduce the lift-induced drag and the utilization of the passive shock boundary layer control concept to reduce the wave drag. R.E.P.

A91-24411#
ANALYSIS OF CRESCENT WINGS USING A SUBSONIC PANEL METHOD
C. W. BURKETT (Southampton, University, England) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1065-1072. refs
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Recent experimental and computational studies have indicated that rearward curvature of a wing can reduce the induced drag factor to values less than that obtained from the unswept elliptical wing considered optimal in classical wing theory. The origin of this induced drag reduction is investigated by using a three-dimensional panel method which features a wake relaxation routine to model the nonlinear behavior of the trailing wake. The effect of wake nonplanarities is assessed by comparing rigid and relaxed wake solutions. Results showed reductions in induced drag factor of up to 16 percent for wings with rearward curvature. Wake relaxation consistently gave increased drag compared to the planar wake case, but the detrimental effect was reduced for wings of rearward curvature. Sectional drag data demonstrates that rearward planform curvature encourages a thrust force at the tips while minimizing the high drag at the root found on wings of constant sweep. Author

A91-24412*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SUPERSONIC LAMINAR FLOW CONTROL ON COMMERCIAL TRANSPORTS
R. D. WAGNER, M. C. FISCHER, F. S. COLLIER, JR. (NASA, Langley Research Center, Hampton, VA), and W. PFENNINGER (Analytical Services and Materials, Inc., Hampton, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1073-1089. refs
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This paper provides an overview of the status of supersonic laminar flow control. Existing research into the aerodynamic problems of subsonic and supersonic laminar flow control is first reviewed to provide a prospective for subsequent discussions of recent studies to evaluate the potential performance benefits of the application of laminar flow control to supersonic transports. A flight research program to provide a realistic assessment of the technical feasibility is then described. Author

A91-24413#
LAMINAR FLOW EXPERIMENTS WITH A LARGE HALF MODEL IN TRANSONIC FLOW
R. HENKE and F. X. MUENCH (Deutsche Airbus GmbH, Bremen, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1090-1097. Research supported by BMFT. refs
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A series of tests involving laminar flow have been conducted, beginning with flight tests with the VFW-ATTAS experimental aircraft and then with a 1:13.5-scale pilot model in the TWG Goettingen wind tunnel. Low-speed tests using the large model were conducted in the DNW wind tunnel, followed by high-speed tests in the SIMA wind tunnel. These experiments were aimed at providing a proper correlation between wind tunnel and flight test data for laminar wing flow, and at obtaining further data with the wind tunnel model under conditions that cannot be tested with an aircraft. Crossflow instability, attachment line instability, and Tollmien-Schlichting instability are studied, and the flight test distributions have been matched with some tests at almost the same Reynolds number. R.E.P.

A91-24422*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NUMERICAL INVESTIGATION OF THE ORIGIN OF VORTEX ASYMMETRY OF FLOWS OVER BODIES AT LARGE ANGLE OF ATTACK
DAVID DEGANI (NASA, Ames Research Center, Moffett Field, CA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1162-1172. refs
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The occurrence of the flow about a slender body of revolution placed at incidence to an incoming stream is numerically examined

for angles of attack ranging from 20 to 80 degrees and a Reynolds number of 200,000 based on maximum body diameter. Over a certain range of Reynolds numbers, the trend of flowfields around slender bodies at incidence can be roughly divided into three main categories: (1) at alpha = 0-30 deg, the flow is steady and symmetric; (2) at alpha = 30-60 deg, the flow under normal conditions is usually asymmetric, but the level of the asymmetry depends on the amount of disturbances present on the tip of the body; and (3) at alpha 60-90 deg, the flow in the wake of the body acts in a fashion similar to that of the Karman vortex shedding behind a two-dimensional circular cylinder. For each of these categories the range of incidence may change by + or - 10 degrees, depending on the quality of flow, or body finish. R.E.P.

A91-24423#
APPLICATION OF A MULTIBLOCK CFD SYSTEM TO OBTAINING FLOWFIELD PREDICTIONS ABOUT WING BODY PYLON STORE CONFIGURATIONS
A. J. BAXENDALE (Aircraft Research Association, Ltd., Bedford, England) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1173-1183. Research supported by the Ministry of Defence Procurement Executive. refs
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The field of computational fluid dynamics (CFD) continues to develop rapidly, providing the aerodynamics engineer with increasingly powerful design tools. In this paper, the application of the currently most advanced CFD method available to the UK Aerospace Industry is described. The method, known as Euler Multiblock, has been used to analyze the flow about derivatives of a wing/body/pylon/store research model in the transonic flow region, making use of an extensive experimental data base to validate results. This data base was produced during wind tunnel tests to assess earlier pylon design techniques, which were guided by a transonic small perturbation code, with the coupled aim of providing experimental data against which to validate more advanced techniques as they become available. Following brief descriptions of the Multiblock system and the pylon design exercise, theoretical results are shown and discussed which demonstrate the ability of the system to predict the flow in regions of high interference such as close to wing pylon junctions, on pylons and on simple stores. The discussion is then broadened to describe, more generally, the potential of the Miltiblock method for military aircraft design and development. Author

A91-24424#
BLUNT TRAILING EDGE ANALYSIS OF SUPERCRITICAL AIRFOILS BY A NAVIER-STOKES CODE
NAOKI HIROSE and NOBUHIKO KAMIYA (National Aerospace Laboratory, Chofu, Japan) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1184-1193. refs
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A preliminary analysis of flow about the blunt trailing edge of NACA 0012 and supercritical airfoils in transonic speed was made utilizing a two-dimensional time-averaged Navier-Stokes code with turbulence model of Baldwin and Lomax. A very fine mesh distribution was focused at the trailing edge region where conventional codes treat as sharp trailing edge with zero thickness. Computation was made for NACA 0012 airfoil with three kinds of trailing edge thicknesses: cusp-type sharp, standard and 1 percent thickness and compared with the result of conventionally-treated trailing edge. A 15-percent-thickness supercritical airfoil with trailing edge thickness of 0.5 percent was also analyzed. It was found that a vortex shedding similar to the Karman vortices is formed and surface pressure near the trailing edge shows unsteady oscillations due to vortices. The magnitude and periodicity of the oscillation is governed by the bluntness. Also, it was shown that 'Kutta condition' is not necessarily satisfied for the blunt trailing edge. Author

A91-24432#
JET TRAINER AEROFOIL SELECTION
J. BENETKA, M. KLADRUBSKY, and Z. PERNICA (Vyzkumny a Zkusebni Letecky Ustav, Prague, Czechoslovakia) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1290-1298. refs
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Results are presented of a comparative study which indicates some advantages of different types of pressure distributions of airfoils at various regimes of operation. Both theoretical and experimental methods are used for preliminary selection of an airfoil, convenient for application to a new-generation jet trainer wing. It is noted that an airfoil of high c(Lmax) requires different design c(p) distribution than another intended for high M(DD) and good transonic behavior. Despite this, it was shown that both of these contradictory requirements can be satisfied in some way and that an optimum solution may soon be found. The study was performed experimentally at low Reynolds numbers and is supported by calculations at higher Re. L.K.S.

A91-24433#
THE LIFT AND PITCHING MOMENT CHARACTERISTICS OF AN AIRFOIL IN ISOLATED AND TANDEM CASES
M. A. YUKSELEN (Istanbul Technical University, Turkey) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1299-1309. refs
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The lift and pitching moment characteristics of a NACA 65(1) 012 based airfoil model are investigated in isolated and tandem cases experimentally at a Reynolds number of about 650,000 and theoretically in the potential flow case. For the potential flow calculations a complex panel method was developed starting from the Cauchy integral theorem. The method was tested widely in an isolated case and for multielement airfoils and was also used for correcting the wind tunnel wall effects in isolated and tandem cases. In the isolated case the lift and pitching moment characteristics of the airfoil were obtained by pressure measurements. The comparisons made with the complex panel method results and with the experimental and theoretical characteristics of the basic NACA airfoil revealed viscosity and Reynolds-number effects. L.K.S.

A91-24434#
AN INVESTIGATION INTO THE FLOW AT THE JUNCTION BETWEEN A FLAT PLATE AND AN AEROFOIL
D. ABDULRAZAK and D. R. PHILPOTT (Hatfield Polytechnic, England) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1310-1315. refs
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The development of a flow traverse system to measure local properties in the flowfield downstream of a region of wing/body junction, including local vorticity, is discussed. Results are presented for the flow around a NACA 0018 section mounted on a flat plate in a low speed wind tunnel. Vorticity traverses downstream of the wing trailing edge confirm the existence of a primary and secondary horseshoe vortex system. It is also found that the trailing vortex pair formed by the primary vortex moves apart downstream of the wing trailing edge, which is consistent with observed oil-film visualizations. L.K.S.

A91-24435#
TRANSONIC WING DESIGN FOR TRANSPORT AIRCRAFT
J. HUA and Z. Y. ZHANG (Northwestern Polytechnical University, Xian, People's Republic of China) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1316-1322. Research supported by Chinese Aeronautical Youth Scientific Foundation, Northwestern Polytechnical University, DLR, et al. refs
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The aerodynamic design of two transonic wings is described in the paper. The design method is an improved iterative residual correction method with closed form integral formulations to replace numerical integrations, using a new procedure including a weighted smoothing approach. Design criteria, the viscous correction method, control of spanwise lift and thickness distributions, and specification of target pressure distributions for transonic wing design are also discussed. Computation results on the supercritical wing show that the optimum cruise speed is improved by 0.05 Mach number while the aerodynamic efficiency increased by 14.5 percent at Cl = 0.5, compared with the B737-300 wing. The designed NPU-NLF1 wing has straight isobars from 0.1 to 0.9 half-span, and reasonable lift and thickness distributions in the span direction. Author

A91-24437#
ANALYSIS AND OPTIMIZATION OF SCRAMJET INLET PERFORMANCE
S. MOLDER and R. J. MCGREGOR (Ryerson Polytechnical Institute, Toronto, Canada) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1328-1339. refs
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The available-energy-based hypersonic inlet efficiency parameters and an exergy-based term are compared on plots of concentration ratio vs compression ratio. An assessment of intake efficiency is performed through calculations to obtain scramjet propulsive performance, also as a function of contraction and compression ratio. It is found that caloric gas imperfections need to be considered when calculating inviscid flow in hypersonic air inlets. It is recommended that inlet performance ultimately be judged against the performance of the engine. Results indicate that the use of efficiency definition based on exergy directly incorporates losses due to viscous dissipation and heat transfer. Sample results on a typical configuration show that an optimized scramjet inlet will produce a combuster delivery Mach number approximately 0.6 times that of the freestream at delivery temperatures around 600 K. L.K.S.

A91-24443#
PREDICTION OF INVISCID SUPERSONIC/HYPERSONIC AIRCRAFT FLOWFIELDS
A. VERHOFF and D. STOOKESBERRY (McDonnell Aircraft Co., Saint Louis, MO) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1394-1404. refs
Copyright

In order to numerically solve the Euler equations for supersonic and hypersonic flow, a spatial marching method called SCRAM has been developed. SCRAM is based on the QAZ1D form of the Euler equations (Verhoff and O'Neil, 1984) and has been shown to be an accurate and efficient prediction method for supersonic/hypersonic inviscid flow about complex configurations. The code has been coupled with a versatile grid generation procedure for construction of high-quality computational grids about such shapes. Pressure distributions, forces, and moments compare well with test data for configurations having arbitrary nose shapes, aft-swept wing trailing edges, vertical tails, and control surface deflections. Efficient real-gas capability has been validated against analytic cone solutions. L.K.S.

A91-24444#
NUMERICAL ANALYSIS OF VISCOUS HYPERSONIC FLOW PAST A GENERIC FOREBODY
K. M. WANIE and M. A. SCHMATZ (MBB GmbH, Munich, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1405-1414. refs
Copyright

The viscous hypersonic flow past an analytically defined generic transport aircraft forebody is numerically simulated using a Navier-Stokes code. The governing equations are given in general three-dimensional curvilinear form and the computational method is outlined. The results are discussed in detail. Particular emphasis is layed upon the sensitivity of the solutions to variations of physical parameters. Main point of the investigation is the influence of turbulence, real gas effects and radiation on the global and local character of the flow. As it is expected turbulence has a significant influence on boundary-layer velocity profiles and boundary-layer thickness, while at the Mach number in consideration real gas effects and radiation play a minor role for these features. On the other hand it is found that real gas effects and radiation reduce the thermal loads considerably, resulting in less effort for isolation than indicated by predictions neglecting them. Author

A91-24445#
LARGE-SCALE NUMERICAL AERODYNAMIC SIMULATIONS FOR COMPLETE AIRCRAFT CONFIGURATIONS
SUSUMU TAKANASHI (National Aerospace Laboratory, Chofu, Japan) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1415-1426. Research supported by NASDA and Japan Aircraft Development Cooperation. refs
Copyright

Navier-Stokes simulations of transonic flows are carried out for complete configurations of two kinds of test models which were designed to investigate the aerodynamic characteristics of the developing airplanes using the transonic wind tunnel. An O-O grid system for the computation is constructed by the automatic procedure based on the electrostatic theory. The Reynolds-averaged Navier-Stokes equations are solved on a supercomputer, FACOM VP-400, using an implicit finite volume, upwind TVD scheme. Computed pressure distributions as well as force coefficients are also compared with the experimental data. Author

A91-24446#
TRANSPORT AIRCRAFT AERODYNAMIC IMPROVEMENT BY NUMERICAL OPTIMIZATION
D. DESTARAC and J. RENEAUX (ONERA, Chatillon, France) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1427-1438. Research supported by Aerospatiale and Service Technique des Programmes Aeronautiques. refs
Copyright

Various applications of numerical optimization to the aerodynamic improvement of transport aircraft are presented from airfoil to wing design and control of interference phenomena. The method associates the CONMIN constrained minimization code with two-dimensional and three-dimensional aerodynamic programs. In two-dimension, the case of two airfoil designs in the same operating conditions but with geometric constraints corresponding to two alternative wing structures illustrates the usefulness of numerical optimization when geometrical control is required. In three-dimension, possibilities of wing drag minimization are shown, drag being split into its basic components to ensure better reliability of the objective calculations and more control in the design procedure. Finally, an example is given of minimization of wing/power plant interference effects on a four-engined jet aircraft, a problem for which numerical optimization is a promising approach. Author

A91-24468*# AS&M, Inc., Hampton, VA.
DESIGN ASPECTS OF LONG RANGE SUPERSONIC LFC AIRPLANES WITH HIGHLY SWEPT WINGS
W. PFENNINGER and C. S. VEMURU (AS&M, Inc., Hampton, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1641-1654. refs
(Contract NAS1-18235; NAS1-18599)

Studies on supersonic long-range LFC (laminar flow control) aircraft were performed with the aim of maximizing L/D and

alleviating sonic boom during supersonic cruise. It is found that configurations with highly swept LFC wings of very high structural aspect ratio, with the sweep increasing toward the wing root and braced externally by wide chord laminarized struts, appear especially promising. In the supersonic cruise design condition the wing upper surface isobars are swept such that the flow in the direction normal to them is transonic with embedded supersonic zones and practically shock-free over most of the span, with M-perpendicular equal to the two-dimensional design values of advanced SC LFC airfoils, e.g., of the X-787 or X-6 type. B.J.

A91-24471#
FLOW FEATURES OF HIGHLY-SWEPT WINGS AT SUBSONIC AND SUPERSONIC SPEEDS
P. R. ASHILL, J. L. FULKER, M. J. SIMMONS, and C. J. BETTS (Royal Aerospace Establishment, Bedford, England) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1678-1689. refs
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A combined, experimental-theoretical investigation of flows over highly-swept, delta wings with round leading edges is described. The flows include those at high subsonic and supersonic speeds about three wings, two of which are designed for attached flow at supersonic maneuver conditions. The main flow features on and off design are identified, including separations at the leading edge at subsonic speeds and at the shock at supersonic speeds. Scale effects on flows with leading-edge separation are described and means of simulating flight conditions for such flows by the use of transition trips are discussed. A method for solving Euler's equations is assessed by comparison with experiment and is shown to be inadequate for flows with separation. A technique for prescribing the flow conditions at shock-induced separation in an Euler solver is shown to give predictions in good agreement with measurement. Author

A91-24472#
AERODYNAMIC ANALYSIS OF THE FLOW CHARACTERISTICS OF A DELTA-CANARD CONFIGURATION
A. FERRETTI and A. SALVATORE (Aeritalia S.p.A., Turin, Italy) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1690-1700. refs
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A complete cycle of aerodynamic analysis of the local flow characteristics on a delta-canard aircraft configuration has been performed through the examination of wind-tunnel and flight-data covering subsonic-transonic and supersonic regimes. A pressure plotting wind tunnel model scale 1:13 has been tested in different entries of wind tunnels. Flow characteristics have been investigated in the whole Mach-alpha range of interest, analyzing development of vortex flow on the wing surface and the effects of canard on it. Key aerocharacteristics, like trailing edge pressure and minimum pressure coefficient on the wing, have been identified and correlated to the insurgence of peculiar flow structures obtaining a prediction criterion of transition from attached to vortex flow. The availability of in-flight pressure measurements over the flying surfaces of a demonstrator aircraft has allowed a comparison of wind tunnel versus flight data, evaluating the effects of varying the Reynolds number. A comparison of the experimental results with computational estimates has been carried out in order to assess the reliability of the theoretical methods in predicting complex three-dimensional flow fields. Author

A91-24473#
INVESTIGATIONS INTO THE FLOW BEHIND CASTELLATED BLUNT TRAILING EDGE AEROFOILS IN SUPERSONIC FLOW
S. L. GAI, E. C. MAGI, and A. PRYTZ (University College; Australian Defence Force Academy, Campbell, Australia) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1701-1711. Research supported by Australian Research Grants Scheme. refs
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The paper reports an investigation into the flow behind the base of a castellated blunt trailing edge aerofoil at supersonic speeds at a Mach number of 2. The investigation has shown that strong gradients exist in the spanwise direction and the formation of the wake shock occurs further away from the wake axis and the wake neck is broader and diffused. This would indicate that the vortex street that is formed at the base of the shock becomes weaker. A theoretical analysis based on vorticity conservation would then suggest that part of the spanwise vorticity must be transformed into streamwise vorticity and hence result in decreased drag. Detailed data involving pressure measurements, Schlieren and holographic interferometry and laser velocimetry are presented. Author

A91-24474#
SOME DESIGN CONSIDERATIONS AND PROSPECTS OF APPLYING LEADING-EDGE VORTEX FLAPS TO COMBAT AIRCRAFT WINGS
R. K. NANGIA (British Aerospace, PLC, Bristol, England) and G. E. LOCKLEY (British Aerospace, PLC, Kingston, England) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1712-1720. refs
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Wind tunnel data on variable camber devices, strakes, and leading edge vortex flaps (LEVFs) are compared with reference to performance, stability, control, and high alpha characteristics. The results highlight differences in LEVF applications on wings of different sweep. It is shown that the LEVF is a 'tolerant' device which successfully exploits the natural tendency of the flow, i.e., separation at high Mach - C(L) conditions. By controlling flow separation the bluff-body type behavior can be postponed to higher angles of attack, thereby significantly enhancing the aerodynamic envelope of a given aircraft. B.J.

A91-24483#
AERODYNAMIC DESIGN VIA OPTIMIZATION
KI D. LEE and SINAN EYI (Illinois, University, Urbana) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1808-1818. refs
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An aerodynamic design optimization method is presented which generates an airfoil producing a specified surface pressure distribution at a transonic speed. The design procedure is based on coupled Euler and boundary layer technology in order to include the rotational viscous physics which characterizes transonic flows. A least-square optimization technique is used to minimize pressure discrepancies between the target and designed airfoils. The method is demonstrated with several examples at transonic speeds. The design optimization process converges quickly, which makes the method attractive for practical engineering applications. Author

A91-24484#
CONVERGENCE ACCELERATION AND WAVE DRAG DETERMINATION IN TRANSONIC AIRFOIL CALCULATIONS
S. V. LIAPUNOV (Tsentral'nyi Aerogidrodinamicheskii Institut, Moscow, USSR) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1819-1825. refs
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It is shown that one of the reasons for a relatively slow iteration process convergence during transonic potential flow calculations by relaxation methods is the calculation in the vicinity of the infinity point. The exclusion of this domain from the calculation region and using of the Dirichlet type condition on its boundary leads to an appreciable convergence acceleration and computational time reduction. The analogous method can be utilized for the calculations of axisymmetrical bodies and wings. The second question involved deals with the determination of the wave drag

in the potential airfoil flow calculations. The drag values were corrected for the nonconservativity of the finite-difference scheme and potential model errors and the result agrees well with the Euler equation solutions. Author

A91-24485#
DEVELOPMENT AND VALIDATION OF A CHARACTERISTIC BOUNDARY CONDITION FOR A CELL-CENTERED EULER METHOD
J. I. VAN DEN BERG and J. W. BOERSTOEL (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1826-1832. Research supported by Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart. refs
Copyright

The development and numerical validation of a solid-wall boundary condition is presented for the numerical solution of the Euler equations with a cell-centered central-difference scheme. This solid-wall boundary condition was obtained from the theory of characteristics, and was also formulated for a cell-centered central-difference scheme. The boundary condition was developed to clarify the question what the effect is of various boundary-condition algorithms on the accuracy of the three-dimensional numerical solution of the Euler equations. The numerical validation of the solid-wall boundary condition consists of a comparison of results obtained with the conventional - and the new solid-wall boundary condition. Also discretization and convergence errors, as well the grid dependency of the solution, were investigated. As a test case, the NLR 7301 airfoil was chosen. Calculations were performed for the supercritical, shock-free flow at M(infinity) = 0.721, alpha = -0.194 deg, and, for a flow with a strong shock, at M(infinity) = 0.70, alpha = 2.0 deg. Author

A91-24486*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DEVELOPMENT OF UNSTRUCTURED GRID METHODS FOR STEADY AND UNSTEADY AERODYNAMIC ANALYSIS
JOHN T. BATINA (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1833-1843. Previously announced in STAR as N91-11673. refs
Copyright

The current status of the development of unstructured grid methods in the Unsteady Aerodynamic Branch at NASA-Langley is described. These methods are being developed for steady and unsteady aerodynamic applications. The flow solvers that were developed for the solution of the unsteady Euler and Navier-Stokes equations are highlighted and selected results are given which demonstrate various features of the capability. The results demonstrate 2-D and 3-D applications for both steady and unsteady flows. Comparisons are also made with solutions obtained using a structured grid code and with experimental data to determine the accuracy of the unstructured grid methodology. These comparisons show good agreement which thus verifies the accuracy. Author

A91-24494#
EXPERIMENTAL STUDY ON DRAG REDUCTION OF HYPERSONIC TRANSPORT CONFIGURATION
Y. AIHARA, E. MORISHITA, T. OKUNUKI (Tokyo, University, Japan), S. NOMURA, and K. HOZUMI (National Aerospace Laboratory, Chofu, Japan) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1899-1907. refs
Copyright

The paper describes drag-reduction studies for HST configurations with a Mach number of 7, a Reynolds number of about one-million, and a volume coefficient of about 0.1. Characteristics tests with several variations of the configuration demonstrated that total slenderizing and blending of the wind-body assembly can lower the drag. The maximum available L/D ratio is 5.5. It is pointed out that better performance is expected if thermal control of the flow is implemented. B.J.

A91-24497#
NUMERICAL EXPERIMENTS USING NAVIER STOKES CODES FOR GENERALISED HYPERSONIC SHAPES
NING QIN, ZHIJIAN WANG, and BRYAN RICHARDS (Glasgow, University, Scotland) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1927-1937. Research supported by SERC, Ministry of Defence, and British Aerospace, PLC. refs
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In this paper numerical experiments are carried out to model the hypersonic flow over generalized shapes representing a spaceplane during re-entry. The modeling uses solutions of the locally conical reduced set of Navier-Stokes equations as well as the full three-dimensional equations. A variety of high-resolution schemes such as flux-vector splitting, flux-difference splitting, and TVD have been explored, as well as some novel acceleration techniques. Results are presented of the shock interaction in a corner and the high-Reynolds-number flows over a blunt delta wing and a body with canopy at 30 deg angle of attack (representing shapes being explored under the Hermes program). The excellent agreement with experiment demonstrates the value of developments of this nature, bearing in mind the difficulty in generating quality experimental results in the hypersonic flow regime. Author

A91-24508#
A MULTIGRID LU FACTORIZATION SCHEME FOR THE THIN-LAYER NAVIER-STOKES EQUATIONS
TIMO SIIKONEN, JAAKKO HOFFREN, and SEPPO LAINE (Helsinki University of Technology, Espoo, Finland) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2023-2034. refs
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A finite-volume-based numerical method for the solution of the Euler and thin-layer Navier-Stokes equations is presented. The convective part of the fluxes is solved using a flux-vector splitting method and the diffusive part using central differences. The equations are integrated in time with an approximately factored implicit scheme. Convergence is accelerated by applying a multigrid technique. Results are presented for inviscid and viscous flows over an NACA 0012 airfoil and for three-dimensional laminar and turbulent flows over a body of revolution at high angles of attack. Author

A91-24512#
THREE DIMENSIONAL TRANSONIC FULL POTENTIAL SOLUTION BY AN INTEGRAL EQUATION METHOD
N. L. ARORA and J. P. AGARWAL (Indian Institute of Technology, Kanpur, India) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2055-2064. Research supported by the Aeronautics Research and Development Board and Aeronautical Development Agency of India. refs
Copyright

A hybrid numerical scheme is developed to solve the full potential equation for steady inviscid three-dimensional transonic flow. An integral-equation formulation is obtained by application of Green's third identity and solved using a combination of surface panels and field-volume elements. The derivation is given in detail, with particular attention to the discretization, the evaluation of influence coefficients, the construction of artificial viscosity, and the iteration scheme. Results for ONERA M-6 and RAE C wings are compared with Euler solutions and experimental data in graphs; the efficiency and accuracy of the method are demonstrated. D.G.

A91-24513#
CONTROLLING THE LEADING-EDGE VORTEX ON THE VORTEX FLAP USING MASS INJECTION
YANHUA QIN (Chinese Aerodynamic Research and Development Center, Mianyang, People's Republic of China), TINGDING HSING, and FENGGAN ZHUANG (Beijing University of Aeronautics and Astronautics, People's Republic of China) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2065-2072. refs
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The use of mass injection (spanwise blowing) to improve the effectiveness of a full-span constant-chord 30-deg-deflection leading-edge vortex flap in reducing drag is investigated experimentally. Data obtained on a half-span model of a 74-deg delta wing in the low-speed wind tunnel and water tunnel of the China Aerodynamic Research and Development Center are presented in graphs and discussed in detail. It is shown that a single nozzle located near the vortex-flap hinge line is more effective in reducing drag than a jet located further to the rear. Multinozzle blowing is also found to reduce drag, but further studies are needed to optimize the individual nozzle jet momentum coefficients. D.G.

A91-24514#
APPLICABILITY OF EULER ANALYSIS TO PROP-FAN AERODYNAMIC DESIGN
MAKOTO KOBAYAKAWA, RYOJI TAKAKI (Kyoto University, Japan), YOSHIFUMI KAWAKAMI (Sumitomo Precision Products, Ltd., Amagasaki, Japan), and FREDERICK B. METZGER (Hamilton Standard, Windsor Locks, CT) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2073-2081. refs
Copyright
Applicability of a numerical code to aerodynamic design of a prop-fan is guaranteed by precise agreement of numerical results with experimental data; i.e., not only integrated performance indices such as power coefficient and net efficiency but also pressure distribution on the blade surface should agree well between computed and experimental results. An Euler code using the TVD scheme is developed for this purpose. The numerical calculations are performed for the SR-7L prop-fan at freestream Mach number 0.5. The computed power coefficient, Cp = 1.734, shows comparatively good agreement with the experimental data, Cp = 1.440 + or - 0.080 if the measurement error of the blade twisted angle is considered. Author

A91-24518#
SUBSONIC STEADY, UNSTEADY AERODYNAMIC CALCULATION FOR WINGS AT HIGH ANGLE OF ATTACK
ZHENG-YIN YE, YONG-NIAN YANG, and LING-CHENG ZHAO (Northwestern Polytechnical University, Xian, People's Republic of China) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2105-2110. refs
Copyright
A numerical method for computing the nonlinear airloads on wings in subsonic flow with separated vortices at high angles of attack is developed analytically and demonstrated. Green's theorem is applied to the full nonlinear equation for the velocity potential, and the resulting expression is simplified using a generalized Prandtl-Glauert transformation and solved numerically in the time domain. Results for sample problems are presented in graphs and shown to be in good agreement with published experimental data. In the case of steady flow, the present potential-difference method reduces to a nonlinear vortex-lattice method. D.G.

A91-24519*# Kansas Univ., Lawrence.
MODERN DEVELOPMENTS IN SHEAR FLOW CONTROL WITH SWIRL
S. FAROKHI (Kansas, University, Lawrence), R. TAGHAVI (Sverdrup Technology, Inc., Cleveland, OH), and E. J. RICE (NASA, Lewis Research Center, Cleveland, OH) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2111-2122. Previously announced in STAR as N90-22000. refs
(Contract NCC3-56; NAG3-1098)
Copyright
Passive and active control of swirling turbulent jets is experimentally investigated. Initial swirl distribution is shown to dominate the free jet evolution in the passive mode. Vortex breakdown, a manifestation of high intensity swirl, was achieved at below critical swirl number (S = 0.48) by reducing the vortex core diameter. The response of a swirling turbulent jet to single frequency, plane wave acoustic excitation was shown to depend strongly on the swirl number, excitation Strouhal number, amplitude of the excitation wave, and core turbulence in a low speed cold jet. A 10 percent reduction of the mean centerline velocity at x/D = 9.0 (and a corresponding increase in the shear layer momentum thickness) was achieved by large amplitude internal plane wave acoustic excitation. Helical instability waves of negative azimuthal wave numbers exhibit larger amplification rates than the plane waves in swirling free jets, according to hydrodynamic stability theory. Consequently, an active swirling shear layer control is proposed to include the generation of helical instability waves of arbitrary helicity and the promotion of modal interaction, through multifrequency forcing. Author

A91-24522#
VISCOUS SUPERSONIC FLOW PAST A WEDGE-SHAPED BODY
Z. DZYGADLO and S. WRZESIEN (Wojskowa Akademia Techniczna, Warsaw, Poland) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2145-2153. refs
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Numerical simulation methods for steady two-dimensional supersonic viscous flows on sharp-edged wedges are described, summarizing results reported by Dzygdalo and Wrzesien (1987-1989). The problem formulation, based on the conservation-law version of the unsteady Navier-Stokes equations, is reviewed; the transformation to dimensionless form and the definition of the computational domain are explained; and the solution algorithm is outlined. Results for freestream Mach number 2.0, 2.5, and 3.0; Reynolds number 250, 500, 1000, and 2000; and wedge angle 15, 20, and 30 deg are presented in graphs and briefly characterized. D.G.

A91-24523#
TWO-STEP-METHOD FOR THE CALCULATION OF WALL INTERFERENCES IN SLOTTED TEST SECTIONS
J. AMECKE (DLR, Goettingen, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2154-2163. refs
Copyright
The two-step technique developed by Amecke (1986) for determination of the two-dimensional wall interferences in wind-tunnel test sections with longitudinally slotted walls is described and demonstrated. The method requires that two sets of measurements be obtained, one with open and one with closed slots, all other parameters being kept the same. The mathematical derivation of the method is outlined, and results from its experimental verification in the transonic wind tunnel at DLR Braunschweig (with the test section empty and with a NACA 0012 profile) are presented in extensive graphs and briefly characterized. It is pointed out that the method is limited to moderate Mach numbers and nonchoking flow conditions during the closed-slot test. D.G.

A91-24525#
HYPERSONIC FLOW FIELDS AROUND HERMES COMPUTED BY EULER CODES

B. ARLINGER and B. WINZELL (Saab-Scania AB, Linkoping, Sweden) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2183-2191.
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The flow field around a complete Hermes configuration has been computed by combining a time-marching and a space-marching Euler code. The computations have been done for hypersonic Mach numbers and high angles of attack with special focus on the leeside flow patterns. The combination of time- and space-marching technique for the Euler equations is very cost-effective, because the time-marching solver, which is the most time-consuming, is applied only in the nose region where a subsonic pocket exists. Results are presented for grids with more than 10 mission points, and a comparison is also made between a coarse grid time-marching solution around a larger part of Hermes and a space-marching solution. Author

A91-24573#
DUSTY SUPERSONIC VISCOUS FLOW OVER A TWO-DIMENSIONAL BLUNT BODY
R. ELANGOVAN and H. V. CAO (Boeing Military Airplanes, Wichita, KS) Journal of Thermophysics and Heat Transfer (ISSN 0887-8722), vol. 4, Oct. 1990, p. 529-533. refs
Copyright

A91-24576#
INCREMENTAL FORCE AND MOMENT COEFFICIENTS FOR A PARALLEL BLADE-VORTEX INTERACTION
P. RENZONI and R. E. MAYLE (Rensselaer Polytechnic Institute, Troy, NY) AIAA Journal (ISSN 0001-1452), vol. 29, Jan. 1991, p. 6-13. refs
(Contract DAAG29-92-K-0093)
Copyright

Blade-vortex interactions occur in helicopter rotors when a rotor blade passes close to or through a tip vortex trailing from the same or another blade. An unsteady, parallel blade-vortex interaction model was developed using a discrete free-vortex method and classical potential flow theory. The tip vortex was modeled by a single vortex and, for a close encounter, by a cluster of vortices. The analysis allows the airfoil to move either steadily or unsteadily through the fluid and allows a freely convecting wake. The results of numerous blade-vortex calculations are presented, and simple equations are obtained for its incremental force and moment coefficients, which account for interactions at different initial vortex heights, vortex strengths, and airfoil angles of attack. Comparison with recent experimental results are also presented. Author

A91-24580#
COMPUTATION OF NAVIER-STOKES SOLUTIONS EXHIBITING ASYMMETRIC VORTICES
M. J. SICLARI and F. MARCONI (Grumman Corporate Research Center, Bethpage, NY) AIAA Journal (ISSN 0001-1452), vol. 29, Jan. 1991, p. 32-42. refs
Copyright

An efficient Navier-Stokes solver is used to demonstrate the existence of asymmetric vortex flows on slender cones flying at supersonic speeds and at very high angles of attack. The iteration scheme is continued until the residual or error is reduced to machine zero. The computations were carried out on very fine grids issues of unsteadiness in the solution or large truncation error are minimized. These types of asymmetries have been noted experimentally for years; in addition, inviscid analytical/computational models have indicated the existence of these types of solutions. This paper is the first to present Navier-Stokes solutions which firmly demonstrate that these flows exist and that they are not experimental or computational anomalies. Author

A91-24583#
IMPLEMENTATION OF A ROTARY-WING NAVIER-STOKES SOLVER ON A MASSIVELY PARALLEL COMPUTER
BRIAN E. WAKE and T. ALAN EGOLF (United Technologies Research Center, East Hartford, CT) AIAA Journal (ISSN 0001-1452), vol. 29, Jan. 1991, p. 58-67. refs
Copyright

An unsteady, compressible, three-dimensional, implicit Navier-Stokes solver (NSR3D) for helicopter and propeller applications has been implemented using FORTRAN with 8X array extensions on the massively parallel connection machine (CM-2). In this paper, the modifications to the original algorithm necessary to overcome communication bottlenecks and achieve reasonable computational efficiency on the CM-2 are described. The modified implicit solver achieves better than twice the speed of a CRAY-2 processor on a 16384 processor CM-2. The CM-2 and FORTRAN 8X array extensions, including coding examples, are briefly described. Some programming issues for difficult problems such as solving the linear systems, the boundary conditions, and the dissipation switching are discussed. Results for a selected application are also provided. Author

A91-24595#
UNSTEADY TRANSONIC COMPUTATIONS ON POROUS AEROFOILS
C. P. CHEN and M. J. SHEU AIAA Journal (ISSN 0001-1452), vol. 29, Jan. 1991, p. 148-150. refs
Copyright

A computational procedure is presented which combines the internal integral equation method and the finite-difference technique to yield full potential solutions with large embedded supersonic regions and strong shocks for porous airfoils in transonic flow. The integral equation method is integrated via Green's theorem to show that the velocity at any point in the field space is expressible in terms of the effects of source and velocity distributions on the airfoil's mean camber-line. The results of the porous airfoil are compared to those of a solid airfoil to demonstrate the effect of porosity on pressure distribution. O.C.

A91-24650*# Vigyan Research Associates, Inc., Hampton, VA.
DSMC CALCULATIONS FOR THE DELTA WING
M. CEVDET CELENLIGIL (Vigyan Research Associates, Inc., Hampton, VA) and JAMES N. MOSS (NASA, Langley Research Center, Hampton, VA) Workshop on Hypersonic Flows for Reentry Problems, Antibes, France, Jan. 22-25, 1990, Paper. 25 p.

Results are reported from three-dimensional direct simulation Monte Carlo (DSMC) computations, using a variable-hard-sphere molecular model, of hypersonic flow on a delta wing. The body-fitted grid is made up of deformed hexahedral cells divided into six tetrahedral subcells with well defined triangular faces; the simulation is carried out for 9000 time steps using 150,000 molecules. The uniform freestream conditions include M = 20.2, T = 13.32 K, rho = 0.00001729 kg/cu m, and T(wall) = 620 K; corresponding to lambda = 0.00153 m and Re = 14,000. The results are presented in graphs and briefly discussed. It is found that, as the flow expands supersonically around the leading edge, an attached leeside flow develops around the wing, and the near-surface density distribution has a maximum downstream from the stagnation point. Coefficients calculated include C(H) = 0.067, C(DP) = 0.178, C(DF) = 0.110, C(L) = 0.714, and C(D) = 1.089. The calculations required 56 h of CPU time on the NASA Langley Voyager CRAY-2 supercomputer. D.G.

A91-24739
THE EFFECT OF WALLS ON INSTABILITY WAVES IN SUPERSONIC SHEAR LAYERS
P. J. MORRIS and M. G. GIRIDHARAN (Pennsylvania State University, University Park) Physics of Fluids A (ISSN 0899-8213), vol. 3, Feb. 1991, p. 356-358. Research supported by USAF. refs
(Contract N00014-88-K-0242)
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A spatial stability analysis is performed to determine the effect of wall placement on instability waves in confined supersonic shear layers. It is shown that the growth rates of Kelvin-Helmholtz instability waves are independent of wall height. However,

supersonic instability waves are found to exhibit peaks and valleys in their growth rate curve as a result of the reinforcement and cancellation of the reflected Mach waves at the shear layer. Finally, it is shown how the instability growth rates in a ducted shear layer may be maximized by the proper choice of the duct width to height ratio. Author

A91-24750
ZONES OF INFLUENCE IN A TWO-DIMENSIONAL, UNSTEADY, HYPERSONIC BOUNDARY LAYER
A. P. ROTHMAYER (Iowa State University of Science and Technology, Ames) Royal Society (London), Proceedings, Series A - Mathematical and Physical Sciences (ISSN 0080-4630), vol. 431, no. 1881, Oct. 8, 1990, p. 37-59. Research supported by United Technologies Corp. refs
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An asymptotic structure is developed for a linear, high-frequency, unsteady disturbance superimposed upon a steady, possibly separated, nonlinear flow. The unsteady viscous sublayer is found to split into a two-region structure. The leading-order flowfield is driven primarily by the upper region, which coincides with the region of non-parallel flow in the original steady viscous sublayer. It is found that introducing a viscous-inviscid interaction into the unsteady problem drastically alters the domain of dependence of the unsteady flow throughout the entire viscous sublayer. The determination of the correct domain of dependence is found to involve a subtle interplay between the convective terms, the pressure-displacement interaction and the non-parallel base flow. Preliminary extensions to fully nonlinear unsteady interactive boundary layers are noted. Author

A91-25129
FLOW STRUCTURE NEAR THE SURFACE OF A FLAT BARRIER IN A RAREFIED-GAS JET FLOW [STRUKTURA TECHENIIA VBLIZI POVERKHNOSTI PLOSKOI PREGRADY, OBTEKAEMOI STRUEI RAZREZHENNOGO GAZA]
B. F. PANOV Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), Oct. 1990, p. 49-52. In Russian.
Copyright

Experimental results are presented on the positions of the maxima in the distributions of pressure and tangential stress on the surfaces of parallel and perpendicular barriers in supersonic jet flows. Nozzles with Mach numbers of 1, 3, and 4.6 were used in the experiments. Data on the stagnation-point behavior on a flat barrier in an underexpanded low-density jet are presented, and the flow pattern near the surface is evaluated. B.J.

A91-25264
COMPARISON OF DIFFERENT GASDYNAMIC APPROXIMATIONS DURING THE NUMERICAL MODELING OF HYPERSONIC FLOW OF A RAREFIED GAS PAST BODIES [SRAVNENIE RAZLICHNYKH GAZODINAMICHESKIKH PRIBLIZHENII PRI CHISLENNOM MODELIROVANII GIPERZVUKOVOGO OBTEKANIIA TEL RAZREZHENNYM GAZOM]
V. G. SHCHERBAK (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR) Teplofizika Vysokikh Temperatur (ISSN 0040-3644), vol. 28, Nov.-Dec. 1990, p. 1164-1170. In Russian. refs
Copyright

A comparison is made between the results of the numerical modeling of hypersonic flow past bodies, with allowance for nonequilibrium chemical reactions, obtained by using parabolized Navier-Stokes equations, a local self-similar approximation, a thin viscous shock layer model, and direct statistical modeling by the Monte Carlo method. The incoming flow parameters correspond to the conditions of motion along a gliding entry trajectory at heights of 92-11 km. The influence of sliding effect in a chemically nonequilibrium chemical mixture on the flow characteristics is examined. For solving the parabolized Navier-Stokes equations, a numerical method using global iterations is proposed. V.L.

A91-25333#
NUMERICAL SIMULATIONS OF SEPARATED FLOWS AROUND BLUFF BODIES BY THE DISCRETE VORTEX METHOD
SHIGERU ASO (Kyushu University, Fukuoka, Japan) and MASANORI HAYASHI (Nishinippon Institute of Technology, Fukuoka, Japan) Kyushu University, Faculty of Engineering, Memoirs (ISSN 0023-6160), vol. 50, Sept. 1990, p. 277-294. refs

Separated flows around bluff bodies are simulated numerically by the discrete vortex method combined with the panel method. The potential flows around bluff bodies are expressed by discrete vortices, and separated shear layers are expressed by a row of discrete vortices. A combination of the discrete vortex method with the panel method, in which a potential flow around bluff bodies is expressed by a set of singular points distributed on the body surface, has been applied for the numerical simulations of separated flows around bluff bodies. In the calculations, bluff bodies are expressed by sets of discrete bound vortices. In the calculations, the procedures to determine the strength and location of the shedding vortex are investigated carefully. A new vortex shedding model is proposed in order to express a separated shear layer as a weak and fine row of vortices for the calculations of separated flows around rectangular, trapezoidal, and concave cylinders. The results show excellent agreements with experiments. Author

A91-25335#
DOUBLE LINEARIZATION THEORY FOR A ROTATING SUPERSONIC ANNULAR CASCADE OF OSCILLATING BLADES
MASANOBU NAMBA (Kyushu University, Fukuoka, Japan) and PING LI Kyushu University, Faculty of Engineering, Memoirs (ISSN 0023-6160), vol. 50, Sept. 1990, p. 309-340. refs

A three-dimensional theory for unsteady supersonic annular cascade with subsonic axial flow velocity is developed. It is assumed that the annular cascade blades operate with small steady loading, and vibrate with infinitesimal displacement amplitude. Vibrations both normal and parallel to the chord of the blades are considered. The steady and unsteady components of disturbance are treated on the basis of the double linearization theory so that both the steady and unsteady flow fields are governed by linear differential equations, which are solved by using the Green function method. Numerical results of the present three-dimensional theory are compared with the results of the strip theory approximation to investigate three-dimensional effects. There are noteworthy differences in the effects of nonuniform angle of attack, camber and thickness between subsonic and supersonic annular cascades. The three-dimensional effects on the aerodynamic instability of the supersonic annular cascade are generally small. Author

A91-25668
NASP INLET DESIGN AND TESTING ISSUES
DAVID M. VAN WIE, MICHAEL E. WHITE, and GRIFFIN P. CORPENING (Johns Hopkins University, Laurel, MD) Johns Hopkins APL Technical Digest (ISSN 0270-5214), vol. 11, July-Dec. 1990, p. 353-362. refs
Copyright

The principal considerations related to the measurement and prediction of scramjet inlet performance are presented. Development of an efficient inlet system that is able to operate over the entire flight regime is crucial for the successful operation of the National Aerospace Plane, and the design of such an inlet presents many challenges due to the many different high-speed fluid dynamic issues that have to be addressed during the design process. Elongated inlets are necessary to capture and compress a given amount of airflow and, due to this feature of hypersonic flow fields, it is advantageous to integrate the inlet into the undersurface of the vehicle forebody to utilize the compression produced by the vehicle as part of the inlet. Further details provided include high-temperature effects, blunt leading edge effects, boundary layer development, hypersonic inlet performance, and air capture measurements. R.E.P.

A91-25728* Maryland Univ., College Park.
INTERNATIONAL HYPERSONIC WAVERIDER SYMPOSIUM, 1ST, UNIVERSITY OF MARYLAND, COLLEGE PARK, MD, OCT. 17-19, 1990, PROCEEDINGS
JOHN D. ANDERSON, JR., ED., MARK J. LEWIS, ED. (Maryland, University, College Park), STEPHEN CORDA, ED. (Johns Hopkins University, Laurel, MD), and ISAIAH M. BLANKSON, ED. (NASA, Washington, DC) Symposium sponsored by the University of Maryland and NASA,. College Park, MD, University of Maryland, 1990, 651 p. For individual items see A91-25729 to A91-25731, A91-25733 to A91-25756.
(Contract NAGW-2146)

The papers presented in this volume provide an overview of current theoretical and experimental research in the field of hypersonic waveriders. In particular, attention is given to efficient waveriders from known axisymmetric flow fields, hypersonic waverider design from given shock waves, limitations of waveriders, and aerodynamic stability theory of hypersonic waveriders. The discussion also covers momentum analysis of waverider flow fields, tethered aerothermodynamic research for hypersonic waveriders, simulation of hypersonic waveriders, and an idealized tip-to-tail waverider model. V.L.

A91-25729*# RANN, Inc., Palo Alto, CA.
HYPERSONIC WAVERIDER CONFIGURATIONS FROM THE 1950'S TO THE 1990'S
A. J. EGGERS, JR., HOLT ASHLEY, GEORGE S. SPRINGER (Rann, Inc., Palo Alto, CA), JEFFREY V. BOWLES, and MARK D. ARDEMA (NASA, Ames Research Center, Moffett Field, CA) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 82 p. refs

The conceptual evolution of waverider configurations and their applications to hypersonic air vehicles are examined in the context of evolving mission requirements and technological advances. The fundamental objective of employing configurations which tend to maximize the payload fraction is emphasized, and the achievement of this objective over the time period of interest is reviewed, starting with high drag ballistic vehicles through low lift-drag ratio lifting bodies to the revived interest in high lift-drag ratio configurations. Practical applications of research in the area of lifting waveriders are discussed with particular reference to the B-70 Valkyrie and the Space Shuttle. V.L.

A91-25730*# Oklahoma Univ., Norman.
ANALYSIS OF CONE-DERIVED WAVERIDERS BY HYPERSONIC SMALL-DISTURBANCE THEORY
MAURICE L. RASMUSSEN (Oklahoma, University, Norman) and XIAOHAI HE IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 46 p. refs
(Contract NAG1-886)

Hypersonic small-disturbance theory is used to analyze slender waveriders derived from axisymmetric flows past circular cones. Viscous effects are accounted for by means of laminar boundary-layer theory. The shape of the waverider is determined by specifying the upper freestream surface, from which the lower compression surface can then be obtained. When this is done, the lift, drag, and pitching moment are determined in terms of quadratures over the shock layer in the base plane. They are functions of freestream Mach number, freestream Reynolds number based on the length of the waverider, some measure of slenderness, and other parameters relating to the shape of the waverider. The functional relationships can be cast in terms of similarity laws. The lift-to-drag ratio is determined for a wide range of shapes and parameters. Author

A91-25731#
EFFICIENT WAVERIDERS FROM KNOWN AXISYMMETRIC FLOW FIELDS
J. PIKE (Cranfield Institute of Technology, England) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 25 p. refs

The possibility of improving the lift-to-drag ratio by varying the anhedral in a systematic manner is examined. It is shown, in particular, that good lift-to-drag ratios can be achieved by balancing the efficient lateral compression of the flow near the axis of symmetry with the inefficiency of high lateral shock inclination near the wing tips and the large friction drag due to excessive surface inclination to the horizontal. An improvement in the equivalent lift-to-drag ratio of the lower surface of nearly 20 percent has been achieved, producing a lower surface with an inviscid lift-to-drag ratio of 11.1 for a lift coefficient of 0.057 at Mach 4. V.L.

A91-25733*# Colorado Univ., Boulder.
HYPERSONIC WAVERIDER DESIGN FROM GIVEN SHOCK WAVES
H. SOBIECZKY, F. C. DOUGHERTY, and K. JONES (Colorado, University, Boulder) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 18 p. Research supported by DLR. refs
(Contract NAG1-880)

An attempt is made to generate waverider flows from given shock wave geometries using two approaches. In the first approach, axisymmetric flows are used to construct more general flows based on the concept of osculating cones. Conical waverider design can thus be extended to yield results also for shocks forming a slope surface. The second approach involves solving the ill-posed problem of prescribing a shock wave and finding the flow field behind it. A new numerical marching technique with some features of characteristic cross marching is used to solve the Euler equation. The code selection and some test cases are discussed. V.L.

A91-25736#
LIMITATIONS OF WAVERIDERS
LEON SCHINDEL (U.S. Navy, Naval Surface Weapons Center, White Oak, MD) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 13 p.

Some limitations and possible disadvantages of waveriders are examined with a view to avoiding their inappropriate applications. In particular, it is noted that the 'optimum waverider' is not really the optimum configuration. It is also shown that constraints make the optimum impractical and constraints on the configuration make the optimum waverider unusable. The high lift/drag ratio design is used as the primary example, but the comments presented here also apply to some extent to waveriders designed for low drag and high lift. V.L.

A91-25739#
AERODYNAMIC STABILITY THEORY OF HYPERSONIC WINGS
GRAFTON W. H. HUI (Waterloo, University, Canada) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 29 p. Research supported by NSERC. refs

This paper presents a summary of the theoretical works of the author and his collaborators on predicting dynamic stability of wings performing pitching oscillations in hypersonic flight. Based on the analytical formulas obtained for the stability derivatives of wings of simple shape, conclusions are drawn regarding the effects on the damping-in-pitch derivative of the following flight parameters: the angle of attack, the thickness of the wing, the pivot-axis position of oscillation, the flight Mach number, the ratio of the specific heats of the gas, the sweepback angle, the camber (chordwise concavity), and the anhedral (spanwise concavity) and dihedral (spanwise convexity) of the wing. These conclusions based on simple wing shapes may throw light to indicate the stability trends of more complex shapes. Author

A91-25740#
IMPACTS OF VOLUMETRIC CONSTRAINTS ON WAVERIDER DESIGN AND PERFORMANCE

KEVIN G. BOWCUTT, JEFF M. WEIR, and GLENN G. MYERS (Rockwell International Corp., Downey, CA) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 42 p. Research supported by Rockwell International Independent Research and Development Program. refs

The Hypersonic Arbitrary Body Program (HABP) and a three-dimensional CFD code were used for the aerodynamic analysis of an optimized (high lift-to-drag ratio) hypersonic waverider shape derived from cone flows. For all inviscid aerodynamic coefficients, the predictionss of the waverider optimization program agreed well with the results of the two analysis programs. A parametric study was conducted to determine the effects of volume constraints on waverider shape and performance. The resulting shapes and associated performance of optimized waveriders versus minimum allowable volume and fuselage fineness ratio are presented. V.L.

A91-25742#
LEADING EDGE OPTIMIZATION FOR HYPERSONIC VEHICLES
AJAY P. KOTHARI (Astrox Corp., Greenbelt, MD) and KEVIN G. BOWCUTT (Rockwell International Corp., Los Angeles, CA) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 27 p. Research supported by USAF. refs

The hypersonic vehicles are expected to encounter very high heating rates especially over the leading edges. Reduction in these rates can be achieved by blunting these leading edges. However, this may result in adversely affecting the pressure drag and may also influence transition to turbulence and separation and result in turbulent boundary layer heating. An approach that optimizes the shapes of these leading edges to minimize drag while maintaining a constraint for the heat load into the leading edges is taken. A full Navier-Stokes code was also written to validate the results obtained by the leading edge optimization technique and to study the flowfield. Various optimized leading edge shapes have been obtained. The same approach of optimizing these leading edges can also be applied to the whole configuration of a hypersonic vehicle with different functional optimizations and various different constraints. Author

A91-25743#
ON WAVERIDER SHAPES APPLIED TO HYPERSONIC CONFIGURATIONS
SHEAM-CHYUN LIN (National Taiwan Institute of Technology, Taipei, Republic of China), JAW-YEN YANG (National Taiwan University, Taipei, Republic of China), and CHENG-SHENG WANG (Chung-Shan Institute of Science and Technology, Taipei, Republic of China) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 19 p. refs

A scheme for systematic study of overall aerodynamic design of a hypersonic configuration is set forth. The study involves two parts: (1) new shapes generated from analytic and (2) computer verification. The shape of the hypersonic vehicle is to be modeled by means of waverider derived from perturbed flow stemming from the hypersonic flow past a cone with transverse curvature. The design scheme offers an explicit, closed-form, approximate analytic form for aerodynamic performance parameter, which can be used to identify the pertinent parameters to be varied systematically. Furthermore, this analytical result provides a possibility to devise new body shapes of interest. A high resolution shock capturing finite difference computer code is used to complement and verify this approximate solution. Author

A91-25744#
THE WAVERIDER WING IN RETROSPECT AND PROSPECT - A PERSONALISED VIEW
TERENCE R. F. NONWEILER (Wellington, Victoria University, New Zealand) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 24 p. refs

The evolution of the waverider concept from the simple caret wing is briefly reviewed, with emphasis on the aerothermal properties of a sharp-edged wing. Measures by which the leading-edge temperature can be reduced are examined, with particular attention given to the use of heat conductivity in sharp edge preservation when other forms of leading-edge cooling, aside from radiation, are employed. The importance of lift-to-drag ratio in the aerogravity assist maneuver of planetary swing-by is mentioned with reference to the viability of sharp-edged waverider wings at extreme flight speeds. V.L.

A91-25745#
A REVIEW OF FORCE MEASUREMENTS ON DELTA AND CARET WINGS MADE AT IMPERIAL COLLEGE, LONDON 1965-1975
J. L. STOLLERY (Cranfield Institute of Technology, England) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 17 p. refs

The early measurements made in the gun tunnels at Imperial College are collected and reviewed. They compare the performance of flat bottomed delta wings with caret wings of the same planform over the incidence range 0 equal to or less than alpha equal to or less than 60 deg. The comparison clearly shows the higher lift coefficients achievable at a given incidence from the caret wing. Author

A91-25746#
A STUDY OF AERODYNAMIC PERFORMANCE OF CONE-DERIVED WAVERIDER CONFIGURATION
KOICHI HOZUMI and SHIGEYA WATANABE (National Aerospace Laboratory, Tokyo, Japan) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 18 p. refs

Wind tunnel test results for a series of cone-derived waverider configurations at Mach 7.1 are examined with a view to possible hypersonic transport applications. A comparison with data obtained for conventional flat-bottom configurations confirms the high L/D and low lift characteristics of the present configurations. The advantages of the high L/D, low lift waverider configurations over high L/D, high lift hypersonic transport configurations are discussed. V.L.

A91-25748#
LOW-SPEED WIND TUNNEL TESTING OF A MACH 6 VISCOUS OPTIMIZED WAVERIDER
DAVID VANHOY (USAF, Flight Test Center, Edwards AFB, CA) and EVERETT JONES (Maryland, University, College Park) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 12 p. refs

This paper presents the results from the low-speed wind tunnel tests of a 1/64 scale model of a Mach 6 viscous optimized waverider with aerodynamically sharp leading edges and a sharp-edged delta wing with the same length, span, and base thickness as the waverider. The tests were conducted in the spring of 1988 at the University of Maryland's Glenn L. Martin Wind Tunnel. The tests were designed to determine the nature of the subsonic flow field of the waverider and to determine the applicability of existing subsonic theory regarding delta wings to the low-speed aerodynamics of waveriders. Also, a comparison was made between the low-speed performance of the waverider and existing hypersonic vehicles like the X-15 and the Space Shuttle. Author

A91-25749*# Maryland Univ., College Park.
SEVERAL FAMILIES OF VISCOUS OPTIMIZED WAVERIDERS - A REVIEW OF WAVERIDER RESEARCH AT THE UNIVERSITY OF MARYLAND
JOHN D. ANDERSON, JR., MARK J. LEWIS (Maryland, University, College Park), and STEPHEN CORDA (Johns Hopkins University, Laurel, MD) IN: International Hypersonic Waverider Symposium,

1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 39 p. Research supported by NASA. refs

Theoretical and experimental research conducted by the Hypersonic Group at the University of Maryland in the area of viscous optimized waveriders is reviewed. In particular, the motivation for this class of waveriders is discussed, and results obtained to date are presented. Various waverider families generated from different flows and designed for different applications are examined, including waveriders using chemically reacting flow effects and very high altitude applications. V.L.

A91-25750*# University of Southern California, Los Angeles.
FLAT PLATE AT INCIDENCE AS A WAVERIDER IN RAREFIED HYPERSONIC FLOW
H. K. CHENG, E. Y. WONG, L. N. HOOVER (Southern California, University, Los Angeles, CA), and V. K. DOGRA (Vigyan Research Associates, Inc., Hampton, VA) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 32 p. Research supported by DOD. refs
(Contract NAGW-1061)

The physical validity of continuum models and their ability to predict the critical aerothermodynamic properties of a waverider at high altitudes are examined using a flat plate at angle of attack as a generic hypersonic lifting vehicle. For a shock layer far from local translational equilibrium, a theoretical study based on Grad's thirteen-moment equations shows that the Navier-Stokes based solutions can correctly predict the drag, lift, and surface heat transfer rate, with the prediction error comparable to that of the standard shock-layer theory. The conclusion is supported by a comparison with direct simulation Monte Carlo calculations. V.L.

A91-25751*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FLOW FIELD ANALYSIS FOR A CLASS OF WAVERIDER CONFIGURATIONS
ANUTOSH MOITRA (NASA, Langley Research Center; High Technology Corp., Hampton, VA) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 16 p. refs

A package of computer codes for analysis of flow fields for waverider configurations is described. The package consists of a surface/volume grid generator and a finite-volume flow solver. The grid generator defines body geometries and computational grids by an algebraic homotopy procedure. The algebraic procedure is versatile in its application and can readily generate configurations in the class of blended wing-body geometries. This code has the ability to produce a wide variety of geometries in the given class with varying geometrical attributes. The flow solver employs a finite-volume formation and solves the explicit, Runge-Kutta integration technique. The method or flow simulation incorporates several techniques for acceleration of the convergence of the interaction process and an entropy corrected enthalpy damping procedure for efficient computation of high Mach number flows. Author

A91-25752#
HYPERSONIC VISCOUS FLOWS AROUND WAVERIDER CONFIGURATIONS
SAJID R. CHAUDHRY, NING QIN, and B. E. RICHARDS (Glasgow, University, Scotland) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 33 p. refs

Results of a numerical simulation of viscous effects in waverider flows are presented for two waverider configurations: a caret wing and a cone with two symmetric negative dihedral delta wings. In the presence of a boundary layer, the viscous effects are shown to have a significant influence over different flow field parameters. Furthermore, in the presence of a strong shock, viscous effects cannot be ignored even in some low supersonic flow cases. A comparison between computational and experimental results suggests that a locally conical Navier-Stokes code can be effectively used for the shapes studied to provide an understanding of the flow process since it gives considerable detail of the flow phenomenon. V.L.

A91-25753#
NONEQUILIBRIUM EFFECTS ON THE AERODYNAMIC HEATING OF HYPERSONIC WAVERIDER VEHICLES
GEORGE R. INGER (Iowa State University of Science and Technology, Ames) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 25 p. refs

The aerodynamic heating aspect of waverider vehicle configurations is examined in the high altitude hypersonic flight regime when nonequilibrium dissociation/recombination in the flow field and finite surface catalysis effects are both important. Analyses of these effects are given for three important heating regions: the nose, the swept wing leading edge attachment line, and the windward body centerline. Moreover, closed form relationships for the relative nonequilibrium effects are developed for each region that enable both computer code-prediction validation and cost-effective parametric engineering studies. Author

A91-25754#
SIMULATION OF HYPERSONIC WAVERIDER FLOW
B. MUELLER, P. NIEDERDRENK, and H. SOBIECZKY (DLR, Institut fuer Theoretische Stroemungsmechanik, Goettingen, Federal Republic of Germany) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 32 p. refs

An effective computational approach is presented which consists of a fast adaptive hyperbolic grid generator and an upwind relaxation marching method for solving three-dimensional Euler equations. Details of the solution procedure are presented, as are test results obtained for several configurations, including waveriders with sharp and rounded leading edges and a Saenger forebody. V.L.

A91-25756#
A NEW LAGRANGIAN METHOD FOR STEADY HYPERSONIC FLOW COMPUTATION
GRAFTON W. H. HUI and C. Y. LOH (Waterloo, University, Canada) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 32 p. Research supported by NSERC. refs

A Godunov shock capturing scheme and a second order TVD scheme are employed to solve the Euler equations for steady supersonic/hypersonic flow using a new Lagrangian formulation for steady flow that requires only three independent variables (two stream functions and the Lagrangian time). The new Lagrangian approach is shown to be superior to the conventional Eulerian method. In particular, the Lagrangian method requires no grid generation, yet the flow tangency condition on the solid boundary is automatically satisfied; it resolves slip line (contact line) discontinuities crisply, and its accuracy improves with increasing Mach number, making it more suitable for hypersonic flow computations. V.L.

A91-25840
AN EFFICIENT FINITE-DIFFERENCE ALGORITHM FOR COMPUTING AXISYMMETRIC TRANSONIC NACELLE FLOW FIELDS
MINGKE HUANG (Nanjing Aeronautical Institute, People's Republic of China) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 3, Nov. 1990, p. 225-232. refs
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A finite difference method for computing the axisymmetric, transonic flows over a nacelle is presented in this paper. By use of the conservative full-potential equation, body-fitted grid, and exact boundary conditions, a new AF scheme is constructed according to the criterion of optimum convergence. The proposed scheme has been applied to transonic nacelle flow problems.

Computation for several nacelles shows the rapid convergence of this scheme and excellent agreement with the experimental results. Author

A91-25842
DIGITAL GENERATION OF TWO-DIMENSIONAL FIELD OF TURBULENCE FOR FLIGHT SIMULATION
YELUN XIAO (Beijing University of Aeronautics and Astronautics, People's Republic of China) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 3, Nov. 1990, p. 239-245. Research supported by NNSFC.
Copyright

In some special cases of flight simulation a two-dimensional field of turbulence must be generated in which the turbulent wind speeds are stochastic functions of two coordinates. For this purpose a simple and efficient technique for the digital generation of a two-dimensional field of turbulence; i.e., for the production of turbulent speed sequences on a rectangular network, is proposed in this paper. The correlation of the turbulent field so generated is found to be in good agreement with the theoretical correlation of the turbulence model, and thus the feasibility of the proposed method is verified. Two possible operation modes (off-line and on-line) of the turbulence generator in flight simulation are also discussed. Author

A91-25876#
2-E FORCING FUNCTION EFFECTS ON TURBOMACHINE GUST UNSTEADY AERODYNAMICS
STEVEN R. MANWARING and SANFORD FLEETER (Purdue University, West Lafayette, IN) Journal of Aerospace Power (ISSN 1000-8055), vol. 6, Jan. 1991, p. 2-8. refs
(Contract F49620-88-C-0022)

To investigate the forcing function effects on the fundamental 2-E gust unsteady aerodynamic response of a multistage turbomachine blade row, a series of fundamental experiments are performed in an axial flow research compressor. The 2-E unsteady aerodynamic forcing function excitations are generated by both a circumferential inlet flow distortion and the wakes from airfoil-type obstructions which are representative of an airfoil, strut, or probe excitation. Author

A91-25878#
EXPERIMENTAL INVESTIGATION OF TURBULENT DRAG REDUCTION IN COMPRESS CASCADE
RUNTIAN MIAO, LIANGUI WANG (Shenyang Aeroengine Manufacture Co., People's Republic of China), GE GAO, and ZHIMING TANG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 6, Jan. 1991, p. 13-16. In Chinese, with abstract in English.

Recent theory and experiments indicate that turbulent drag is directly related to tiny coherent (organized) structure inside the turbulent boundary, and in a turbulent flowfield the flow drag of a specially designed nonsmooth surface can be less than that of a smooth surface. Based on this theory, six compressor cascades with different patterned surfaces have been studied. The profile of the cascades was chosen from a stator vane of a reference compressor. The experiments have been performed in a near-sonic wind tunnel. The results obtained at the same Mach number as the reference compressor works indicate that the appropriate patterns on the surface improve the performances of cascades. Compared with the reference smooth cascade, the best one of six tested cascades raised the critical Mach number by 7.3 percent. The air flow deflection angle at the design conditions increased by 0.9 deg. Correspondingly, the deviation angle decreased by 0.9 deg. Maximum static compression ratio rises by 0.0177. Author

A91-25879#
PREDICTION OF STALL MARGIN FOR MULTISTAGE AXIAL-FLOW COMPRESSORS
JIUNQIANG ZHU and ZHIWEI LIU (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 6, Jan. 1991, p. 17-20. In Chinese, with abstract in English.

Two methods for predicting the onset of rotating stall in multistage axial flow compressors are provided in this paper. First, the semiempirical criterion about the isolated blade row is extended to the analysis of the multistage axial flow compressors. The downstream condition of preceeding stage is considered as the upstream one of the next stage and a similar calculation is made for every stage. By comparing the flows for each unit at the onset of rotating stall, the stall margin of the multistage compressor can be determined. The results of the prediction agree with the experimental data fairly well. Secondly, with the help of the unsteady two-dimensional incompressible flow model, the inception criterion of rotating stall for a double stages axial flow compressor is derived in detail according to a small disturbance stability theory. The characteristic equation is solved iteratively using a Newton-Raphson scheme. Good agreement between the analytical and experimental results indicates that the analysis is believable. These approaches can be used to predict the stall margin for subsonic and transonic multistage axial flow compressors. Author

A91-25883#
INFLUENCE OF DOWNSTREAM DISTORTION ON PERFORMANCE OF AXIAL COMPRESSOR
JUN HU, GUOCAL TANG, and HUIMIN ZHANG (Nanjing Aeronautical Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 6, Jan. 1991, p. 33-37. In Chinese, with abstract in English. refs

The development of a new method to predict the unstalled characteristics and the onset of flow instability is described for an axial compressor operating in a circumferentially distorted downflow. This method adopts the 'semi-actuator disk' to replace the blade rows of the compressor and the downstream distorting component, and assumes the flow fields outside the disks to be two-dimensional, ideal, compressible, and unsteady. The effects of total pressure distortion coefficient and spacing between the compressor and the distorting component on the performance of a compressor have been investigated in detail by means of this method. It is found that the losses of both pressure rise and axial flow coefficient at instability increase linearly with the distortion coefficient, a conclusion similar to that for inlet flow distortion. The spacing has a crucial effect on the losses of both pressure rise and axial flow coefficient too. Author

A91-25884#
THROUGHFLOW CALCULATION IN AN AXIAL-FLOW COMPRESSOR STAGE USING AVERAGED NAVIER-STOKES EQUATIONS
FANGYUAN ZHU (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 6, Jan. 1991, p. 38-40. In Chinese, with abstract in English.

The averaged N-S and the zero equations or two-equation models of the turbulent flow are presented in order to model the viscous flow of the throughflow in the stage and multistage of turbomachinery. The application of the zero-equation model of the turbulent flow is described. An effective method to handle the end wall conditions is presented and the results of the throughflow calculation in the stages of a transonic axial compressor are given. The comparison of the computed results with the experimental data shows that the model and method provided are feasible and effective. Author

A91-26076#
NAVIER-STOKES CALCULATIONS OF HYPERSONIC FLOW CONFIGURATIONS WITH LARGE SEPARATION BY AN IMPLICIT NON-CENTERED METHOD
C. MARMIGNON, F. COQUEL (ONERA, Chatillon, France), and H. HOLLANDERS (Aerospatiale, Les Mureaux, France) (ICNMFD, Meeting, 12th, Oxford, England, July 9-13, 1990) ONERA, TP no.

1990-172, 1990, 6 p.
(ONERA, TP NO. 1990-172)

Hypersonic laminar flows on a two-dimensional ramp (M0 = 5.0, Re = 1.5 x 10 to the 6th) and on a double ellipse and a double ellipsoid (M0 = 8.15, Re = 1.67 x 10 to the 7th) are simulated numerically for angles of attack 0 and 30 deg. The complete time-dependent Navier-Stokes equations are solved using the implicit noncentered finite-volume method described by Hollanders and Marmignon (1989), and the results are presented graphically. Good general agreement with published experimental data is demonstrated, with the exception of some heat-flux predictions. D.G.

A91-26081#
DETERMINATION OF VORTEX-BREAKDOWN CRITERIA BY SOLVING THE EULER AND NAVIER-STOKES EQUATIONS [DETERMINATION DE CRITERES D'ECLATEMENT TOURBILLONNAIRE PAR RESOLUTION DES EQUATIONS D'EULER ET DE NAVIER-STOKES]
T. H. LE, PH. MEGE (ONERA, Chatillon, France), and Y. MORCHOISNE (ONERA, Chatillon; Paris VI, Universite, France) (NATO, AGARD, Symposium on Vortex Flow Aerodynamics, 6th, Scheveningen, Netherlands, Oct. 1-4, 1990) ONERA, TP no. 1990-180, 1990, 11 p. In French. Research supported by DRET. refs
(ONERA, TP NO. 1990-180)

A parametric study based on numerical simulations which solve Euler and Navier-Stokes equations is performed on the configuration of an isolated vortex subjected to an initial perturbation. An analysis of the vortex-breakdown characteristics indicates the phenomenon appears abruptly, the phenomenon is three-dimensional and unsteady by nature, and the turbulence is characterized by small-scale structures that are established at a specified moment. This analysis permits a criterion to be specified that is based on an appropriately defined local Rossby number to determine the area where breakdown occurs. R.E.P.

A91-26093#
THE USE OF TURBULENCE MODELS TO CALCULATE COMPRESSIBLE FLOWS IN TURBOMACHINES [MISE EN OEUVRE DE MODELES DE TURBULENCE POUR LE CALCUL D'ECOULEMENTS COMPRESSIBLES EN TURBOMACHINES]
LAURENT CAMBIER (ONERA, Chatillon, France) and CHRISTOPHE VUILLEZ (SNECMA, Moissy-Cramayel, France) ONERA, TP no. 1990-192, 1990, 22 p. In French. Research supported by DRET. refs
(ONERA, TP NO. 1990-192)

It is noted that, in order to correctly predict flow in turbomachine vane assemblies in terms of performance and operational limits, it is necessary to take into account the phenomena associated with the viscosity of the fluid and in particular to provide an appropriate description of the turbulence. A review is presented of quasi-three-dimensional calculations used in designing vane assemblies. Several models are presented that were tested on reference configurations and the provisional solution for the quasi-three-dimensional code in operation and for the three-dimensional code in development. Results of various calculations illustrating these different points are described. Finally, based on the results obtained, the methodology to be followed to determine the reliability required for the forecasting of internal turbulent flows is described. R.E.P.

A91-26096#
EXPERIMENTAL STUDY OF THE SHOCK/BOUNDARY LAYER INTERACTION AT HIGH MACH NUMBER [ETUDE EXPERIMENTALE DE L'INTERACTION ONDE DE CHOC-COUCHE LIMITE A GRAND NOMBRE DE MACH]
MARIE-CLAIRE COET, BRUNO CHANETZ, and JEAN DELERY (ONERA, Chatillon, France) (Journees d'Etudes sur les Ecoulements Hypersoniques, Roscoff, France, Oct. 22-24, 1990) ONERA, TP no. 1990-198, 1990, 13 p. In French. Research supported by Dassault Aviation. refs
(ONERA, TP NO. 1990-198)

The purpose of this study is to simulate the viscous interaction phenomena that develop on the control surfaces or wing-fuselage joints of a hypersonic aircraft during reentry into the atmosphere. Wind tunnel tests have been conducted to increase understanding of the viscous interaction phenomena, and to determine the factors required to validate the computation codes. These tests were performed on models cooled by the internal circulation of liquid nitrogen, in order to obtain more practical wall temperature/friction temperature ratios. Tests on two- and three-dimensional obstacles utilized schlieren photography and visual displays using viscous coating and thermal sensitive paint, as well as pressure measurements and heat flux. Results of the three-dimensional flow tests at Mach 10 characterize two obstacles with laminar boundary layer at the separation level. For these two obstacles the laminar flow type is confirmed by the diminution of the flux coincident with the formation of the primary separation. R.E.P.

A91-26111*# Vigyan Research Associates, Inc., Hampton, VA.
PREDICTION OF VORTICAL FLOWS ON WINGS USING INCOMPRESSIBLE NAVIER-STOKES EQUATIONS
C.-H. HSU (Vigyan Research Associates, Inc., Hampton, VA) and C. H. LIU (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Nov. 1990, p. 913, 914. refs
(Contract NAS1-18585)
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Grid-density and Reynolds-number effects on integral values and static pressure distributions are presently studied in the steady-state Navier-Stokes solutions obtained for the flow around a round-edged double delta wing using an upwind-relaxation finite-difference algorithm. It is found that while the computed longitudinal aerodynamic coefficients are in good agreement with extant experimental data, the magnitudes of suction-pressure peaks are underpredicted in the vicinity of the trailing edge. It is judged that additional computations employing finer-grid solutions in the vortical flow region are required. O.C.

A91-26115#
TURBULENT-FLOW CALCULATIONS FOR FLOW OVER WINGS NEAR MAXIMUM LIFT
J. E. DEESE and R. K. AGARWAL (McDonnell Douglas Research Laboratories, Saint Louis, MO) Journal of Aircraft (ISSN 0021-8669), vol. 27, Nov. 1990, p. 929-935. Research supported by Douglas Aircraft Co. Previously cited in issue 21, p. 3253, Accession no. A89-47693. refs
Copyright

A91-26116#
SERIES COMPLEX-POTENTIAL SOLUTION OF FLOW AROUND ARBITRARY AIRFOILS
M. F. ZEDAN (King Saud University, Riyadh, Saudi Arabia) Journal of Aircraft (ISSN 0021-8669), vol. 27, Nov. 1990, p. 936-940. refs
Copyright

An accurate, concise, and numerically efficient method has been developed to solve incompressible irrotational flow around arbitrary airfoils. The airfoil is transformed into a near-circular shape by an inverse Joukowski transformation. The flow around the transformed shape is then solved by adding a uniform flow, a circulation, and a series complex potential. The method gives almost exact results for a number of Karman-Trefftz airfoils with widely varying geometrical parameters and for the NACA 0012 wing section. For most of these airfoils, the method has been found to be generally more accurate than the Hess-Smith panel method, but at a fraction of the numerical labor. Author

A91-26117#
APPLICATIONS OF AN EULER AERODYNAMIC METHOD TO FREE-VORTEX FLOW SIMULATION
P. RAJ, J. M. KEEN, and S. W. SINGER (Lockheed Aeronautical Systems Co., Burbank, CA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Nov. 1990, p. 941-949. Research supported by Lockheed Aeronautics Systems Co. Previously cited in issue 16, p. 2592,

Accession no. A88-40708. refs
(Contract F33615-84-C-3005)
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A91-26118#
DETERMINATION OF THE AERODYNAMIC CHARACTERISTICS OF THE MISSION ADAPTIVE WING
STEPHEN B. SMITH (USAF, Flight Test Center, Edwards AFB, CA) and DAVID W. NELSON (Boeing Advanced Systems, Seattle, WA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Nov. 1990, p. 950-958. Previously cited in issue 16, p. 2594, Accession no. A88-40733. refs

A91-26120#
DESIGN OF A NATURAL LAMINAR FLOW AIRFOIL FOR LIGHT AIRCRAFT
K. R. SRILATHA, G. S. DWARAKANATH, and P. RAMAMOORTHY (National Aeronautical Laboratory, Bangalore, India) Journal of Aircraft (ISSN 0021-8669), vol. 27, Nov. 1990, p. 966-968. refs
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A novel, natural laminar flow (NLF) airfoil for light aircraft, designated NLF-208, has been shown to outperform the Wortmann-profile FX-60-177 in L/D potential, and to be more structurally practical in virtue of its greater thickness. Its potential fabrication difficulties have prompted a modification of the airfoil to incorporate a degree of trailing-edge bluntness. An analysis is presented which demonstrates that the blunter trailing edge, and any surface waviness due to fabrication, have no significant deleterious effect on performance characteristics. O.C.

A91-26122#
AIRFOIL DESIGN FOR ENDURANCE UNMANNED AIR VEHICLES
RICHARD M. HOWARD (U.S. Naval Postgraduate School, Monterey, CA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Nov. 1990, p. 971-973. refs

The Eppler and Somers (1980) method has been used to develop a low Reynolds number airfoil suitable for long-endurance flight unmanned air vehicles. Airfoil performance parameters are compared with those of other airfoils under consideration for the same requirements. It is established that substantial chord percentages of natural laminar flow are not a primary requirement of all aircraft designs; in order to maximize endurance, a tradeoff between increased drag at low lift coefficient values and reduced drag at very high lift conditions may prove beneficial. O.C.

A91-26123#
CONSTANT SWIRL ANGLE INLET GUIDE VANES
RICHARD M. ANDRES (Saint Louis University, Cahokia, IL) Journal of Aircraft (ISSN 0021-8669), vol. 27, Nov. 1990, p. 973, 974.
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Constant swirl-angle inlet guide vanes for increasing the operating envelope of a wind-tunnel compressor are obtainable via flapped inlet guide vanes having a constant flap chord percentage in conjunction with a constant solidity; the constant solidity yields a guide vane geometry whose vane chord is proportional to radius. While for small turning angles the axial velocity variation is small, and the tangential velocity nearly constant, large turning angles involve the tangential and radial velocity components' approach of an inverse-radius relationship. O.C.

A91-26133
LAMINAR FLOW ANALYSIS OF A ROTOR IN HOVER
R. GANESH RAJAGOPALAN (Iowa State University of Science and Technology, Ames) and CHIN K. LIM American Helicopter Society, Journal (ISSN 0002-8711), vol. 36, Jan. 1991, p. 12-23. Research supported by the Iowa State University of Science and Technology. refs
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A new, self-contained procedure has been developed to analyze the flowfield and performance of helicopter rotors. The steady, laminar Navier-Stokes equations are solved in an axisymmetric cylindrical coordinate system. The spinning rotor is idealized as point momentum sources distributed along the span of the rotor with functional relationship to the local flow conditions. The method has been tested on several rotors in hover and the integrated performance, the rotor loads, and the wake correlation results compare very well with experimental data. In additon, overall flowfield characteristics are in agreement with the physics of the flow. Both the far wake and the near wake are captured by the solution procedure. Author

A91-26192*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE AERODYNAMIC CHARACTERISTICS OF VORTEX INGESTION FOR THE F/A-18 INLET DUCT
BERNHARD H. ANDERSON (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 39 p. Previously announced in STAR as N91-15303. refs
(AIAA PAPER 91-0130) Copyright

A Reduced Navier-Stokes (RNS) solution technique was successfully combined with the concept of partitioned geometry and mesh generation to form a very efficient 3-D RNS code aimed at the analysis-design engineering environment. Partitioned geometry and mesh generation is a pre-processor to augment existing geometry and grid generation programs which allows the solver to (1) recluster an existing gridlife mesh lattice, and (2) perturb an existing gridfile definition to alter the cross-sectional shape and inlet duct centerline distribution without returning to the external geometry and grid generator. The present results provide a quantitative validation of the initial value space marching 3-D RNS procedure and demonstrates accurate predictions of the engine face flow field, with a separation present in the inlet duct as well as when vortex generators are installed to suppress flow separation. The present results also demonstrate the ability of the 3-D RNS procedure to analyze the flow physics associated with vortex ingestion in general geometry ducts such as the F/A-18 inlet. At the conditions investigated, these interactions are basically inviscid like, i.e., the dominant aerodynamic characteristics have their origin in inviscid flow theory. Author

A91-26195#
INVISCID STABILITY OF HYPERSONIC STRONG INTERACTION FLOW OVER A FLAT PLATE
NORMAN D. MALMUTH (Rockwell International Science Center, Thousand Oaks, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 14 p. refs
(AIAA PAPER 91-0031) Copyright

Viscous hypersonic flow near the leading edge of a flat plate is investigated, applying a method which combines multistructured asymptotic theory with numerical techniques. Asymptotic expansions valid for a process at high Reynolds number and Mach number and small flow deflection are substituted into the laminar Navier-Stokes equations and boundary conditions, recovering the two-deck structure (cool inviscid shock layer and hot boundary layer) found by Stewartson (1964). These decks are then used to describe a steady mean flow, on which small-amplitude unsteady fluctuations are superimposed. Numerical results on the propagation of these disturbances are presented in graphs for different initial conditions, frequencies, and specific heat ratios. Higher amplification is found to be associated with higher frequencies and thinner shock layers, the latter related to high Mach number and high-temperature effects on the specific heat ratio. The applicability of the present analysis to the NASP program is indicated. D.G.

A91-26327*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ICING CHARACTERISTICS OF A NATURAL-LAMINAR-FLOW, A MEDIUM-SPEED, AND A SWEPT, MEDIUM-SPEED AIRFOIL
COLIN S. BIDWELL (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan.

7-10, 1991. 32 p. refs
(AIAA PAPER 91-0447) Copyright

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

A91-26330*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PREDICTION OF ICE SHAPES AND THEIR EFFECT ON AIRFOIL PERFORMANCE
JAIWON SHIN (NASA, Lewis Research Center, Cleveland, OH), BRIAN BERKOWITZ (NASA, Lewis Research Center, Cleveland; Sverdrup Technology, Inc., Brook Park, OH), HSUN H. CHEN, and TUNCER CEBECI (California State University, Long Beach) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 22 p. refs
(AIAA PAPER 91-0264) Copyright

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

A91-26331*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
IMPROVED VISUALIZATION OF FLOW FIELD MEASUREMENTS
JEFFREY HILTON MILES (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 36 p. refs
(AIAA PAPER 91-0273) Copyright

A capability is proposed that makes it feasible to apply to measured flow field data the visualization tools developed to display numerical solutions for computational fluid dynamic problems. The measurement monitor surface (MMS) methodology was used for the analysis of flow field measurements within a low-aspect-ratio transonic axial-flow fan rotor acquired with two-dimensional laser anemometry. It is shown that the MMS method may be utilized to generate input for the multidimensional processing and analytical tools developed for numerical flow field simulation data. Thus an experimenter utilizing an interactive graphics program could illustrate scalar quantities such as Mach number by profiles, contour lines, carpet plots, and surfaces employing various color intensities. Also, flow directionality can be shown by the display of vector fields and particle traces. R.E.P.

A91-26448
THEORY AND PRACTICE OF THE AERODYNAMIC EXPERIMENT [TEORIIA I PRAKTIKA AERODINAMICHESKOGO EKSPERIMENTA]
EVGENII L. BEDRZHITSKII, BORIS S. DUBOV, and ALEKSANDR N. RADTSIG Moscow, Izdatel'stvo MAI, 1990, 216 p. In Russian. refs
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The principles and methods of wind tunnel testing are examined with particular reference to the planning, preparation, and organization of the aerodynamic experiment; processing of test results; and principles of the gasdynamic analysis of wind tunnels. Attention is given to the typical equipment of a wind tunnel testing facility and to the general design and layout of measuring instruments and data processing and measuring systems. The methods and means of the metrological support of wind tunnel testing are also discussed. V.L.

A91-26564#
INFLUENCE OF EXIT-BOUNDARY CONDITIONS ON TRANSONIC-DIFFUSER FLOW FIELDS
JUNFEI YIN and CHENGYI PENG (Nanjing Aeronautical Institute, People's Republic of China) Journal of Propulsion Technology (ISSN 1001-4055), Feb. 1991, p. 19-23. In Chinese, with abstract in English. refs

An experimental investigation of normal-shock-wave/turbulent-boundary-layer interaction in a transonic diffuser was made between the choked and the nonchoked exit condition. The divergent angle of the diffuser was 6 deg, and the Mach number before the shock wave was 1.335. The experimental results showed that, in the nonchoked exit-boundary condition, the rms shock oscillation, the scale of the separation bubble, and the boundary-layer growth were greater than those in the choked condition. For the straight-wall diffuser, the ratio of rms shock oscillation to the length of separation bubble was nearly constant. Author

A91-26679#
A INVISCID-VISCOUS INTERACTION METHOD TO PREDICT THE THREE-DIMENSIONAL TRANSONIC VISCOUS FLOW PERFORMANCE OF AXIAL TURBINE
MANCHU GE, JIANQIAO LUO, YINGPING LOU, HONGSHENG LIU, and GUOLING ZHANG (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 11, Nov. 1990, p. 369-375. In Chinese, with abstract in English. refs

An alternative iterative method solving the three-dimensional transonic viscous flow performance has been successfully developed. A three-dimensional potential equation is deduced with the nonorthogonal curvilinear coordinates for the inviscid region. A corresponding general boundary layer differential equation is deduced for viscous region. A direct solving method is adopted for the potential equation. With this method developed in this paper, the main characteristics of three-dimensional viscous flow can be shown obviously for the calculation of turbomachine. Several examples were calculated. The calculated results show that this method is reasonable and satisfactory. Author

A91-26680#
PRESSURE BASED CALCULATION METHOD USED FOR NOZZLE FLOWS
ZHONGQIU DU and JIANZHONG XU (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 11, Nov. 1990, p. 376-380. In Chinese, with abstract in English.

The pressure-based method of predicting all speed flows under the nonorthogonal coordinates is one of the advanced methods developed in recent years. In this paper, the characteristics of the pressure equation and the calculation methods are discussed, and a new pressure equation for compressible flows is suggested by introducing the density influence implicitly. The calculated examples of nozzle flows with large variation of Mach number demonstrate that both the method and computer code in the study are practical and effective, and can be widely used. Author

A91-26682#
A THROUGHFLOW CALCULATING METHOD OF AXIAL COMPRESSOR WITH TURBULENT MIXING
JIANYI DU and JIANZHONG XU (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 11, Nov. 1990, p. 385-388. In Chinese, with abstract in English. refs

A method for dealing with second flows and turbulent diffusion and mixing simultaneously is presented. In the method, viscous terms are included in the equation of stream function. The computing results show that, compared to the current methods, this method is accurate and more suitable for engineering.
Author

A91-26683#
RESEARCH OF ONSET OF ROTATING STALL FOR COMPRESSIBLE FLOW
JUNQIANG ZHU and ZHIWEI LIU (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 11, Nov. 1990, p. 389-392. In Chinese, with abstract in English.

With the help of an unsteady two-dimensional compressible flow model, the inception criterion of rotating stall for double and single blade row in axial compressor has been derived. Good agreement between the theoretical and experimental results indicate that the theoretical analysis is trustworthy. Influence of compressibility on the onset boundary of rotating stall is discussed.
Author

A91-26686#
NUMERICAL SIMULATION OF TRANSONIC FLOW IN CASCADES
SHUNLONG LIU and HONG YANG (Harbin Shipbuilding Engineering Institute, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 11, Nov. 1990, p. 400-403. In Chinese, with abstract in English. refs

On the basis of Deton (1982), a time-dependent finite volume method is proposed. The paper starts from the basic equations in integral form and adopts a simple quadrilateral grid. The differencing scheme constructed in the paper is stable and capable of determining the position of shock waves correctly. The method is applied to calculating transonic flowfields with shock waves of three plane cascades and a cascade of arbitrary stream surface of revolution. The computed results show that the blade-surface pressure and Mach-number distributions coincide well with experimental data.
Author

A91-27251
A CRITERION FOR LEADING-EDGE SEPARATION
E. O. TUCK (Adelaide, University, Australia) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 222, Jan. 1991, p. 33-37. refs
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The aerodynamic stall problem of determining of the critical angle of attack above which the laminar boundary layer separates near the leading edge is theoretically addressed. It is shown that, at least as a prediction of laminar leading-edge separation, the appropriate rate of increase is as the square root of the nose radius. Specifically, the angle of attack in radians at which the leading-edge separation first occurs is proportional to the square root of the ratio of nose radius to chord, the coefficient of proportionality being about 0.818.
C.D.

A91-27258
ON THE STRUCTURE OF HIGH-REYNOLDS-NUMBER SUPERSONIC TURBULENT BOUNDARY LAYERS
ERIC F. SPINA, JOHN F. DONOVAN, and ALEXANDER J. SMITS (Princeton University, NJ) Journal of Fluid Mechanics (ISSN 0022-1120), vol. 222, Jan. 1991, p. 293-327. refs
(Contract AF-AFOSR-88-0120)
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Experimental results are presented that reveal key features of the large-scale organized structures in a supersonic, turbulent boundary layer. Space-time correlation results indicate the existence of large-scale structures of a size comparable to delta, with a spanwise extent only slightly less than the vertical scale. The convection velocity of the large-scale motions is nearly constant across 80 percent of the boundary layer and is equal to approximately 0.9U(infinity). It is shown that positive events detected with the VITA conditional sampling technique correspond to steep gradients in the streamwise mass flux which extend across most of the boundary layer. These sharp gradients appear to be the upstream interfaces of large-scale turbulent 'bulges', similar to those seen in incompressible boundary layers.
Author

A91-27338
HYPERSONIC AND HIGH TEMPERATURE GAS DYNAMICS
JOHN D. ANDERSON, JR. (Maryland, University, College Park) New York, McGraw-Hill, 1989, 704 p. refs
Copyright

The fundamental principles of hypersonic flow analysis and high-temperature gas dynamics are presented in a textbook for advanced undergraduate or graduate engineering students. Chapters are devoted to hypersonic shock and expansion-wave relations, local surface inclination methods, approximate and exact methods for hypersonic inviscid flowfields, viscous hypersonic flows, the thermodynamics of chemically reacting gases, statistical thermodynamics, and kinetic theory. Consideration is given to chemical and vibrational nonequilibrium, inviscid high-temperature equilibrium and nonequilibrium flows, transport properties in high-temperature gases, viscous high-temperature flows, and radiative gas dyamics. Diagrams, drawings, graphs, photographs, and sample problems are provided.
D.G.

A91-27508
NUMERICAL SIMULATION OF VORTEX BREAKDOWN ONSET
WU ZHANG (Beijing University, People's Republic of China), SHIJUN LUO (Northwestern Polytechnical University, Xian, People's Republic of China), and PEIYE ZHU (Ministry of Aeronautics and Astronautics Industry, Institute for Computing Technology, Xian, People's Republic of China) International Journal of Engineering Science (ISSN 0020-7225), vol. 29, no. 2, 1991, p. 237-242.
Copyright

Based on an improved inviscid multiple line-vortex model (MLVM), numerical simulation for vortex flows over a pointed-nose body of revolution at high angles of attack is used to study the vortex breakdown onset. The result indicates that vortex breakdown occurs at angle of attack 38 deg with the special initial locations of the free vortex lines given, which coincides with the result of flow visualization in a water tunnel. The calculations also show that the adverse pressure gradient may be one of the reasons which result in vortex breakdown.
Author

A91-27515
APPROXIMATE INVERSE METHOD OF COMPUTING AIRFOIL SECTION SHAPE [PRIBLIZNA INVERZNI METODA PRO VYPOCET TVARU PROFILU]
PETR BERAK Zpravodaj VZLU (ISSN 0044-5355), no. 4, 1990, p. 179-191. In Czech. refs
Copyright

The paper summarizes linearized formulas for computing airfoil section shape from the required velocity distribution on the airfoil section under conditions of shock-free flow past the leading edge. A simple numerical computational method was designed and verified. The consequences of linearization are demonstrated on examples. Much better results than with computation of the whole thickness and camber of the airfoil are attained for the modifications of well-tried airfoil sections. An example is introduced showing a reduction of moment to 40 percent with respect to the MS(1)-0313, where the probable reduction of maximum lift coefficient was only 0.08.
Author

A91-27516
FINITE DIFFERENCE METHOD FOR TWO- AND THREE-DIMENSIONAL INVISCID STEADY TRANSONIC FLOWS IN A CHANNEL [METODA SITI PRO RESENI STACIONARNIHO ROVINNEHO A PROSTOROVEHO NEVAZKEHO TRANSSONICKEHO PROUDENI V KANALE]
KAREL KOZEL and NGUYEN VAN NHAC Zpravodaj VZLU (ISSN 0044-5355), no. 4, 1990, p. 193-198. In Czech.
Copyright
A method of numerical solution of two- and three-dimensional steady inviscid flows in a channel is discussed. The flow field is described by an unsteady system of Euler equations that is solved using the MacCormack difference scheme. The numerical results obtained are compared to those obtained using one-dimensional theory. Author

A91-27518
AERODYNAMIC MODIFICATION OF MS AIRFOIL SECTIONS [AERODYNAMICKE MODIFIKACE PROFILU MS]
PETR BERAK Zpravodaj VZLU (ISSN 0044-5355), no. 5, 1990, p. 253-267. In Czech. refs
Copyright
A method of designing new airfoil sections by using local changes of pressure distribution from a well-tried airfoil section is intruduced. A nonsimplified inverse method is necessary for attaining precise pressure distributions. The concept and verification of an iterative inverse computation program developed in the Aeronautical Research and Test Institute is described. The development of the airfoil sections was based upon the MS(1)-0313 and MS(1)-0317 airfoil sections because they attain high lift coefficients. New airfoil sections having similar lift distributions and zero-lift moment reduced to the range from 46 to 25 percent were computed. A 30 percent straight segment was attained on the lower side of the trailing edge of the D30 airfoil sections; the K25 airfoil sections have, in addition, a 25 percent straight segment on their upper sides. Author

A91-27519
NUMERICAL SOLUTION OF STEADY VISCOUS COMPRESSIBLE FLOWS OVER A FLAT PLATE [NUMERICKE RESENI STACIONARNIHO OBTEKANI DESKY VAZKOU STLACITELNOU TEKUTINOU]
KAREL KOZEL (Chech Technical University, Prague, Czechoslovakia) and JAROSLAV LAIN (State Research Institute for Machine Construction, Bechovice, Czechoslovakia) Zpravodaj VZLU (ISSN 0044-5355), no. 5, 1990, p. 269-280. In Czech. refs
Copyright
The work deals with numerical solution of steady laminar compressible flows over a flat plate described by a system of Navier-Stokes equations for different Re. Three difference schemes were used for numerical solution: an unsplit MacCormack predictor and two Runge-Kutta methods. A time-dependent method was used to compute a steady state solution. The aim of this work is to test the suitability of the difference schemes and artificial viscosity as well as properties of the convergence of the methods to a steady state. Numerical results for Re = 100, 500, 1000, 10,000 and freestream M = 0.2 were compared to the Blasius solution for the case of viscous incompresible flows over a flat plate. Author

A91-27524
EXPERIMENTAL INVESTIGATION OF THE TRANSONIC CENTRIFUGAL COMPRESSOR INDUCER CASCADES
KAREL CELIKOVSKY and PAVEL SAFARIK Zprava VZLU, no. Z-61, 1990, p. 1-10. refs
Copyright
The paper discusses the results of straight cascade measurements in a supersonic wind tunnel, modelling the operation of the centrifugal compressor transonic inducer tip sections. The influence of splitter position both on the velocity distribution along the airfoil chords and the suction side flow separation is specified. Wind tunnel simulation of the impeller geometrical constraints for the inducer section by means of airfoil straight plate tails is presented. Author

A91-27561
AERODYNAMIC NOISE OF A SERRATED TRAILING EDGE
M. S. HOWE (BBN Laboratories, Cambridge, MA) Journal of Fluids and Structures (ISSN 0889-9746), vol. 5, Jan. 1991, p. 33-45. refs
(Contract N00167-87-C-0021)
Copyright
A discussion is given of the production of sound by low Mach number turbulent flow over the trailing edge of a serrated airfoil. The airfoil is modeled by a flat plate set at zero angle of attack to the mean flow, and attention is given to both limiting cases in which the chord of the airfoil is either large or small relative to the characteristic acoustic wavelength. A formula is proposed for interpolating predictions at intermediate frequencies. Numerical results are presented. Author

A91-27562
FLUTTER STABILITY OF ANNULAR WINGS IN INCOMPRESSIBLE FLOW
H. FOERSCHING and K. VON DIEST (DLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) Journal of Fluids and Structures (ISSN 0889-9746), vol. 5, Jan. 1991, p. 47-67. refs
Copyright
A systematic parametric investigation of the flutter behavior of the annular wing in inviscid incompressible flow is performed. First, the equations of motion are set up and the aerodynamic model for the calculation of the motion-induced unsteady airloads in terms of related aerodynamic coefficients, applying a higher-order panel technique, is explained. The aeroelastic stability equations are then derived in nondimensional form and the procedure used for the numerical solution of these equations is outlined. Numerical results are presented for a variety of systematic parameter variations, and overall trends in the aeroelastic stability of the annular wing and the effects of the dominant parameters are pointed out.
Author

A91-27783#
SIMILARITY RULES FOR TRANSFORMATION BETWEEN HIGH- AND LOW-SPEED MODELS OF HIGH PRESSURE AXIAL COMPRESSOR BLADINGS
NIANGUO ZHU, LIPING XU, and MAOZHANG CHEN (Beijing University of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, July 1990, p. 193-198. In Chinese, with abstract in English. refs
The similarity rules are based on general aerodynamic similarity theory and derived for the transformation between transonic and subsonic flows, transonic and incompressible flows, and subsonic and incompressible flows, respectively, as well as in the cases of full disturbance, according to the linear small-perturbation theory, the transonic small-perturbation theory, and the full potential equation. The validity of the similarity transformations under the inviscid assumption is verified by two-dimensional and quasi-three-dimensional numerical simulations. This work provides an essential basis for the similarity transformation between high- and low-speed models of high-pressure axial compressors.
Author

A91-27795#
ROTATING STALL AND SURGE IN AXIAL FLOW COMPRESSOR
DIYI TANG, JIE GUO, LIJUN LI, and WEIYANG QIAO (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, July 1990, p. 245-250. In Chinese, with abstract in English. refs
The instability behavior of compressors is studied in detail with hot-wire and hot-film probes and transient-pressure 3-hole probes on single-rotor, single-stage, and multistage compressors, respectively. After analyzing signals with power-spectral and correlation analysis, it is found that there are two kinds of disturbances, peripheral oscillation in the flow. On the basis of

this fact. it is proposed that the flow separation from airfoils results in peripheral oscillation and axial oscillation simultaneously, providing a new model to describe the flow destabilizing mechanism. Author

A91-27796#
STUDY ON THE SECONDARY FLOW AND IT'S CONTROL IN COMPRESSOR
DEPING TAO, ZEYAN PEN, and XINLU WEI (Beijing University of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, July 1990, p. 251-256. In Chinese, with abstract in English. refs

A systematic experimental investigation of secondary flow in the C4 and BC-6 airfoil cascades has been completed. A end-wall corner flow model has been provided. The C4 airfoil variations of the outlet angle along the blade height have been calculated by the secondary flow theory. They approach the experimental results. The influence of the tip clearance on the blade stall flutter is also investigated in flutter experiments with the BF-1 compressor rotor. An experimental study on the reduction of secondary flow is carried out using both leading-edge sweep and end-bending techniques. The total pressure loss coefficients of these two cascades decrease significantly. The results of the whole-compressor flowfield calculation for end-bending cascades are in good agreement with the experimental data. Author

A91-27801*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EXPERIMENTAL INVESTIGATION OF OSCILLATING CASCADE AERODYNAMICS
DANIEL H. BUFFUM (NASA, Lewis Research Center, Cleveland, OH) and SANFORD FLEETER (Purdue University, West Lafayette, IN) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, July 1990, p. 275-282. refs

A series of experiments are performed in the NASA Lewis Transonic Oscillating Cascade Facility to provide fundamental data quantifying the high subsonic and transonic steady and oscillating aerodynamics of a biconvex airfoil cascade at realistic reduced frequency values for all interblade phase angles. This is accomplished by developing and utilizing an unsteady aerodynamic influence-coefficient technique in which only one cascaded airfoil is oscillated at a time. The vector summation of the resulting airfoil-surface unsteady pressures (measured on a dynamically instrumented airfoil) makes it possible to determine the unsteady aerodynamics of an equivalent cascade with all airfoils oscillating at any specified interblade phase angle. Author

A91-27906#
NAVIER-STOKES AND MONTE CARLO RESULTS FOR HYPERSONIC FLOW
LYLE N. LONG (Pennsylvania State University, University Park) AIAA Journal (ISSN 0001-1452), vol. 29, Feb. 1991, p. 200-207. Research sponsored by Lockheed Corp. Previously cited in issue 03, p. 263, Accession no. A89-14984. refs
Copyright

A91-27910#
NONEQUILIBRIUM HYPERSONIC FLOWS OVER CORNERS
MAURIZIO PANDOLFI, RENZO ARINA, and NICOLA BOTTA (Torino, Politecnico, Turin, Italy) AIAA Journal (ISSN 0001-1452), vol. 29, Feb. 1991, p. 235-241.
Copyright

The hypersonic nonequilibrium flow of air over concave and convex corners is investigated. The description of the flowfield is based on the Euler equations and a chemical model that accounts for the finite rate reactions. An upwind formulation and the related space-marching technique are developed in order to achieve the numerical solution of the fluid dynamical and chemical equations, coupled together. The attention is focused on the effects of nonequilibrium chemistry on fluid dynamics. The transition from the frozen flow condition, just behind the corner, and the equilibrium flow, reached at very large distances far downstream, is characterized by intermediate strong nonequilibrium chemical processes. Such a transition promotes dissipations that, in turn, generate vorticity. Author

A91-27919*# Arizona Univ., Tucson.
EFFECTS OF COMPRESSIBILITY ON DYNAMIC STALL
K.-Y. FUNG (Arizona, University, Tucson) and L. W. CARR (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 29, Feb. 1991, p. 306-308. Previously cited in issue 20, p. 3344, Accession no. A88-48874. refs
(Contract NCA2-196; AF-AFOSR-83-0071; AF-AFOSR-88-0163)
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A91-28091
A STUDY OF STABILITY TO STEADY-STATE BOUNDARY LAYER PERTURBATIONS USING A SWEPT WING MODEL [ISSLEDOVANIE USTOICHIVOSTI K STATSIONARNYM VOZMUSHCHENIIAM POGRANICHNOGO SLOIA NA MODELI SKOL'ZIASHCHEGO KRYLA]
IU. S. KACHANOV, O. I. TARARYKIN, and A. V. FEDOROV (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Oct. 1990, p. 11-21. In Russian. refs
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The stability of a boundary layer on a swept wing with respect to steady-state perturbations was investigated under carefully controlled experimental conditions using a specially developed method for introducing three-dimensional perturbations of specified intensity into the boundary layer. The characteristics of hydrodynamic stability are determined. Expressions are obtained which relate the instability wave increment and wave vector direction to the transverse wave number. The stability characteristics of the boundary layer flow are also analyzed in terms of linear stability theory using the plane-parallel approximation. V.L.

A91-28106
DEVELOPMENT OF MODELS FOR CALCULATING HEAT TRANSFER UNDER CONDITIONS OF SUPERSONIC TURBULENT SEPARATED FLOWS [RAZVITIE MODELEI DLIA RASCHETA TEPLOOBMENA V USLOVIIAKH SVERKHZVUKOVYKH TURBULENTNYKH OTRYVNYKH TECHENII]
A. A. ZHELTOVODOV, E. G. ZAULICHNYI, and V. M. TROFIMOV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), July-Aug. 1990, p. 96-104. In Russian. refs
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Quasi-two-dimensional separation in the vicinity of slanted steps and ledges was investigated experimentally in order to determine the applicability of an approach proposed in an earlier study (Zaulichnyi and Trofimov, 1986) to such flows. The approach is based on the use of a nonequilibrium boundary layer model which includes changes in the intensity of large-scale turbulence in addition to compressibility, nonisothermality, and other factors that are considered asymptotically. The effect of the interaction of the turbulent boundary layer with compression shocks and rarefaction waves on the intensity of heat transfer is examined. V.L.

A91-28107
EFFECT OF WAVE PROCESSES ON VISCOUS-NONVISCOUS INTERACTION OF SUBSONIC AND SUPERSONIC JETS WITH SUPERSONIC AND SUBSONIC WAKES IN A DUCT AND A PIPE [VLIIANIE VOLNOVYKH PROTSESSOV NA VIAZKO-NEVIAZKOE VZAIMODEISTVIE DO- I SVERKHZVUKOVOI STRUI SO SVERKH- I DOZVUKOVYM SPUTNYM POTOKOM V KANALE I TRUBE]
I. S. BELOTSERKOVETS and V. I. TIMOSHENKO PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), July-Aug. 1990, p. 112-117. In Russian. refs
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The effect of wave processes in nonviscous flow on flow characteristics in the viscous regions under conditions of the

interaction of subsonic and supersonic jets with supersonic and subsonic wakes in ducts or pipes is investigated analytically using an approach developed in previous studies (Belotserkovets and Timoshenko, 1984, 1988). The approach is based on a model which uses boundary layer equations to describe subsonic flows and nonviscous flow (Euler) equations to describe supersonic flows. The model includes relations describing viscous-nonviscous interaction, which follow from asymptotically matched solutions to differential equations. V.L.

A91-28113
INSTABILITY OF AN ENTROPIC LAYER ON A BLUNTED PLATE IN THE PATH OF SUPERSONIC GAS FLOW [NEUSTOICHIVOST' ENTROPIINOGO SLOIA NA ZATUPLENNOI PLASTINE, OBTEKAEMOI SVERKHZVUKOVYM POTOKOM GAZA]
A. V. FEDOROV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Sept.-Oct. 1990, p. 63-69. In Russian. refs
Copyright
Natural oscillations in an entropic layer on a plate in supersonic flow are analyzed in the context of linear theory. By using the method of matched expansions, well posed boundary conditions for the perturbations are obtained. It is shown that, in higher approximations, the entropic layer instability is described by nonviscous equations. The natural acoustic oscillations and the unstable mode are analyzed numerically and asymptotically. V.L.

A91-28116
CONSIDERATION OF THE LOCAL SINGULARITIES OF A VORTEX LIFTING SURFACE IN THE DISCRETE VORTEX METHOD [UCHET LOKAL'NYKH OSOBENNOSTEI NESUSHCHEI VIKHREVOI POVERKHNOSTI V METODE DISKRETNYKH VIKHREI]
D. N. GORELOV and O. V. CHERNOV PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Nov.-Dec. 1990, p. 38-46. In Russian. refs
Copyright
In the discrete vortex method, the problem of determining the control points can be solved separately for each wing area with allowance for local singularities of the vortex lifting surface prescribed in accordance with the selected class of solution for the initial singular integral equation. Here, control points are determined for a rectangular wing of finite span in the case where the wing is modeled by U-shaped vortices and closed vortex frames. Examples of calculations of aerodynamic characteristics and attached masses are presented to demonstrate the high efficiency of the computational schemes proposed here. V.L.

A91-28118
MUTUAL EFFECTS OF VIBRATIONAL-DISSOCIATION RELAXATION IN SUPERSONIC FLOW OF A VISCOUS GAS PAST BLUNT BODIES [VZAIMNYE VLIIANIIA KOLEBATEL'NO-DISSOTSIONNOI RELAKSATSII PRI SVERKHZVUKOVOM OBTEKANII ZATUPLENNYKH TEL VIAZKIM GAZOM]
A. G. TIRSKII and V. G. SHCHERBAK PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Nov.-Dec. 1990, p. 55-60. In Russian. refs
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The existing models of supersonic gas flows past blunt bodies including the effects of vibration-dissociation interaction are briefly reviewed. The models are compared using simplified Navier-Stokes equations with allowance for the structure of a viscous compression shock, and the effect of thermodynamic nonequilibrium on flow characteristics is demonstrated. It is shown that consideration of the mutual effects of vibrational relaxation and chemical reactions is essential for the correct modeling of supersonic flows with physicochemical transformations in the case where the vibration relaxation time is comparable with the duration of dissociation reactions. V.L.

A91-28121
EFFECT OF AN ENTROPIC LAYER ON THE STABILITY OF A SUPERSONIC SHOCK LAYER AND THE LAMINAR-TURBULENT BOUNDARY LAYER TRANSITION [VLIIANIE ENTROPIINOGO SLOIA NA USTOICHIVOST' SVERKHZVUKOVOGO UDARNOGO SLOIA I PEREKHOD LAMINARNOGO POGRANICHNOGO SLOIA V TURBULENTNYI]
V. I. LYSENKO PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Nov.-Dec. 1990, p. 74-80. In Russian. refs
Copyright
The effect of the bluntness of the leading edge of a flat plate on the stability of external (relative to the boundary layer) shock layer flow (i.e., stability of the entropic layer proper), stability of the laminar boundary layer, and laminar-turbulent boundary layer transition was investigated experimentally. The wind tunnel experiments were carried out at free-stream Mach 4 and 6 using models in the form of flat steel plates with a beveled leading edge of varying bluntness. It is found that an increase in the entropic layer (with increasing bluntness) destabilizes perturbations in the entropic layer itself as well as first-mode perturbations in the boundary layer. V.L.

A91-28141
NUMERICAL METHOD FOR SOLVING THE PARABOLIZED NAVIER-STOKES EQUATIONS IN PROBLEMS OF SUPERSONIC FLOW PAST BODIES [CHISLENNYI METOD RESHENIIA PARABOLIZOVANNYKH URAVNENII NAV'E-STOKSA V ZADACHAKH SVERKHZVUKOVOGO OBTEKANIIA TEL]
IU. V. GLAZKOV, G. A. TIRSKII, and V. G. SHCHERBAK (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR) Akademiia Nauk SSSR, Doklady (ISSN 0002-3264), vol. 315, no. 6, 1990, p. 1322-1325. In Russian. refs
Copyright
The global iteration method is used to solve the problem of supersonic flow past bodies in the framework of the parabolized Navier-Stokes equations. This method represents a unified approach to calculating flow in the subsonic and supersonic regions without the need for other computational data or the approximate specification of the longitudinal pressure gradient in the subsonic near-surface layer. Results are presented for flow past a spherically blunt cone. B.J.

A91-28150
METHOD FOR DETERMINING HEAT FLUXES AND FRICTION IN THREE-DIMENSIONAL HYPERSONIC FLOW PAST BODIES USING TWO-DIMENSIONAL SOLUTIONS [METOD OPREDELENIIA TEPLOVYKH POTOKOV I TRENIIA V TREKHMERNYKH ZADACHAKH GIPERZVUKOVOGO OBTEKANIIA S POMOSHCH'IU DVUMERNYKH RESHENII]
I. G. BRYKINA, V. V. RUSAKOV, and V. G. SHCHERBAK (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR) Akademiia Nauk SSSR, Doklady (ISSN 0002-3264), vol. 316, no. 1, 1991, p. 62-66. In Russian. refs
Copyright
A method for solving three-dimensional hypersonic flow problems using two-dimensional solutions is proposed which is suitable for arbitrary Re numbers and takes the real gas properties into account. The method is based on the use of similarity relations that express the heat flux and friction on the surface of a three-dimensional body through their values on the surface of an axisymmetric body. Results are presented for the steady hypersonic viscous-gas flow past a blunt body. B.J.

A91-28151* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ENSAERO - A MULTIDISCIPLINARY PROGRAM FOR FLUID/STRUCTURAL INTERACTION STUDIES OF AEROSPACE VEHICLES
G. P. GURUSWAMY (NASA, Ames Research Center, Moffett Field,

CA) Computing Systems in Engineering (ISSN 0956-0521), vol. 1, no. 2-4, 1990, p. 237-256. refs
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A computational procedure is developed that uses a moving zonal grid concept to model complex flexible aerospace vehicles. The Euler/Navier-Stokes equations are used to model the flow, and computations are made using efficient methods based on both central and upwind schemes. The structure is represented by a finite element method which can model general aerospace vehicles. Provisions are made to accommodate other disciplines such as controls and thermal loads. The code is capable of computing unsteady flows on flexible wings with vortical flows. Adaptation of this procedure for parallel processing and validation for complete aerospace configurations is in progress. A.F.S.

A91-28385
EXPERIMENTAL INVESTIGATION OF VORTEX FORMATION IN THE WAKE OF A FLAT PLATE FOR SUBSONIC AND SUPERSONIC FREESTREAM MACH NUMBERS
W. ALTHAUS (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) Experiments in Fluids (ISSN 0723-4864), vol. 9, no. 5, 1990, p. 267-272. refs
(Contract DFG-SFB-25)
Copyright

Holographic interferometry was used to study the wake of a 6-mm-thick flat plate as a function of the freestream Mach number, surface roughness, and the distance d (distance from the location where surface roughness ends to the trailing edge). Experimental results are discussed with emphasis on the influence of these parameters on the vortex shedding frequency and the density and time-averaged velocity distributions and their correlations. It is shown, in particular, that the turbulent wake of a flat plate can be changed to a vortical wake if the surface of the plate is roughened above a critical value and the distance d is of the order of 5 mm. V.L.

A91-28400*# Old Dominion Univ., Norfolk, VA.
KINEMATIC DOMAIN DECOMPOSITION TO SIMULATE FLOWS PAST MOVING OBJECTS
OKTAY BAYSAL and GUAN-WEI YEN (Old Dominion University, Norfolk, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(Contract NAG1-1150)
(AIAA PAPER 91-0725) Copyright

A new method is developed to solve the unsteady Navier-Stokes equations on a composite grid which consists of subdomain grids moving with respect to each other. These subdomains are structured grids with different topologies. However, their interfaces are unstructured in the sense that they may or may not arbitrarily overlap with each other. This method captures the boundary-motion-induced flow component. The method is demonstrated for a transonic flow past an airfoil which experiences a combined motion of pitching and plunging. Author

N91-16990*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A PARAMETRIC EXPERIMENTAL INVESTIGATION OF A SCRAMJET NOZZLE AT MACH 6 WITH FREON AND ARGON OR AIR USED FOR EXHAUST SIMULATION
JAMES M. CUBBAGE (Vigyan Research Associates, Inc., Hampton, VA.) and WILLIAM J. MONTA Washington Feb. 1991 106 p
(NASA-TP-3048; L-16707; NAS 1.60:3048) Avail: NTIS HC/MF A06 CSCL 01/1

A parametric experimental investigation of a scramjet nozzle was conducted with a gas mixture used to simulate the scramjet engine exhaust flow at a free-stream Reynolds number of approximately 6.5 x 10(exp 6) per foot. External nozzle surface angles of 16, 20, and 24 deg were tested with a fixed-length ramp and for cowl internal surface angles of 6 and 12 deg. Pressure data on the external nozzle surface were obtained for mixtures of Freon and argon gases with a ratio of specific heats of about 1.23, which matches that of a scramjet exhaust. Forces and moments were determined by integration of the pressure data. Two nozzle configurations were also tested with air used to simulate the exhaust flow. On the external nozzle surface, lift and thrust forces for air exhaust simulation were approximately half of those for Freon-argon exhaust simulation and the pitching moment was approximately a third. These differences were primarily due to the difference in the ratios of specific heats between the two exhaust simulation gases. A 20 deg external surface angle produced the greatest thrust for a 6 deg cowl internal surface angle. A flow fence significantly increased lift and thrust forces over those for the nozzle without a flow fence. Author

N91-16992*# Arizona State Univ., Tempe. Dept. of Mechanical and Aerospace Engineering.
NEAR-WALL MODELLING OF COMPRESSIBLE TURBULENT FLOWS Semiannual Progress Report, 1 Jul. - 31 Dec. 1990
RONALD M. C. SO 31 Dec. 1990 50 p
(Contract NAG1-1080)
(NASA-CR-187731; NAS 1.26:187731) Avail: NTIS HC/MF A03 CSCL 01/1

Work was carried out to formulate near-wall models for the equations governing the transport of the temperature-variance and its dissipation rate. With these equations properly modeled, a foundation is laid for their extension together with the heat-flux equations to compressible flows. This extension is carried out in a manner similar to that used to extend the incompressible near-wall Reynolds-stress models to compressible flows. The methodology used to accomplish the extension of the near-wall Reynolds-stress models is examined and the actual extension of the models for the Reynolds-stress equations and the near-wall dissipation-rate equation to compressible flows is given. Then the formulation of the near-wall models for the equations governing the transport of the temperature variance and its dissipation rate is discussed. Finally, a sample calculation of a flat plate compressible turbulent boundary-layer flow with adiabatic wall boundary condition and a free-stream Mach number of 2.5 using a two-equation near-wall closure is presented. The results show that the near-wall two-equation closure formulated for compressible flows is quite valid and the calculated properties are in good agreement with measurements. Furthermore, the near-wall behavior of the turbulence statistics and structure parameters is consistent with that found in incompressible flows. Author

N91-16993*# Naval Research Lab., Washington, DC.
COMPRESSIBILITY EFFECTS ON DYNAMIC STALL OF OSCILLATING AIRFOILS Final Report
M. S. CHANDRASEKHARA and M. F. PLATZER 23 Aug. 1990 42 p Sponsored in part by NASA, Ames Research Center; Army; Navy; and AF
(Contract MIPR-ARO-137-86; ARO-23394-EG)
(NASA-CR-187870; NAS 1.26:187870; AD-A228046; ARO-23394.10-EG) Avail: NTIS HC/MF A03 CSCL 01/1

This study's aim was to obtain a basic understanding of the effect of compressibility on the phenomenon of dynamic stall under typical flight conditions encountered by a helicopter in forward flight, so that eventually a means for its control can be devised and thus, its flight envelope can be expanded. The first phase of the study was devoted to building a drive system to produce the necessary unsteady airfoil motion. A novel design was arrived at and built. It uses a four-bar chain mechanism of which the airfoil is one of the links. The drive can produce a sinusoidal variation of the angle of attack as: alpha = alpha sub 0 + alpha sub m(sin omega+), with the mean angle of attack alpha0, continuously variable from 0 to 15 deg, the amplitude of oscillation alpha sub m, from 2 to 10 degs and the frequency from 0 to 100 Hz, in an oncoming flow Mach number M, from 0 to 0.5. The drive was installed in the indraft wind tunnel at NASA Ames Research Center. Stroboscopic schlieren studies and interferograms as well as holographic interferometry studies were conducted for a wide range of flow conditions, amplitudes and frequencies. Results show that compressibility effects appear at M = 0.3, that a dynamic stall vortex forms for all Mach numbers, and that for M is greater than or = 0.3, the dynamic stall angle decreases as M increases. On

the otherhand, increasing the degree of unsteadiness, delays deep stall monotonically at all Mach numbers. GRA

N91-16994 Texas Univ., Arlington.
EXPERIMENTAL STUDY OF A TWO-DIMENSIONAL PROPULSIVE WING IN A LOW-SPEED WIND TUNNEL Ph.D. Thesis
CHANG SOO JEON 1990 219 p
Avail: Univ. Microfilms Order No. DA9033482

The experimental study of 2-dimensional propulsive wing in a low speed wind tunnel was performed to general an experimental data bank which can help future possible evolutions of STOL aircraft. A model employing a modified NACA 0025 airfoil sections with three different height-to-chord ratio propulsive nozzles exhausting over the upper surface of the airfoil at the 70 percent chord position was tested. Test data were obtained for angles of attacks of -5, 0, 5, 10, and 15 degrees, referenced to the coordinate system of the symmetric NACA 0025 airfoil, and at wind tunnel dynamic pressures of 0, 1, 51, and 10 lbf/sq ft. The propulsive flow was simulated by a compressed air source with nozzle pressure ratios ranging from 1 to 1.4 and measured jet momentum coefficients from 0 to 18. A significant entrainment of air proceeding the nozzle exhaust station was observed that contributed directly to lift enhancement. The lift coefficient and entrainment velocity increment were found to correlate directly with the propulsive velocity increment. Different nozzle area ratios showed little effect on entrainment velocity increment of the external flow and thus on life coefficient. Lift enhancement beyond the effect of boundary layer control due to jet blowing was approximately predicted by the effective velocity ratio. Correlations based on momentum pressure parameters employing a 'neutral point' concept were also found to provide an excellent correlation of the lift enhancement and entrainment velocity. Jet-flap theory was compared with experimental results. Lift curve slopes of test results were always higher then theoretical ones. Wake data showed negative profile drag coefficients with power-on. Thrust recovery of the jet was independent of angle of attack and jet deflection angle. Flow visualization was used in an attempt to improve understanding of the fundamental flow structure of the propulsive wing.
Dissert. Abstr.

N91-16995 Colorado Univ., Boulder.
A MULTIPLE FRAMES OF REFERENCE APPROACH TO AEROELASTIC COMPUTATIONS: APPLICATION TO AIRFOIL FLUTTER ANALYSIS Ph.D. Thesis
TZER-YUAAN LIN 1990 152 p
Avail: Univ. Microfilms Order No. DA9032852

In order to predict the dynamic response of a rigid or flexible structure in a fluid flow, the equations of motion of the structure and the fluid must be solved simultaneously. A straightforward approach to the solution of the coupled fluid/structure dynamic equations requires moving at each time step at least the portions of the fluid grid that are close to the moving structure. A more economical approach is derived for the transient solution of the aeroelastic coupled problem. The governing equations of motion of the fluid is derived with respect to multiple moving frames of reference. Each of these frames is attached to a carefully selected node of the discretized structure. For a rigid aeroelastic configuration, the result is the implicit generation of a structure-attached corotational fluid grid. In this case, so single grid point needs to be explicitly moved or updated during the transient analysis, even when the structure undergoes large rigid-body motion. If the effect of small elastic deformations is also to be included, the spatial metrics used for computing the unsteady flow soltuions need to be continuously modified according to the deforming shape of the structure. Consequently, a spatial metrics updating scheme is also developed in addition to the corotational approach. The proposed approach for fluid/structure interaction problems rests on two essential ingredients: a flow solver, and a structure analyzer. Time accurate Euler/Navier-Stokes solvers are considered for unsteady flow computations. The ARC2D code is selected and modified to handle the fluid part while an in-house developed finite element code is chosen to analyze the structure. Both codes are modified to interact according to the proposed coupling strategy. The proposed approach for coupled simulation is first validated with the prediction of unsteady flow and the flutter analysis of a NACA0012 airfoil. Next, it is applied to investigate the aeroelastic response of an infinite flexible wing-like structure in transonic flow. Dissert. Abstr.

N91-16996 Texas Univ., Austin..
HIGH-ALTITUDE HYPERSONIC AERODYNAMICS OF BLUNT BODIES Ph.D. Thesis
WALTER HARMON RUTLEDGE 1990 285 p
Avail: Univ. Microfilms Order No. DA9031704

A computational fluids dynamics scheme is presented to solve the unsteady thin layer Navier-Stokes (TLNS) equations over a blunt body at high altitude, high Mach number atmospheric reentry flow conditions. This continuum approach is directed to low density hypersonic flows by accounting for non-zero bulk viscosity effects in near frozen flow conditions. The TLNS equations are solved over an axisymmetric body at zero incidence relative to the free stream. The time dependent axisymmetric governing equations are transformed into a computational plane, then cast into weak conservative form and solved using a first-order fully implicit scheme in time with second-order flux vector splitting for spatial derivatives. The resulting implicit matrix from this finite-difference scheme is inverted using a line successive-over-relaxation (SOR) method. The numerical procedure also utilizes an increasing Courant-Friedrichs-Lewy (CFL) number with time resulting in a non-time accurate scheme which provides accelerated convergence to the desired steady-state solution. The computational space is defined over representative sphere and sphere/cone geometries using a body-fitted clustered algebraic grid within a fixed domain. The thermochemical effects at high altitudes are modeled using a frozen flow assumption. At lower altitudes, an equilibrium chemistry package is used to model real gas effects. The effects of high temperature transport properties are included. At the present time, nonequilibrium thermochemistry effects are not modeled. Catalytic wall, ionization, and radiation effects are also not excluded from the current analysis. However, the significant difference from previous studies is the inclusion of the capability to model non-zero bulk viscosity effects. The importance of bulk viscosity is reviewed and several blunt body flow field solutions are presented to illustrate the potential contribution of this phenomena at high altitude hypersonic conditions. The current technique is compared with experimental data and other approximate continuum solutions. A variety of test cases are also presented for a wide range of free stream Mach conditions. Discussion of the results includes representative trends at chemical equilibrium as well as at frozen flow conditions.
Dissert. Abstr.

N91-16997 Purdue Univ., West Lafayette, IN.
AERODYNAMICS OF A LINEAR OSCILLATING CASCADE Ph.D. Thesis
DANIEL HAVENS BUFFUM 1990 262 p
Avail: Univ. Microfilms Order No. DA9031301

The aerodynamics of a linear oscillating cascade are investigated using experimental and computational methods. Experiments are performed to quantify the torsion mode oscillating cascade aerodynamics of the NASA Lewis Transonic Oscillation Cascade for subsonic inlet flow field using two methods: (1) simultaneous oscillating of all the cascaded airfoils at various values of interblade phase angle; and (2) the unsteady aerodynamic influence of coefficient technique. Analysis of these data and correlation with classical linearized unsteady aerodynamic analysis predictions indicate that the wind tunnel walls enclosing the cascade have, in some cases, a detrimental effect on the cascade unsteady aerodynamics. An Euler code for oscillating cascade aerodynamics is modified to incorporate improved upstream and downstream boundary conditions and also the unsteady aerodynamic influence coefficient technique. The new boundary conditions are shown to improve the unsteady aerodynamic predictions of the code, and the computational unsteady

aerodynamic influence coefficient technique is shown to be a viable alternative for calculation of oscillating cascade aerodynamics.
Dissert. Abstr.

N91-16998# Royal Aircraft Establishment, Farnborough (England).
THE EFFECT OF A SPLITTER PLATE ON THE SYMMETRY OF SEPARATED FLOW AROUND A DELTA WING OF LOW ASPECT RATIO
S. B. ZAKHAROV Mar. 1990 13 p Transl. into ENGLISH from Vliyanie Razdelitel'noi Plastiny na Simmetrichnost' Otryvnogo Obtekaniya Treugol'nogo Kryla Malogo Udlineniya, Uchenye Zapiski Tsagi (USSR), v. 17, no. 3, 1986
(BR115576; RAE-LT-2177) Copyright Avail: NTIS HC/MF A03

Using the approximation of the theory of slender bodies, an investigation is made into the non-uniqueness of solutions for separated flow around a delta wing of low aspect ratio in the presence of a delta splitter plate on the upper surface of the wing and in the plane of symmetry. An improved method of formulation offers increased accuracy, when applied to the solution of similarity problems in vortex sheets. Some substantially asymmetrical solutions to the problem of separated flow around the wing under symmetrical conditions of flow are obtained, as well as some symmetrical ones. Considerable attention is paid to an explanation of the nature of the bifurcations in solutions and to a qualitative description of hysteresis in the aerodynamic characteristics as a result of a quasi-stationary change in angle of attack and yaw angle by the use of a simplified mathematical model of a vortex sheet vortex and cut. Author

N91-17001*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AN EVALUATION OF THREE TWO-DIMENSIONAL COMPUTATIONAL FLUID DYNAMICS CODES INCLUDING LOW REYNOLDS NUMBERS AND TRANSONIC MACH NUMBERS
RAYMOND M. HICKS and SUSAN E. CLIFF Jan. 1991 50 p
(NASA-TM-102840; A-90202; NAS 1.15:102840) Avail: NTIS HC/MF A03 CSCL 01/1

Full-potential, Euler, and Navier-Stokes computational fluid dynamics (CFD) codes were evaluated for use in analyzing the flow field about airfoils sections operating at Mach numbers from 0.20 to 0.60 and Reynolds numbers from 500,000 to 2,000,000. The potential code (LBAUER) includes weakly coupled integral boundary layer equations for laminar and turbulent flow with simple transition and separation models. The Navier-Stokes code (ARC2D) uses the thin-layer formulation of the Reynolds-averaged equations with an algebraic turbulence model. The Euler code (ISES) includes strongly coupled integral boundary layer equations and advanced transition and separation calculations with the capability to model laminar separation bubbles and limited zones of turbulent separation. The best experiment/CFD correlation was obtained with the Euler code because its boundary layer equations model the physics of the flow better than the other two codes. An unusual reversal of boundary layer separation with increasing angle of attack, following initial shock formation on the upper surface of the airfoil, was found in the experiment data. This phenomenon was not predicted by the CFD codes evaluated. Author

N91-17002*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
OPTICAL MEASUREMENT OF PROPELLER BLADE DEFLECTIONS IN A SPIN FACILITY
JOHN K. RAMSEY, ERWIN H. MEYN, ORAL MEHMED, and ANATOLE P. KURKOV Oct. 1990 11 p
(NASA-TM-103115; E-5439; NAS 1.15:103115) Avail: NTIS HC/MF A03 CSCL 01/1

A nonintrusive optical system for measuring propeller blade deflections has been used in the NASA Lewis dynamic spin facility. Deflection of points at the leading and trailing edges of a blade section can be obtained with a narrow light beam from a low power helium-neon laser. A system used to measure these deflections at three spanwise locations is described. Modifications required to operate the lasers in a near-vacuum environment are also discussed. Author

N91-17004# Arizona Univ., Tucson. Dept. of Aerospace and Mechanical Engineering.
COMPUTATIONAL STUDIES OF COMPRESSIBILITY EFFECTS ON DYNAMIC STALL Final Report, 1 Jun. 1988 - 31 Aug. 1990
K.-Y. FUNG 27 Sep. 1990 94 p Presented at the NASA/AFOSR/ARO Workshop, Moffett Field, CA, 17-19 Apr. 1990
(Contract AF-AFOSR-0163-88; AF PROJ. 2307)
(AD-A229007; AFOSR-90-1131TR) Avail: NTIS HC/MF A05 CSCL 01/1

The dynamic stall characteristics of several airfoils in sinusoidal pitch oscillations as well as in constant rate pitch ramps over a wide range of unsteady flow conditions have been investigated. It is found that: (1) the flow before the onset of stall can be considered quasi-steady and predicted using inviscid theory; (2) the effect of unsteadiness on the onset of dynamic stall depends on the airfoil geometry and whether the flow has become locally supersonic; and (3) the effect of the freestream Mach number on the onset is rather insensitive to the airfoil geometry. Our analysis on both experimental and numerical results predicts the presence of a separation bubble at the leading edge. It also suggests that the bursting of the bubble, or failure to reattach after the initial separation, is the onset mechanism for most of the dynamic stall cases studied. The effects of transition on bubble bursting (the onset of massive separation of dynamic stall) are studied numerically by choosing the location at which the turbulence model is switched from molecular to turbulent eddy viscosity in the numerical code. It was found that at angles of attack close to the static stall angle, minor movements in the transition point could cause a separation bubble to burst, and that bubble bursting is more susceptible to transition point location in a locally supersonic flow than a subsonic flow. GRA

N91-18030*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DETAILED FLOW-FIELD MEASUREMENTS OVER A 75 DEG SWEPT DELTA WING
SCOTT O. KJELGAARD and WILLIAM L. SELLERS, III Washington Oct. 1990 45 p Original contains color illustrations
(NASA-TP-2997; L-16718; NAS 1.60:2997) Avail: NTIS HC/MF A03; 16 functional color pages CSCL 01/1

Results from an experimental investigation documenting the flowfield over a 75 deg swept delta wing at an angle-of-attack of 20.5 deg are presented. Results obtained include surface flow visualization, off-body flow visualization, and detailed flowfield surveys for various Reynolds numbers. Flowfield surveys at Reynolds numbers of 0.5, 1.0, and 1.5 million based on the root chord were conducted with both a Pitot pressure probe and a 5-hole pressure probe; and 3-component laser velocimeter surveys were conducted at a Reynolds number of 1.0 million. The Pitot pressure surveys were obtained at 5 chordwise stations, the 5-hole probe surveys were obtained at 3 chordwise stations and the laser velocimeter surveys were obtained at one station. The results confirm the classical roll up of the flow into a pair of primary vortices over the delta wing. The velocity measurements indicate that Reynolds number has little effect on the global structure of the flowfield for the Reynolds number range investigated. Measurements of the non-dimensional axial velocity in the core of the vortex indicate a jet like flow with values greater than twice freestream. Comparisons between velocity measurements from the 5-hole pressure probe and the laser velocimeter indicate that the pressure probe does a reasonable job of measuring the flowfield quantities where the velocity gradients in the flowfield are low.
Author

N91-18031*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PHYSICALLY WEIGHTED APPROXIMATIONS OF UNSTEADY AERODYNAMIC FORCES USING THE MINIMUM-STATE METHOD
MORDECHAY KARPEL (Technion - Israel Inst. of Tech., Haifa.) and SHERWOOD TIFFANY HOADLEY Washington Mar. 1991 46 p
(NASA-TP-3025; L-16491; NAS 1.60:3025) Avail: NTIS HC/MF A03 CSCL 01/1

The Minimum-State Method for rational approximation of unsteady aerodynamic force coefficient matrices, modified to allow physical weighting of the tabulated aerodynamic data, is presented. The approximation formula and the associated time-domain, state-space, open-loop equations of motion are given, and the numerical procedure for calculating the approximation matrices, with weighted data and with various equality constraints are described. Two data weighting options are presented. The first weighting is for normalizing the aerodynamic data to maximum unit value of each aerodynamic coefficient. The second weighting is one in which each tabulated coefficient, at each reduced frequency value, is weighted according to the effect of an incremental error of this coefficient on aeroelastic characteristics of the system. This weighting yields a better fit of the more important terms, at the expense of less important ones. The resulting approximate yields a relatively low number of aerodynamic lag states in the subsequent state-space model. The formulation forms the basis of the MIST computer program which is written in FORTRAN for use on the MicroVAX computer and interfaces with NASA's Interaction of Structures, Aerodynamics and Controls (ISAC) computer program. The program structure, capabilities and interfaces are outlined in the appendices, and a numerical example which utilizes Rockwell's Active Flexible Wing (AFW) model is given and discussed. Author

N91-18032*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN EXPLICIT UPWIND ALGORITHM FOR SOLVING THE PARABOLIZED NAVIER-STOKES EQUATIONS
JOHN J. KORTE Washington Feb. 1991 71 p Original contains color illustrations
(NASA-TP-3050; L-16753; NAS 1.60:3050) Avail: NTIS HC/MF A04; 1 functional color page CSCL 01/1

An explicit, upwind algorithm was developed for the direct (noniterative) integration of the 3-D Parabolized Navier-Stokes (PNS) equations in a generalized coordinate system. The new algorithm uses upwind approximations of the numerical fluxes for the pressure and convection terms obtained by combining flux difference splittings (FDS) formed from the solution of an approximate Riemann (RP). The approximate RP is solved using an extension of the method developed by Roe for steady supersonic flow of an ideal gas. Roe's method is extended for use with the 3-D PNS equations expressed in generalized coordinates and to include Vigneron's technique of splitting the streamwise pressure gradient. The difficulty associated with applying Roe's scheme in the subsonic region is overcome. The second-order upwind differencing of the flux derivatives are obtained by adding FDS to either an original forward or backward differencing of the flux derivative. This approach is used to modify an explicit MacCormack differencing scheme into an upwind differencing scheme. The second order upwind flux approximations, applied with flux limiters, provide a method for numerically capturing shocks without the need for additional artificial damping terms which require adjustment by the user. In addition, a cubic equation is derived for determining Vegneron's pressure splitting coefficient using the updated streamwise flux vector. Decoding the streamwise flux vector with the updated value of Vigneron's pressure splitting improves the stability of the scheme. The new algorithm is applied to 2-D and 3-D supersonic and hypersonic laminar flow test cases. Results are presented for the experimental studies of Holden and of Tracy. In addition, a flow field solution is presented for a generic hypersonic aircraft at a Mach number of 24.5 and angle of attack of 1 degree. The computed results compare well to both experimental data and numerical results from other algorithms. Computational times required for the upwind PNS code are approximately equal to an explicit PNS MacCormack's code and existing implicit PNS solvers. Author

N91-18033*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LOW-SPEED WIND-TUNNEL TEST OF AN UNPOWERED HIGH-SPEED STOPPABLE ROTOR CONCEPT IN FIXED-WING MODE
MICHAEL B. LANCE, DANIEL Y. SUNG, and ROBERT H. STROUB (National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.) Washington Mar. 1991 53 p
(NASA-TM-4250; L-16716; NAS 1.15:4250) Avail: NTIS HC/MF A04 CSCL 01/1

An experimental investigation of the M85, a High Speed Rotor Concept, was conducted at the NASA Langley 14 x 22 foot Subsonic Tunnel, assisted by NASA-Ames. An unpowered 1/5 scale model of the XH-59A helicopter fuselage with a large circular hub fairing, two rotor blades, and a shaft fairing was used as a baseline configuration. The M85 is a rotor wing hybrid aircraft design, and the model was tested with the rotor blade in the fixed wing mode. Assessments were made of the aerodynamic characteristics of various model rotor configurations. Variation in configurations were produced by changing the rotor blade sweep angle and the blade chord length. The most favorable M85 configuration tested included wide chord blades at 0 deg sweep, and it attained a system lift to drag ratio of 8.4. Author

N91-18034# Duke Univ., Durham, NC. School of Engineering.
PROCEEDINGS OF THE 3RD WORKSHOP ON DYNAMICS AND AEROELASTIC STABILITY MODELING OF ROTORCRAFT SYSTEMS Final Report, 1 May 1989 - 30 Jun. 1990
EARL H. DOWELL 14 Mar. 1990 239 p Workshop held in Durham, NC, 12-14 Mar. 1990 Sponsored in part by Duke Univ.
(Contract DAAL03-89-G-0023)
(AD-A227930; ARO-26466.1-EG-CF) Avail: NTIS HC/MF A11 CSCL 01/3

The workshop was held as scheduled. Sessions included rotorcraft dynamics research, physical modeling, rotorcraft centers of excellence, aeroelasticity and stability, response dynamics and control, mathematics of modeling, and experimental-theoretical investigations. GRA

N91-18035# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.
SPECIAL COURSE ON INVERSE METHODS FOR AIRFOIL DESIGN FOR AERONAUTICAL AND TURBOMACHINERY APPLICATIONS
Nov. 1990 259 p Course held in Rhode-Saint-Genese, Belgium, 14-18 May 1990; sponsored by AGARD and the von Karman Inst.
(AGARD-R-780; ISBN-92-835-0591-3; AD-A230761) Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Three major aspects of airfoil design are examined both for aeronautical and turbomachine application. Optimization of target pressure distribution and velocity distribution are studied. Both direct optimization resulting from an inverse boundary layer calculation and an iterative optimization of the losses are presented. Airfoil design by means of inverse methods is also studied. This ranges from simple parametric definitions of 2-D cross sections to a detailed numerical definition of 3-D shapes. The methodology to account for a large number of constraints and off-design operation is also discussed and illustrated by a large number of applications.

N91-18036# Pennsylvania State Univ., University Park. Dept. of Aerospace Engineering.
AERODYNAMIC SHAPE DESIGN
GEORGE S. DULIKRAVICH *In* AGARD, Special Course on Inverse Methods for Airfoil Design for Aeronautical and Turbomachinery Applications 10 p Nov. 1990

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Design of aerodynamic shapes can be accomplished by using the methodologies from computational fluid dynamics and optimization. Two basic categories of the inverse (design) formulations are surface flow design and flow field design. A number of methods in both categories are discussed and critically evaluated. Open questions remain to be specified of a more appropriate surface pressure, acceleration of iterative algorithms, increased versatility of the design methods, direct use of the existing and future flow field analysis software. Author

N91-18037# National Technical Univ., Athens (Greece). Thermal Turbomachinery Lab.
ARBITRARY BLADE SECTION DESIGN BASED ON VISCOUS CONSIDERATIONS
K. D. PAPAILIOU and B. BOURAS *In* AGARD, Special Course on Inverse Methods for Airfoil Design for Aeronautical and Turbomachinery Applications 53 p Nov. 1990
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Theoretical tools are proposed that may help the designer in aerodynamic design. In fact, a complete (viscous and inviscid) inverse procedure is proposed, but, it is pointed out that in order to obtain results, it has to be combined with a sound direct (analysis) one. Various examples are chosen in order to demonstrate the use of the proposed tools. These examples do not cover all cases, but rather converge to the conclusion that the proposed tools may prove to be quite useful, while, each design must be considered as a separate case. Author

N91-18038# National Aerospace Lab., Amsterdam (Netherlands).
OPTIMIZATION OF TARGET PRESSURE DISTRIBUTIONS
R. F. VANDENDAM, J. A. VANEGMOND, and J. W. SLOOFF *In* AGARD, Special Course on Inverse Methods for Airfoil Design for Aeronautical and Turbomachinery Applications 13 p Nov. 1990
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An overview is presented of the possibilities and problems associated with the use of numerical optimization techniques in aerodynamic design. First, an inventory is made of the alternative aerodynamic design methods, the numerical optimization approach being one of them. The development of optimizing design methods is outlined and a short exposition of the state of the art in numerical optimization is given. This is followed by a discussion on the practical use of numerical optimization techniques in aerodynamic design, in particular the inverse numerical optimization approach. An important step in this approach is the optimization of target pressure distributions, which are used by inverse methods to find the corresponding geometry. The procedure for finding target pressure distributions is explained and illustrated by some examples. Author

N91-18039# Grumman Aerospace Corp., Bethpage, NY.
GEOMETRIC AND SURFACE PRESSURE RESTRICTIONS IN AIRFOIL DESIGN
G. VOLPE *In* AGARD, Special Course on Inverse Methods for Airfoil Design for Aeronautical and Turbomachinery Applications 14 p Nov. 1990
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In order to design a physically acceptable airfoil that corresponds to a prescribed surface pressure or speed distribution, various restrictions have to be met by the imposed target and by the contour. It is shown that the need to meet geometric prerequisites and a specified free stream value imposes constraints on the prescribed surface values which, unless satisfied, inhibit the existence of a solution. In this classical problem of airfoil design, the prescribed surface distribution must contain enough degrees of freedom in order that it may be modified sufficiently to satisfy the contraints. The nature of the constaints is discussed, and they are expressed in forms which are amenable to numerical solution procedures in transonic as well as incompressible flows. THe discussion is accompanied by a description of the general characteristics of airfoil geometries and surface flows. Author

N91-18040# Grumman Aerospace Corp., Bethpage, NY.
TRANSONIC SHOCK FREE WING DESIGN
G. VOLPE *In* AGARD, Special Course on Inverse Methods for Airfoil Design for Aeronautical and Turbomachinery Applications 16 p Nov. 1990
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The problem of constructing wing profiles that yield specified pressure distributions and/or performance characteristics is discussed. A practical solution to the problem, which consists of a physically acceptable profile, exists only if certain constraints are satisfied by the prescribed characteristics and by the profile itself. These constraints are addressed in various manners by the several methodologies that are proposed. The various approaches are discussed along with the relative advantages and disadvantages of each. The inverse approach is considered in detail to provide a link to the classical incompressible design problem and to establish a raison d'etre for the other methodologies. Author

N91-18041# Pennsylvania State Univ., University Park. Dept. of Aerospace Engineering.
A STREAM-FUNCTION-COORDINATE (SFC) CONCEPT IN AERODYNAMIC SHAPE DESIGN
GEORGE S. DULIKRAVICH *In* AGARD, Special Course on Inverse Methods for Airfoil Design for Aeronautical and Turbomachinery Applications 6 p Nov. 1990
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A new approach to the inverse design of 2-D aerodynamic shape was developed. This formulation is based on a Stream Function Coordinate (SFC) concept for steady, irrotational, compressible, inviscid, planar flows. It differs from the classical stream function formulation in that it treats the y coordinate of each point on a streamline as a function of the x coordinate and the stream function psi, i.e., $Y = Y(x,psi)$. This new formulation is especially suitable for the computation of stream line shapes, and therefore, for determination of aerodynamic shapes subject to specified surface pressure distributions. An additional advantage of this new formulation is that it requires the generation of only a 1-D grid in the x direction. The grid in the y direction is computed as a part of the solution since y coordinates of the streamlines are treated as the unknowns in the SFC formulation. In addition, the SFC method is equally suitable for the analysis of the flow fields around given shapes. A computer code was developed on the basis of SFC formulation. It is capable of performing flow field analysis and inverse design of airfoil cascade shapes by changing a single input parameter. Author

N91-18042# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).
SUBSONIC AND TRANSONIC CASCADE DESIGN
OLIVIER LEONARD *In* AGARD, Special Course on Inverse Methods for Airfoil Design for Aeronautical and Turbomachinery Applications 18 p Nov. 1990
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Two iterative methods for blade design, using direct flow solvers and a blade geometry change algorithm, are presented. Both procedures start with the analysis of a given cascade geometry using an existing flow solver. The difference between the calculated velocity distribution and the required one is used to calculate a flow distortion. In the first method, this flow distortion is produced by singularities while in the second method the distortion is derived by imposing the required velocity distribution as a boundary condition. This flow distortion is used by the modification algorithm and results in a new blade shape for which the calculated velocity is closer to the desired one. Examples for both subsonic and transonic flows are presented and show a rapid convergence to the geometry required for the desired velocity distribution. The

main advantage of the proposed method is that existing analysis codes can be used, for the design and for the off-design analysis. Some restrictions which have to be imposed on the required velocity distributions are also discussed. Author

N91-18043# Politecnico di Torino (Italy).
INVERSE METHODS FOR 3D INTERNAL FLOWS
LUCA ZANNETTI and FRANCESCO LAROCCA (Fiat Aviazione S.p.A., Turin, Italy) *In* AGARD, Special Course on Inverse Methods for Airfoil Design for Aeronautical and Turbomachinery Applications 16 p Nov. 1990
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The objective was a numerical method for designing 3-D ducts and blade rows. The method applies to inviscid compressible rotational flow, and it is based on the time dependent technique. The walls where the design pressure is prescribed are considered as flexible and impermeable. Starting from some initial guessed configuration, the computation follows the transient which occurs while the flexible walls move and finally reach a steady shape. Author

N91-18044# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
VISCOUS AND INVISCID INVERSE SCHEMES USING NEWTON'S METHOD
MARK DRELA *In* AGARD, Special Course on Inverse Methods for Airfoil Design for Aeronautical and Turbomachinery Applications 16 p Nov. 1990
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Developments in design analysis methodology for airfoils and cascades are presented. Shortcomings of standard inverse methods in flows involving shock waves are overcome by a modal geometry perturbation inverse method driven by a least squares pressure mismatch minimization. The method is incorporated into an existing viscous inviscid zonal method. Simultaneous solution of the flow field equations and the pressure mismatch minimization equations is obtained by a full Newton method. This leads to very large computational savings compared to traditional minimization methods. The method is also applicable to viscous flows with or without separation regions present. The Newton based solution scheme, which yields sensitivity information as a by-product, also allows very efficient solution of general optimization problems. Perturbation of the geometry and flow field is specified outside of the Newton solver so as to drive any aerodynamic and/or geometric quantity to its minimum. The availability of free sensitivity information and the rapid reconvergence property of the Newton method after each optimization cycle again gives very large computational savings. Author

N91-18045# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Dept. of Aerodynamics.
ONE POINT AND MULTI-POINT DESIGN OPTIMIZATION FOR AIRPLANE AND HELICOPTER APPLICATION
J. J. THIBERT *In* AGARD, Special Course on Inverse Methods for Airfoil Design for Aeronautical and Turbomachinery Applications 47 p Nov. 1990
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Numerical optimization techniques are described and the use is shown as to how these techniques can be used. Emphasis is put on the applications with various optimization cases described in details. One point optimization cases for airfoil and wing designs with different objective functions, constraints and design variables are presented as well as multiple design point cases for helicopter blade airfoil applications. Author

N91-18046# National Aerospace Lab., Amsterdam (Netherlands).
CONSTRAINED SPANLOAD OPTIMIZATION FOR MINIMUM DRAG OF MULTI-LIFTING-SURFACE CONFIGURATIONS
R. F. VANDENDAM *In* AGARD, Special Course on Inverse Methods for Airfoil Design for Aeronautical and Turbomachinery Applications 15 p Nov. 1990
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A method is presented for the determination of optimal spanloads for multi lifting surface configurations. Algorithms are given for choosing the spanwise distributions of lift, pitching moment, chord and thickness to chord ratio of lifting elements. The choices are optimal in that they minimize induced plus viscous drag while satisfying constraints of aerodynamic, flight mechanical, and structural nature. The configuration that can be dealt with, may consist of a number of segments representing, for instance, wings or parts of wings, horizontal tails or canards, winglets, flap rail fairings, etc. Also the interaction between propellers and lifting elements may be included in the procedure. The induced drag is computed using the Trefftz plane integral, while the viscous drag follows from form factor methods. Novel mathematical formulations of the constrained optimization problem are used, that are based on the calculus of variations. The method can be used as a first step in the inverse numerical optimization approach to provide a starting point for the specification of target pressure distributions. Theoretical models and methods underlying the analysis and optimization are presented. Author

N91-18047# Sverdrup Technology, Inc., Eglin AFB, FL.
AERODYNAMIC OPTIMIZATION BY SIMULTANEOUSLY UPDATING FLOW VARIABLES AND DESIGN PARAMETERS
M. H. RIZK *In* AGARD, Special Course on Inverse Methods for Airfoil Design for Aeronautical and Turbomachinery Applications 22 p Nov. 1990 Previously announced as N90-20991
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The application of conventional optimization schemes to aerodynamic design problems leads to inner-outer iterative procedures that are very costly. An alternative approach is presented based on the idea of updating the flow variable iterative solutions and the design parameter iterative solution simultaneously. Two schemes based on this idea are applied to problems of correcting wind tunnel wall interference and optimizing advanced propeller designs. Computations are performed to test the schemes' efficiency, accuracy, and sensitivity to variations in the computational parameters. Author

N91-18048# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.
AERODYNAMICS OF ROTORCRAFT
Nov. 1990 307 p Special course held in Rhode-Saint Genese, Belgium, 2-5 Apr. 1990, in Ankara, Turkey, 9-11 Apr. 1990, and at Moffett Field, CA, 14-17 May 1990; sponsored by AGARD and the von Karman Inst.
(AGARD-R-781; ISBN-92-835-0592-1) Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The course first summarizes the various configurations of different rotary-wing aircraft and the simple methods to calculate their performance. Methods for designing efficient rotors are explained and justified. The optimization codes for airfoil and blade determinations are described. The rotor design can be improved by using advanced three dimensional aerodynamic codes, whose actual possibilities are presented. The consequences of specific aerodynamic phenomena are examined such as rotor wake on blade airloads and on rotor noise prediction. The state of the art of fuselage aerodynamics and on the problems related to rotor wake and fuselage interactions is given. An important part of the course is devoted to the experimental methods used for wind-tunnel and flight tests, in order to understand correctly the physical phenomena involved, and to acquire reliable data necessary for code validation.

N91-18049# Sikorsky Aircraft, Stratford, CT. Research and Advanced Design Div.
OVERVIEW OF HELICOPTER AND V/STOL AIRCRAFT
EVAN A. FRADENBURGH *In* AGARD, Aerodynamics of Rotorcraft

18 p Nov. 1990
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The development and history of the helicopter are briefly reviewed. Fundamental mechanisms of the helicopter are then described. The addition of auxiliary propulsion to a winged helicopter eliminates the restriction to normal speed. Rotorcraft configuration for high speed performance is examined. V/STOL concepts and economic impact are discussed. The roles of system complexity and reliability are discussed with an emphasis on cost effectiveness. The relationship of technical aerodynamics is examined against a background of other aspects of rotorcraft. B.G.

N91-18050# Sikorsky Aircraft, Stratford, CT. Research and Advanced Design Div.
BASIC AERODYNAMICS FOR ROTOR PERFORMANCE
EVAN A. FRADENBURGH *In* AGARD, Aerodynamics of Rotorcraft 12 p Nov. 1990
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Basic physics fundamental to helicopter flight; rotor and propeller performance in axial flight; hover performance; helicopter power requirements for forward flight; autorotation; ground effect and vertical drag effect; blade element theories; use of dimensionless coefficients for helicopter performance; and rotor lift drag ratio as a measure of aerodynamic efficiency are briefly discussed. B.G.

N91-18051# Aerospatiale, Marignane (France). Helicopter Div.
ROTOR AND BLADE AERODYNAMIC DESIGN
A. VUILLET *In* AGARD, Aerodynamics of Rotorcraft 59 p Nov. 1990
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This course is mainly related to the main rotor while the tail rotor and fenestron design are also discussed. The rotor is one of the helicopter's most specific component and plays a significant role as far as performance is concerned. The objective is to describe methods and give effective results that are useful in the design of a helicopter. The rotor's general sizing is discussed first. Studying engine failures and performance in autorotation as well as the power required in hover usually determines the rotor diameter; peripheral speed is selected in accordance with noise criteria; and the chord is dependent on the target maximum speed and load factor. The selection of the number of blades is more difficult and decided according to the vibration level transmitted at the airframe or noise rather than aerodynamic criteria. The rotor calculation methods, i.e., blade balance energy, blade element theory, and vortex theory are then described with a judgment as to their efficiency. The numerical optimization techniques are presented with their advantages by giving application examples on the selection of airfoil distribution spanwise. Fine optimization of the blade itself where the evolution of the airfoil design methods is explained with OA airfoils as an example is presented. The results obtained with blade planforms and tip shapes are largely discussed and two contradictory trends, i.e., blade tapering and enlarged tip as on WHL's BERP blade are presented. The influence of the anhedral and twist optimization are discussed. Tail rotor and fenestron designs are discussed. Author

N91-18052# Westland Helicopters Ltd., Yeovil (England). Dept. of Aerodynamics.
FUSELAGE AERODYNAMIC DESIGN ISSUES AND ROTOR/FUSELAGE INTERACTIONAL AERODYNAMICS. PART 1: PRACTICAL DESIGN ISSUES
F. T. WILSON *In* AGARD, Aerodynamics of Rotorcraft 16 p Nov. 1990
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The more important helicopter fuselage aerodynamic design issues and also interactional problems faced by the helicopter airframe aerodynamicist, including performance and handling optimization and special effects caused by rotor downwash impingement on the fuselage at low and high speeds are addressed. The experimental approach remains the principal tool for the solution of helicopter fuselage aerodynamic problems since existing theoretical methods still possess deficiencies such as an inability to model strong three dimensional effects and separated flow areas both on the fuselage and aft of the rotor head. Flight testing is not generally used for helicopter fuselage aerodynamic research work and the use of small scale wind tunnel models remains the principal experimental tool for airframe design. However, CFD methods are being increasingly used to supplement wind tunnel testing and research programs are underway to constantly improve and update techniques in both fuselage and rotor/fuselage interactional aerodynamics. Author

N91-18053# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany, F.R.).
FUSELAGE AERODYNAMICS DESIGN ISSUES AND ROTOR/FUSELAGE INTERACTIONAL AERODYNAMICS. PART 2: THEORETICAL METHODS
S. R. AHMED *In* AGARD, Aerodynamics of Rotorcraft 38 p Nov. 1990
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Theoretical methods currently available to predict helicopter fuselage flow and interaction phenomena are reviewed. In view of the enormous challenge a helicopter flow field poses for CFD, only inviscid flow codes with subsequent viscous corrections have found applications in industry. The basic modules of such methods to treat the isolated fuselage flow are explained and the predictions compared with experimental data. Also newer developments, to devise codes based on time-averaged or time-dependent Navier-Stokes equations are discussed and their present capabilities indicated. Interaction phenomena remains for the foreseeable future beyond the possibilities of present viscous flow codes. Status and development trends of inviscid codes to simulate rotor/body/wake interaction phenomena is discussed and evaluated. Author

N91-18054*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE APPLICATION OF CFD TO ROTARY WING FLOW PROBLEMS
F. X. CARADONNA (Army Aviation Research and Development Command, Saint Louis, MO.) *In* AGARD, Aerodynamics of Rotorcraft 38 p Nov. 1990
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Rotorcraft aerodynamics is especially rich in unsolved problems, and for this reason the need for independent computational and experimental studies is great. Three-dimensional unsteady, nonlinear potential methods are becoming fast enough to enable their use in parametric design studies. At present, combined CAMRAD/FPR analyses for a complete trimmed rotor soltution can be performed in about an hour on a CRAY Y-MP (or ten minutes, with multiple processors). These computational speeds indicate that in the near future many of the large CFD problems will no longer require a supercomputer. The ability to convect circulation is routine for integral methods, but only recently was it discovered how to do the same with differential methods. It is clear that the differential CFD rotor analyses are poised to enter the engineering workplace. Integral methods already constitute a mainstay. Ultimately, it is the users who will integrate CFD into the entire engineering process and provide a new measure of confidence in design and analysis. It should be recognized that the above classes of analyses do not include several major limiting phenomena which will continue to require empirical treatment because of computational time constraints and limited physical understanding. Such empirical treatment should be included, however, into the developing CFD, engineering level analyses. It is likely that properly constructed flow models containing corrections from physical testing will be able to fill in unavoidable

gaps in the experimental data base, both for basic studies and for specific configuration testing. For these kinds of applications, computational cost is not an issue. Finally, it should be recognized that although rotorcraft are probably the most complex of aircraft, the rotorcraft engineering community is very small compared to the fixed-wing community. Likewise, rotorcraft CFD resources can never achieve fixed-wing proportions and must be used wisely. Therefore the fixed-wing work must be gleaned for many of the basic methods. Author

N91-18055# Johnson Aeronautics, Palo Alto, CA.
AIRLOADS, WAKES, AND AEROELASTICITY
WAYNE JOHNSON *In* AGARD, Aerodynamics of Rotorcraft 20 p Nov. 1990 Previously announced as N90-21738
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Fundamental considerations regarding the theory of modeling of rotary wing airloads, wakes, and aeroelasticity are presented. The topics covered are: airloads and wakes, including lifting-line theory, wake models and nonuniform inflow, free wake geometry, and blade-vortex interaction; aerodynamic and wake models for aeroelasticity, including two-dimensional unsteady aerodynamics and dynamic inflow; and airloads and structural dynamics, including comprehensive airload prediction programs. Results of calculations and correlations are presented. Author

N91-18056# McDonnell-Douglas Helicopter Co., Mesa, AZ. Aero/Acoustics Div.
AEROACOUSTICS OF ROTORCRAFT
R. D. JANAKIRAM *In* AGARD, Aerodynamics of Rotorcraft 33 p Nov. 1990
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A review of the state-of-the-art of rotorcraft aeroacoustics with emphasis on helicopter noise is presented. The fundamentals of rotorcraft aeroacoustics are discussed in terms of the underlying source mechanisms, theoretical models and prediction methodologies in three categories of rotor noise; rotational (non-impulsive) noise; impulsive noise including high-speed impulsive noise, blade-vortex interaction noise and main rotor/tail rotor interaction noise; and broadband noise. Key model rotor and flight test experiments are also discussed. Recent developments, especially those that occurred in the 1980s in the area or rotorcraft (or helicopter) aeroacoustics are discussed in three categories: aeroacoustic testing and data base development, noise prediction, and noise reduction. Author

N91-18057# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
CONSIDERATIONS ON WIND-TUNNEL TESTING TECHNIQUES FOR ROTORCRAFT
J. J. PHILIPPE *In* AGARD, Aerodynamics of Rotorcraft 34 p Nov. 1990
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For many years, wind-tunnel testing is a necessity when designing and building a rotorcraft. The first reason is certainly the fact that numerical methods are still far from being capable of accurate rotor and fuselage performance prediction. Even if now there are more and more sophisticated codes, more and more detailed experimental results are needed in order to validate these codes and to fix their domain of validity. The second reason for wind-tunnel testing is to reduce risks and costs in rotorcraft development, especially if using a new design or if flying in a flight domain not yet explored or one that is considered dangerous. Try before flying is perhaps even more necessary for the rotary wing aircraft community than for the fixed-wing community, due to the complexity of the configurations involved in an aircraft having to assure vertical take-off, hover, and forward flight. The third reason for wind-tunnel testing is related to the need for optimized configuration: too many parameters are concerned with this aim and it would be unrealistic to try to build and test too many full-scale prototypes. Wind-tunnel testing is a good way to confirm the performance of a specific design and to select the most appropriate configuration to build for flight testing and validation. Author

N91-18058# Royal Aerospace Establishment, Bedford (England). Helicopter Aeromechanics Section.
EXPERIMENTAL TECHNIQUES IN HELICOPTER AERODYNAMICS FLIGHT RESEARCH
P. BROTHERHOOD and M. J. RILEY *In* AGARD, Aerodynamics of Rotorcraft 25 p Nov. 1990
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The techniques used in the study of main and tail rotor aerodynamics by measurements on full-scale helicopters in flight are described. The strengths and weaknesses of flight research are discussed and some comparisons with wind tunnel techniques are drawn. The application of various types of sensors is discussed together with a more general discussion on data acquisition, recording, and processing. Airworthiness aspects including fatigue damage monitoring are also considered. Examples which illustrate the various techniques and provide informative comparisons with theory are presented. The use of comparative techniques in which opposite blades in a single rotor are individually modified and the use of indicator sensors to supplement or replace complete chordwise pressure distributions are highlighted. Author

N91-18059 Leicester Univ. (England).
UNSTEADY AERODYNAMIC FORCES ON PARACHUTE CANOPIES Ph.D. Thesis
R. J. HARWOOD 1988 272 p
Avail: Univ. Microfilms Order No. BRD-90617

Unsteady force coefficients were determined for a range of parachute canopy models. These coefficients are required for prediction of the aerodynamic stability of full scale parachutes under conditions of unsteady motion during descent. The method of obtaining these coefficients required the collection of force and acceleration data for parachute canopy model which were tested in unsteady conditions. This was achieved by imposing oscillatory motion on individual canopies during towing tests. Two modes of unsteady motion were imposed on a canopy under test: one with axial oscillations; and one with lateral oscillations. A mathematical model describing such modes of motion consists of a general equation for the unsteady force developed on a bluff body. An identification technique is used to determine the mean values per cycle of each parameter by substitution of the data obtained from these tests as functional variables in the mathematical model. The results indicate a strong dependence in oscillatory motion of the mean value per cycle for the axial added mass coefficient on the unsteady force parameter. Dissert. Abstr.

N91-18060# Oak Ridge National Lab., TN. Applied Technology Div.
EVALUATION OF THERMOGRAPHIC PHOSPHOR TECHNOLOGY FOR AERODYNAMIC MODEL TESTING
M. R. CATES, K. W. TOBIN, and D. BARTON SMITH Aug. 1990 31 p
(Contract DE-AC05-84OR-21400; MIPR-EY-7483-89-0007)
(DE91-005631; ORNL/ATD-40) Avail: NTIS HC/MF A03

The goal for this project was to perform technology evaluations applicable to the development of higher-precision, higher-temperature aerodynamic model testing at Arnold Engineering Development Center (AEDC) in Tullahmoa, Tennessee. With the advent of new programs for design of aerospace craft that fly at higher speeds and altitudes, requirements for detailed understanding of high-temperature materials become very important. Model testing is a natural and critical part of the development of these new initiatives. The well-established thermographic phosphor techniques of the Applied Technology Division at Oak Ridge National Laboratory are highly desirable for diagnostic evaluation of materials and aerodynamic shapes as studied in model tests. Combining this state-of-the-art thermographic technique with modern, higher-temperature models will greatly improve the practicability of tests for the advanced

aerospace vehicles and will provide higher precision diagnostic information for quantitative evaluation of these tests. The wavelength ratio method for measuring surface temperatures of aerodynamic models was demonstrated in measurements made for this project. In particular, it was shown that the appropriate phosphors could be selected for the temperature range up to approximately 700 F or higher and emission line ratios of sufficient sensitivity to measure temperature with 1 percent precision or better. Further, it was demonstrated that two-dimensional image-processing methods, using standard hardware, can be successfully applied to surface thermography of aerodynamic models for AEDC applications. DOE

N91-18064*# Kansas Univ. Center for Research, Inc., Lawrence. Flight Research Lab.
FOURIER FUNCTIONAL ANALYSIS FOR UNSTEADY AERODYNAMIC MODELING
C. EDWARD LAN and SUEI CHIN Feb. 1991 101 p
(Contract NAG1-1087)
(NASA-CR-187964; NAS 1.26:187964; KU-FRL-872-2) Avail: NTIS HC/MF A06 CSCL 01/1

A method based on Fourier analysis is developed to analyze the force and moment data obtained in large amplitude forced oscillation tests at high angles of attack. The aerodynamic models for normal force, lift, drag, and pitching moment coefficients are built up from a set of aerodynamic responses to harmonic motions at different frequencies. Based on the aerodynamic models of harmonic data, the indicial responses are formed. The final expressions for the models involve time integrals of the indicial type advocated by Tobak and Schiff. Results from linear two- and three-dimensional unsteady aerodynamic theories as well as test data for a 70-degree delta wing are used to verify the models. It is shown that the present modeling method is accurate in producing the aerodynamic responses to harmonic motions and the ramp type motions. The model also produces correct trend for a 70-degree delta wing in harmonic motion with different mean angles-of-attack. However, the current model cannot be used to extrapolate data to higher angles-of-attack than that of the harmonic motions which form the aerodynamic model. For linear ramp motions, a special method is used to calculate the corresponding frequency and phase angle at a given time. The calculated results from modeling show a higher lift peak for linear ramp motion than for harmonic ramp motion. The current model also shows reasonably good results for the lift responses at different angles of attack. Author

N91-18065# Helsinki Univ. Technology, Otaniemi (Finland). Lab. of Aerodynamics.
NUMERICAL SIMULATION OF TRANSONIC FLOW AROUND AIRFOILS AT HIGH REYNOLDS NUMBERS USING ALGEBRAIC TURBULENCE MODELS
JAAKKO HOFFREN and TIMO SIIKONEN 1990 33 p
(B-29; ISBN-951-22-0441-X; ISSN-0358-2620) Avail: NTIS HC/MF A03

Turbulent flows at high Reynolds numbers around airfoils are simulated with a finite volume Navier-Stokes solver. Two algebraic turbulence models are added to the FINFLO program, and the performance of the code is tested by comparisons with reference results, laying special emphasis on the accuracy of the calculated force coefficients. The effects of some computation aspects are studied, and the efficiency of the code is briefly evaluated. Author

N91-18066*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SEA LEVEL STATIC CALIBRATION OF A COMPACT MULTIMISSION AIRCRAFT PROPULSION SIMULATOR WITH INLET FLOW DISTORTION
MARK J. WON Nov. 1990 181 p LIMITED REPRODUCIBILITY: More than 20% of this document may be affected by color photographs Original contains color illustrations
(NASA-TM-102838; A-90194; NAS 1.15:102838) Avail: NTIS HC/MF A09; 11 functional color pages CSCL 01/1

Wind tunnel tests of propulsion-integrated aircraft models have identified inlet flow distortion as a major source of compressor airflow measurement error in turbine-powered propulsion simulators. Consequently, two Compact Multimission Aircraft Propulsion Simulator (CMAPS) units were statically tested at sea level ambient conditions to establish simulator operating performance characteristics and to calibrate the compressor airflow against an accurate bellmouth flowmeter in the presence of inlet flow distortions. The distortions were generated using various-shaped wire mesh screens placed upstream of the compressor. CMAPS operating maps and performance envelopes were obtained for inlet total pressure distortions (ratio of the difference between the maximum and minimum total pressures to the average total pressure) up to 35 percent, and were compared to baseline simulator operating characteristics for a uniform inlet. Deviations from CMAPS baseline performance were attributed to the coupled variation of both compressor inlet-flow distortion and Reynolds number index throughout the simulator operating envelope for each screen configuration. Four independent methods were used to determine CMAPS compressor airflow; direct compressor inlet and discharge measurements, an entering/exiting flow-balance relationships, and a correlation between the mixer pressure and the corrected compressor airflow. Of the four methods, the last yielded the least scatter in the compressor flow coefficient, approximately + or - 3 percent over the range of flow distortions. Author

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AIR TRANSPORTATION AND SAFETY

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

A91-24281
THE MATHEMATICAL MODELLING AND COMPUTER SIMULATION OF FIRE DEVELOPMENT IN AIRCRAFT
E. R. GALEA (Thames Polytechnic, London, England) and N. C. MARKATOS (Athens, National Technical University, Greece) International Journal of Heat and Mass Transfer (ISSN 0017-9310), vol. 34, Jan. 1991, p. 181-197. Research supported by SERC and Civil Aviation Authority. refs
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A study is presented of a transient or steady-state, three-dimensional mathematical field model describing aircraft cabin fires, which will eventually replace reliance on empiricism. The computer code implementing the model utilizes a body-fitted coordinate formulation to detail accurately the aircraft interior, which is neither polar-cylindrical nor Cartesian. Investigation of the effect of openings in the compartmentation of the cabin and fuselage of a 737 aircraft on the temperature distribution in an empty cabin is conducted. With the interior fitted with seats, overhead containers, and ceiling panels, the effect of the air conditioning system on the temperature distribution within the burning fuselage is studied. The results indicate that a reverse flow situation, i.e., cold air injected through floor vents and hot air drawn out at ceiling vents, sharply lowers the temperature throughout the fuselage. It is concluded that the utilization of this venting procedure could lead to the control of the rate of spread of fire within the cabin. R.E.P.

A91-24323#
THE INFLUENCE OF AIRCRAFT CABIN CONFIGURATION ON PASSENGER EVACUATION BEHAVIOUR
HELEN MUIR and CLAIRE MARRISON (Cranfield Institute of Technology, England) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 168-173.
Copyright

The UK's Civil Aviation Authority has conducted an experimental investigation of passenger behavior during aircraft emergencies, giving attention to the influence of changes in cabin configuration affecting access to emergency exits, and therefore the rate at which evacuation can be conducted. The configurations, which involved a range of widths for the passageway through a bulkhead aperture leading to floor level exits, and a range of seating configurations adjacent to an overwing exit, were evaluated when the passengers were (1) competing to evacuate the aircraft, and (2) evacuating in an orderly manner. The results obtained suggest that blockages which have occurred in emergency evacuations can be significantly reduced when the passageway through a bulkhead is greater than 30 inches. O.C.

A91-24364#
HARMONIZATION OF U.S. AND EUROPEAN GUST CRITERIA FOR TRANSPORT AIRPLANES
TERENCE J. BARNES (FAA, Seattle, WA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 586-593. refs

The current status of an international projets aimed at reevaluating gust criteria for the next generation of commercial transports is examined. In particular, attention is given to the task of harmonizing the FAR-23 and JAR-25 gust criteria. The background and history of the current gust criteria are briefly reviewed, as are the advantages and disadvantages of the criteria. The current proposal contains four elements instead of the seven required previously; the four elements are: far gust (Pratt formula), PSD design envelope, revised JAA discrete gust, and round-the-clock gust. V.L.

A91-24447#
CERTIFICATION OF LARGE AIRPLANE COMPOSITE STRUCTURES - RECENT PROGRESS AND NEW TRENDS IN COMPLIANCE PHILOSOPHY
JEAN ROUCHON (Toulouse, Centre d'Essais Aeronautique, France) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1439-1447. refs
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Three key issues in the certification procedures used for large aircraft composite structures are discussed: second-source material qualification, conditions to simulate environmental effects, and damage tolerance demonstration for accidental impact damage. A compliance philosophy has been developed to qualify a second-source material for an already certified part. Additionally, a recommended steady condition for the relative humidity equivalent, in terms of material equilibrium moisture content, to the hygrothermal history encountered by the aircraft is established. The need for a probabalistic approach to select the inspection intervals for accidental impacts in damage-tolerance justifications is examined. L.K.S.

A91-24527#
THE ANALYSIS OF THREE ICING FLIGHTS WITH VARIOUS ICE ACCRETION STRUCTURES WHEN REACHING ICING DEGREE SEVERE
H.-E. HOFFMANN (DLR, Institut fuer Physik der Atmosphaere, Wessling, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2203-2210. refs
Copyright

Three icing flights are discussed - one in the clouds of a high pressure area, the other two in the clouds of warmfronts - on which severe aircraft icing occurred. The ice accretion on the wing underside expanded to 50 and 70 cm, far beyond the area which can be deiced pneumatically on the wing of the DLR icing research aircraft of Do 28 type. Author

A91-24698
AIR INCIDENTS WITHOUT END? I [LUFTZWISCHENFAELLE UND KEIN ENDE? I]
JOACHIM F. BENTZIEN Zeitschrift fuer Luft- und Weltraumrecht (ISSN 0340-8329), vol. 39, Dec. 1990, p. 345-359. In German. refs
Copyright

Recent air incidents arising when military aircraft entered the air space of a foreign nation without permission are listed and briefly described, and their international legal implications are considered. The types of incidents examined are: (1) those where aircraft were actually shot down, (2) those where aircraft were forced to land or turn back, (3) those where confrontation occurred in a nation's coastal air-defense zone, (4) those where crew members were captured and punished or aircraft were confiscated, and (5) those where aircraft carrying heads of state or diplomats were attacked. T.K.

A91-26178
VERIFYING FIRE SAFETY
GEORGE MARSH Aerospace Composites and Materials (ISSN 0954-5832), vol. 3, Jan.-Feb. 1991, p. 32-35.
Copyright

Airworthiness authorities and the airlines have continuously sought over the years to make cabin interiors safer in the event of fire. Though aircraft interior designers have favored plastics for their low weight, functional strength and decorative effect, many plastics tend to emit smoke and toxic gases when they burn, producing lethal gases such as hydrochloric acid, hydrogen cyanide, sulfur dioxide, carbon monoxide, and various oxides of nitrogen. FAR Part 25 has been progressively developed to include more stringent flammability and emission criteria for cabin interiors. In 1986, the FAA issued a requirement for a heat release rate test using a calorimeter that takes six-inch-square specimens and tests them under controlled conditions by applying heat radiantly from a surrounding grid of glow bars. To date, reproducibility of tests remains a major problem confronting the continuing search for new and suitable cabin materials that are thermally stable with high ignition temperatures, and give low generated heat on burning and low char residue, and are low in smoke and toxic gas emissions. R.E.P.

A91-26190*# Sikorsky Aircraft, Stratford, CT.
RESULTS OF A SUB-SCALE MODEL ROTOR ICING TEST
ROBERT J. FLEMMING (Sikorsky Aircraft, Stratford, CT), THOMAS H. BOND (NASA, Lewis Research Center, Cleveland, OH), and RANDALL K. BRITTON (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 31 p. Previously announced in STAR as N91-14309. refs
(AIAA PAPER 91-0660) Copyright

A heavily instrumented sub-scale model of a helicopter main rotor was tested in the NASA Lewis Research Center Icing Research Tunnel (IRT) in September and November 1989. The four-bladed main rotor had a diameter of 1.83 m (6.00 ft) and the 0.124 m (4.9 in) chord rotor blades were specially fabricated for this experiment. The instrumented rotor was mounted on a Sikorsky Aircraft Powered Force Model, which enclosed a rotor balance and other measurement systems. The model rotor was exposed to a range of icing conditions that included variations in temperature, liquid water content, and median droplet diameter, and was operated over ranges of advance ratio, shaft angle, tip Mach number (rotor speed) and weight coefficient to determine the effect of these parameters on ice accretion. In addition to strain gage and balance data, the test was documented with still, video, and high speed photography, ice profile tracings, and ice molds. The sensitivity of the model rotor to the test parameters is given, and the result to theoretical predictions are compared. Test data quality was excellent, and ice accretion prediction methods and rotor performance prediction methods (using published icing lift and drag relationships) reproduced the performance trends observed in the test. Adjustments to the correlation coefficients to improve the level of correlation are suggested. Author

A91-26193*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NUMERICAL SIMULATION OF ICE GROWTH ON A MS-317 SWEPT WING GEOMETRY
M. G. POTAPCZUK and C. S. BIDWELL (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 23 p. Previously announced in STAR as N91-14310. refs
(AIAA PAPER 91-0263) Copyright

An effort to develop a 3-D ice accretion modeling method was initiated. This first step towards creation of a complete aircraft icing simulation code builds on previously developed methods for calculating 3-D flow fields and particle trajectories combined with a 2-D ice accretion calculation along coordinate locations corresponding to streamlines. The types of calculations necessary to predict three-dimensional ice accretion is demonstrated. Results of calculations using 3-D method for a MS-317 swept wing geometry are projected onto a 2-D plane parallel to the free stream direction and compared to experimental results for the same geometry. It is anticipated that many modifications will be made to this approach, however, this effort will lay the groundwork for future modeling efforts. Results indicate that rime ice shapes indicate a difficulty in accurately calculating the ice shape in the runback region.
Author

A91-26697
DOES EUROPE NEED A NEW FLIGHT SAFETY SYSTEM? [BRAUCHT EUROPA EINE NEUE FLUGSICHERUNG?]
HANS-ULRICH OHL (Bundesanstalt fuer Flugsicherung, Frankfurt am Main, Federal Republic of Germany) Luft- und Raumfahrt (ISSN 0173-6264), vol. 11, 4th Quarter, 1990, p. 24-26, 28. In German.
Copyright

The problems posed for the European ATC network by the continuing rapid increase in air traffic are surveyed, and solution strategies are briefly characterized. Incompatibilities among the ATC systems of the different countries have led to a call for standardization and some degree of central control, as summarized in the ICAO/FANS Communication, Navigation, and Surveillance Concept and the Future European Air Traffic Service (FEATS) plan approved by the European Air Navigation Planning Group in 1989. Requirements for such a system include complete secondary-radar (SR) coverage, a central computer for real-time analysis of the SR data, means for collecting aircraft flight-management-system data as a backup information source, a centralized flight-plan data base to facilitate strategic planning, and delay-free data transfer among all airports and ATC facilities.
T.K.

A91-26790
SPECIAL CONSIDERATIONS FOR HELICOPTER SAFETY
RICHARD J. ADAMS IN: Aviation psychology. Aldershot, England and Brookfield, VT, Gower Technical, 1989, p. 210-230. refs
Copyright

This paper presents an analysis of helicopter safety problems and the root causes of pilot error accidents considering both the statistically prevalent causes and the insight obtained from surveying professional helicopter pilots. A number of criteria are addressed, including motivational and personality factors, qualifications and experience, the flying environment, operational hazards, and accident characteristics. It is concluded that pilot training and proficiency have the greatest impact on the pilot error accident rate and the helicopter's mission profile significantly affects the overall accident rate. Considerations are then proffered on ways to improve helicopter safety.
R.E.P.

A91-27829
AVIATION SECURITY AND PAN AM FLIGHT 103 - WHAT HAVE WE LEARNED?
NANCY JEAN STRANTZ Journal of Air Law and Commerce (ISSN 0021-8642), vol. 56, Winter 1990, p. 413-489. refs
Copyright

The changes in aviation law and security occasioned by the disaster of Pan Am Flight 103 are reviewed. The most important changes are the recent reexamination of the proposed reforms to the Warsaw Convention and related compensation plans, the introduction in 1989 of both the Aviation Airport Technology and Research Act and the Aviation Security Act, and the release of a report by the President's Commission on Aviation Security and Terrorism and the introduction in 1990 of the Aviation Security Improvement Act. Detailed attention is given to the legislative initiatives and the prospects for their success.
C.D.

N91-17005# Federal Aviation Administration, Atlantic City, NJ.
FLIGHT EVALUATION OF SEVERAL GROUND DEICING/ANTI-ICING FLUIDS ON GENERAL AVIATION AIRCRAFT Final Report
DAVID L. KOHLMAN and MAHYAR RAHBARRAD (Kohlman Aviation Corp., Colorado Springs, CO.) Dec. 1990 90 p
(Contract DTFA03-90-P-00804)
(DOT/FAA/CT-TN90/31) Avail: NTIS HC/MF A05

The aerodynamic effects of aircraft ground deicing/anti-icing fluids is a topic that has received increasing attention in recent years as the use of these fluids becomes more widespread and sophisticated. An important consideration with respect to the use of these fluids is the effect of residual fluid remaining on the aircraft during the takeoff roll and initial climb. A flight test program to determine these effects on the takeoff and climb performance for two general aviation aircraft was conducted. The flight tests were performed in Topeka, Kansas, and Duluth, Minnesota. Results indicate that the presence of the deicing/anti-icing fluids on the aerodynamic surfaces of the test aircraft can reduce aerodynamic lift and increase liftoff airspeed. However, the flight test pilots reported no obvious changes in the performance of handling characteristics of the aircraft.
Author

N91-17007# Federal Aviation Administration, Washington, DC. Office of Safety Analysis.
STUDY OF THE RELATIONSHIPS BETWEEN NEAR MIDAIR COLLISIONS (NMAC'S), MIDAIR COLLISIONS (MAC'S) AND SOME POTENTIAL CAUSAL FACTORS
JOEL M. YESLEY Mar. 1990 30 p
(PB90-268491) Avail: NTIS HC/MF A03 CSCL 01/3

The relationships between near midair collision (NMAC) and midair collision (MAC) incidence and some potential explanatory factors was examined by using regression techniques. In addition, the hypothetical existence of a relationship between NMAC and MAC incidence was examined in detail. All NMAC's and MAC's occurring within major airport hubs over the 1984 to 1986 period were examined in the first part. No statistically significant relationships were found to exist between the occurrence of NMAC's and MAC's over the entire 1981 to 1986 period, although the correlation was considerably stronger over the 1983 to 1986 period.
- Author

N91-17008# Federal Aviation Administration, Atlantic City, NJ.
INVESTIGATION OF ACCIDENTAL DC-7 FIRE DAMAGE OCCURRING JUNE 28, 1989
THOMAS RUST et al. Dec. 1990 41 p
(DOT/FAA/CT-TN89/55) Avail: NTIS HC/MF A03

Three groups of investigators were formed to determine the circumstances that caused an accidental, fuselage-destroying fire that occurred on June 28, 1989, in the research and development area of the FAA Technical Center. From interviews with witnesses and analysis of the structural fire damage to the fuselage, a probable sequence of events was developed and an analysis of the contributing causes of the damage was determined. A number of recommendations for future test scenarios were established in order to prevent the extensive fire damage that resulted during this test.
Author

N91-17009*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AVIATION SAFETY AND AUTOMATION TECHNOLOGY FOR SUBSONIC TRANSPORTS
JAMES A. ALBERS Jan. 1991 54 p Presented at the 1991

AIAA International Aerospace Conference and Engineering Show, 13 Feb. 1991, Los Angeles, CA
(NASA-TM-103831; A-91039; NAS 1.15:103831) Avail: NTIS HC/MF A04 CSCL 01/3

Discussed here are aviation safety human factors and air traffic control (ATC) automation research conducted at the NASA Ames Research Center. Research results are given in the areas of flight deck and ATC automations, displays and warning systems, crew coordination, and crew fatigue and jet lag. Accident investigation and an incident reporting system that is used to guide the human factors research is discussed. A design philosophy for human-centered automation is given, along with an evaluation of automation on advanced technology transports. Intelligent error tolerant systems such as electronic checklists are discussed along with design guidelines for reducing procedure errors. The data on evaluation of Crew Resource Management (CRM) training indicates highly significant positive changes in appropriate flight deck behavior and more effective use of available resources for crew members receiving the training. Author

N91-17010# Systems Control Technology, Inc., Arlington, VA.
ANALYSIS OF HELICOPTER MISHAPS AT HELIPORTS, AIRPORTS, AND UNIMPROVED SITES Final Report
LEN D. DZAMBA, ROBERT J. HAWLEY, and RICHARD J. ADAMS Jan. 1991 78 p Prepared in cooperation with Advanced Aviation Concepts, Jupiter, FL
(Contract DTFA01-87-C-00014)
(SCT-90RR-46; DOT/FAA/RD-90/8) Avail: NTIS HC/MF A05

A task was undertaken to determine possible inadequacies in FAA design standards and guidelines set forth in the Heliport Design Advisory Circular (AC 150/5390-2). This report is based upon the results of an analysis of helicopter mishaps which occurred within a 1 mile radius of various landing sites, including heliports, airports, and unimproved sites. NTSB and U.S. Army reports describing mishaps that occurred at or near a facility were used. The focus of the analysis was to determine the manner in which facility design may contribute to the mishaps. Particular attention was given to issues concerning the size, obstruction clearance, and adequacy of facility protected airspace and operational areas. Mishap type and location, as well as the applicable design issues, were analyzed from the reports and are discussed. It is concluded that overall, the Heliport Design Advisory Circular provides very good guidelines for heliport design and is a valid instrument. Several areas for possible improvement within the document have been identified. Recommendations include areas addressing obstruction marking, facility maintenance, wind indicator location, and guidelines for operations at airports.
Author

N91-18006*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FUTURE REGIONAL/COMMUTER CHALLENGES Abstracts Only
W. DON HARVEY *In* Wichita State Univ., Proceedings: Techfest 17 p 2 1991
Avail: NTIS HC/MF A03 CSCL 01/3

Technological advances in the next ten years will represent a continuum of the steady improving state-of-the-art in all the major disciplines. In the past there was a number of step changes in technology, but no known really large quantum jumps are envisioned at present which could be readily applied to short haul aircraft. The one exception in the field of aerodynamics might be the application of natural laminar flow on short haul and laminar flow control on long haul aircraft. The aim in the 1990's will be to single out the major areas where advances will contribute to overcome important constraints such as fuel conservation, noise, airspace and airport saturation, and surface transportation competition. Y.S.

N91-18020# Wichita State Univ., KS. National Inst. for Aviation Research.
AVIATION SAFETY ENHANCEMENTS THROUGH THE INTERNATIONAL AIRCRAFT DATABASE RESEARCH PROJECT Abstract Only
JOHN HUTCHINSON and BRENT BOWEN *In its* Proceedings: Techfest 17 p 19 1991
Avail: NTIS HC/MF A03

Aircraft operational safety is dependent upon the prompt distribution of airworthiness directives issued by the Federal Aviation Administration (FAA). It is very important to enhance the timely distribution of airworthiness information to the operators of U.S. registered aircraft. To facilitate this, a prototype system is under development which will track, identify, and retrieve civil aircraft information on both a domestic and international basis. The final result will be the delivery of a turn-key system to the FAA. This system will comply with FAA requirements for data management as well as incorporate a user-friendly, automated, menu driven filing and retrieval system. Author

N91-18021# Wichita State Univ., KS. Dept. of Mechanical Engineering.
COMPUTER SIMULATIONS OF AN AIRCRAFT OCCUPANT-RESTRAINT SYSTEM Abstract Only
DEREN MA and HAMID M. LANKARANI *In its* Proceedings: Techfest 17 p 20 1991
Avail: NTIS HC/MF A03

A multi-segment model of the human body, the seat, the restraint system, and a computer environment are presented to simulate the post-crash response of the occupant in the specific types of surges such as frontal or rear collisions. The human body is modeled as a collection of elements interconnected by an array of kinematic joints constraining the relative motion of the elements. The model includes head-neck, upper body, upperarms, forearms, thighs, and lower legs. Nonlinear torsional spring-dampers are incorporated at the joints mimicking the anatomical characteristics and limits. To perform a dynamic analysis, a three-dimensional code is developed that generates and numerically solves the governing differential equations of motion in a systematic fashion. Simple graphical images of the system are obtained from a post-processing program. This computerized model and the results of the simulations provide means for predicting motion response and possible injuries of crash victims with much less effort and more data, but consistent with the results of anthropomorphic dummies. Author

N91-18028# Kansas Univ., Lawrence. Dept. of Aerospace Engineering.
ON THE FEASIBILITY OF SMALL, VERY-LONG-RANGE CIVIL TRANSPORTS Abstract Only
JAN ROSKAM *In* Wichita State Univ., Proceedings: Techfest 17 p 26 1991
Avail: NTIS HC/MF A03

The technical and economical feasibility of developing a 150 passenger 6000 nm range civil transport is discussed. Such a transport could connect a large number of city pairs which cannot be economically serviced by existing, much larger wide body jet transports. It is shown which combinations of aerodynamic, propulsive, and structural technologies will allow such a transport to be developed such that it can compete on a cost-per-seat-mile basis with todays wide body jets. Author

N91-18029# Merkel Aircraft Co., Wichita, KS.
SPORT AVIATION AND SAFETY Abstract Only
EDWIN MERKEL *In* Wichita State Univ., Proceedings: Techfest 17 p 27 1991
Avail: NTIS HC/MF A03

The Sport Aviation Manufacturers Association is seeking to develop and secure appropriate modifications in the FAR certification rules and airworthiness standards. The primary emphasis must be safety of flight, which must start with handling qualities. Handling qualities must start with the spin phenomena,

since aircraft accident history reveals the spin to be the greatest source of general aviation accidents. Y.S.

N91-18069# Sikorsky Aircraft, Stratford, CT. Advanced Design and Business Development.
DESIGN OF THE ADVANCED CARGO AIRCRAFT. THE US ARMY'S NEXT GENERATION TRANSPORT ROTORCRAFT: AN OVERVIEW
CHRIS JARAN *In* AGARD, Progress in Military Airlift 8 p Dec. 1990
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A family of rotorcraft were defined to meet the projected requirements of the U.S. Army for combat airlift in the year 2000 and beyond. A detailed definition of equipment and mission load inventories was developed, and a knowledge-based simulation assessed the capability of various-size aircraft to transport these inventories in three combat theaters: Europe, Southwest Asia, and Latin America. Payload capabilities of 18, 26, 30, and 39 thousand lb with 270 nm (500 km) radius of action at Army hot day ambients were identified as potentially cost effective design points. A 9 x 9 ft (2.74 x 2.74 m) cabin cross section was required, with a cabin length of 32 to 41 ft (9.75 to 12.5 m) depending on design payload. Single and tandem rotor helicopter solutions were defined for each of the four design payloads. A tilt rotor solution was also examined. A single rotor configuration with a design gross weight of 94,000 lb (42,637 kg), a rotor diameter of 122 ft (37.2 m), and three engines served as a baseline for evaluation of the impact of various design criteria and system technology levels. Author

N91-18070# Construcciones Aeronauticas S.A., Madrid (Spain). Projects Div.
GENERAL CONFIGURATION ASPECTS ON AIRLIFTER DESIGN
J. L. LOPEZDIEZ, J. R. HERRERA, and J. L. ASENJO *In* AGARD, Progress in Military Airlift 14 p Dec. 1990
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The history and actual process followed at CASA for the analysis of the requirements and selection of the most suitable configuration for a new Military Airlifter System are presented. The importance of an adequate initial choice of some parameters such as fuselage cross-section and length, wing area and geometry related to load and unload operations was emphasized. Peace time and war time operations must be taken into account to get a realistic view of essential factors such as fleet size and life-cycle cost for the transport system. Finally the availability of suitable powerplants is an important factor to fix the final specifications of a Military Airlifter System. Author

N91-18071# Plans du Transport Aerien Militaire, Velizy-Villacoublay (France).
LESSONS DRAWN FROM FRANCE'S RECENT OPERATIONAL EXPERIENCES REGARDING THE DESIGN OF MILITARY TRANSPORT AIRCRAFT [ENSEIGNEMENTS TIRES PAR LA FRANCE DE SES EXPERIENCES OPERATIONNELLES RECENTES EN MATIERE DE CONCEPTION D'AVIONS DE TRANSPORT MILITAIRE]
A. BEVILLARD *In* AGARD, Progress in Military Airlift 8 p Dec. 1990 In FRENCH
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Since the end of the second world war the French military has conducted operations in a number of diverse theaters including Indochina, Algeria and Chad. Lessons drawn from these operational experiences, related to the design of military transport aircraft are discussed and specific design criteria for a future fleet of transport aircraft are defined. The essential characteristics of a future military transport include: (1) a cargo bay with a minimum height and width of 4 meters (larger than the current dimensions of the C-160 and C-130); (2) good tactical capabilities combined with a significant operating range; and (3) interoperability (since the development of this aircraft will require a european, if not an american-european cooperative effort. Transl. by M.G.

N91-18072# Joint Air Transport Establishment, Brize Norton (England).
RECENT IMPROVEMENTS TO THE RAF AIR TRANSPORT FORCE
D. MACINTOSH *In* AGARD, Progress in Military Airlift 7 p Dec. 1990
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The most significant improvement to the United Kingdom's Military Air Transport Force in recent years is described: the procurement of the Lockheed L1011 Tristar aircraft into the RAF service. The reasons behind the introduction of the Tristar, and its subsequent modifications into three very capable tanker, freighter, and passenger carrying variants are outlined. Moreover, some of the aircraft's capabilities and drawbacks are discussed. In addition, and with a view to the future, some of the cost disadvantages of an aging air transport fleet are considered. Furthermore, the RAF approach to considering a timescale for the introduction of a possible replacement transport aircraft is presented. Author

N91-18074# Aerospatiale, Toulouse (France). Div. Avions.
APPLICATION OF NEW TECHNOLOGIES IN THE DESIGN OF THE COCKPIT IN FUTURE MILITARY TRANSPORT AIRCRAFT [APPORT DES TECHNOLOGIES NOUVELLES DANS LA CONCEPTION DU POSTE DE PILOTAGE D'UN FUTUR AVION DE TRANSPORT MILITAIRE]
J. BORREL, M. DUTURC, and G. MITONNEAU *In* AGARD, Progress in Military Airlift 20 p Dec. 1990 In FRENCH
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Aerospatiale's experiences in the design and development of cockpits for the Airbus-series aircraft and the C-160 military transport are discussed. The evolution of cockpit display instruments, automatic flight control, and flight management systems utilized for the Airbus series is summarized. The application of new technologies in the cockpits of future military transport aircraft is discussed. Transl. by M.G.

N91-18075# Aeritalia S.p.A., Naples (Italy). Flight Deck and Avionics Systems.
ADVANCED TECHNOLOGY APPLICATION IN THE FLIGHT DECK DESIGN FOR MILITARY TRANSPORT AIRCRAFTS
V. AFELTRA and A. LAPASTINA *In* AGARD, Progress in Military Airlift 8 p Dec. 1990
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The continuous growing in systems/functions installed in the modern aircraft, imposed by the more and more demanding requirements in terms of performance and safety, is leading to the development and the application of new components and systems in the area of cockpit indication and automatic controller integration. The cathode ray tube (CRT) and other multifunction display technologies are rapidly replacing many of the dials, panels, and gauges of the old cockpit. Artificial intelligence and high level automation are emerging in digital avionics. These systems would take over the crew in many cockpit management functions such as reconfiguration to compensate fault or execute emergency procedures. The design and certification aspects are analyzed which relate to the adoption of these new technologies and some aspects of human factor engineering are discussed which become an integral part for the cockpit design, for the symbology, and for the logic integration of the function within the automatic control and display systems. Author

N91-18081# Societe Nationale d'Etudes et de Construction de Moteurs Aeronautiques, Corbeil (France). Centre d'Essais de Villaroche.
IMPROVING MILITARY TRANSPORT AIRCRAFT THROUGH HIGHLY INTEGRATED ENGINE-WING DESIGN

A. LARDELLIER *In* AGARD, Progress in Military Airlift 15 p Dec. 1990
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Current studies have shown the interest of very large bypass ratio (BPR) engines (10 is less than BPR is less than 14) to power Long Range Airliners, at cruise speed exceeding Mach 0.8. A further benefit in terms of installed SFC (specific fuel consumption) can be expected for Future Large Aircraft (FLA), cruising at Mach 0.75. Compared to an equivalent turbofan, a very large bypass engine can deliver a higher thrust during takeoff, thus improving the high lift capability of the aircraft. Taking into account that a conventional front fan engine is likely to show a large radar cross section (RCS), and that this problem would have to be addressed for FLA, the engine perferred concept is a ducted aft contrafan. The resulting high hub-tip ratio fan flow path, combined with slow rotating composite fan-blades is indeed a good approach toward reduction of the engine RCS. In order to minimize the extra-weight due to the long duct, a highly integrated engine-wing design is proposed, offering a reduced friction drag; particular attention is paid to the maintenance and transportation problems. Author

N91-18083*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF ADVANCED TECHNOLOGIES TO FUTURE MILITARY TRANSPORTS
RODNEY L. CLARK, ROY H. LANGE (Lockheed Aeronautical Systems Co., Marietta, GA.), and RICHARD D. WAGNER *In* AGARD, Progress in Military Airlift 8 p Dec. 1990
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive
CSCL 01/3

Long range military transport technologies are addressed with emphasis of defining the potential benefits of the hybrid laminar flow control (HLFC) concept currently being flight tested. Results of a 1990's global range transport study are presented showing the expected payoff from application of advanced technologies. Technology forecast for military transports is also presented. Author

N91-18086# Dornier-Werke G.m.b.H., Friedrichshafen (Germany, F.R.).
APPLICATION OF CIVIL AIR TRANSPORT TECHNOLOGY TO MILITARY AIRLIFT
JOHANNES SPINTZYK *In* AGARD, Progress in Military Airlift 14 p Dec. 1990
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Due to a strong market demand and competition the civil passenger aircraft have improved considerably in performance and operating cost in the last 30 years. These improvements were achieved mainly by progress in technology. Comparable improvements were not achieved in military aircraft. The military transport aircraft in operation today are of older design. Civil and military transport technologies are identical to a large extent. Therefore, application of the advanced civil transport technology to a new military transport aircraft promises a leap in performance improvements and operating cost reductions. Moreover, changes in tasks and requirements can be incorporated in a new design. The example of an advanced medium transport aircraft shows promising indications of the improvements which are possible by applying civil transport technology and encourages further investigations. Author

N91-18091# British Aerospace Aircraft Group, Woodford (England). Airlines Div.
FIMA AND EUROFLAG: PROGRESS IN MEETING MILITARY AIRLIFT AND FLA REQUIREMENTS FOR THE 21ST CENTURY
D. K. EMPSON *In* AGARD, Progress in Military Airlift 10 p Dec. 1990
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Progress is reviewed made initially by the Future International Military Airlifter (FIMA) Group and, since 1989, by its successor the European Future Large Aircraft Group (EUROFLAG), in studying the potential for development of a collaborative program to satisfy airlift requirements for the 21st century. EUROFLAG studies indicate that future military transport and other Future Large Aircraft (FLA) designs based on mid-1990's, modern but proven technology standards, can provide a greatly enhanced airlift capability at significantly lower fleet life cycle costs and with major manpower savings compared with aircraft in service today. Theses attributes are important in a world climate of shrinking defence budgets, growing manpower shortages and defence scenario uncertainties. European or transatlantic collaboration to develop and manufacture such aircraft is seen as the most economical way for air forces to obtain the operational capability required at the lowest cost. Author

N91-18092# Boeing Helicopter Co., Philadelphia, PA.
V-22 OPERATIONAL CAPABILITIES
ROBERT B. TAYLOR *In* AGARD, Progress in Military Airlift 9 p Dec. 1990
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The operational capabilities of the V-22 Osprey, the world's first operational tilt rotor aircraft, are described. The designed-in capabilities of the V-22, plus its performance characteristics, provide a multi-mission aircraft that will improve the capability of all service forces well into the 21st century. Key elements in providing a broad operational capability are shipboard compatibility, payload-range, maneuverability, high speed capability with an external load, reduced vulnerability, and glass cockpit integrated avionics for reduced pilot workload during day and night missions. Author

N91-18093# Westland Helicopters Ltd., Yeovil (England).
TACTICAL SUPPORT EH101
J. C. FIELDING *In* AGARD, Progress in Military Airlift 10 p Dec. 1990
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The development and use of military tactical helicopters from the early beginnings to the present day are reviewed. The background to the EH101 is presented explaining the rationale of its design philosophy and the application of technology and equipments to meet the requirements of the late '90s and the early 21st century. The operational capabilities and applications of the EH101 related to a changing fast-moving battlefield environment are also discussed. Author

N91-18094*# Vigyan Research Associates, Inc., Hampton, VA.
A REAL TIME DYNAMIC DATA ACQUISITION AND PROCESSING SYSTEM FOR VELOCITY, DENSITY, AND TOTAL TEMPERATURE FLUCTUATION MEASUREMENTS
STEVEN J. CLUKEY Feb. 1991 278 p
(Contract NAS1-18585)
(NASA-CR-182069; NAS 1.26:182069) Avail: NTIS HC/MF A08
CSCL 01/3

The real time Dynamic Data Acquisition and Processing System (DDAPS) is described which provides the capability for the simultaneous measurement of velocity, density, and total temperature fluctuations. The system of hardware and software is described in context of the wind tunnel environment. The DDAPS replaces both a recording mechanism and a separate data processing system. DDAPS receives input from hot wire anemometers. Amplifiers and filters condition the signals with computer controlled modules. The analog signals are simultaneously digitized and digitally recorded on disk. Automatic acquisition collects necessary calibration and environment data. Hot wire sensitivities are generated and applied to the hot wire data to compute fluctuations. The presentation of the raw and processed data is accomplished on demand. The interface to DDAPS is described along with the internal mechanisms of DDAPS.

A summary of operations relevant to the use of the DDAPS is also provided. Author

N91-18095# Technische Univ., Munich (Germany, F.R.). Institut fuer Luft- und Raumfahrt.
A SAFETY ANALYSIS OF COMMERCIAL AIRPLANE DITCHING Ph.D. Thesis [EINE SICHERHEITSANALYSE DER NOTWASSERUNG VON VERKEHRSFLUGZEUGEN]
CHRISTIAN JAHNCKE 1989 165 p In GERMAN
(ETN-91-98801) Avail: NTIS HC/MF A08

Based on the simulation program developed for Extended Range Operations (EROPS) aircrafts, possible rescue systems and their probabilities are described. The restrictions of flight control through weather influence, by example of the North Atlantic Ocean are determined, and safety examinations for various service conditions are carried out. ESA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A91-24450#
STRATEGIC OPTIONS FOR FUTURE AIR TRAFFIC SYSTEMS
S. A. N. MAGILL (Royal Signals and Radar Establishment, ATC Systems Research Div., Malvern, England) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1461-1467. Research supported by the Civil Aviation Authority of England. refs
Copyright

This paper explores some possible ways of increasing the air traffic capacity of the busiest parts of en-route airspace in the early years of the next century. Because controller workload is the key capacity-constraining factor, and because there is no prospect of a completely automatic system in the foreseeable future, certain controller-related constraints have a dominant effect on any proposed innovations. Technological developments in navigation, computing and communications are summarized. Options for future air traffic systems are discussed against this background, including those in route structure, airspace sectorization, time control, and flow control. Finally, there is a brief description of a computer simulation which is being built to attempt to quantify the capacity implications of these options. Author

A91-24464#
AIRBORNE COLLISION AVOIDANCE SYSTEMS - THE UK EXPERIENCE
R. M. ABLETT (Civil Aviation Authority, London, England) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1586-1594.
Copyright

The history of the development of ACAS is briefly reviewed. The forms of ACAS are listed before concentrating on TCAS II which is the U.S. implementation of the form of ACAS currently being developed for public transport aircraft. The theory behind the logic used in TCAS II is outlined. UK inputs to the development of modification of the logic are described together with work using recorded radar data to conduct safety studies. The UK operational trial of TCAS II using a British Airways Boeing 737 aircraft and Allied-Bendix prototype equipment is described together with the initial objectives and the findings. Potential benefits over and above those drawn solely from collision avoidance protection are considered. Author

A91-24680
THE 1988 FEDERAL RADIONAVIGATION PLAN AND THE CIVIL GLOBAL POSITIONING SYSTEM SERVICE
DAVID C. SCULL (DOT, Washington, DC) IN: NAV 89 - Satellite navigation; Proceedings of the Conference, London, England, Oct. 17-19, 1989. London, Royal Institute of Navigation, 1989, 7 p.
Copyright

The provisions of the 1988 Federal Radionavigation Plan are summarized. The development of the Plan in cooperation between the Departments of Transportation and Defense is described, and the individual system plans are listed and briefly characterized, including radio beacons, Loran-C, Omega, VOR/DME, Tacan, ILS/MLS/DME-P, and Transit. Particular attention is given to the military and civil versions of Navstar GPS for air and surface navigation. The potential advantages of differential GPS are outlined, and the organizational structure set up by the DOT to administer civil use of GPS is discussed. D.G.

A91-24681
ADS EXPERIMENTS IN WESTERN EUROPE AND POSSIBLE FUTURE DEVELOPMENTS
M. E. COX (EUROCONTROL, Brussels, Belgium), G. A. COOKE (Civil Aviation Authority, London, England), E. ESTEBAN (Direccion General de Aviacion Civil, Madrid, Spain), and E. MEYENBERG (EUROCONTROL, Bretigny, France) IN: NAV 89 - Satellite navigation; Proceedings of the Conference, London, England, Oct. 17-19, 1989. London, Royal Institute of Navigation, 1989, 7 p. Translation. Previously cited in issue 15, p. 2290, Accession no. A90-35353.
Copyright

A91-24682
U.S. PROGRAM FOR DEVELOPMENT OF SATELLITE SERVICES FOR AIR TRAFFIC CONTROL
CLYDE A. MILLER (FAA, Washington, DC) IN: NAV 89 - Satellite navigation; Proceedings of the Conference, London, England, Oct. 17-19, 1989. London, Royal Institute of Navigation, 1989, 4 p.
Copyright

FAA plans for incorporating satellite navigation and communication technology into the U.S. ATC system are discussed, and ongoing experimental trials are described. Topics addressed include navigation with Navstar GPS, the requirements for certification of GPS as a nonprecision approach aid, a satellite-based Automatic Dependent Surveillance (ADS) capability for ocean air space, a demonstration of low-data-rate digital voice transmission via satellite, satellite navigation-data transmission as part of ADS, the proposed Oceanic Data Display and Planning System, and feasibility studies of integrated GPS/Glonass receiver equipment. D.G.

A91-24683
UK GPS TRIALS
ROBERT A. FRAMPTON (Royal Aerospace Establishment, Farnborough, England) IN: NAV 89 - Satellite navigation; Proceedings of the Conference, London, England, Oct. 17-19, 1989. London, Royal Institute of Navigation, 1989, 4 p.
Copyright

The current status of experimental trials of airborne receivers for use with the Navstar GPS satellite navigation system in the UK is surveyed. The history of GPS receiver development at RAE is recalled, and it is pointed out that the primary aim has been a single high-performance system integrating inertial and satellite navigation. The ground-based and airborne test facilities are described; the advantages of ground-based GPS simulations are explained; and preliminary results are presented in graphs and briefly characterized. D.G.

A91-24684
ADVANCES AND TEST RESULTS IN DIFFERENTIAL GPS NAVIGATION
ROBERT P. DENARO and RUDOLPH M. KALAFUS (Trimble Navigation, Ltd., Sunnyvale, CA) IN: NAV 89 - Satellite navigation;

Proceedings of the Conference, London, England, Oct. 17-19, 1989. London, Royal Institute of Navigation, 1989, 5 p. refs
Copyright

The development of GPS user receivers based on the differential navigation principle is described. Particular attention is given to improvements in temporal processing (differential correction, intelligent filtering algorithms, potential problems with carrier smoothing, and measures against multipath propagation effects), regional-network and wide-area-control approaches to spatial processing, postprocessing to refine differential GPS solutions, and ground and autonomous integrity-monitoring schemes. It is shown that 2-3-m accuracy is a realistic goal for second-generation multichannel differential GPS receivers. D.G.

A91-24685
DATA LINKS FOR DIFFERENTIAL GPS

WALTER F. BLANCHARD (Navigation Management, Ltd., London, England) IN: NAV 89 - Satellite navigation; Proceedings of the Conference, London, England, Oct. 17-19, 1989. London, Royal Institute of Navigation, 1989, 11 p. refs
Copyright

The performance demands for the radio channel used in differential-type satellite positioning systems to transmit correction data to distant users are reviewed. Consideration is given to range requirements (500-1000 km), data rates (repetition rates, number of monitors, and error rates), frequency selection criteria for line-of-sight transmission, troposcatter and ionoscatter transmission, and the use of existing transmission systems (marine radio beacons, navigation systems, GEO communication satellites, or spread-spectrum systems). It is argued that multiple monitors and data rates well in excess of 50 bps are necessary, and that no one frequency band and transmission scheme can meet the needs of users of all types in all locations. Diagrams, maps, graphs, and tables of numerical data are provided. D.G.

A91-24692
INTERPRETATION OF RECENT GPS INTEGRITY STUDIES

JERRY BRADLEY (FAA, Washington, DC) and RONALD BRAFF (Mitre Corp., McLean, VA) IN: NAV 89 - Satellite navigation; Proceedings of the Conference, London, England, Oct. 17-19, 1989. London, Royal Institute of Navigation, 1989, 6 p. refs
Copyright

Since the late 1970s, the Federal Aviation Administration (FAA) has been intensively analyzing the application of GPS to the U.S. National Airspace System (NAS). Early on, the results of this work indicated that the major problem areas were GPS signal integrity and reliability of signal coverage for sole means navigation, especially for the nonprecision phase of flight. This paper starts with a brief history of these FAA activities as background for a more detailed discussion of the most recent research on GPS signal integrity. Based on the interpretation of these studies, the rationale for the FAA's development of an independent-external monitoring system for GPS integrity is presented. The rationale for the architecture of the selected approach, the satellite-broadcast GPS Integrity Channel, is also presented. Author

A91-24694
GPS INADEQUACIES - COMPARATIVE STUDY INTO SOLUTIONS FOR CIVIL AVIATION

J.-M. DURAND (CNES, Toulouse, France) IN: NAV 89 - Satellite navigation; Proceedings of the Conference, London, England, Oct. 17-19, 1989. London, Royal Institute of Navigation, 1989, 7 p. refs
Copyright

The capabilities and inherent deficiencies of Navstar GPS as an en route, terminal, and nonprecision-approach navigation aid for civil aviation are reviewed, and technological aspects of proposed solutions are examined. The problems identified are the loss of system integrity for up to 2 h before a satellite transmitting false information is corrected or shut down, temporary limitations on satellite visibility, and intentional degradation of performance under the Selective Availability policy. The solutions evaluated include: (1) GPS receivers with autonomous integrity monitoring capability; (2) GPS plus onboard systems (INS, altimeter, high-stability clock, etc.); (3) GPS plus existing navigation systems (VOR/DME, Omega, Loran-C, Glonass, etc.); and (4) an external monitoring system broadcasting integrity information as supplementary GPS messages. Solutions (2) and (3) or a combination of these are considered most feasible at present. D.G.

A91-24980
MATCHING AERIAL IMAGES TO 3-D TERRAIN MAPS

JEFFREY J. RODRIGUEZ (Arizona, University, Tucson) and J. K. AGGARWAL (Texas, University, Austin) IEEE Transactions on Pattern Analysis and Machine Intelligence (ISSN 0162-8828), vol. 12, Dec. 1990, p. 1138-1149. refs
(Contract DAAL03-87-K-0089)
Copyright

A terrain-matching algorithm is presented for use in a passive aircraft navigation system. A sequence of aerial images is matched to a reference digital map of the three-dimensional terrain. Stereo analysis of successive images results in a recovered elevation map. A cliff map is then used as a novel compact representation of the three-dimensional surfaces. The position and heading of the aircraft are determined with a terrain-matching algorithm that locates the unknown cliff map within the reference cliff map. The robustness of the matching algorithm is demonstrated by experimental results using real terrain data. I.E.

A91-25402
AN/TPS-73 - A NEW TACTICAL, SOLID-STATE AIR TRAFFIC CONTROL RADAR SYSTEM WITH MULTI-MISSION CAPABILITY

D. BROSNIHAN (U.S. Navy, Naval Space and Warfare Systems Command, Arlington, VA), F. SCIRE, J. PERROTTA (Unisys Corp., Blue Bell, PA), E. GIACCARI, and M. DI LAZZARO (Selenia S.p.A., Rome, Italy) IN: IEEE 1990 International Radar Conference, Arlington, VA, May 7-10, 1990, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1-5.
Copyright

The AN/TPS-73 is a mobile, completely solid-state, integrated primary surveillance S-band radar and L-band monopulse secondary surveillance radar system. Housed in a single shelter for rapid deployment, the system was designed to meet the air traffic control requirements of surveillance, detection, tracking, and identification in an adverse clutter and electronic countermeasures environment. The full band pulse-to-pulse frequency agility transmission of low-peak-power-coded waveforms provides the quiet radar characteristics necessary for survivability, while simultaneously maintaining high target visibility throughout the surveillance volume. An adaptive refinement to moving target detection, coupled with the high system stability, enables automatic and effective suppression of time and spatial varying clutter. Five thousand hours for the mean-time between critical failure is achieved in a cost-effective manner by a combination of fail-soft and standby redundant elements, ensuring high system availability in a sustained hostile environment. I.E.

A91-25413
ESTIMATING THE RESIDUAL ERROR OF THE REFLECTIVITY DISPLACEMENT METHOD FOR AIRCRAFT MOTION ERROR EXTRACTION FROM SAR RAW DATA

JOAO MOREIRA (DLR, Institut fuer Hochfrequenztechnik, Oberpfaffenhofen, Federal Republic of Germany) IN: IEEE 1990 International Radar Conference, Arlington, VA, May 7-10, 1990, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 70-75. refs
Copyright

The performance of the reflectivity displacement method is reported. The reflectivity displacement method extracts all the necessary motions of the aircraft from the radar backscatter signal using a new radar configuration and new methods for evaluating the azimuth spectra of the radar signal. Hence, an inertial navigation system is unnecessary for many applications. An error analysis of

this method is carried out, and a comparison of two processed images with and without motion compensation is shown, proving the estimated performance. I.E.

A91-25495
ANALYSIS OF THE THEORETICAL RADAR RETURN SIGNAL FROM AIRCRAFT PROPELLER BLADES
J. MARTIN and B. MULGREW (Edinburgh, University, Scotland) IN: IEEE 1990 International Radar Conference, Arlington, VA, May 7-10, 1990, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 569-572. Research supported by SERC and Ferranti International. refs
Copyright

The theoretical return signal from aircraft propeller blades is analyzed. The basic theory involved is described, some simulation results are examined, and some practical considerations are discussed. It is shown that the modulation contained in the return signal is a form of frequency modulation and results in a number of sidebands about the center frequency of the target. It has also been shown that the modulation is due to six main variables, four of which are parameters of the propeller blades, one of which depends on the radar, and one of which depends on the aspect angle of the propeller. I.E.

N91-17011# Federal Aviation Administration, Atlantic City, NJ.
MICROWAVE LANDING SYSTEM (MLS) BACK AZIMUTH OPERATIONAL ISSUES FLIGHT TESTS Technical Note, Dec. 1989 - May 1990
EDWARD J. PUGACZ Sep. 1990 23 p
(Contract FAA-T06039)
(AD-A228659; DOT/FAA/CT-TN90/3) Avail: NTIS HC/MF A03 CSCL 17/7

This test plan describes a series of flight tests using Microwave Landing System (MLS) back azimuth guidance for missed approach and departure procedures. Issues to be addressed during these flight tests are: (1) The proper point in a missed approach to switch from approach azimuth to back azimuth guidance; (2) the largest MLS back azimuth offset angle usable for departures and missed approaches; and (3) the correct back azimuth full scale sensitivity. Approximately 10 industry pilots will participate as test subjects. The flights will be tracked by a radar tracker throughout each procedure. Individual and composite plots of each approach will be produced, and answers to in-flight and post-flight questionnaires will be complied. The processed data will be made available to the international aviation community to aid in the formulation of back azimuth usage guidelines. GRA

N91-17012# Royal Aerospace Establishment, Farnborough (England).
ADVANCES IN NAVIGATION SUPPORT SYSTEMS BASED ON OPERATIONAL PILOT'S HEURISTICS
F. DEBLON, A. GUENGANT, C. VALOT, R. AMALBERTI (Centre d'Enseignement et de Recherches de Medecine Aeronautique, Paris, France), and E. J. LOVESEY, ed. Aug. 1990 26 p Transl. into ENGLISH from conference paper Presented at the Advances in Techniques and Technologies for Air Vehicle Navigation and Guidance Symposium, Lisbon, Portugal, 9-12 May 1989 Original language document was announced as N90-16737
(RAE-TRANS-2184; BR115578; AD-A230719) Avail: NTIS HC/MF A03

The combination of the future high threat battlefield environment and the trend toward single seat combat aircraft provides the need to develop on-board decision support systems. The Pilot's Assistant offers a means of fulfilling such a requirement. While this concept covers different classes of aids, the development of a navigation support system is focused on. Special attention was paid to the quality of the man-machine interface of such a real time aid. It is suggested that because the quality of this interface is critical, the best solution consists of computerizing the man's navigational expertise, (rather than with optimal multiexpert software). Thus the eliciting of pilot expertise, while conducting low level nap-of-the-earth penetration missions has been important. An artificial intelligence computer model of navigation is derived from this cognitive model with respect to the use of a concurrent object oriented language. An extended description of this program is given, including ways of implementing the Pilot's Assistant in future French aircraft. Author

N91-18007*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DOPPLER GLOBAL VELOCIMETRY
JIM USRY *In* Wichita State Univ., Proceedings: Techfest 17 p 3-4 1991
Avail: NTIS HC/MF A03 CSCL 17/7

A new program to develop a Doppler Global Velocimeter (DGV) for application in the High angle-of-Attack Technology Program is discussed. The Flight research instrument system will make non-intrusive multicomponent velocity measurements of the vortical flow field around an aircraft in flight. The DGV will provide a means to obtain airborne experimental data to evaluate and refine computational fluid dynamic models and to correlate with wind-tunnel data sets. The primary use of the instrument system will be to provide a flexible research tool to map the 3D velocity field at various locations around an aircraft during high angle-of-attack maneuvers at subsonic, transonic, and supersonic speeds. Other potential applications may include shock definition and interactions, external stores flow interactions, rotary flow field definition, non-steady flow field definition, measurement of inlet and duct flow field, and measurement of hypersonic flow field in flight. Y.S.

N91-18096*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AIRBORNE FOUR-DIMENSIONAL FLIGHT MANAGEMENT IN A TIME-BASED AIR TRAFFIC CONTROL ENVIRONMENT
DAVID H. WILLIAMS and STEVEN M. GREEN (National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.) Washington Mar. 1991 35 p
(NASA-TM-4249; L-16825; NAS 1.15:4249) Avail: NTIS HC/MF A03 CSCL 17/7

Advanced Air Traffic Control (ATC) systems are being developed which contain time-based (4D) trajectory predictions of aircraft. Airborne flight management systems (FMS) exist or are being developed with similar 4D trajectory generation capabilities. Differences between the ATC generated profiles and those generated by the airborne 4D FMS may introduce system problems. A simulation experiment was conducted to explore integration of a 4D equipped aircraft into a 4D ATC system. The NASA Langley Transport Systems Research Vehicle cockpit simulator was linked in real time to the NASA Ames Descent Advisor ATC simulation for this effort. Candidate procedures for handling 4D equipped aircraft were devised and traffic scenarios established which required time delays absorbed through speed control alone or in combination with path stretching. Dissimilarities in 4D speed strategies between airborne and ATC generated trajectories were tested in these scenarios. The 4D procedures and FMS operation were well received by airline pilot test subjects, who achieved an arrival accuracy at the metering fix of 2.9 seconds standard deviation time error. The amount and nature of the information transmitted during a time clearance were found to be somewhat of a problem using the voice radio communication channel. Dissimilarities between airborne and ATC-generated speed strategies were found to be a problem when the traffic remained on established routes. It was more efficient for 4D equipped aircraft to fly trajectories with similar, though less fuel efficient, speeds which conform to the ATC strategy. Heavy traffic conditions, where time delays forced off-route path stretching, were found to produce a potential operational benefit of the airborne 4D FMS. Author

N91-18097# Engineering and Economics Research, Inc., Vienna, VA.
AIR TRAFFIC CONTROL AND AIRSPEED SYSTEMS 2010 AIR TRAFFIC CONTROL OPERATIONAL CONCEPT Final Technical Report
ALEX BRIDEWELL, KENT SIMMONS, and TOM PICKEREL 30

Apr. 1990 23 p
(Contract F19628-87-C-0172)
(AD-A229003) Avail: NTIS HC/MF A03 CSCL 17/7

The purpose of this report is to present an operations concept which delineates the expected personnel and equipment interactions between DoD ATC facilities and the FAA NAS in the year 2010. In order to portray these interactions, scenarios will be used. Two scenarios were defined - one showing a military aircraft progressing through the NAS and a second showing how a DoD aircraft will transition from the military ATC system into Special Use Airspace (SUA) and back to the military ATC. The intent is to show, in an animated format, the interactions between personnel, including the required information to be passed, and the hardware/software interfaces necessary to pass the information. GRA

N91-18098# Engineering and Economics Research, Inc., Vienna, VA.
DEPARTMENT OF DEFENSE AIR TRAFFIC CONTROL AND AIRSPACE SYSTEMS INTERFACE WITH THE NATIONAL AIRSPACE SYSTEM Final Report
ALEX BRIDEWELL, TOM PICKEREL, and KENT SIMMONS 30 Mar. 1990 65 p
(Contract F19628-87-C-0172)
(AD-A229088) Avail: NTIS HC/MF A04 CSCL 17/7

This report assesses the intra-agency interoperability of a broad spectrum of ATC and airspace management systems. The FAA NAS plan is summarized to describe the national system that will exit in 1999. Military ATC systems are projected to the same period and evaluated by type of system (i.e., fixed or tactical), application (i.e., radar, position/navigation, communications, etc.), and branch of military service. The evaluation includes a discussion of the expected interfaces between military and civil system components. The assessment describes potential impacts of incompatible and non-interoperable systems on the DoD in terms of safety and operational effectiveness and probable impacts on specific Air Force mission requirements. The report does not assess in depth the DoD's tactical ATC components or the tactical command and control systems that are not directly related to ATC. GRA

N91-18099# Human Factors Solutions, Rockville, MD.
FUTURE NORTH AMERICAN AIR TRAFFIC CONTROL SYNERGY HUMAN FACTORS SOLUTION Final Technical Report
PAMELA MYERS Dec. 1989 17 p
(Contract F19628-89-C-0099)
(AD-A229255) Avail: NTIS HC/MF A03 CSCL 17/7

This innovative research effort was proposed in response to the challenge of integrating the lessons learned in developing the American and Canadian airspace systems into the planning process for an interoperable, trans-century, North American airspace system. The intent was to identify opportunities for increasing efficiencies, reciprocal benefits, and cooperation between the U.S. and Canada which would result in a proposed functional organizational matrix. This strawman organization would provide DoD with a framework for mutual airspace management gains between the U.S. and Canada. GRA

N91-18100# Federal Aviation Administration, Atlantic City, NJ.
DIFFERENTIAL GPS TERMINAL AREA TEST RESULTS Technical Report, Nov. 1989 - Nov. 1990
L. FRANK PERSELLO Nov. 1990 62 p
(Contract T0704E)
(DOT/FAA/CT-TN90/48) Avail: NTIS HC/MF A04

Flight tests conducted by the Federal Aviation Administration (FAA) Technical Center to examine the performance of the differential global positioning system (DGPS) in the terminal area are described. The tests employed a Convair 580 (CV 580) and a pair of Motorola Eagle Mini Rangers. With the advent of a maturing global positioning system (GPS) constellation, the FAA is assuming a more intensive stance in addressing the many questions/problems associated with GPS. These DGPS tests investigated the obtainable accuracy under static and dynamic conditions. The static tests employed survey points as a baseline. The dynamic tests incorporated terminal area flight profiles and nonprecision approaches using a laser tracker as a baseline. The accuracy performance of DGPS showed an order of magnitude improvement in the static environment and a 4 to 5 fold improvement in the dynamic environment over stand alone GPS. The DGPS tests were conducted in an effort to build an FAA DGPS data base to aid in addressing GPS questions/problems. Author

N91-18101# Federal Aviation Administration, Atlantic City, NJ.
CHICAGO O'HARE SIMULTANEOUS ILS APPROACH DATA COLLECTION AND ANALYSIS Technical Report, Jan. 1989 - Feb. 1990
JAMES THOMAS and DOMINIC TIMOTEO Apr. 1990 149 p
(Contract F2006A)
(DOT/FAA/CT-TN90/11) Avail: NTIS HC/MF A07

Data on aircraft execution simultaneous instrument landing system (ILS) approach in instrument meteorological conditions were collected at Chicago O'Hare International Airport (ORD) between January 24 and March 14, 1989, for the purposes of analyzing the ILS navigational characteristics of these aircraft. Aircraft position data were collected using the in-place ORD airport surveillance primary and secondary radars. The data were reduced and analyzed at the FAA Technical Center to provide a measure of dispersion about the approach centerline and containment within various zones and envelopes of interest surrounding the approach centerline. Conclusions concerning the approach flight characteristics are drawn and recommendations are made concerning potential applications. Author

N91-18102# Computer Technology Associates, Inc., McKee City, NJ.
SIMULATION OF QUADRUPLE SIMULTANEOUS PARALLEL ILS APPROACHES AT D/FW, PHASE 3 Final Report, Sep. 1989 - Aug. 1990
T. FISCHER, G. YASTROP, and B. STARTZEL-DEHEL Aug. 1990 127 p
(Contract DTFA03-89-C-00023)
(DOT/FAA/CT-90/15) Avail: NTIS HC/MF A07

This was phase 3 of an ongoing effort to evaluate plans for increasing air traffic capacity in the Dallas/Fort Worth (D/FW) area. The objective was to evaluate the traffic handling ability of controllers during Instrument Meteorological Conditions (IMC) for D/FW's proposed quadruple parallel approach airport configuration using a real time air traffic control (ATC) simulation. Both dual and quadruple simultaneous parallel Instrument Landing System (ILS) approaches were simulated with controllers monitoring approach traffic. Blunders were introduced by having simulated aircraft deviate toward adjacent localizers. Some of the blundering aircraft also simulated a loss of radio communication. The ability of the controllers to maintain distance between blundering aircraft and aircraft in parallel approaches was the central issue. Also, a few runs evaluated the missed approach procedures with the controllers monitoring the departing and missed approach aircraft. Based upon the findings of the simulation, it was concluded that the quadruple simultaneous parallel ILS approach procedures are safe and workable for the airport configuration tested. Therefore, the operations at D/FW were recommended. Author

N91-18103# Rijksluchtvaartdienst, The Hague (Netherlands).
ACTIVITIES REPORT OF THE CIVIL AERONAUTICS BOARD Annual Report, 1989 [RIJKSLUCHTVAARTDIENST, JAARVERSLAG 1989]
1990 70 p In ENGLISH and DUTCH
(ETN-91-98773) Avail: NTIS HC/MF A04

The activities of the Dutch Civil Aeronautics Board in the fields of air traffic inspection, transport and infrastructure, air traffic security, air traffic and environment, air traffic responsibility, the safety of air traffic above the North Sea, aerodynamics, flight tests and simulation, construction and materials, and computer sciences for aeronautics, are summarized. ESA

N91-18104# Technische Univ., Brunswick (Germany, F.R.).
EXAMINATIONS OF THINNING OUT A DIRECTION FINDER ANTENNA FOR THE DAS AIRPLANE NAVIGATION SYSTEM Ph.D. Thesis [UNTERSUCHUNGEN ZUR AUSDUENNUNG EINER PEILANTENNE FUER DAS FLUGZEUGNAVIGATIONSSYSTEME DAS]
UWE KUMMER 1990 141 p In GERMAN
(ETN-91-98789) Avail: NTIS HC/MF A07

The characteristics of an azimuthal angular measurement device was described. The Distance measuring equipment based Azimuth System (DAS) was used in connection with the Distance Measuring Equipment (DME), in order to determine the distance and the lines of position of airplanes. The scanned receiving signal was subjected to a discrete Fourier transformation, in order to determine the incident directions of signals. A special signal to interference ratio was defined to characterize the immunity from disturbances. Using a special program, the minimum interference ratios of a pair of variates were obtained and compared. The characteristics of the best arrangements with minimum interference ratios were listed. They showed a better resistance to spurious signals. ESA

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AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A91-24303*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ADVANCED COMPOSITES RESEARCH AND DEVELOPMENT FOR TRANSPORT AIRCRAFT
JOHN G. DAVIS, JR., JAMES H. STARNES, JR., and NORMAN J. JOHNSTON (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. XLV-LIV. refs
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This paper highlights past experiences, lessons learned, state-of-the-art and current research activities directed at providing an integrated 'affordable' data base for composite structures. Composite secondary and empennage structures are in production on several transport aircraft. The weight reduction potential of composite structures is well documented. However, the cost to develop and produce composite structures remains the major barrier to increased application of this technology to transport aircraft. Specific technology items that are being developed under the NASA Advanced Composites Technology Program are described. Materials, design concepts, structural mechanics methodology and manufacturing processes and equipment are under development or are emerging that are expected to lead to an integrated 'affordable' data base. Technology verification for the next decade is expected to require fabrication and testing of full-scale wing-box and fuselage-section components before certificatiaon can occur and production commitments can be made. Author

A91-24308#
THE INTEGRATION OF STRUCTURAL OPTIMIZATION IN THE GENERAL DESIGN PROCESS FOR AIRCRAFT
O. SENSBURG, J. SCHWEIGER, H. GOEDEL, and A. LOTZE (MBB GmbH, Munich, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 30-39. refs
Copyright

A powerful aircraft structural design optimization code designated 'MBB-LAGRANGE' has been developed which employs gradients and mathematical programming to simultaneously address a variety of constraints. Attention is given to the solution of large scale linear equation systems via an iterative method, in order to illustrate the effort involved in formulating the physical problem with maximum mathematical efficiency. MBB-LAGRANGE has been applied to the heat flux and frequency optimization of a satellite structure, the design of a CFRP wing, and the aeroelastic tailoring of a composite fin. O.C.

A91-24309#
CONCEPTUAL DESIGN OF CIVIL TRANSPORT AIRCRAFT BY A NUMERICAL OPTIMIZATION TECHNIQUE
C. MICHAUT, D. CAVALLI, and H. T. HUYNH (ONERA, Chatillon, France) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 39a-39g. refs
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A numerical code has been developed in order to quantify the impact of new technologies on the whole aircraft from their preliminary design step. It is composed of two parts related to the aircraft and to an iterative optimization technique, based on a generalized gradient algorithm. This method allows to determine the best choice of the aircraft main parameters (wing planform, weights, flight profile) which minimizes a selected criterion, while satisfying all the mission requirements (take-off field length, approach, speed, etc.). Validation of this code has been achieved by comparison between results provided by the proposed method and real parameters related to a current transport aircraft.
Author

A91-24311#
APPLICATION OF METHODS AND TOOLS FOR COMPUTER-AIDED DESIGN IN INVESTIGATION OF PROSPECTS FOR CIVIL AIRCRAFT PROGRESS
V. E. DENISOV (Tsentral'nyi Aerogidrodinamicheskii Institut, Moscow, USSR) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 45-50.
Copyright

An interactive computer workstation system has been developed for the preliminary design of prospective passenger aircraft. This user-friendly system is specifically tailored to (1) the selection of rational aircraft parameters, (2) the analysis of alternative design concepts for a given set of performance specifications, (3) the initial identification of those performance requirements, and (4) the selection of requirements with regard to the unification of engines for two distinct aircraft designs. O.C.

A91-24328#
STRUCTURAL OPTIMIZATION OF AIRCRAFTS - PRACTICE AND TRENDS
C. PETIAU (Dassault Aviation, Vaucresson, France) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 210-221. refs
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The 'CATIA-ELFINI' CAD code fully integrates structural analysis and structural optimization for composite material airframe components. Attention is presently given to two illustrative examples of structural and aeroelastic optimization for wing and vertical fin carbon fiber-reinforced epoxy resin matrix structures. Optimization encompasses 'bending' design variables, nonlinear and postbuckling analysis, ply stacking orders, and shape optimization. Given a specific geometry, CATIA-ELFINI derives mass and stiffness matrices as linear functions of design variables. O.C.

A91-24341#
AEROELASTIC STABILITY OF COMPOSITE BEARINGLESS ROTOR BLADES
MING XU (Naval Research Center, Shanghai, People's Republic of China) and SHI-CUN WANG (Nanjing Aeronautical Institute, People's Republic of China) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC,

American Institute of Aeronautics and Astronautics, Inc., 1990, p. 344-351. refs
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An attempt is made to establish and define the generalized constitutive equations for composite laminated beams with large bending-torsion coupled deflection, in which the constitutive equations of the relevant problem for laminated plates or shells are included formally. The effects of geometrical parameters of the flexure on aeroelastic stability of isotropic bearingless blades are studied first. For composite blades, the transverse shear stress is considered in the constitutive equation and analytical formulas. Then the flutter stability of flap bending, lead-lag bending, and torsion of composite rotor blades in hover is investigated by using a finite-element formulation based on Hamilton's principle. The emphasis is put on analyzing the influence of layered angles and stacking sequence on dynamic stabilities of composite hingeless and bearingles rotor blades. Author

A91-24349#
MULTIDISCIPLINARY OPTIMISATION IN AIRCRAFT DESIGN
D. L. I. KIRKPATRICK and J. S. SMITH (Royal Aerospace Establishment, Farnborough, England) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 434-441. refs
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This paper outlines the multivariate optimization (MVO) program developed at RAE to help in the assessment of new aircraft projects and in guiding the aeronautical research program towards the most promising research thrusts. In this program the disciplines of aeronautical science are integrated in design synthesis equations which yield the optimum aircraft design which meets specified mission requirements using a given level of technology. This paper indicates that the MVO program can be used to investigate the effects on aircraft design of changed requirements or of advances in aeronautical technology. The paper also emphasizes the importance of the nonaeronautical disciplines of economic, social, and operational analysis which influence the design of a transport or of a combat aircraft. Author

A91-24350*# Rockwell International Corp., Los Angeles, CA.
OPTIMIZATION OF AIRCRAFT CONFIGURATIONS IN A MULTIDISCIPLINARY ENVIRONMENT
TRENT R. LOGAN, FRANK F. ABDI (Rockwell International Corp., Los Angeles, CA), and JAROSLAW SOBIESZCZANSKI-SOBIESKI (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 442-449. refs
Copyright

A decomposition and multidisciplinary optimization methodology for aircraft design is presented, based on multilevel optimization and use of global sensitivity equations to account for interdisciplinary effects. A brief study of a hypersonic cruise vehicle is developed to illustrate methodology. The vehicle is sized for minimum take-off gross weight considering aerodynamics, structures, and mission performance. Author

A91-24352*# General Dynamics Corp., Fort Worth, TX.
APPLICATION OF ADVANCED MULTIDISCIPLINARY ANALYSIS AND OPTIMIZATION METHODS TO VEHICLE DESIGN SYNTHESIS
ROBERT DAVID CONSOLI (General Dynamics Corp., Fort Worth, TX) and JAROSLAW SOBIESZCZANSKI-SOBIESKI (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 458-467. refs
Copyright

Advanced multidisciplinary analysis and optimization methods, namely system sensitivity analysis and non-hierarchical system decomposition, are applied to reduce the cost and improve the visibility of an automated vehicle design synthesis process. This process is inherently complex due to the large number of functional disciplines and associated interdisciplinary couplings. Recent developments in system sensitivity analysis as applied to complex non-hierarchic multidisciplinary design optimization problems enable the decomposition of these complex interactions into sub-processes that can be evaluated in parallel. The application of these techniques results in significant cost, accuracy, and visibility benefits for the entire design synthesis process. Author

A91-24362#
IN-FLIGHT SIMULATOR FOR EVALUATION OF PERSPECTIVE CONTROL CONCEPTS OF THE TRANSPORT AIRPLANE
S. BORIS and V. ROGOZIN (Flight Research Institute, USSR) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 561-567.
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The general design and features of an in-flight simulator based on the Tu-154M transport aircraft are described. The simulator, which has been designed as a testbed for advanced control concept, is equipped with sidestick controllers, a miniwheel, a digital flight control system, and head-up displays. All the systems of the simulator have variable flight characteristics. The simulator can be controlled using a ground-based computer included into the telemetry aircraft-ground-aircraft control link. Results of the optimization of minicontrollers of different types are reviewed, and the aircraft handling characteristics are discussed as a function of the type of controller. V.L.

A91-24363#
ON THE DEVELOPMENT OF THE BAFR (BASIC AIRCRAFT FOR FLIGHT RESEARCH) IN PORTUGAL
L. M. B. C. CAMPOS and J. R. C. AZINHEIRA (Lisboa, Universidade Tecnica, Lisbon, Portugal) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 568-577. Research supported by Junta Nacional de Investigacao Cientifica e Tecnologica and Instituto Nacional de Investigacao Cientifica. refs
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The objectives and general design of the BAFR test facility, which is a CASA 212 Aviocar twin-turboprop light transport fitted with an extensive set of instrumentation and a telemetry system, are reviewed. The discussion covers a summary of two research projects making direct use of the BAFR facility, the establishment of a severity scale for atmospheric disturbances in terms of their effect on aircraft flight performance, and validation of a nonlinear model of the longitudinal stability of aircraft in a dive in still air. Finally, possible applications of the BAFR facility are discussed. V.L.

A91-24365*# Korea Advanced Inst. of Science and Technology, Seoul (Republic of Korea).
STATIC AEROELASTIC ANALYSIS OF COMPOSITE WING
IN LEE, CHANG SUN HONG (Korea Advanced Institute of Science and Technology, Seoul, Republic of Korea), HIROKAZU MIURA (NASA, Ames Research Center, Moffett Field, CA), and SEUNG KO KIM IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 594-601. refs
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A static aeroelastic analysis capability that can predict aerodynamic loads for the deformed shape of the composite wing has been developed. The finite element method (FEM) was used for composite plate structural analysis, and the linear vortex lattice method (VLM) was used for steady aerodynamic analysis. The final deformed shape of the wing due to applied forces is determined by iterative manner using FEM and VLM. FEM and VLM analysis are related by a surface spline interpolation procedure. The wing with Gr/Ep composite material has been investigated to see the wing deformation effect. Aerodynamic load change due to wing flexibility has been investigated. Also, the effect of fiber orientation and sweep angle on the deformation

pattern and aerodynamic coefficients are examined. For a certain fiber orientation, the deflection and aerodynamic loading of the composite wing is very much reduced. The swept forward wing has more significant effect of wing flexibility on aerodynamic coefficient than the swept back wing does. Author

A91-24381#
STOVL AIRCRAFT PROPULSION INTEGRATION
J. L. BENSON, Y. T. CHIN, G. L. HERSTINE, and D. P. RAYMER (Lockheed Aeronautical Systems Co., Burbank, CA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 719-724. refs
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This paper describes the Lockheed Aeronautical Systems Company's advanced STOVL aircraft design efforts from the perspective of propulsion system integration. The design approaches and performance characteristics of some of the aircraft concepts studied are briefly presented. The airframe/propulsion integration features of the split-flow-in-hover propulsion concept are then described in more detail. This is followed by a description of the propulsion integration features in general for STOVL designs. Specific inlet and nozzle performance data are presented which are applicable to a variety of STOVL concepts. Author

A91-24398#
DAMAGE TOLERANCE ANALYSIS AND TESTING OF THE FIGHTER AIRCRAFT 37 VIGGEN
BJORN PALMBERG, MATS-OLOF OLSSON, PER-OLOF BOMAN, and ANDERS F. BLOM (Flygtekniska Forsoksanstalten, Bromma, Sweden) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 909-917. Previously announced in STAR as N91-13448.
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The Swedish fighter aircraft 37 Viggen was reassessed in terms of damage tolerance evaluation. Four versions of the main wing attachment frame and some components in the fin were subjected to detailed analyses and damage tolerance testing. It was necessary to perform very extensive finite element analyses, in order to get accurate stress distribution in critical sections for subsequent evaluation of three dimensional stress intensity factors. The stress analyses were mainly checked on the basis of traditional static and fatigue testing results available from the design phase of the aircraft. It was concluded that the methodology used is state of the art and that it has been successfully verified. Extension of the original design life may be possible. Author

A91-24425*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
BEHAVIOR OF COMPOSITE/METAL AIRCRAFT STRUCTURAL ELEMENTS AND COMPONENTS UNDER CRASH TYPE LOADS - WHAT ARE THEY TELLING US?
HUEY D. CARDEN (NASA, Langley Research Center, Hampton, VA), RICHARD L. BOITNOTT (NASA, Langley Research Center; U.S. Army, Aerostructures Directorate, Hampton, VA), and EDWIN L. FASANELLA (Lockheed Engineering and Sciences Co., Hampton, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1195-1208. Previously announced in STAR as N90-25368. refs
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Failure behavior results are presented from crash dynamics research using concepts of aircraft elements and substructure not necessarily designed or optimized for energy absorption or crash loading considerations. To achieve desired new designs which incorporate improved energy absorption capabilities often requires an understanding of how more conventional designs behave under crash loadings. Experimental and analytical data are presented which indicate some general trends in the failure behavior of a class of composite structures which include individual fuselage frames, skeleton subfloors with stringers and floor beams but without skin covering, and subfloors with skin added to the frame-stringer arrangement. Although the behavior is complex, a strong similarity in the static and dynamic failure behavior among these structures is illustrated through photographs of the experimental results and through analytical data of generic composite structural models. It is believed that the similarity in behavior is giving the designer and dynamists much information about what to expect in the crash behavior of these structures and can guide designs for improving the energy absorption and crash behavior of such structures. Author

A91-24426#
ANALYSIS OF THE DYNAMIC BEHAVIOR OF AIRCRAFT STRUCTURES DURING CRASH IMPACTS
GIL WITTLIN (Lockheed Aeronautical Systems Co., Burbank, CA) and LARRY NERI (FAA, Technical Center, Atlantic City, NJ) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1209-1224. refs
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A digital computer program developed for the purpose of performing aircraft crash dynamics analysis is described. The program, called KRASH, computes the time histories of N interconnected masses, each allowed six degrees of freedom. The program describes the interaction between a series of massless interconnecting structural elements and concentrated rigid body masses to which the strutural elements are attached at their ends with the appropriate end fixity. The manner in which the structure moves and the forces act is directly related to the manner in which the aircraft being analyzed is modeled and the direction and magnitude of the external forces, as in the situation whenever the real structure is idealized mathematically. A description of KRASH validation tests and models, a range of application both for metals and composites, pertinent response time histories, and deformations are also discussed. L.K.S.

A91-24429#
AERODYNAMIC DESIGN FOR A NEW REGIONAL AIRCRAFT
E. GREFF (Deutsche Airbus GmbH, Bremen, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1251-1265. Research supported by BMFT. refs
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The status of aerodynamic design work for the MPC 75 short-haul passenger aircraft and the trade-offs already performed for the basic aerodynamic technologies of natural laminar flow/variable camber versus a conventional turbulent transonic wing and turbulence management via riblets are discussed. Design integration aspects of the propulsion system for a profan as well as for a wing-mounted high bypass turbofan are discussed. A number of diagrams are presented providing such information as design requirements affecting aerodynamic design, comparison of basic configurations, drag breakdown in cruise, the principles and potential of NLF technology, the potential of riblets, fuel savings due to engine technology, model and wind-tunnel strategy, an aerodynamic development concept, comparison of typical wing sections, comparison of spanwise pressure distributions, scaled aerodynamic efficiency, buffet boundaries, a high-lift concept, and determination of amplification exponents. L.K.S.

A91-24430#
QUIET STOL RESEARCH AIRCRAFT ASUKA - DEVELOPMENT AND FLIGHT TEST
MIKIHIKO MORI, YOSHIO HAYASHI (National Aerospace Laboratory, Chofu, Japan), NOBUYUKI TAKASAKI, and TAKASHI TSUJIMOTO (Kawasaki Heavy Industries, Ltd., Kakamigahara, Japan) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1266-1276. refs
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Development and flight test results of the Japanese research project on the fan jet quiet STOL research aircraft Asuka are presented. Asuka is designed to perform research on powered lift

technology and STOL operation. Asuka provides many technological features including upper-surface blowing flaps, a boundary layer control system, a stability and control augmentation system, a flight control system with triplex hydromechanical series servo actuator, sonic abatement techniques, and a newly developed high bypass ratio fan jet engine with bleed air. The flight tests were conducted from October 1985 to March 1989 and flew about 170 hours and 97 flights. Particular attention was devoted to the aerodynamic performance of the high lift device and control techniques for STOL approach and landing. Some selected data are presented with an explanation of the flight tests. L.K.S.

A91-24431#
ASPECTS OF THEORETICAL AND EXPERIMENTAL INVESTIGATIONS ON AIRFRAME/ENGINE INTEGRATION PROBLEMS

H. HOHEISEL, R. KIOCK, C. C. ROSSOW, A. RONZHEIMER (DLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany), W. BAUMERT (DLR, Goettingen, Federal Republic of Germany) et al. IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1277-1289. refs

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In view of the development of ultra-high bypass engines, the aerodynamic interference between airframe and engine becomes more and more important. This study describes as a first step the flow field around an Airbus-type configuration with a conventional turbofan engine. Theoretically, the three-dimensional Euler equations were solved using a cell-vertex method using a multi-block structure. Experimentally, a half model based on the Airbus A320 and scaled about 1:10 with a Turbo-Powered Simulator was investigated at low speed. The results show good agreement between theory and experiment. Author

A91-24439#
TOOLS AND METHODS USED FOR CERTIFICATION OF THE FOKKER 100 AUTOMATIC LANDING SYSTEM PERFORMANCE

H. C. VAN DE HULST and A. MULDER (Fokker Aircraft, Amsterdam, Netherlands) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1352-1360.

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The Monte Carlo simulation technique is applied to the Fokker 100 autoland system in order to demonstrate performance compliance of this system with airworthiness requirements. A correlation method is developed which is intended to verify the validity of the currently used simulation model. In order to obtain Joint Airworthiness Authorities' approval for operations with the automatic landing system on the Fokker 100, various tools and methods were developed and applied. In the absence of adequate certification guidelines, an efficient and practicable validation method was developed to verify the credibility of the simulation model by statistical correlation against a series of flight test results. These flight results were obtained using an accurate trajectory measurement system which combines a forward-looking camera with inertial sensing. L.K.S.

A91-24441#
INTEGRATED STRUCTURAL OPTIMIZATION IN THE PRELIMINARY AIRCRAFT DESIGN

G. BINDOLINO, M. LANZ, P. MANTEGAZZA, and S. RICCI (Milano, Politecnico, Milan, Italy) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1366-1378. refs

(Contract CNR-86,00865,59)

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The paper presents a numerical procedure for the integrated design of structural and control parameters of aerospace structures in a preliminary to intermediate design phase. The approach is based on a multimodel formulation of the aeroservoelastic problem, allowing to take into account completely different and independent models and/or flight conditions coupled only by a set of structural and control design variables. Several servo-structural responses, such as displacements, stresses, buckling loads and aeroelastic characteristics, can be evaluated and used in order to build up appropriate objective and constraint functions during the optimization process. Some examples are discussed to demonstrate the soundness of the approach and its flexibility of use. Author

A91-24442#
LOAD ALLEVIATION AND RIDE SMOOTHING INVESTIGATIONS USING ATTAS

R. KOENIG and K.-U. HAHN (DLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1379-1393. refs

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The modeling of the DLR's Advanced Technologies Testing Aircraft System (ATTAS) aircraft is discussed, and the design of the control system is examined. The system is a load-alleviation and ride-smoothing system (LARS) and has been designed using simulation and optimization techniques. The results of simulations and first flight tests show the expected alleviation of vertical accelerations in turbulence. The damping of the first wing bending mode can be significantly improved, as illustrated by the simulation results. The objective of the LARS program is the acquisition of knowledge about passenger comfort under consideration of structure load alleviation, effects on flight path accuracy, and pilot workload reduction. L.K.S.

A91-24452#
EXTENDED RANGE OPERATION OF TWO AND THREE TURBOFAN ENGINED AIRPLANES

R. MARTINEZ-VAL and E. PEREZ (Escuela Tecnica Superior de Ingenieros Aeronauticos, Madrid, Spain) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1479-1484. refs

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The behavior of two and three turbofan aircraft after engine failure is studied comparatively. A simple but fairly realistic treatment of the range equation makes it possible to investigate the extended range operations of aircraft after any prescribed decrease of thrust while keeping the best possible long-range attitude. This approach takes into account increases in parasitic drag and considers variations of specific fuel consumption and thrust with height and Mach number. All the powerplant characteristics are represented by a few dimensionless parameters. The model provides the cruise conditions (height and Mach number) after engine failure and makes it possible to determine the additional fuel needed to reach the final destination. Results for a typical 5000-km route demonstrate the relative disadvantages of twins. B.J.

A91-24454#
IN-FLIGHT PRESSURE DISTRIBUTION MEASUREMENTS - INSTRUMENTATION, DATA HANDLING AND COMPARISON WITH WINDTUNNEL DATA

H. KANNEMANS (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) and D. F. VOLKERS (Fokker Aircraft, Schiphol, Netherlands) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1496-1505. Research supported by Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart. refs

Copyright

As part of the certification of the Fokker 100 aircraft, in-flight wing pressure distributions were measured. The objective of the analysis presented in the present paper is to make a comparison of flight test data with wind-tunnel data. To this end, an accurate calibration was made of the in-flight angle of attack, providing the appropriate reference conditions used for the comparison with

wind-tunnel data. Corrections were applied for differences in wing shape, due to differences in flight test and wind-tunnel conditions, as well as due to production tolerances. This way the validity of the test methods and available extrapolation techniques were investigated. The results of this investigation confirm that, for the type of wing section used in the Fokker 100, full-scale characteristics of the wing can be predicted from wind-tunnel model experiments. Author

A91-24455#
DEVELOPMENT OF A MEASUREMENT TECHNIQUE FOR DAMPING DERIVATIVES IN PITCH
G. GUGLIERI, F. B. QUAGLIOTTI (Torino, Politecnico, Turin, Italy), and A. CAVALLARI (Italian Aerospace Research Centre, Capua, Italy) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1506-1512. refs
Copyright

The Turin Polytechnical Institute is conducting a long-range research program designed to evaluate damping derivatives in pitch in connection with the high-AOA performance of new-generation fighter aircraft. The first phase of activity consisted in the development of an experimental system which was tested in a low-speed wind tunnel. The model configuration tested corresponds to the AGARD Standard Dynamic Model (SDM). It is concluded that the first part of the program gave satisfactory results: the system, qualified using the SDM, was found to be reliable, and the preliminary results are comparable to those obtained in other wind tunnels. B.J.

A91-24459#
NEW AIRCRAFT PLATFORMS FOR EARTH SYSTEM SCIENCE - AN OPPORTUNITY FOR THE 1990S
JOHN S. LANGFORD (Aurora Flight Sciences, Alexandria, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1534-1538. refs
Copyright

The 1986 discovery of a massive ozone hole over Antarctica has focused international scientific, political, and popular attention on the chemistry and dynamics of the middle atmosphere. During the 1990s the need for in situ data on this region will grow dramatically, in order to both complement and supplement various space- and ground-based observations. Recent advances in low-Reynolds-number aerodynamics, lightweight composite structures, microelectronics, and energy conversion systems offer the possibility of a new class of unmanned aircraft well suited to this purpose. This paper reviews some of the fundamental limits applicable to any very high-altitude subsonic design, and then reviews three projects under way at Aurora Flight Sciences. The first, designated Perseus, is an Antarctic ozone probe designed to carry 50 kg payloads to altitudes of approximately 25 km and return them for reuse during the austral spring of 1992. Theseus, the second program, is a larger platform designed to carry payloads of up to 250 kg at ranges greater than 20,000 km and to altitudes of up to 35 km. Odysseus is a solar-powered aircraft designed to carry 100 kg class payloads at altitudes of approximately 20 km for very long durations, measured in months or years. Author

A91-24460*# AS&M, Inc., Hampton, VA.
THE DESIGN AND FLIGHT TESTING OF A LONG ENDURANCE RPV
SHAHID SIDDIQI and TECK-SENG KWA (AS&M, Inc., Hampton, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1539-1549. refs
(Contract NAS1-18599)
Copyright

This paper covers the design process for a long endurance RPV. The 56-pound RPV must operate in the 25-60 knot speed range at low altitudes. An airfoil designed for low-Reynolds-number applications was used with a wing of aspect ratio 22 to reach an estimated L/D(max) of 25. Wing tip feathers were designed to reduce the induced drag. A comparison between the computed aerodynamic predictions and wind-tunnel results is given. The estimated endurance is on the order of 50 hours/gallon of fuel. A three-surface configuration was chosen, and the predicted handling quality and performance results obtained so far are given. The structural challenges in building a lightweight structure for the wing and control surfaces are outlined. The flight test program is currently underway. Author

A91-24490#
MILITARY TRAINER AIRCRAFT - TURBOPROP OR JET?
O. L. P. MASEFIELD and E. A. P. BURDAK (Pilatus Aircraft, Ltd., Stans, Switzerland) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1858-1864.
Copyright

This paper makes a summary of the specifications issued by several of the world's air forces for training aircraft. The teaching effectiveness targets of these specifications are assessed by developing a mathematical model based on a highly modified form of Bazzocchi's analysis. The paper reviews the different performance and handling characteristics of several modern turboprop and jet trainer aircraft and relates these characteristics to the requirements. A separate model is established to estimate the purchase and operating costs of the various types of training equipment. An overall training cost-effectiveness result is then established. The advantages and disadvantages of each type of training system equipment is discussed in a general manner and conclusions drawn as to the most cost-effective mix. Special reference is made to the performance of the turboprop compared to the jet aircraft in the 'Primary' training phase and their relative cost-effectiveness discussed. Author

A91-24491#
AAA (ADVANCED AIRCRAFT ANALYSIS) - A USER-FRIENDLY APPROACH TO PRELIMINARY AIRCRAFT DESIGN
J. ROSKAM, S. M. MALAEK, and W. ANEMAAT (Kansas, University, Lawrence) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1865-1882. refs
Copyright

The utility of a user-friendly code developed for preliminary aircraft designers and aircraft design students is demonstrated. All applicable performance and flying quality regulations are built-in, providing the designer with instant appraisal of the status of his design in relation to these regulations. The program features a common data base, built-in help files for theory and for design decision-making, and report-quality graphics for display of design decision results and trade studies. B.J.

A91-24492#
DESIGN AND FLIGHT TEST ON HIGH AOA/SPIN CHARACTERISTICS OF XT-4 INTERMEDIATE JET TRAINER
N. TODA, N. UDAGAWA, T. ICHIHASHI (Japan Defense Agency, Tokyo), H. KOMAKI, N. MORITA (Kawasaki Heavy Industries Co., Ltd., Kakamigahara, Japan) et al. IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1883-1890.
Copyright

Designs, development tests, and flight tests pertaining to the high AOA/spin characteristics of the XT-4 are described. Rotary-balance and spinning wind tunnel tests and spin testing using RPV models were performed to predict the poststall behavior. It was found that the XT-4 is extremely resistant to departure during the maneuver and that it has the capability of getting into intentional spin followed by a hands-off smooth recovery from any mode with engine distortion tolerance. B.J.

A91-24502#
NONLINEAR MODELLING IN AIRBORNE SIMULATIONS

J.-MICHAEL BAUSCHAT (DLR, Institut fuer Flugmechanik, Brunswick, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1966-1975. refs
Copyright

The in-flight simulation technique, which is implemented on the DLR research aircraft ATTAS (Advanced Technologies Testing Aircraft System) will be presented. After this brief overview, two particular developments will be discussed in detail. One is a nonlinear 6-degrees-of-freedom real-time aircraft model for the in-flight simulation, the other is a quasi-nonlinear feedforward controller in the ATTAS model following system. Both systems have been investigated in fight-tests, where a typical wide-body transport aircraft has been simulated. Some selected flight-test results will be given, which show the high quality of the developed model following system during nonlinear simulation tasks. The research aircraft and the ATTAS ground-based simulator will be presented briefly. Author

A91-24510#
MATHEMATICAL MODELING OF OPTIMAL PASSIVE CONTROL OF ROTOR HEAD VIBRATIONS
J. JANKOVIC (Beograd, Univerzitet, Belgrade, Yugoslavia) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2039-2045.
Copyright

Numerical methods for the simulation of helicopter-rotor structural dynamics are developed analytically and demonstrated. The derivation of the governing equations is outlined, with an emphasis on the treatment of viscous damping and passive vibration control, extending and refining the analysis of King (1987). A procedure for reducing the resulting system of equations is described, and numerical results for sample simulations are presented in graphs. It is shown that the effectiveness of the absorber depends on the value of parameter beta, which should be kept below about 0.05. D.G.

A91-24511#
ANALYSIS OF METHODS FOR MODELLING REAL FLIGHT SITUATIONS
JOZSEF ROHACS (Budapesti Muszaki Egyetem, Budapest, Hungary) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2046-2054. refs
Copyright

Nonlinear stochastic modeling methods for aircraft flight are described, summarizing the results of recent investigations. In these methods, flight is considered as the controlled three-dimensional motion of a flexible body, determined by the given realization of the stochastic deviation process of aerodynamic and flight-engineering characteristics and disturbed stochastically by the real environmental conditions. The derivation of the model equations is outlined; the relationships among the submodels are shown in extensive diagrams; the statistical analysis and incorporation of empirical data are discussed; and some typical simulation results are presented in graphs. D.G.

A91-24517#
FINITE ELEMENT APPLICATION TO INTERIOR NOISE PREDICTION IN AIRCRAFT FUSELAGE
C. WENIGWIESER and S. HAEUSLER (Dornier Luftfahrt GmbH, Friedrichshafen, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2094-2104.
Copyright

The use of general-purpose FEM codes to predict cabin noise and structural vibration in the Do-328 propeller-driven passenger aircraft is described. The structural-acoustic analysis method of Haeusler et al. (1989) is reviewed; the mode shapes and resonant frequencies for various two- and three-dimensional cavities are determined by eigenvalue analysis in the uncoupled case; the modeling of structure-cavity coupling is explained; and results for a two-dimensional structure and cavity, a three-dimensional fuselage test section, and the full-sized Do-328 fuselage are presented in extensive tables and graphs and discussed in detail. Good general agreement with experimental measurements is obtained, illustrating the importance of accounting for mode interactions in acoustic FEM modeling. D.G.

A91-24524#
COMPUTERAIDED CONCEPTUAL AIRCRAFT CONFIGURATION DEVELOPMENT BY AN INTEGRATED OPTIMIZATION APPROACH
C. HABERLAND, W. FENSKE, O. KRANZ, and R. STOER (Berlin, Technische Universitaet, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2164-2173. refs
Copyright

The objective of the conceptual design phase is the development of the aircraft configuration which is most efficient for a given specification. To numerically assist this procedure a CAE-system is presented which, as main attributes, handles arbitrary analysis and synthesis methods as modules in a method library, applies an always consistent and complete computer internal modeling of geometry and performance, and controls the design processing through a design management system as a central user interface. To point out the potential of this open program architecture, and, in particular, the modeling approach chosen, an aerodynamic analysis of complete aircraft configurations is discussed. Furthermore, it can be shown that paralleling the multivariate optimization with the design synthesis leads to a more efficient strategy than the conventional successive procedure. With this integrated optimization approach a comparative concept evaluation can be performed. Author

A91-24528#
THE DESIGN OF INTERCONTINENTAL SUPERSONIC TRANSPORT AIRCRAFT OF SECOND GENERATION BY USING GLOBAL OPTIMIZATION TECHNIQUES
ADRIANA NASTASE (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2211-2222. refs
Copyright

The application of the optimum optimorum (OO) theory of Nastase (1973, 1974, 1979, and 1980) to the design of wings and wing-fuselage configurations for long-range supersonic aircraft is described. The equations for determination of the axial disturbance velocities, for optimization of the aircraft with retracted flaps, and for optimization of the flap shape are derived in detail, and selected results from experimental verification tests on the OO delta wing Adela in the DLR Koeln trisonic wind tunnel are presented in graphs. The accuracy and high computational efficiency of the OO approach are demonstrated. D.G.

A91-24529#
AN INTEGRATED APPROACH TO DESIGN FOR RELIABILITY MAINTAINABILITY AND MISSION READINESS OF COMBAT AIRCRAFT
J. P. FIELDING (Cranfield Institute of Technology, England) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2223-2230.
Copyright

The application of systematic R&M modeling techniques during a student group-design project in 1987-1988 (for a close-air-support military aircraft called S-87) is described. The fundamental principles of design for reliability, design for maintainability, and design for survivability are reviewed; the incorporation of aircraft design data into a general model to generate predictions of

operational defect rates, maintenance requirements, and combat availability is explained; and diagrams, graphs, and tables produced in the S-87 project are included. D.G.

A91-25837#
F-117A - FIRST IN STEALTH
RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 29, Feb. 1991, p. 32-35, 42.
Copyright

The development history of the F-117A stealth fighter is reviewed, and some of its features are highlighted. The process by which the demonstrator and production contracts were obtained is traced. Radar evading techniques are discussed, noting that the F-117 was built to have minimum radar reflection straight ahead of the aircraft; the leading edge of the wings is swept up 67 deg to ensure that radar from dead ahead gets reflected well off to the sides. Additionally, some of the materials used in F-117 construction are of the ferrite-type RAM, which absorbs energy by converting it to heat when the radar waves strike the ferrite and cause its molecules to oscillate. It is pointed out that, although the F-117 is virtually radar-free, it has both an infrared imaging system and a laser system which designates targets for the aircraft's two 2000-lb bombs. Simulator training is emphasized as essential for pilots of this vehicle. L.K.S.

A91-25897#
AERODYNAMIC DESIGN OF LOW-DRAG FUSELAGES
R. H. WICKENS (National Research Council of Canada, Institute for Aerospace Research, Ottawa) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 36, Dec. 1990, p. 189-201. refs

A review of current research and technology as applied to the aerodynamic design of the aircraft fuselage is presented with particular reference to drag. Research on the possibility of achieving long runs of natural laminar flow at low Reynolds numbers has confirmed the benefits of shaping the contour and manipulation of the pressure gradients. This concept can potentially halve the drag of the all-turbulent fuselage but may be difficult to achieve at the high Reynolds numbers experienced by current transport aircraft. New concepts for the reduction of skin-friction drag of the turbulent boundary layer by the use of longitudinal grooves (riblets) or the breaking up of the large eddies in turbulent layer (LEBU) have proved encouraging and a potential reduction on skin friction of 8 percent is anticipated. The most likely method for the design of long fuselages at high Reynolds numbers will be a hybrid concept which employs laminar flow control over the forward surfaces, mid-chord shaping to delay transition, and devices such as riblets and LEBUs to manipulate the turbulent boundary layers on the aft portions. Author

A91-25950#
SOME THOUGHTS ON THE DESIGN OF SUBSONIC TRANSPORT AIRCRAFT FOR THE 21ST CENTURY
JERRY T. CALLAGHAN and ROBERT H. LIEBECK (Douglas Aircraft Co., Long Beach, CA) Cockpit (ISSN 0742-1508), Oct.-Dec. 1990, p. 5-13.

A study is presented that was conducted in response to NASA Langley's question whether there is an aerodynamic renaissance for the long-haul transport. First, a baseline group of aircraft was prepared utilizing the derivative/evolutionary approach. Then an attempt was made to define a revolutionary design using unlimited technical optimism. Subsequently, the results of the two design approaches were compared. A blended wing-body/span-loader as an example of a revolutionary idea for application to the large transport design problem is examined. System weight and structural enhancements are assumed to be the same as for the Synergistic Technology Transport (STT), and laminar flow control and riblets are incorporated on both lower and upper surfaces of the aircraft. It is concluded that the evolutionary development cycle will continue and the results could be outstanding as shown by the STT. Also, energy and environmental requirements may demand the development of revolutionary configurations. R.E.P.

A91-26099
IS A STAGED SST THE ANSWER?
Aerospace Engineering (ISSN 0736-2536), vol. 11, Feb. 1991, p. 17-19.
Copyright

Recent studies indicate that a staged supersonic transport concept offers several advantages over conventional SST configurations. A staged SST could be optimized for cruise flight and also would not be subject to the noise and runway-length constraints normally associated with a transport aircraft. The cumulative effect of the various weight saving factors is an appreciably lower launch/takeoff weight. Other advantages include the fact that a landing gear would not be required and the staged SST can be designed to low-speed criteria. These initial studies suggest that launch and recovery operations from another aircraft could be made feasible with the use of a 747 type aircraft as the support vehicle. R.E.P.

A91-26119#
FEASIBILITY STUDY ON THE DESIGN OF A LAMINAR FLOW NACELLE
R. RADESPIEL, K. H. HORSTMANN, and G. REDEKER (DLR, Institut fuer Entwurfsaerodynamik, Federal Republic of Germany) Journal of Aircraft (ISSN 0021-8669), vol. 27, Nov. 1990, p. 959-965. Previously cited in issue 09, p. 1291, Accession no. A89-25506. refs
Copyright

A91-26441
FUNDAMENTALS OF METROLOGY IN AVIONICS [OSNOVY METROLOGII V AVIAPRIBOROSTROENII]
GENNADII D. KURZENKOV Moscow, Izdatel'stvo MAI, 1990, 312 p. In Russian. refs
Copyright

The principles of theoretical and legal metrology are examined with particular reference to avionics. Attention is given to methodological problems, methods of measurement error estimation, metrological characteristics of measuring devices and their normalization, and metrological data formats. The discussion also covers the metrological support of aviation equipment and the general design and applications of analog measuring instruments. V.L.

A91-26650
STRUCTURAL OPTIMIZATION OF AIRCRAFTS
C. PETIAU (Dassault Aviation, Vaucresson, France) IN: *Optimization: Methods and applications, possibilities and limitations*; Proceedings of the International Seminar, Bonn, Federal Republic of Germany, June 7, 8, 1989. Berlin and New York, Springer-Verlag, 1989, p. 83-105. refs
Copyright

The numerical optimization techniques used in aircraft design at Dassault-Breguet are surveyed and illustrated with extensive diagrams and sample computer graphics. The methods are based on the FEM software package CATIA-ELFINI, as described by Petiau and Lecina (1978). Consideration is given to the basic optimization approach (cost functions, design variables, constraints, and sensitivities), the special problems encountered in optimizing composite structures (analysis of failure criteria, local buckling, and design constraints), and a design example involving a CFRP combat-aircraft wing. Also discussed are the overall organization of the design process; the problem of identification and computation with uncertain data; and the incorporation of flexible design variables, postbuckling analysis, shape optimization, and thermal optimization (e.g., for the Hermes space plane program). T.K.

A91-26695
THE ROCKWELL/MBB X-31A EXPERIMENTAL AIRCRAFT IN FLIGHT TEST [EXPERIMENTALFLUGZEUG ROCKWELL/MBB X-31A IN ERPROBUNG]
Luft- und Raumfahrt (ISSN 0173-6264), vol. 11, 4th Quarter, 1990, p. 8-10, 12-14. In German.
Copyright

The design and development of the X-31A are reviewed and illustrated with extensive drawings and photographs, with an emphasis on the cooperation between U.S. and German engineering teams in the X-31A program. The X-31A is a 14.85-m-long 7.26-m-wingspan canard-delta fighter configuration equipped with an F404 engine and CFRC thrust-vector paddles (deflectable up to 12 deg off the longitudinal axis) to increase maneuverabilty and permit operation at angles of attack up to 70 deg. The materials used for the surface panels include Al (51 percent), Al-Li (4 percent), graphite-epoxy (17 percent, including the delta wings), steel (5 percent), Ti (5 percent), CFRC (2 percent), GFRP (1 percent), and other materials (15 percent). About 600 components (43 percent of the aircraft weight) were taken over from previous aircraft, making it possible to limit the program cost to about $200 million. The successful first flight of the X-31A took place on October 11, 1990, and a 400-h flight test program is in progress. T.K.

A91-26696
DORNIER AND AERITALIA - STUDIES FOR THE NEW AAA AMPHIBIOUS AIRCRAFT [DORNIER UND AERITALIA - STUDIEN FUER DAS NEUE AMPHIBIENFLUGZEUG AAA]
Luft- und Raumfahrt (ISSN 0173-6264), vol. 11, 4th Quarter, 1990, p. 16-20. In German.
Copyright

An overview of the Advanced Amphibious Aircraft (AAA) development program is presented and illustrated with drawings and photographs. The primary mission planned for the shoulder-wing twin-turboprop AAA is fighting forest fires in the Mediterranean region; secondary missions include air and water pollution surveillance, detecting and combatting oil spills, and maritime police surveillance. The planing-tail fuselage of the proposed AAA configuration features a pair of 'cobra-hood' bulges which provide static and dynamic stabilization on the water and reduce spray formation. The AAA is currently in the design study stage under Eureka funding, and a decision on further development is to be made in 1992. T.K.

A91-26700* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AIRCRAFT LANDING GEAR SYSTEMS
JOHN A. TANNER, ED. (NASA, Langley Research Center, Hampton, VA) Warrendale, PA, Society of Automotive Engineers, Inc. (SAE PT-37), 1990, 352 p. No individual items are abstracted in this volume.
(SAE PT-37) Copyright

Topics presented include the laboratory simulation of landing gear pitch-plane dynamics, a summary of recent aircraft/ground vehicle friction measurement tests, some recent aircraft tire thermal studies, and an evaluation of critical speeds in high-speed aircraft. Also presented are a review of NASA antiskid braking research, titanium matrix composite landing gear development, the current methods and perspective of aircraft flotation analysis, the flow rate and trajectory of water spray produced by an aircraft tire, and spin-up studies of the Space Shuttle Orbiter main gear tire. R.E.P.

A91-26798
THE TUPOLEV TU-160 'BLACKJACK'
ROY BRAYBROOK Air International (ISSN 0306-5634), vol. 40, Jan. 1991, p. 9-15.
Copyright

Development of the Tu-160 and comparative data with the B-1A and B-1B are presented. The B-1B was designed as an improvement over the B-1A to provide a greater weapons load, greater range and better low-level penetration capability. The B-1B was to achieve its increase in effectiveness relative to the B-1A by taking its maximum weight from 395,000 lb to 477,000 lb, and by reducing its radar cross-section by a factor of ten, giving a radar signature equal to only one percent of the B-52 signature. It has been announced that the Blackjack has a maximum weight of 606,000 lb, a four man crew, and a max speed of Mach 2.07, which indicates that it is designed for both high and low level penetration. The B-1B's max speed of Mach 1.2 points to a design criterion aimed only at low level penetration. Unrefueled combat radius for both the Tu-160 and the B-1B is essentially the same, about 3,940 nautical miles. Engine thrust for the Tu-160 is 55,115 lb for each of its four engines, which is about 80 percent more than that of the B-1B's 30,780 lb engines. It is believed that the greater size of the Tu-160 enables it to carry a greater number of air-launched cruise missiles internally for supersonic penetration at medium altitude. R.E.P.

A91-27517
FATIGUE DAMAGE OF AN AIRCRAFT FROM THE GROUND-AIR-GROUND CYCLE [UNAVOVE POSKOZENI LETOUNU OD CYKLU ZEME-VZDUCH-ZEME]
JOSEF VLACHYNSKY Zpravodaj VZLU (ISSN 0044-5355), no. 4, 1990, p. 199-205. In Czech. refs
Copyright

Two methods for calculating the fatigue damage from the ground-air-ground cycle are shown. The first considers the quasi-static behavior while the second considers the dynamic behavior of the aircraft. The application of these methods to the calculation of fatigue damage for the L-410 UVP wing is described. Author

A91-27875
ATF - THE USAF'S FUTURE FIGHTER PROGRAMME
ROY BRAYBROOK Air International (ISSN 0306-5634), vol. 40, Feb. 1991, p. 65-70.
Copyright

A review is presented of the background fighter concepts that have led to the current test prototypes that are envisaged as the eventual jet fighter of the early 21st century. Basic details are then provided for the two competing aircraft (YF-22/YF-23) and engines (F119/F120), from which it is expected a final winner will be determined. The broad USAF requirements called for a modern-technology combat fighter comparable in weight to the F-15 of the mid-1990s, with a STOL capability to reduce sensitivity to runway bombing, and a high-level penetration capability due to a low radar signature plus the ability to fly at supersonic speeds without afterburner. Engine thrust with afterburner was nominally figured at 35,000 lb per engine, giving an aircraft thrust to weight ratio of 1.4:1. Air-to-air guided weapons are to be carried internally and launched from hydraulically-powered weapon racks. One of the engine types in the test program, the F-120, is a variable-bypass design, which can operate at low speeds as a turbofan and as a turbojet at high speeds. Some preliminary cost figures are discussed along with details on basic avionics that are being evaluated in separate test beds. R.E.P.

A91-27876
SST - THE NEXT STEP
BRIAN WALTERS Air International (ISSN 0306-5634), vol. 40, Feb. 1991, p. 71-74.
Copyright

A review is presented of current research being conducted by the world's leading aerospace manufacturers for a future high speed transport aircraft. The general requirements for an advanced SST center on 250 to 300 passengers, a 5000 nm range at full payload and a speed of about Mach 2.2. Fuel consumption, noise attenuation and emissions are major considerations that will require unforeseen advances in any future development program. Propulsion systems are being studied in joint projects, both in the U.S. and Europe, which concepts include variable nozzles and the use of new lightweight temperature-resistant materials to achieve weight reductions. One engine being studied features two sets of variable-area bypass injectors, one aft of the fan and the other aft of the low pressure turbine. Another engine concept has led to the use of a variable-geometry inlet as well as a variable-geometry core inlet, with this bypass turbojet having an ejector assembly that doubles as a thrust reverser. Various design concepts for SST aircraft are also described. R.E.P.

A91-27926
MULTIPLE POWER QUESTIONS
BILL SWEETMAN Interavia Aerospace Review (ISSN 0020-6512), vol. 46, Feb. 1991, p. 18-20.
Copyright

As jet engine reliability continues to improve, the question of whether two, three or four engines is the right number for commercial aircraft is examined. ICAO and the FAA have extended the extended-range twin operations rule from an initial 60 minutes duration to 180 minutes, which covers practically all operations. This rule requires a 0.02 inflight shutdown rate, demonstrated for the entire fleet of a particular type of aircraft/engine combination. Economics is becoming the driving force in this selection process. Nine of the 13 aircraft types currently in development or production are powered by two engines. Some of the arguments for the long-range quad state are that it requires less installed power, as it has 75 percent of thrust available for climb with one engine out, and that the better load distribution across the wing saves weight. On the twin side it is stated that in the case of the 777 aircraft the minimum thrust is not set by takeoff and climb, but by the all-engines thrust requirement at the end of the climb. It is noted that no manufacturer is presently designing a new trijet although studies using this configuration are still being performed. R.E.P.

A91-28025#
GUST LOADS ON AIRCRAFT: CONCEPTS AND APPLICATIONS
FREDERIC M. HOBLIT Research sponsored by Lockheed Aeronautical Systems Co. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1988, 317 p. refs
Copyright

The theoretical basis and practical implementation of current techniques for determining gust loads on aircraft are examined in work intended as a reference guide and supplementary textbook for courses in aeroelasticity, flight mechanics, or flight control. Chapters are devoted to the generation of gust loads and the characteristics of turbulence, discrete-gust static and dynamic loads, power-spectral density methods for gust loads, continuum turbulence gust loads, and load combinations and design conditions. Also considered are the formulation and solution of the gust-response equations of motion, short-cut methods, spanwise variation of vertical gust velocity, the treatment of nonlinear systems, the analysis of gust-response flight-test data, the adequacy of the stationary-Gaussian idealization of gust structure, and the current status of discrete-gust load requirements. D.G.

A91-28257* Douglas Aircraft Co., Inc., Long Beach, CA.
INTERIOR NOISE OF THE MCDONNELL DOUGLAS UHB DEMONSTRATOR
D. N. MAY and M. A. SIMPSON (Douglas Aircraft Co., Long Beach, CA) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 199-204. (Contract NAS1-18037)
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A91-28258
EVALUATION OF INTERIOR NOISE PREDICTION PROCEDURES FOR UDF-POWERED COMMERCIAL AIRCRAFT BASED ON EXPERIMENTAL MODAL ANALYSIS
STEVEN E. MARSHALL (*Boeing Commercial Airplanes, Seattle*, WA) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 205-210. refs
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A91-28259 Lockheed Aeronautical Systems Co., Burbank, CA.
ACOUSTIC TRANSMISSION LOSS FLIGHT TEST RESULTS FOR AN AIRCRAFT CABIN ENCLOSURE
HERBERT L. KUNTZ, ED., ROBERT J. GATINEAU, and ROLAND A. PRYDZ (Lockheed Aeronautical Systems Co., Burbank, CA) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 211-216. (Contract NAS1-18036; NAS3-24339)
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Results are reported from flight tests of a noise-reducing cabin enclosure comprising a 10-ft-long 544-kg interior chamber with 1-ft-thick end walls, supported by 21 floor vibration isolators and isolated from the aircraft cabin by 600 hemispherical Helmholtz resonators tuned to 225 Hz at 0 C. The test aircraft was the NASA Lewis Propfan Test Assessment aircraft, a Gulfstream II with a single wing-mounted 2.7-m-diameter 8-blade SR-7L propfan powerplant. Test flights of 10.7 km at Mach 0.8 were performed with no resonators, with inactive resonators, and with active resonators; the results are presented in graphs and briefly characterized. The average A-weighted sound levels with active resonators are shown to be about 25 dB lower than those with no resonators. T.K.

A91-28270* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EN ROUTE NOISE TEST PRELIMINARY RESULTS
WILLIAM L. WILLSHIRE, JR. and DONALD P. GARBER (NASA, Langley Research Center, Hampton, VA) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 309-312.
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Preliminary results are reported from ground measurements of noise emitted by a full-scale advanced single-rotation turbofan model mounted on the wing of the NASA Lewis Propfan Test Assessment aircraft during test flights in October 1987. The procedures and instruments employed in the test program are described, and the data are presented in tables. The repeatability of the measurements is shown to be good within one test day, with day-to-day variations attributed to cross-wind convection. Fair agreement is found between these measurements and the predictions of ray-tracing models. T.K.

A91-28277
FULL SCALE DEMONSTRATION TESTS OF CABIN NOISE REDUCTION USING ACTIVE NOISE CONTROL
M. A. SIMPSON, T. M. LUONG (Douglas Aircraft Co., Long Beach, CA), M. A. SWINBANKS (MAS Research, Ltd., Cambridge, England), M. A. RUSSELL (W. S. Atkins Consultants, Epsom, England), and H. G. LEVENTHALL (South Bank Polytechnic, London, England) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 459-462.
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N91-17014*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STATIC FOOTPRINT LOCAL FORCES, AREAS, AND ASPECT RATIOS FOR THREE TYPE 7 AIRCRAFT TIRES
WILLIAM E. HOWELL, SHARON E. PEREZ, and WILLIAM A. VOGLER (Lockheed Engineering and Sciences Co., Hampton, VA.) *Washington* Feb. 1991 95 p
(NASA-TP-2983; L-16521; NAS 1.60:2983) Avail: NTIS HC/MF A05 CSCL 01/3

The National Tire Modeling Program (NTMP) is a joint NASA/industry effort to improve the understanding of tire mechanics and develop accurate analytical design tools. This effort includes fundamental analytical and experimental research on the

structural mechanics of tires. Footprint local forces, areas, and aspect ratios were measured. Local footprint forces in the vertical, lateral, and drag directions were measured with a special footprint force transducer. Measurements of the local forces in the footprint were obtained by positioning the transducer at specified locations within the footprint and externally loading the tires. Three tires were tested: (1) one representative of those used on the main landing gear of B-737 and DC-9 commercial transport airplanes, (2) a nose landing gear tire for the Space Shuttle Orbiter, and (3) a main landing gear tire for the Space Shuttle Orbiter. Data obtained for various inflation pressures and vertical loads are presented for two aircraft tires. The results are presented in graphical and tabulated forms. Author

N91-17015 Virginia Polytechnic Inst. and State Univ., Blacksburg.
OPTIMAL RIGID-BODY ROTATIONAL MANEUVERS Ph.D. Thesis
RAJIV SINGH CHOWDHRY 1989 176 p
Avail: Univ. Microfilms Order No. DA9017038

Optimal rigid-body angular maneuvers are investigated, using restricted control moments - a problem inspired in the context of rotational maneuvers for super-maneuverable aircraft. Most of the analysis is based on the formulation with no direct control over the roll component of angular velocity. Optimal rigid-body angular rate control is examined via an approximate dynamic model. The proposed model admits analytical solutions of the optimality conditions. The analysis reveals that over a large range of boundary conditions, there are, in general, several distinct extremal solutions. Second-order necessary conditions are investigated to establish local optimality of candidate minimizers. Global optimality of the extremal solutions is discussed. Next, the optimal angular rate problem is studied using the exact dynamic model. Numerical solutions of optimality conditions are obtained which corroborate and extend the findings of the approximate problem. The qualitative features of multiple extremal solutions did not satisfy the Jacobi necessary condition. The choice of minimizing solution could be narrowed down to two sub-families of extremal solutions. The studies look at minimum control effort families of extremal solutions. As a next step, the minimum time control of angular rates is examined with prescribed hard bounds on available control. Existence of singular subarcs in time-optimal trajectories is explored. Qualitative features exhibited by the exact problem are preserved. In addition, the control space is deformed to allow roll control and its effect on extremal solutions is investigated. The kinematics are introduced into the optimal control problem. Minimum time attitude control of a rigid-body is investigated with prescribed hard bounds on available control. The attitude of the rigid-body is defined using Euler parameters. Existence of singular subarcs in time-optimal trajectories is explored. Dissert. Abstr.

N91-17016# General Accounting Office, Washington, DC. National Security and International Affairs Div.
NAVAL AVIATION: THE V-22 OSPREY, PROGRESS AND PROBLEMS
12 Oct. 1990 11 p
(AD-A228905; GAO/NSIAD-91-45) Avail: NTIS HC/MF A03 CSCL 01/3

The V-22 is a tiltrotor aircraft designed to take off and land vertically like a helicopter and to fly like an airplane by tilting its wing-mounted rotors to function as propellers. The V-22 is being developed to perform various combat missions, including medium lift assault for the Marine Corps, combat search and rescue for the Navy, and long range special operations for the Air Force. The V-22 is intended to replace the CH-46 Sea Knight helicopter for the Marine Corps and to supplement existing aircraft for the Air Force. The Navy is developing the aircraft under a fixed price incentive contract with Bell Helicopter Textron, Inc., and Boeing Helicopter Company. The full scale development contract was awarded in May 1986 and requires the two contractors to produce six aircraft for flight testing and three for ground testing. It included an option to buy 12 aircraft under pilot production. The engine is being developed under a firm fixed price contract by the Allison Gas Turbine Division of General Motors. GRA

N91-17017 California Univ., Los Angeles.
A FINITE DIFFERENCE APPROXIMATION METHOD FOR FLEXIBLE FLIGHT STRUCTURES Ph.D. Thesis
JOSEPH SAMUEL CISNEROS 1990 147 p
Avail: Univ. Microfilms Order No. DA9034020

A recent area of interest is the development of numerical techniques to simulate control laws for flexible flight structures. The goal of any discrete scheme is to faithfully reproduce the structure and dynamics of the original system. This goal can become quite elusive, since the establishment of an analytic truth model is somewhat subjective, the structures typically being quite complex. The most popular method to date is the finite element method. A relatively overlooked method is to discretize the continuous partial differential equation model by means of finite differences. A modified approach to this method will be discussed here, in which the spatial coordinate is discretized by means of a finite difference and the temporal coordinate is then discretized by calculating the matrix exponential. Discrete representations of the wave equation and the Euler-Bernoulli equation are provided, which maintain the properties of the continuous system, in particular, those properties discussed by Prof. Balakrishnan in his state space formulation of these equations. In this formulation, the partial differential equations with boundary inputs are cast in state space form over a suitable Hilbert Space, similar to the finite dimensional LQR theory. In order to simulate this system and to arrive at computational verification of the continuous time-infinite dimensional results, an approach to the discretization of this system of equations called the finite-expo difference method (FED) is proposed. The consistency, stability, and hence convergence of FED is shown. Furthermore, by choosing higher order finite difference approximations of the spatial coordinate, it is shown that excellent modal approximations can be obtained. Dissert. Abstr.

N91-17018# Royal Aerospace Establishment, Bedford (England).
THE RAE GENERIC VSTOL AIRCRAFT MODEL: GVAM87 DOCUMENTATION GUIDE
E. A. M. MUIR and M. G. KELLETT Jan. 1990 89 p
(RAE-TM-FM-38; BR115855) Copyright Avail: NTIS HC/MF A05

An unclassified, extended version of the RAE Bedford's mathematical Generic VSTOL Aircraft Model (GVAM) was developed to provide RAE, British industry, and universities with a comprehensive, nonlinear, vectored thrust aircraft model for use in Advanced Short Take Off and Vertical Landing (ASTOVL) control law design studies and real time piloted simulation. New modes of operation for the aerodynamic control surfaces, nozzles, and reaction control systems were introduced as well as plenum chamber burners on the front nozzles and an optional chin fin. The configuration can be varied to include some or all of these additional motivators, allowing the user to tailor the model to his own requirements. Author

N91-17019# Aerospace Medical Research Labs., Wright-Patterson AFB, OH.
BASEOPS DEFAULT PROFILES FOR TRANSIENT MILITARY AIRCRAFT Interin Report, Sep. 1989 - Feb. 1990
WAYNE R. LUNDBERG Feb. 1990 79 p
(AD-A229184; AAMRL-TR-90-028) Avail: NTIS HC/MF A05 CSCL 20/1

Default Power Setting/Airspeed/Altitude vs. Distance Profiles for transient Military Aircraft takeoff and landings is described. The data cataloged are also accessible directly from the USAF BASEOPS program via the Load command. BASEOPS is a computerized operations input program for Airbase Noise analyses done under the Air Force Air Installation Compatible Use Zone (AICUZ) program. These profiles were adapted from the database previously developed for use at the Air Force Engineering Services Center (AFESC). Modifications were made to accommodate

improved technical information on the flight performance and nominal thrust management for several military aircraft types. Due to the variability in operational parameters at different airbases for the same type aircraft, these data serve primarily as a guideline for input of transient aircraft profiles, which are not usually known to the airbase noise planner. GRA

N91-17562*# Boeing Military Airplane Development, Seattle, WA.
ADVANCED EMBEDDED PROCESSING: PRESENT AND FUTURE
GERALD C. COHEN *In* NASA, Langley Research Center, NASA Formal Methods Workshop, 1990 42 p Nov. 1990
Avail: NTIS HC/MF A22 CSCL 01/3

Integrated airframe/propulsion control system architecture is discussed. The main objectives of the program are: design and validation methodology for system architecture; system design; system specification; and small-scale system testing. Y.S.

N91-18012# Cessna Aircraft Co., Wichita, KS.
DESIGNING AIRCRAFT STRUCTURES FOR TOLERANCE TO FATIGUE DAMAGE Abstract Only
ROBERT B. HELD and DENNIS L. LONGHOFER *In* Wichita State Univ., Proceedings: Techfest 17 p 8 1991
Avail: NTIS HC/MF A03

The airframes of the general aviation fleet evolved through static strength-fatigue strength-fail safe strength design criteria. Designing for tolerance to fatigue damage became a significant part of the design philosophy. Structural fatigue began to play a larger role in the airframe design with the desire for lighter weight structure, improved performance, higher operational weight, and increased usage. The design evolution moved into the phase where the principles of fracture mechanics have become a tool to set economic service lives and airframe inspection periods. The history in fatigue design, fleet history, the impact of fracture mechanics on the fleet aircraft and future designs are discussed. Author

N91-18013# Cessna Aircraft Co., Wichita, KS.
AIRFRAME CORROSION Abstract Only
L. AYALA *In* Wichita State Univ., Proceedings: Techfest 17 p 9 1991
Avail: NTIS HC/MF A03

Aircraft concerns have provided the need to focus on problems associated with airframe exposure to operating usage and environmental conditions. These concerns were traditionally addressed in the airframe design. Emphasis on aging aircraft has resulted in renewed interest to provide protection against environmental conditions that enhance corrosion activity. Common causes of airframe corrosion, specific examples, treatment and rework of damaged areas are discussed. A brief discussion of industry activities on corrosion issues is included. Author

N91-18023# Wichita State Univ., KS. National Inst. for Aviation Research.
EXPERIMENTAL STUDIES OF GENERAL AVIATION WINGS AT HIGH ANGLES OF ATTACK Progress Report Abstract Only
MELVIN H. SNYDER *In its* Proceedings: Techfest 17 p 22 1991
Avail: NTIS HC/MF A03

Work continues on the projects of developing general aviation wings which can be laterally controlled into and through the stall. In 1989 a paper was presented which suggested that lateral control of a wing, and possibly additional lift at angles of attack above stall, could be obtained by use of hinged control surfaces at the leading-edge near the wing tips. This idea was pursued using a flow visualization model in the water tunnel and a reflection plane wind tunnel model. Both models used a modified NFL airfoil section and leading-edge and trailing-edge ailerons. The wind tunnel tests included both force and pressure distribution tests. A summary of these results is presented as well as outline of wing tip surveys currently going on in the water tunnels. Author

N91-18024# Wichita State Univ., KS. Dept. of Mechanical Engineering.
MODELING HIGH ANGLE-OF-ATTACK FORCES AND MOMENTS USING A NEURAL NETWORK Abstract Only
JAMES E. STECK and KAMRAN ROKHSAZ (Missouri Univ., Rolla.) *In its* Proceedings: Techfest 17 p 23 1991
Avail: NTIS HC/MF A03

The current interest in super-maneuverable aircraft, which achieve angle of attack excursions of greater than 90 deg, has generated a need for modeling force and moment behavior at these high angles of attack. The force and moment coefficients are highly nonlinear functions of the angle of attack time histories. An appropriately constructed artificial neural network can be used as a discrete model of a highly nonlinear continuous time system. A network is 'trained' to predict the force and moment coefficients of a 70 deg sweep delta wing during a sinusoidal angle of attack time history from 0 to 90 deg and returning to 0 deg. Experimental data for reduced frequencies of 0.0, 0.01, 0.03, and 0.04 are presented to the network. The network is trained so that it models these frequencies with sufficient accuracy. The network is then used to independently predict the force and moment coefficients for an intermediate reduced frequency of 0.02. These predictions are favorably compared to experimental data for this reduced frequency. Author

N91-18026# Wichita State Univ., KS. Dept. of Mechanical Engineering.
EXPERIMENTAL STUDY OF INLET LIPS DESIGNED TO CREATE A UNIFORM EXIT VELOCITY PROFILE Abstract Only
PAUL O. STERANKA, JR. and ABDUL S. TOHMAZ *In its* Proceedings: Techfest 17 p 25 1991
Avail: NTIS HC/MF A03

An experimental study was conducted in order to evaluate a set of inlet lips designed and fabricated for use in the internal aerodynamic test facility. The inlet lips were designed to create a uniform velocity at the entrance to test ducts studied in parallel computational and experimental investigations of flow through ducts with offset and diffusion, which can often be found in aircraft engine inlets. The fabrication and experimental study of the inlet tips is presented. Laser Doppler anemometry was used to make non-intrusive measurements of the velocity profiles at several stations for comparison with the predicted profiles from the design calculations. The experimental results show the inlet lips perform as designed. Author

N91-18076# Aeronautical Systems Div., Wright-Patterson AFB, OH. Systems Program Office.
C-17 PILOTED COCKPIT TESTING
WILLIAM G. HECKATHORN *In* AGARD, Progress in Military Airlift 14 p Dec. 1990
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The C-17 aircraft under development will have a worldwide airlift mission in both combat and peacetime environments. With only two pilots in the cockpit, (eliminating the navigator and flight engineers, standards of Military Airlift Command (MAC) operations) design and testing must be logically thought out and executed to enhance mission completion and reduce the pilot workload. Numerous test facilities are being used to test the state-of-the-art avionics, its interference with the pilots, and the ability of the pilots to accomplish this mission. Author

N91-18082# De Havilland Aircraft Co. of Canada Ltd., Downsview (Ontario). Powered Lift Technology Div.
THE DEVELOPMENT OF VERY THICK MULTI-FOIL WINGS FOR HIGH SPEED, POWERED LIFT TRANSPORT AIRCRAFT APPLICATIONS
J. E. FARBRIDGE *In* AGARD, Progress in Military Airlift 20 p Dec. 1990 Sponsored in part by Department of National Defence, Ottawa, Ontario and Department of Industry, Ottawa, Ontario
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The theoretical development of the multi-foils between 18 and

30 percent thickness/chord is discussed and results are presented from high Reynolds number, high speed, 2D and 3D tunnel tests on foils up to 24 percent thickness/chord ratio. Both blown and unblown characteristics of the foils are reviewed. The integration of these multi-foil sections into high speed advanced USTOL (Ultra-Short Takeoff and Landing) transport aircraft studies using the ejector flap concept led to the potential for very efficient cruising transport aircraft with USTOL capability using only the thrust required for cruise. Several other potential applications for thick multi-foil section are also discussed. Author

N91-18084# Military Airlift Command, Scott AFB, IL.
C-130 REAR VISION DEVICE (BUBBLE)
MARK JULICHER *In* AGARD, Progress in Military Airlift 5 p Dec. 1990
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Three devices for providing rearward vision were developed and tested. The first device was a standard HC-130 observation door as used in search and rescue operations. The second device was a 180 deg field-of-view (FOV) bubble mounted on the cockpit overhead escape hatch. The third device was similar to the second but provided a 360 deg FOV. The three devices were tested at various exercises and in special sorties against fighters. The test findings confirmed that the 360 deg FOV bubble proved to be the best of the three devices for warning against air-to-air attack and for observing the attacking aircraft during evasive maneuvers. A great deal of experience has now been gained through bubble operations. That experience can be conveniently divided into three parts: equipment, training, and the tactics. Those three topics and the future of the rear vision device program are also discussed. Author

N91-18085# Wright Research Development Center, Wright-Patterson AFB, OH. Technology Exploitation Directorate.
TECHNOLOGY AND DESIGN CONSIDERATIONS FOR AN ADVANCED THEATER TRANSPORT
RICHARD V. WIBLE *In* AGARD, Progress in Military Airlift 11 p Dec. 1990
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The design and technology issues posed by the perceived mission requirements for a twenty first century theater transport are addressed. The theater transport of the future will be called upon to operate throughout the world in a variety of climatic conditions, into and out of remote and austere locations with unimproved runways, limited or non-existing landing aids, and in many cases no cargo handling equipment. Such an airlifter will be required to operate near, and occasionally, into enemy territory, where the threat will be more lethal than in the past. The design and technology implications of these perceived requirements are discussed relative to three design/technology issues: field length, which addresses both the impact of takeoff and landing rules on Short Takeoff and Landing aircraft design, and the impact of propulsion and vertical lift payload on Vertical or Short Takeoff and Landing aircraft design; payload/aircraft size, which addresses typical theater transport payloads, productivity as a function of payload and the contribution of advanced materials on aircraft size; and survivability, which addresses the impact of low observables considerations upon theater transport design. Author

N91-18087# Aeroplane and Armament Experimental Establishment, Boscombe Down (England). Fixed Wing Engineering Section.
PROBLEMS IN CONVERTING CIVIL AIRCRAFT TO THE MILITARY TANKER ROLE
R. J. KILFORD *In* AGARD, Progress in Military Airlift 6 p Dec. 1990
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Military tanker aircrafts are being increasingly produced by conversion of civil airliners. Civil and military aircrafts are designed to different philosophies and operated in different ways, the civil operation being predictable, the military less so. These different philosophies are discussed, as well as the problems arising from typical aircraft conversions. It is also suggested how future conversions can benefit from the lessons of the past. Author

N91-18088# Deutsche Airbus G.m.b.H., Bremen (Germany, F.R.).
C 160-TRANSALL LIFE TIME EXTENSION
HARTMUT GRIEM *In* AGARD, Progress in Military Airlift 13 p Dec. 1990
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The C 160-Transall aircraft is described. Procedures for life time extension are discussed. The following subject areas are covered: measures referring to structure; systems modifications and replacements; and program procedures, documentation; and data bases. Y.S.

N91-18089# Lockheed Aeronautical Systems Co., Palmdale, CA.
THE HIGH TECHNOLOGY TEST BED: A RESEARCH PROGRAMME FOR TECHNOLOGY DEVELOPMENT
C. B. PAYNE *In* AGARD, Progress in Military Airlift 14 p Dec. 1990
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Proposed roles for future tactical airlift drive requirements for research and development in the areas of advanced Short Takeoff and Landing (STOL), Electronic Systems, Survivabililty, and Advanced Cockpit capabilities. A common scenario may involve deep penetration into enemy territory with no air or ground support. The transport may be required to land on bomb damaged runways, highways, or dirt roads. The aircraft may have to take on cargo in this area and get airborne again with the same runway requirement. The High Technology Test Bed (HTTB), an Independent Research and Development Program (IRAD) was begun to address technologies required for these future tactical transports. The program utilizes a commercial, stretched C-130 transport as the technology focal point. The aircraft is highly modified to perform the STOL mission and is fully instrumented with a real time data acquisition system. The HTTB undergoes modification spans followed by flight spans to evaluate systems performance. Author

N91-18090# Douglas Aircraft Co., Inc., Long Beach, CA.
THE C-17: MODERN AIRLIFTER REQUIREMENTS AND CAPABILITIES
LEONARD R. TAVERNETTI *In* AGARD, Progress in Military Airlift 10 p Dec. 1990
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The newest military airlift aircraft C-17 can rapidly move substantial quantities of large, modern weaponry in fighting condition any place on the globe. The new air transport capability capitalizes on proven technology which is currently incorporated into today's commercial airliners and front-line fighter aircraft. It is described how existing technology is being applied on the C-17 to satisfy the requirements for modern military airlift aircraft. The C-17 expands the traditional airland and airdrop modes of transportation to include direct delivery of large outsize equipment. This airlifter transports M-1 tanks, AH-64 helicopters, and Bradley Fighting Vehicles, and delivers them to semiprepared austere airfields. The aircraft is operated by a crew of three employing fly-by-wire and mission computer technologies to integrate information and operations. Author

N91-18105*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A METHODOLOGY FOR DESIGNING AIRCRAFT TO LOW SONIC BOOM CONSTRAINTS
ROBERT J. MACK and KATHY E. NEEDLEMAN (Lockheed Engineering and Sciences Co., Hampton, VA.) Washington Feb.

1991 24 p
(NASA-TM-4246; L-16768; NAS 1.15:4246) Avail: NTIS HC/MF A03 CSCL 01/3

A method for designing conceptual supersonic cruise aircraft to meet low sonic boom requirements is outlined and described. The aircraft design is guided through a systematic evolution from initial three view drawing to a final numerical model description, while the designer using the method controls the integration of low sonic boom, high supersonic aerodynamic efficiency, adequate low speed handling, and reasonable structure and materials technologies. Some experience in preliminary aircraft design and in the use of various analytical and numerical codes is required for integrating the volume and lift requirements throughout the design process. Author

N91-18106# Federal Aviation Administration, Atlantic City, NJ.
EVALUATION OF MAGNETIC FUEL TREATMENT FOR AIRCRAFT FUEL SYSTEMS
EARL LEE and AUGUSTO M. FERRARA Jan. 1991 30 p
(DOT/FAA/CT-TN90/54) Avail: NTIS HC/MF A03

The Federal Aviation Administration Technical Center evaluated a device which is intended to improve the fuel efficiency of both piston and turbine engines. This device is marketed by Magnetizer Group Incorporated. The theory behind the device calls for passing the fuel through a magnetic field, which alters the fuel's behavior. The device was evaluated on a Teledyne Continental 0-200. There were no significant changes in either the fuel consumption or the power developed when the device was installed. Author

N91-18107# Royal Aerospace Establishment, Farnborough (England).
THE PREDICTION OF CARRIAGE LOADS AND CHANGES IN AIRCRAFT LONGITUDINAL STABILITY FOR PYLON MOUNTED STORES AT SUBSONIC SPEEDS
D. ISAACS 9 Aug. 1990 34 p Presented at Royal Society Conference Carriage Integration and Release, Bath, England, Apr. 1990
(RAE-TM-AERO-2195; BR115362; ETN-91-98628) Copyright Avail: NTIS HC/MF A03

A method to calculate carriage loads for stores on wing mounted pylons and the effect of those stores on the parent aircraft stability at subcritical speeds is presented. The usual approach to modeling with distributions of sources to represent fuselage, store, wing and pylon displacement effects was used; the lifting effects of wings and pylons were modeled with a vortex lattice. The method is shown to have sufficient accuracy at low or moderate Mach numbers. Examples of fighter aircraft wings were examined and showed that good prediction results are obtained if the flow is subcritical. ESA

N91-18108# Technische Univ., Berlin (Germany, F.R.). Fachbereich Verkehrswesen.
FUEL MANAGEMENT SYSTEM FOR FUTURE COMMERCIAL AIRPLANES Ph.D. Thesis [FUEL MANAGEMENT SYSTEME FUER ZUKUENFTIGE VERKEHRSFLUGZEUGE]
HERBERT BERNARD 1990 143 p In GERMAN
(ETN-91-98796) Avail: NTIS HC/MF A07

A concept is presented for a new type of fuel management system, allowing a higher accuracy of fuel gage determination. The pilots are relieved of control tasks and of the manual operation of fuel distribution. The operational functionality of such a computer aided system is checked with a software prototype. ESA

N91-18151*# Rensselaer Polytechnic Inst., Troy, NY.
INVESTIGATIONS INTO A POTENTIAL LASER-NASP TRANSPORT TECHNOLOGY Final Report, 1989 - 1990
In USRA, *Proceedings of the 6th Annual Summer Conference:* NASA/USRA University Advanced Design Program p 195-202 Nov. 1990
Avail: NTIS HC/MF A14 CSCL 01/3

Laser propelled flight/transport technology is surveyed. A detailed conceptual design is presented for an on-place Mercury-Lightcraft: other designs are briefly explored for larger, 15-place Executive Lightcraft, and 150 to 350 passenger Jumbo Lightcraft. Author

N91-18162*# California State Polytechnic Univ., Pomona.
HIGH ALTITUDE RECONNAISSANCE AIRCRAFT
RENEE ANNA YAZDO and DAVID MOLLER *In* USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 275-282 Nov. 1990
Avail: NTIS HC/MF A14 CSCL 01/3

At the equator the ozone layer ranges from 65,000 to 130,000 plus feet, which is beyond the capabilities of the ER-2, NASA's current high altitude reconnaissance aircraft. The Universities Space Research Association, in cooperation with NASA, is sponsoring an undergraduate program which is geared to designing an aircraft that can study the ozone layer at the equator. This aircraft must be able to cruise at 130,000 feet for six hours at Mach 0.7, while carrying 3,000 lbs. of payload. In addition, the aircraft must have a minimum range of 6,000 miles. In consideration of the novel nature of this project, the pilot must be able to take control in the event of unforeseen difficulties. Three aircraft configurations were determined to be the most suitable - a joined-wing, a biplane, and a twin-boom conventional airplane. The performance of each configuration was analyzed to investigate the feasibility of the project. Author

N91-18163*# California Polytechnic State Univ., San Luis Obispo.
THE CALIFORNIA CORRIDOR TRANSPORTATION SYSTEM: A DESIGN SUMMARY
In USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 283-286 Nov. 1990
Avail: NTIS HC/MF A14 CSCL 01/3

A design group was assembled to find and research criteria relevent to the design of a California Corridor Transportation System. The efforts of this group included defining the problem, conducting a market analysis, formulation of a demand model, identification and evaluation of design drivers, and the systematic development of a solution. The problems of the current system were analyzed and used to determine design drivers, which were divided into the broad categories of cost, convenience, feasibility, environment, safety, and social impact. The relative importance of individual problems was addressed, resulting in a hierarchy of design drivers. Where possible, methods of evaluating the relative merit of proposed systems with respect to each driver were developed. Short takeoff vertical landing aircraft concepts are also discussed for supersonic fighters. Author

N91-18164*# Case Western Reserve Univ., Cleveland, OH.
O-THREE: A HIGH ALTITUDE, REMOTELY PILOTED VEHICLE
In USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 287-290 Nov. 1990
Avail: NTIS HC/MF A14 CSCL 01/3

A conceptual design for a remotely piloted vehicle to be used for ozone research above 80,000 feet was developed as part of the one-semester NASA/Universities Space Research Association Aerospace Design course at Case Western Reserve University in Fall 1989. The O-Three design team chose as its mission requirements a cruise altitude of 100,000 ft, a range of 1000 n.m., an endurance of 6 hrs., a 1000 lb payload, and a power to payload of 2 kW. These are based on the Boeing requirements for an ozone research vehicle. In addition, the vehicle should not be restricted to operation over any particular global location. Efforts were made to minimize atmospheric contamination that might increase the rate of ozone depletion and cause discrepancies in data accuracy. Design was not limited to today's level of technology. The design team was divided into four groups: aerodynamics, structures, stability, and control. The specifications and performance estimates for cruise at altitude are given in tabular form. Author

N91-18165*# Kansas Univ., Lawrence.
PRELIMINARY DESIGN OF A SUPERSONIC SHORT-TAKEOFF AND VERTICAL-LANDING (STOVL) FIGHTER AIRCRAFT
In USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 291-300 Nov. 1990
Avail: NTIS HC/MF A14 CSCL 01/3

A preliminary study of a supersonic short takeoff and vertical landing (STOVL) fighter is presented. Three configurations (a lift plus lift/cruise concept, a hybrid fan vectored thrust concept, and a mixed flow vectored thrust concept) were initially investigated with one configuration selected for further design analysis. The selected configuration, the lift plus lift/cruise concept, was successfully integrated to accommodate the powered lift short takeoff and vertical landing requirements as well as the demanding supersonic cruise and point performance requirements. A supersonic fighter aircraft with a short takeoff and vertical landing capability using the lift plus lift/cruise engine concept seems a viable option for the next generation fighter. Author

N91-18167*# Ohio State Univ., Columbus.
A HYPERSONIC RESEARCH VEHICLE TO DEVELOP SCRAMJET ENGINES
G. M. GREGOREK and R. L. REUSS *In* USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 309-317 Nov. 1990 Previously announced in IAA as A90-49115
Avail: NTIS HC/MF A14 CSCL 01/3

Four student design teams produced conceptual designs for a research vehicle to develop the supersonic combustion ramjet (scramjet) engines necessary for efficient hypersonic flight. This research aircraft would provide flight test data for prototype scramjets that is not available in groundbased test facilities. The design specifications call for a research aircraft to be launched from a carrier aircraft at 40,000 feet and a Mach number of 0.8. The aircraft must accelerate to Mach 6 while climbing to a 100,000 foot altitude and then ignite the experimental scramjet engines for acceleration to Mach 10. The research vehicle must then be recovered for another flight. The students responded with four different designs, two piloted waverider configurations, and two unmanned vehicles, one with a blended body-wing configuration, the other with a delta wing shape. All aircraft made use of an engine database provided by the General Electric Aircraft Engine Group; both turbofan ramjet and scramjet engine performance using liquid hydrogen fuel was available. Explained here are the students' conceptual designs and the aerodynamic and propulsion concepts that made their designs feasible. Author

N91-18168*# Ecole Polytechnique Feminine, Sceaux (France).
CARRIER AIRCRAFT Abstract Only
In USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 319 Nov. 1990
Avail: NTIS HC/MF A14 CSCL 01/3

The Ohio State University planned to conduct a conceptual design of a single research vehicle that could be used to explore the flight regime from Mach 6 to Mach 12. Since this aircraft will be a special purpose vehicle, it need not take off and land in a conventional manner. Indeed, if this aircraft were launched from a larger aircraft that carried it to altitude, then conventional landing gear would not be needed and the extra weight of the fuel needed to take off and climb into the stratosphere would be eliminated. The focus of the students' project was on the design of a carrier aircraft answering to the specifications. Its mission is to take off with the research aircraft from runways of less than 15,000 feet, climb to 40,000 feet, and release the hypersonic aircraft at the speed of Mach 8, and return to base. The range of this mission is 2000 n.m. This study includes the conception of an optimized aircraft (geometry, weights, propulsion, aerodynamics, interactions between the two aircraft, etc.), the longitudinal stability of the composite, and the separation critical phase. Author

N91-18169*# Purdue Univ., West Lafayette, IN.
DESIGN OF A HIGH SPEED BUSINESS TRANSPORT
In USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 321-324 Nov. 1990
Avail: NTIS HC/MF A14 CSCL 01/3

The design of a High Speed Business Transport (HSBT) was considered by the Aeronautical Design Class during the academic year 1989 to 1990. The project was chosen to offer an opportunity to develop user friendliness for some computer codes such as WAVE DRAG, supplied by NASA/Langley, and to experiment with several design lessons developed by Dr. John McMasters and his colleages at Boeing. Central to these design lessons was an appeal to marketing and feasibility considerations. There was an emphasis upon simplified analytical techniques to study trades and to stimulate creative thinking before committing to extensive analytical activity. Two designs stood out among all the rest because of the depth of thought and consideration of alternatives. One design, the Aurora, used a fixed wing design to satisfy the design mission: the Viero used a swept wing configuration to overcome problems related to supersonic flight. A summary of each of these two designs is given. Author

N91-18170*# Worcester Polytechnic Inst., MA.
HIGH ALTITUDE, MICROWAVE-POWERED ATMOSPHERIC SAMPLING AIRCRAFT Abstract Only
In USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 325 Nov. 1990
Avail: NTIS HC/MF A14 CSCL 01/3

The preliminary design af a high altitude, remotely piloted, atmospheric sampling aircraft powered by microwave energy beamed from a ground based antenna has been completed. The aircraft utilizes a horizontal tail and a canard for longitudinal control and to enhance the structural rigidity of the twin fuselage configuration. The wing structure is designed to withstand a gust induced load factor of n equals 3 at cruise altitude, but the low wing loading of the aircraft makes it very sensitive to gusts at lower altitudes, where induced load factors may be in excess of 20. Therefore, a structural load alleviation system is proposed to limit actual loads to the designed structural limit. Since the transmitting antenna would have a diameter of several hundred feet, it would not be readily transportable; so, it is proposed that a single antenna be constructed at a site from which the aircraft is to be flown. The aircraft would be towed aloft to an initial altitude at which the microwave power would be utilized. The aircraft would climb to cruise altitude in a spiral flight path and then orbit the transmitter in a gentle turn. Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A91-24333#
FIBEROPTIC AIR DATA SYSTEM
L. C. MANOHARAN, S. MUTHUVEL, K. SESHADRI (National Aeronautical Laboratory, Bangalore, India), and PHILIP M. DIWAKAR (Indian Institute of Science, Bangalore, India) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 254-256. refs
Copyright

The fiber-optic air data system devised for the Indian National Aeronautical Laboratory's Light Canard Research Aircraft is not affected by EMI and is substantially lighter and less power-consuming than a copper wiring-based system. Expansion of the system to eight channels will be easy, and eventual expansion to 16 channels can be accomplished with only minor

modifications. Processed fiber-optic signals are displayed in the cockpit via LCD system, in recognition of LEDs' insufficient brightness for daylight display; speed and altitude data are conveyed to the pilot. O.C.

A91-24368#
NEW AVIONICS ARCHITECTURE CONCEPT FOR COMMERCIAL AIRCRAFT
H. SUBRA, M. PAQUIER, and D. GRAVES (Aerospatiale, Division Avions, Paris, France) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 607-616.
Copyright

A new concept based on the utilization of standard modules with common frame design has been developed. This presentation covers the key elements of this new concept which is the subject of a full development and research program with the objective to be ready for application on an aircraft launched in 1992. The new concept is aimed at the reduction of the total cost of ownership of avionics. It must also provide more flexibility to add or modify system functions through onboard software loading. Author

A91-24370#
A SYSTEMS APPROACH TO AVIONIC MULTIPROCESSING ARCHITECTURES
J. DENNIS SEALS (AT&T Bell Laboratories, Whippany, NJ) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 624-629.
Copyright

Commercial, military, and aerospace airframes are now being developed that require avionics systems with processing capabilities that rival today's largest supercomputers. To meet these requirements, avionics designers will have to address issues such as software support, multiprocessor control, and open machine architectures as an integral part of the processing system design. This paper describes a heterogeneous multiprocessing architecture (support software, operating system, and hardware) that will meet these real-time processing requirements and significantly reduce software development and support costs. The application support software augments the Ada toolset with a powerful graph language that fonctions as a program design language and, in many cases, is machine-translatable into Ada code. A hybrid control mechanism handles the complexities of multiprocessing control while providing a transparent interface between the application user and physical machine. The machine architecture is based on a modular building block concept and asynchronous communication network that permits processors with different functions, clock speeds, and data bandwidths to be integrated into a common system without major protocol problems or data bottlenecks. Author

A91-24391#
AVIONIC SYSTEMS FUNCTIONAL ANALYSIS AND SPECIFICATION
P. SCHIRLE (Dassault Aviation, Saint-Cloud, France) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 833-842.
Copyright

Current developments and trends in avionics are briefly reviewed in the operational, technological, and methodological contexts. In particular, attention is given to software tools, systems approaches to design, formal and simulation tools, functional analysis and architecture, and design definition. The discussion also covers documentation development and verification, system integration and validation, and bench and flight testing. V.L.

A91-24393#
VALIDATION OF ADVANCED SAFETY ENHANCEMENTS FOR F-16 TERRAIN FOLLOWING
JAMES BLAYLOCK, PHILIP BOOSE (General Dynamics Corp., Fort Worth, TX), DONALD SWIHART, WILLIAM URSCHEL, and BRIAN HICKS (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 849-857.
Copyright

This paper documents the verification approach used to validate system-wide integrity management (SWIM) for its application to the F-16 terrain-following (TF) system in order to maximize flight safety during TF operation. This paper contains a brief summary of the results of Blalock et al. (1988), followed by a strong justification for SWIM validation and the validation approach employed. Verification methods included stand-alone static and dynamic tests, integrated system tests, and flight tests. In particular, the failure modes evaluation testing process is presented. In addition, safety, cost, and robustness benefits attributable to validation of SWIM for F-16 TF are covered. Author

A91-24465#
OPTIMAL FILTERING OF SENSOR SIGNALS FOR TAKE-OFF PERFORMANCE MONITORS (TOPM)
R. KHATWA (Bristol, University, England) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1595-1602. Research supported by SERC. refs
Copyright

Both pilot opinion and the accident statistics indicate a need to improve safety in the take-off phase. A major problem encountered is the high-speed overrun of the runway during a rejected take-off (RTO). At present cockpit instrumentation which presents the type of information necessary for accurate performance during take-off is limited to the airspeed indicator. Additional information to monitor the progress of the take-off would warn pilots of any shortcomings and thus a take-off could be rejected at an earlier stage during the ground roll to prevent a high speed overrun. This paper reviews the development of an efficient Take-Off Performance Monitor (TOPM) and focuses on the role of the Kalman filter in deducing optimal estimates of the take-off conditions. The goal of achieving a high level of accuracy in the outputs while also employing filter algorithms that are both stable and robust has been achieved. Important improvements in operational safety could result from the widespread use of efficient take-off monitors. Author

A91-24466*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
REDUCING WINDSHEAR RISK THROUGH AIRBORNE SYSTEMS TECHNOLOGY
ROLAND L. BOWLES (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1603-1630. refs
Copyright

A preliminary set of performance criteria for predictive windshear detection and warning systems is defined. Candidate airborne remote sensor technologies based on microwave Doppler radar, Doppler lidar, and IR radiometric techniques are examined from the viewpoint of overall system requirements, and the performance of each sensor is evaluated for representative microburst environments and ground clutter conditions. Preliminary simulation results indicate that all three sensors have potential for detecting windshear, and provide adequate warning time to permit flight crews to avoid the affected area or escape from the encounter. B.J.

A91-24467#
STRUCTURE AND METHOD OF THE EXPERT SYSTEM FOR SENSOR FAILURE DETECTION OF AIRCRAFT
ZHONG-KE SHI (Northwestern Polytechnical University, Xian, People's Republic of China) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p.

1631-1637. refs
Copyright

An expert system for the sensor failure detection and isolation of flight test system is introduced. In order to detect and locate faults of an aircraft's sensors with sufficient robustness to parameter changes and noise, accurate discrete-time models are presented, and a multilevel separated-bias algorithm is used for residual sequence generation. The expert system is used for the difficult task of failure isolation and flight decision making. The structure and the method for building the expert system is introduced. The results of simulation and actual application show that the expert system for the (failure detection and isolation) of flight test instruments can declare the faults and locate the failures correctly. This expert system is suitable not only to the flight regime of low angle of attack but also to the flight regime of high angle of attack. Author

A91-24516#
A CONCEPT OF STALL WARNING SYSTEM
JOSE F. ELASKAR (Cordoba, Universidad Nacional, Argentina) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2090-2093. refs
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The operating principle and hardware implementation of an aircraft stall-warning system are described. In this scheme, a sensor mounted near the wing trailing edge measures the ratio of the boundary-layer pressure to the free-stream pressure. This ratio falls from a normal value of 0.9-1.0 to about 0.3-0.5 as the angle of attack increases toward the critical point. Published experimental data on this phenomenon are summarized, and the mechanical design of a pressure-ratio manometer is shown in a drawing and discussed in detail. The need for wind-tunnel or flight tests of this warning system is indicated. D.G.

A91-24520#
FLIGHT TEST VALIDATION OF THE OPERATIONAL LOADS MONITORING SYSTEM (OLMS)
M. SCHMUECKER and V. LADDA (Deutsche Airbus GmbH, Bremen, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2123-2133. refs
Copyright

The design concept and operation of the Operational Loads Monitoring System (OLMS) for the A320 commercial transport aircraft are reviewed, and the procedures being used in validation flight tests are described in detail. The OLMS comprises a data-acquisition unit interfaced to various aircraft sensors, a data-processing unit for calculating loads and storing mission-profile data, and a data-reduction unit for statistical analysis of load-time histories to be stored in memory. The tests explore the effects of system interference, the real-time response of the system, the accuracy of the recalculated loads, the quality of the reduced data, and the selection of data to be stored. Typical preliminary data are presented graphically. D.G.

A91-25838#
TCAS FINALLY MOVES INTO THE COCKPIT
DAVID PRYOR (Allied Signal Aerospace Co., Bendix/King Air Transport Avionics Div., Fort Lauderdale, FL) Aerospace America (ISSN 0740-722X), vol. 29, Feb. 1991, p. 36-38.
Copyright

Three versions of the Traffic Alert and Collision Avoidance System, TCAS, are described. TCAS works by providing a constant flow of data to aircraft on the status of nearby traffic. TCAS I is a low-power, short-range (3-5 n.mi.) system and display unit which can locate aircraft in an immediate vicinity and display their location in a given quadrant. TCAS II has an omni antenna on the bottom and a directional antenna on top of the aircraft; both antennas work with the transponder to interrogate every transponder-equipped aircraft in its surveillance range of 14 n.mi. The system gives visual and voice commands of vertical maneuvers needed to avoid other aircraft. TCAS III is currently under study and will be able to issue horizontal as well as vertical advisories, telling aircraft to maneuver out of the way of other aircraft flying in the vicinity. TCAS has been tested and certified on 20 different types of commercial aircraft, including the B 727, 737-300, 737-400, 747-100, 757, and 767, and the DC-10. L.K.S.

A91-26224#
THE DEVELOPMENT AND APPLICATION OF RADAR ALTIMETERS IN CHINA
Missiles and Spacecraft (ISSN 1001-4144), Oct. 1990, p. 44-47. In Chinese, with abstract in English.

The main parameters of the radar altimeters are presented. The incoherent radar altimeter and dual-function coherent radar altimeter used in ballistic missiles both have rms altimetric accuracy of 3 m. The stretch technology and traveling-wave amplifier are used in the ocean-satellite altimeter with altimetric accuracy + or - 10 cm. Also discussed are solid-state nanosecond-pulse radars used for aircraft altimetry and autoguidance and multifunction airborne radar altimeters used for autolanding, autoguidance, and topographic tracking and avoidance. Y.P.Q.

A91-26627
STUDY ON INTEGRATED COCKPIT DISPLAY USING FLIGHT SIMULATOR
R. SEO, T. WATANABE, M. HIROSE, A. FUJIWARA, K. KOIKE (Kawasaki Heavy Industries, Ltd., Gifu, Japan) et al. IN: Automatic control in aerospace; IFAC Symposium, Tsukuba, Japan, July 17-21, 1989, Selected Papers. Oxford, England and New York, Pergamon Press, 1990, p. 159-164.
Copyright

An effort has been made to define the most effective way of transferring the information required by a pilot via combined graphics and voice messages, using the Cockpit Display Research Tool (CDRT). The CDRT encompasses a multifunction display, a HUD, an interactive voice message and reply system, and a control display unit. Prospective display formats have been simulated on the CDRT for various flight test scenarios and evaluated on the bases of subjective measurements whose rating-scale encompassed several viewpoints; the advantages and shortcomings of the formats are presented in tabular form. O.C.

A91-27005
AIRCRAFT LOW ALTITUDE WIND SHEAR DETECTION AND WARNING SYSTEM
PETER C. SINCLAIR (Colorado State University, Fort Collins) and PETER M. KUHN (ARIS, Inc., Fort Collins, CO) Journal of Applied Meteorology (ISSN 0894-8763), vol. 30, Jan. 1991, p. 3-16. Research supported by ARIS, Inc. refs
(Contract NSF ATM-84-20980; NOAA-43RANR503966)
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The feasibility of using FLIR radiometer as an airborne system for detecting hazardous low-altitude wind shear with at least one-minute of warning to the pilot is considered. Preliminary flight measurements showed that a FLIR system could successfully detect cool downdrafts of downbursts (microbursts/macrobursts, MB) and thunderstorm gust front outflows that are responsible for most LAWS events. A prototype FLIR system (nonscanning, fixed range) was tested near and within Colorado MBs, showing that a minimum warning time of one to four minutes, depending on aircraft speed, can be made available to the pilot prior to an MB encounter. I.S.

A91-27928
DESIGNERS TARGET THE ONE-SCREEN DISPLAY
Interavia Aerospace Review (ISSN 0020-6512), vol. 46, Feb. 1991, p. 38-40, 42, 43.
Copyright

Current cockpit technology that is dominated by advanced head-up displays and cathode ray tubes is reviewed together with anticipated technology consisting of helmet mounted displays (HMDs) attached to moving infrared sensors, giving pilots a wider and clearer view outside the cockpit in bad weather and at night.

Small CRT displays set alongside conventional indicators and electromagnetic dials will be supplanted by one large LCD, indicating to the pilot exactly what he needs to know at any particular time. The two ATF designs are a decided improvement in fighter display design and equipment, but do not conform to the totally fused picture concept. As an example HMDs are not an integral part of the ATF cockpit. The technology that has been chosen to solve the main challenge for all three new tactical aircraft is the active-matrix LCD (AMLCD), which can be used to show any kind of image, including video or graphics. These AMCLDs incorporate a powerful fluorescent backlight that is strong enough to make the imagery visible in direct sunlight. Details are provided on advanced HUDs, including a description of the first transport aircraft HUD to be installed in the C-17. R.E.P.

N91-17060*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
THE EFFECTS OF PRESSURE SENSOR ACOUSTICS ON AIRDATA DERIVED FROM A HIGH-ANGLE-OF-ATTACK FLUSH AIRDATA SENSING (HI-FADS) SYSTEM
STEPHEN A. WHITMORE and TIMOTHY R. MOES Feb. 1991 23 p Presented at the 29th AIAA Aerospace Sciences Meeting, Reno, NV, 7-10 Jan. 1991 Previously announced in IAA as A91-19404
(NASA-TM-101736; H-1690; NAS 1.15:101736) Avail: NTIS HC/MF A03 CSCL 01/4

The accuracy of a nonintrusive high angle-of-attack flush airdata sensing (HI-FADS) system was verified for quasi-steady flight conditions up to 55 deg angle of attack during the F-18 High Alpha Research Vehicle (HARV) Program. The system is a matrix of nine pressure ports arranged in annular rings on the aircraft nose. The complete airdata set is estimated using nonlinear regression. Satisfactory frequency response was verified to the system Nyquist frequency (12.5 Hz). The effects of acoustical distortions within the individual pressure sensors of the nonintrusive pressure matrix on overall system performance are addressed. To quantify these effects, a frequency-response model describing the dynamics of acoustical distortion is developed and simple design criteria are derived. The model adjusts measured HI-FADS pressure data for the acoustical distortion and quantifies the effects of internal sensor geometries on system performance. Analysis results indicate that sensor frequency response characteristics very greatly with altitude, thus it is difficult to select satisfactory sensor geometry for all altitudes. The solution used presample filtering to eliminate resonance effects, and short pneumatic tubing sections to reduce lag effects. Without presample signal conditioning the system designer must use the pneumatic transmission line to attenuate the resonances and accept the resulting altitude variability.
Author

N91-17560*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DIGITAL AVIONICS: A CORNERSTONE OF AVIATION
CARY R. SPITZER *In its* NASA Formal Methods Workshop, 1990 24 p Nov. 1990
Avail: NTIS HC/MF A22 CSCL 09/2

Digital avionics is continually expanding its role in communication (HF and VHF, satellite, data links), navigation (ground-based systems, inertial and satellite-based systems), and flight-by-wire control. Examples of electronic flight control system architecture, pitch, roll, and yaw control are presented. Modeling of complex hardware systems, electromagnetic interference, and software are discussed. Y.S.

N91-18073# Military Airlift Command, Scott AFB, IL. Reliability and Maintainability Technology Div.
C-130 ELECTRONIC COCKPIT: RELIABILITY AND MAINTAINABILITY TECHNOLOGY INSERTION PROGRAM (RAMTIP)
ROBERT L. RUSSELL *In* AGARD, Progress in Military Airlift 6 p Dec. 1990
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The Reliability and Maintainability Technology Insertion Program (RAMTIP) is aimed at accelerating new technologies from the laboratory and applying them to Air Force weapon systems in an effort to improve reliability and maintainability (R and M). This RAMTIP project will replace some sixty analog type cockpit instruments in a Military Airlift Command (MAC) C-130E with six liquid crystal flat panel displays. Five displays are installed on the pilot's/copilot's instrument panel with a sixth display installed at the navigator's station. Designed in the mid-1950s, the C-130 has remained highly cost effective to procure and operate. This is due largely to the simplicity of its systems and the fact that its design and tooling costs have long since been amortized. The aircraft performs a diversity of missions quite well, but the repairing and stocking of obsolete analog type instruments has become logistically difficult and costly. The purpose is to demonstrate the operational effectiveness and suitability of active matrix liquid crystal flat panel displays in the C-130 and to validate the projected R and M improvements of this technology over electromechanical analog instruments and cathode ray tubes (CRT). Although work is still in progress, the successful development and integration of this technology offers significant potential improvement in R and M, redundancy with graceful degradation, and enhanced operational effectiveness. Once proven, this technology can be applied to a wide variety of other aircraft throughout the Air Force inventory and other Department of Defense services, as well as that of the commercial aircraft industry. Author

N91-18109# Federal Aviation Administration, Atlantic City, NJ.
REPORT OF STUDY ON AIRLINES' ANTICIPATED NEAR FUTURE COCKPIT CONTROL AND DISPLAY CAPABILITIES AND PLANS FOR DATA LINK COMMUNICATION Technical Report, Jan. 1991
MICHAEL A. POMYKACZ (Computer Technology Associates, Inc., McKee City, NJ.) Feb. 1991 36 p
(Contract T2003C)
(DOT/FAA/CT-TN91/7) Avail: NTIS HC/MF A03

The findings of a study conducted by CTA Incorporated for the Federal Aviation Administration Technical Center, Airborne Data Link Program are reviewed. For each of seven airlines, the following was studied for their anticipated near future fleets: (1) the quantity of each aircraft model; (2) the cockpit control and display devices that would be onboard each aircraft model; (3) choice of device for the primary data link display; and (4) choice of annunciation form to use. These data were then compiled to determine the total studied fleet's capabilities, as well as their plans for displaying data link information. Author

07

AIRCRAFT PROPULSION AND POWER

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

A91-24359#
ENGINE INLET ICE PROTECTION AND COMPRESSOR CHANGES MADE TO RESIST ICE
L. W. BLAIR, R. L. MILLER, and D. J. TAPPARO (GE Aircraft Engines, Lynn, MA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 535-542.
Copyright

An investigation has been made of means by which to address the problem of ice-induced foreign object damage (FOD) to the first compressor stage rotor's blading in the CT7 turboprop engine. FOD induced compressor blade leading-edge chipping and tip curling. It was experimentally established that blade leading-edge thickness is the most important parameter in ice FOD resistance. As a general rule for durability considerations, the compressor

first-stage blading should be capable of withstanding impact from any piece of ice that can pass between inlet guide vanes. Cutbacks of the blade leading edges yielded a degree of ice FOD resistance which will preclude most field damage. O.C.

A91-24361#
SOME ASPECTS OF THE JOINT GE/VOLVO DEVELOPMENT OF THE F404/RM12 AUGMENTOR
J. C. MAYER (GE Aircraft Engines, Lynn, MA), S. OLOVSSON, and B. SJOBLOM (Volvo Flygmotor, AB, Trollhattan, Sweden) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 554-560. refs
Copyright

A derivative of the GE F404 augmented turbofan jet engine, called RM12, was developed in partnership with Volvo Flygmotor for the Swedish JAS 39 Gripen fighter aircraft. During the development, a half-scale plexiglass model was tested in a water tunnel and the commercially available computer code FLUENT was used to study the aerodynamic flowfield without and with combustion. In this paper, full scale engine development test results, water tunnel flow visualization results and corresponding computational results are presented revealing some of the interesting aspects of the development of the F404/RM12 augmentor. Especially the effect of inlet swirl on the augmentor performance is discussed. Author

A91-24380#
APPLICATIONS OF CFD TECHNOLOGY TO THE DESIGN OF AIRCRAFT PROPULSION SYSTEMS
LEONARD J. HEBERT and RALPH E. PONSONBY (Boeing Commercial Airplanes, Seattle, WA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 709-718. refs
Copyright

Application of computational fluid dynamics (CFD) to propulsion system design has become critically important to improving individual engine component and overall airplane performance at The Boeing Company. The Propulsion Research staff of Boeing Commercial Airplane Group applies CFD techniques as a supplement to or in lieu of testing to optimize the design process and lower developmental cost. This paper presents an overview of the CFD methods currently applied to engineering problems in propulsion system design. Author

A91-24448#
EARLY IN-FLIGHT DETECTION OF FATIGUE CRACKS IN AERO-ENGINE COMPRESSOR AND TURBINE BLADES WITH VIBROACOUSTIC AND DISCRETE-PHASE METHODS
J. LEWITOWICZ, R. SZCZEPANIK, H. DABROWSKI, and R. KUDELSKI (Polish Society of Mechanical Engineers and Technicians, Warsaw, Poland) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1448-1453. refs
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Dynamic variations of engine compressor blade vibration spectra in the course of fatigue crack propagation in blade roots is discussed, with reference to a Polish turbojet engine. Based on this phenomenon, a diagnostic microprocessor device which measures vibrations of turbine engine rotor blades via a discrete-phase method is described. The device is used for the early detection of compressor and turbine blade fatigue cracks. It can convey an estimate of the fatigue crack sizes to the crew and advise the crew how to operate the engine to slow down the crack propagation process in order to get safely back to base. Examples are given of the application of the vibroacoustic method to the ground evaluation of the technical condition of some aero-engine compressor and turbine blades and bearings. L.K.S.

A91-24534#
NON-LINEAR MATHEMATICAL, THERMAL MODELS OF GAS TURBINE ENGINES AND THEIR APPLICATION IN OPERATION
IMRE SANTA (Budapesti Muszaki Egyetem, Budapest, Hungary) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2264-2270. refs
Copyright

The theoretical basis, mathematical formulation, and applicability of some recent turbojet-engine thermal models are examined in an analytical review. Particular attention is given to the governing equations for steady-state and transient-regime operation, the structures of the respective computational algorithms, the modification of the model on the basis of measurement data, and the ability of the model to estimate the values of nonmeasurable parameters (using data on fewer parameters but for a larger number of engine duty cycles). D.G.

A91-25877#
NUMERICAL OPTIMIZATION PROGRAM FOR DESIGNING CONTROLLED DIFFUSION COMPRESSOR BLADING
BO LIU, XINHAI ZHOU, and RUQUN YAN (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 6, Jan. 1991, p. 9-12. In Chinese, with abstract in English.

A numerical optimization design procedure has been worked out for the generation of the Controlled Diffusion Airfoil (CDA) of axial-flow compressors. After the initial blade shape is generated, the design procedure is used to optimize the initial blade profile at design and off-design conditions until a satisfactory final blade shape is achieved. The feasibility of the procedure is demonstrated for a compressor stator blade at hub section with high loading and large flow turning angle. The flow at design conditions of the resulting cascade is shock-free. Compared with conventional cascades, the CDA cascade can enlarge the incidence angle range, increase the critical Mach number, and strengthen the tail edge of the blade. C.D.

A91-25880#
EFFECT OF HUB TREATMENT ON PERFORMANCE OF AN AXIAL FLOW COMPRESSOR
ZHAOHUI DU and ZHIWEI LIU (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 6, Jan. 1991, p. 21-24. In Chinese, with abstract in English. refs

Hub treatment with a circumferential groove was tested in a stator hub and compared with casing treatment over the rotor tip for a single-stage axial-flow compressor. The three-dimensional flowfield at the downflow of stator and rotor blade rows, in particular its endwall flowfield, in optimum operating and near stall states were measured by a micro-five-hole probe. It was shown that stall margin can be improved not only for the single-stage, but also for the rotor, even if the onset of stall is at the rotor tip first. The reason is that the stall affected by the treatment groove retards the appearance of stall. The trend in the variation of most performance parameters of the rotor with hub treatment is similar to that of the isolated rotor with casing treatment. According to analysis of the downflow, a new flow phenomenon is clarified: dangerous stall located at the blade hub and near the pressure surface. Author

A91-25882#
AERODYNAMICAL DESIGN FOR SMALL GASTURBINES
JING SHI and JIANYUAN HAN (Nanhua Powerplant Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 6, Jan. 1991, p. 29-32. In Chinese, with abstract in English.

Advanced small gas turbines feature small mass flow ratio, short vanes and blades with low aspect, high second flow and blade tip leakage losses, and low efficiency. According to a detailed investigation on advanced small gas turbines, some technical design approaches for improving the efficiency of a small gas

turbine, such as vanes with meridional-plane contraction contour, compounded leaned vanes and blades, small blade shroud and so on are presented. Author

A91-25889#
A FLUX VECTOR SPLITTING EXPLICIT SCHEME AND SIMULATION OF 2-D NOZZLE'S PROPULSIVE JET
PENG SHAN (Beijing University of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 6, Jan. 1991, p. 57-62. In Chinese, with abstract in English. refs

The applications of the theory of Flux Vector Splitting (FVS) of Steger and Warming (1981) are investigated. Besides the simplified split flux vector formula, a new explicit scheme is proposed for solving hyperbolic differential equations. It is an explicit two-step FVS scheme of second-order accuracy. A two-dimensional flow of a rectangular nozzle with its jet plume is analyzed numerically by the present scheme. The results indicate some high performances of the present scheme: (1) numerical vibrations near the front surface of shock waves vanish; (2) the scheme runs without artificial viscosity; (3) it takes just as much time as MacCormack's MC72 scheme takes to solve a flow field. The scheme features the higher inherent viscosity of the scheme compared with that of MC72. Author

A91-25890#
AN ANALYTICAL STUDY OF COMPONENT MATCHING REGULARITY OF TURBOJET ENGINE
DAOZHI LIU (Beijing University of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 6, Jan. 1991, p. 63-66. In Chinese, with abstract in English.

Many off-design condition phenomena of a turbojet engine are related to the variation of incidence angles at front and rear compressor stages. Based on component matching regularity, simple and clear analytical equations of the variation of incidence angles at front and rear compressor stages under engine operating conditions have been derived. With these analytical equations, a series of off-design condition phenomena in low or high design pressure ratio engines or in axial, centrifugal, or combined axial-centrifugal engines, as well as in two-spool engines are analyzed systematically, their physical natures are clarified. Various off-design condition problems which may occur can be predicted in advance. Author

A91-25894#
EMBEDDED STRUCTURE OF RECIRCULATION ZONES IN COAXIAL DUMP COMBUSTOR WITH INNER SWIRL INLET
QIANG YU, XINGZHOU LIU, MIN SITU, and MENJUE HU (MAS, 31st Research Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 6, Jan. 1991, p. 79-82. In Chinese, with abstract in English.

A new swirling chamber designed by combining swirlers with bludd bodies is considered in this paper. The cold flowfields in the coaxial dump combustor with inner swirl inlet were measured and investigated using five-hole probes. When the flow ratio of the swirling chamber to the outer annular channel decreases the expansion ability of outer annular flows toward the combustor wall is enhanced, a two-dimensional axisymmetrical central recirculation zone without tangential velocities occurs behind it in the dump combustor in addition to the swirling chamber recirculation zone. Both recirculation zones are embedded in each other. The swirling chamber recirculation zone not only tends to create the central recirculation zone, but also generates suction which makes the latter bigger and stronger. Experimental results of combustion show that the high combustion efficiency is obtained when the embedded structure exists. Author

A91-25895#
DEVELOPMENT OF A INTELLIGENT FORCE METER BY AUTOMATIC ELECTRO-MAGNETIC BALANCING
QUINGFAN ZHANG and BIAO ZHOU (Nanjing Aeronautical Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 6, Jan. 1991, p. 83-85. In Chinese, with abstract in English.

In wind tunnel measurement of surface drag, a force meter with high sensitivity and accuracy is urgently needed. This paper reports the development of an automatically balancing force meter which is a new device not yet seen before. The design principle, software and hardware, and the application of this meter are presented in this paper. Its accuracy is 0.5 percent, repetition 0.1 percent, response time 5 ms, sampling period 100 microsec. Author

A91-25899#
THREE-DIMENSIONAL ISOTHERMAL FLOW MODELLING OF A GAS-TURBINE, REVERSE-FLOW ANNULAR COMBUSTOR
M. K. Y. LAI (National Research Council of Canada, Ottawa) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 36, Dec. 1990, p. 230-235. Research supported by DND and National Research Council of Canada. refs

A mathematical three-dimensional TEACH-based model known as TURCOM has been used to predict a three-dimensional, turbulent, and isothermal flowfield inside an annular reverse-flow combustor of a small gas turbine engine. Sensitivity of overall combustor flow pattern to various inflows is demonstrated. The flowfield pattern is sensitive to the inner and outer dilution jets and wall cooling streams, but less sensitive to the primary dilution jets. The predicted mean velocities are evaluated against published two-dimensional LDV data in a planar (trapezoidal) sector rig. For a selected set of inflow distributions, TURCOM provides good qualitative and fair quantitative description of the flowfield. Author

A91-26025
THE TURBOFAN HANDBOOK [LA PRATIQUE DU TURBOFAN]
ROGER LAMOULINE Paris/Toulouse, France, Technique et Documentation Lavoisier/Teknea, 1990, 207 p. In French.
Copyright

The present work, a comprehensive introduction to state-of-the-art high-bypass ratio turbofans represented by the V2500 engine, proceeds from fundamental principles of the gas turbine cycle to the specific embodiment of these principles in the fan, high pressure compressor, combustor, high and low temperature turbine, and core nozzle components of advanced turbofan designs. Attention is given to the control of fuel-feed and ignition systems, the role of lubrication and filtering systems, and the types and locations of sensors used in engine state monitoring. The two final chapters discuss the range of operating conditions experienced by a turbofan over the various phases of flight, and the characterization of turbofan operating conditions according to thermodynamic formulas. O.C.

A91-26217#
DEVELOPMENT STUDY ON AN AIR-TURBO-RAMJET (ATR) FOR A FUTURE JAPANESE SPACE PLANE
Missiles and Spacecraft (ISSN 1001-4144), Aug. 1990, p. 44-47. In Chinese, with abstract in English.

The Japanese Institute of Space and Astronautical Sciences is conducting development studies on an air-turbo-ramjet (ATR) engine, which is one of the most preferable candidates as an air-breathing propulsion system for future space planes. This paper presents the system design of an expander-cycle ATR engine called ATREX, the scenario of the development study, and the ATR subscale engine model for sea-level static testing. Author

A91-26687#
THE APPLICATION OF BOWED BLADE TO COMPRESSOR
JIEXIAN SU, GUOTAI FENG, JIE WEN, and ZHONGQI WANG (Harbin Institute of Technology, People's Republic of China) Journal of Engineering Thermophysics (ISSN 0253-231X), vol. 11, Nov. 1990, p. 404-407. In Chinese, with abstract in English. refs

Mechanism of bowed blade is studied. A design system for compressor with sweep and dihedral blades is presented. The computer program employing this design system has been

performed and has been used to calculate an example. The computed results are compared with E3 engine's data, and good agreement is shown. The conclusion is that the application of bowed blade to compressor is beneficial to reducing secondary losses. Author

A91-27372
STRUCTURAL ANALYSIS AND OPTIMIZATION OF A PROPFAN-BLADE BY USE OF THE FINITE ELEMENT METHOD
ROLF LAMMERING (DLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) Engineering Computations (ISSN 0264-4401), vol. 7, Dec. 1990, p. 327-337. refs
Copyright

Algorithms applicable to the finite element method are presented and employed in the calculation of a propfan-blade. This blade is discretized as a shallow shell. The constitutive equations for isotropic and layered materials are implemented in the formulation of the finite elements. The quasi-static deformations resulting from centrifugal forces as well as the eigenmodes and eigenfrequencies (as a function of rotational speed) are presented. For a propfan-blade of composite material, methods of mathematical optimization are used to minimize the displacement at the tip of the blade, using fiber orientation as a design variable. In a second calculation, the twisting of the blade is minimized. It is shown that the deformation behavior can be greatly influenced by the fiber orientation. Author

A91-27440
EFFECTIVE OPTIMAL CONTROL OF AN AIRCRAFT ENGINE
S. MAHMOUD (Loughborough University of Technology, England) and D. MCLEAN (Southampton, University, England) Aeronautical Journal (ISSN 0001-9240), vol. 95, Jan. 1991, p. 21-27. refs
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A91-27785#
SIGNAL ANALYSIS TECHNIQUE FOR SURGE-DETONATION OF A TURBOJET ENGINE
KEYANG ZHENG (Beijing University of Aeronautics and Astronautics, People's Republic of China) and GUOHUANG GE (Le Yang Aeroengine Research Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, July 1990, p. 204-208. In Chinese, with abstract in English.

A diagnosis and signal analysis method with FFT signal processer is provided for on surge-detonation of a twin-spool turbojet engine. The experimental surge-detonation under turbulent dynamic inlet distortion conditions has been completed, and the measurement system and test equipment are described. Most of surges in the turbojet compressor under turbulent dynamic inlet distortion conditions are 'drift-mode' surges and appear randomly. The turbojet is far more sensitive to dynamic inlet distortion than to steady inlet distortion. It is shown that the signal analysis method with the FFT signal processor is of great practical value in the failure diagnosis, and it is more accurate, reliable, and convenient than other methods. Author

A91-27787#
SUB-MATRICES ANALYSIS APPLIED TO ENGINE FAULTS DIAGNOSIS
GENGLIN TANG and DAGUANG CHEN (Beijing University of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, July 1990, p. 213-218. In Chinese, with abstract in English.

The submatrix analysis presented in this paper can perform component directed fault diagnosis with fewer measured parameters. The feature of this method is to combine the fault parameters into groups, in each of which the number of fault parameters equals the number of measured parameters to make the fault parameters solvable with respect to measured parameters. In order to select the most likely solution(s), the criteria are also given. The numerical investigation shows that this method is very effective in diagnosing a malfunction occurring in one or two components, which is the usual case at an early stage of engine fault. Application of this method to the JT9D commercial engine verifies its effectiveness. Author

A91-27790#
EXPERIMENTAL TECHNIQUE FOR INVESTIGATION ON FOREIGN OBJECT DAMAGE OF AEROENGINE
WENXIAO QIAO (China Flight Test Establishment, People's Republic of China) and CHANGBING XIONG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, July 1990, p. 227, 228. In Chinese, with abstract in English.

A method to determine the size of a notch on the first stage blade of a compressor with a stress-concentration factor (Kt) of 3 is briefly introduced, which is required for foreign-object damage (FOD) testing of aero engines. It is based on 8-node and 20-node finite-element approaches, respectively. The 8-node super-parameter FEM is used to calculate the stress distribution of a whole blade without and with a notch, and the 20-node three-dimensional isoparameter FEM is applied to computation of local stress distribution around a notch. The practical testing techniques and test results are also presented. Author

A91-27792#
EXPERIMENTAL RESEARCH ON DISTORTION TOLERANCE CAPACITY OF A TWIN-SPOOL TURBOJET
YUEGENG WU, QISHENG YUN, and GUOHUANG GE (Li Yang Aeroengine Research Institute, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, July 1990, p. 231-235. In Chinese, with abstract in English.

Inlet-pressure distortion experiments on a twin-spool turbojet were completed on a ground test rig. Under a variety of conditions of the inlet circumferential and radial pressure distortion, the distorting flow field, the distorting index, the critical distorting angle, and the sensitivity have been measured separately by the steady and dynamic measuring systems. Emphasis was placed on analyzing the effect of inlet circumferential and radial pressure distortions on the performance and reliability of the twin-spool turbojet. The results of the analysis provide the experimental basis for matching between the engine and its intake. Author

A91-27799#
A POWER CORRECTION FORMULA FOR PISTON AEROENGINES
ZIYING LU (Nanhua Power Machinery Co., People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, July 1990, p. 271, 272. In Chinese, with abstract in English.

A new formula to correct the power for piston aero engines is presented. It has the advantage of considering the influence of humidity on power in the simplified calculation. Theoretical analysis and test data show that this new formula is more accurate than that used before. Author

A91-27927
SOVIETS GRADUATE TO NEW POWER CLASS
KEN FULTON Interavia Aerospace Review (ISSN 0020-6512), vol. 46, Feb. 1991, p. 27-31.
Copyright

This paper discusses the new 35,275 lb thrust PS-90A civil turbofan presently being certified in the Soviet Union. Design of this engine started in 1982 and had its first test run in early 1984 with a test flight in 1987 in an IL-76LL. The configuration of this engine consists of a two-shaft turbofan with full-length bypass duct and integral fan thrust reverser. A low pressure system has a single stage fan and two-stage booster compressor with a four-stage turbine section. The high pressure system consists of a 13-stage compressor, a can-annular combustor with 12 front-section liners plus annular aft-section, and a two-stage turbine. It is expected that when this engine goes into production it will power both the Tu-204 and the Il-96 aircraft. R.E.P.

A91-28264
ACOUSTIC TESTING OF MODEL COUNTER ROTATING PROPFANS
J. C. MCCANN (Pratt and Whitney Group, East Hartford, CT) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 237-242.
Copyright

The anechoic acoustic tunnel facility described by Paterson et al. (1973) is used to measure the noise levels generated by different counterrotating propeller models at typical aircraft takeoff and landing speeds. The tunnel setup, model configurations, instrumentation, and test procedures are described, and the results are presented in graphs and briefly characterized. The features found to decrease noise include: (1) higher numbers of blades, (2) differential blade numbers, (3) higher tip sweep, (4) lower or (5) differential tip speed, and (6) reduced rear-rotor diameter.
T.K.

A91-28265* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CRUISE NOISE OF AN ADVANCED SINGLE-ROTATION PROPELLER MEASURED FROM AN ADJACENT AIRCRAFT
RICHARD P. WOODWARD, IRVIN J. LOEFFLER, and RICHARD J. RANAUDO (NASA, Lewis Research Center, Cleveland, OH) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 243-248. refs
Copyright

Results are reported from flight measurements of the noise from a full-scale SR-7L advanced single-rotation turbofan model mounted on the wing of the NASA Lewis Propfan Test Assessment (PTA) aircraft (a modified Gulfstream II). Data obtained on the PTA with an outboard microphone boom and by the NASA Lewis acoustically instrumented Learjet flying along several sidelines relative to the PTA are presented in tables and graphs and briefly discussed. It is found that the PTA-boom and Learjet sound levels are in good agreement at Mach 0.69 and altitude 20,000 ft, but the Learjet values are significantly lower than the boom levels at Mach 0.79 and altitude 36,000 ft.
T.K.

A91-28266
CONTROLLING UDF ENGINE NOISE
B. A. JANARDAN and P. R. GLIEBE (GE Aircraft Engines, Cincinnati, OH) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 249-254.
Copyright

A91-28267
UNSYMMETRICAL BLADE-SPACING - PROPELLER NOISE REDUCTION WITHOUT PERFORMANCE PENALTY
W. DOBRZYNSKI (DLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 255-258.
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N91-17061 Oxford Univ. (England).
AERODYNAMIC AND MECHANICAL PERFORMANCE OF A HIGH-PRESSURE TURBINE STAGE IN A TRANSIENT WIND TUNNEL Ph.D. Thesis
A. G. SHEARD 1989 279 p
Avail: Univ. Microfilms Order No. BRD-90358

The effects of unsteady and three dimensional flow phenomena are recognized as having a major effect on the aerodynamic performance of, and heat transfer to, gas turbine blading. Studying the mechanisms associated with these phenomena requires an experimental facility capable of simulating the environment found in a gas turbine, but at lower total temperature and pressure levels, to allow the use of conventional measurement techniques. This work centers about the design, development, and commissioning of a new experimental facility consisting of a 62 percent size high pressure gas turbine stage mounted in a transient wind tunnel. The new facility provides the required simulation of the turbine design point in a full stage turbine; therefore, it models the unsteady and three dimensional flow phenomena which are the focus of interest. The aerodynamic and mechanical design of the new facility are presented, as is a rigorous stress analysis of the facility's rotating system. The three stage commissioning of the facility is described, concluding with an assessment of the turbine stage performance.
Author

N91-18080# British Aerospace Aircraft Group, Woodford (England). Airlines Div.
THE POWERPLANT OPTIONS FOR A FUTURE LARGE AIRCRAFT
D. G. SPENCER and R. S. CLOUGH *In* AGARD, Progress in Military Airlift 13 p Dec. 1990 Prepared in cooperation with Rolls-Royce Ltd., Derby, England
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Future large aircraft is a generic term used to describe a future medium sized tactical transport aircraft and derivatives for other roles. Its design will utilize modern technology to provide a replacement for airforces' mixed fleets of Hercules, Transall, and a multitude of other aircraft used in tanking, maritime patrol, and other such roles. Studies conducted so far have shown the powerplant to be the key technology for a new military transport aircraft. Relative to the Hercules and the Transall, large gains in capability, savings in cost, are available with modern powerplants. The influence of powerplant selection is so critical that it is likely to drive the mission capability that can be economically provided. The main design requirements are identified for this type of aircraft. The benefits of modern technology when applied to both airframe and engine in a military transport are discussed. Turboprop, turbofan, and propfan engines are compared, and the benefits and availability of civil engines reviewed. Finally, several different aircraft solutions are presented, covering the range of possible powerplants, and their characteristics compared.
Author

N91-18110# Aeronautical Research Labs., Melbourne (Australia).
DESIGN AND PRELIMINARY DEVELOPMENT OF AN ENGINE FOR SMALL UNMANNED AIR VEHICLES
B. G. CATCHPOLE and B. PARMINGTON Aug. 1990 51 p Original contains color illustrations
(ARL-PROP-R-184; AR-006-093) Copyright Avail: NTIS HC/MF A04; 2 functional color pages

A program is described of the advantages obtained from the opposed piston two stroke engine for use in small, propeller driven, unmanned air vehicles requiring power of about 10 to 20 kW. Analysis of the requirements for engines for this duty showed the opposed piston configuration as offering the best compromise in terms of specific output, specific fuel consumption, level of vibration, and complexity. Initial feasibility was shown using a small engine of 67 mL swept volume. The major part of the development, including selection and development of a scavenge air compressor, was carried out using an engine of 225 mL swept volume. The maximum power obtained was 18.9 kW (25 HP) at 7500 rpm. Considerations involved in the selection of the configuration are discussed. The development of the rig engine and of the scavenge air blower is described and details of the performance are given. Factors limiting the performance and the potential for increased output and improved economy are outlined. The initial feasibility of a more radical design, with the connecting rods and crankshafts replaced by a system of cams and rollers, was also shown by making and running an engine. Results are also given.
Author

N91-18111# Argonne National Lab., IL. Energy Systems Div.
COPPER CONTAMINATION EFFECTS ON HYDROGEN-AIR COMBUSTION UNDER SCRAMJET (SUPERSONIC COMBUSTION RAMJET) TESTING CONDITIONS
S. L. CHANG, S. A. LOTTES, and G. F. BERRY 1990 11 p Presented at the 27th JANNAF Combustion Meeting, Cheyenne, WY, 5-9 Nov. 1990
(Contract W-31-109-ENG-38; AF-AFOSR-0009-88)
(DE91-006545; CONF-9011119-3) Avail: NTIS HC/MF A03

Two forms of copper catalytic reactions (homogeneous and heterogeneous) in hydrogen flames were found in a literature survey. Hydrogen atoms in flames recombine into hydrogen molecules through catalytic reactions, and these reactions which affect the timing of the combustion process. Simulations of hydrogen flames with copper contamination were conducted by using a modified general chemical kinetics program (GCKP). Results show that reaction times of hydrogen flames are shortened by copper catalytic reactions, but ignition times are relatively insensitive to the reactions. The reduction of reaction time depends on the copper concentration, copper phase, particle size (if copper is in the condensed phase), and initial temperature and pressure. The higher the copper concentration of the smaller the particle, the larger the reduction in reaction time. For a supersonic hydrogen flame (Mach number = 4.4) contaminated with 200 ppm of gaseous copper species, the calculated reaction times are reduced by about 9 percent. Similar reductions in reaction time are also computed for heterogeneous copper contamination. Under scramjet testing conditions, the change of combustion timing appears to be tolerable (less than 5 percent) if the Mach number is lower than 3 or the copper contamination is less than 100 ppm. The higher rate the Mach number, the longer the reaction time and the larger the copper catalytic effects. DOE

N91-18112# Federal Aviation Administration, Atlantic City, NJ.
STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED IN US COMMERCIAL AVIATION DURING 1987 Final Report
R. A. DELUCIA (Naval Air Propulsion Test Center, Trenton, NJ.), B. C. FENTON, and JANINE BLAKE Jan. 1991 28 p
(Contract DOD/FA7INA-AP-98)
(DOT/FAA/CT-90/19; NAPC-PE-188) Avail: NTIS HC/MF A03

Statistical information relating to gas turbine engine rotor failures which occurred during 1987 in U.S. commercial aviation service use is presented. Three hundred thirty-two failures occurred in 1987. Rotor fragments were generated in 170 of the failures, and of these 12 were uncontained. The predominant failure involved blade fragments, 95 percent of which were contained. Four disk failures occurred and all were uncontained. Forty-nine percent of the 332 failures occurred during the takeoff and climb stages of flight. This service data analysis is prepared on a calendar year basis and published yearly. The data are useful in support of flight safety analyses, proposed regulatory actions, certification standards, and cost benefit analyses. Author

N91-18113# Technische Univ., Munich (Germany, F.R.). Lehrstuhl fuer Flugantriebe.
EXPERIMENTAL PARAMETER DETERMINATION AND SYSTEMS ANALYSIS FOR HELICOPTER GAS TURBINE Ph.D. Thesis [EXPERIMENTELLE KENNWERTERMITTLUNG UND SYSTEMANALYSE BEI HUBSCHRAUBER-GASTURBINEN]
MARTIN MENRATH 1989 203 p In GERMAN
(ETN-91-98798) Avail: NTIS HC/MF A10

A computerized shaft horsepower gas turbine test stand was built. The total measuring system was statistically and dynamically calibrated in separated tests, in order to assess the dependability of identified parameters. Dynamic measuring errors were compensated by corresponding equalizing networks, prior to the evaluation of unsteady measurements. The characteristics of the stationary behavior were obtained with a non parametric model for the total working capacity of the gas turbine. The characteristics of the gas generator were easily obtained with a high degree of accuracy. It was shown that a heat model is to be considered for the identification of the compressor outlet temperature. ESA

N91-18114# Technische Univ., Munich (Germany, F.R.). Lehrstuhl fuer Metallurgie und Metallkunde.
EFFECT OF CORROSION PROTECTIVE COATINGS ON COMPRESSION TURBINE BLADES FOLLOWING DIFFERENT EROSION STRESSES Ph.D. Thesis [WIRKUNG VON KORROSIONSSCHUTZUEBERZUEGEN AUF VERDICHTERLAUFSCHAUFELN NACH UNTERSCHIEDLICHEN EROSIONSBEANSPRUCHUNGEN]
THOMAS W. HAPPLE 1989 172 p In GERMAN Sponsored by BMFT
(ETN-91-98800) Avail: NTIS HC/MF A08

Detailed investigations of inorganic bonded aluminum coatings were performed. These coatings were classified according to their basic corrosion and erosion behaviors. The vibration fracturing corrosion behavior of aluminum coatings was determined for undamaged and eroded state. The test methods were adapted to the complex operating loads of compressor blades. A practice conformed erosion test process was developed. ESA

08

AIRCRAFT STABILITY AND CONTROL

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

A91-24306#
TRANSONIC FLUTTER/DIVERGENCE CHARACTERISTICS OF AEROELASTICALLY TAILORED AND NON-TAILORED HIGH-ASPECT-RATIO FORWARD SWEPT WINGS
KOJI ISOGAI (National Aerospace Laboratory, Tokyo, Japan) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 11-18. refs
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In order to see whether the divergence phenomenon of a transport type high-aspect-ratio forward swept wing can be effectively eliminated by aeroelastic tailoring, the experimental studies have been performed focusing attention especially on the transonic regime. The transonic flutter/divergence boundaries of the two wind tunnel models, one of which simulates the tailored full scale wing and the other of which simulates the nontailored one, have been determined. The tailored model has experienced flutter as predicted by the linear theory which employs the doublet lattice method. That is, the divergence phenomenon is suppressed by aeroelastic tailoring. The nontailored model has experienced flutter contrary to the theoretical prediction, which is conjectured as 'shock stall flutter', in which the shock induced flow separation is playing the dominant role. By comparing the nondimensional flutter boundaries of the two models, it is shown that, by aeroelastic tailoring, the transonic flutter characteristics of this particular wing can be improved about 60-80 percent over that of the nontailored wing. Author

A91-24336#
ACTIVE CONTROL EXPERIMENTAL INVESTIGATION ABOUT AERODYNAMIC CHARACTERISTICS AT HIGH INCIDENCE
YONGNIAN YANG, XINZHI YU, ZONGDONG WANG, and JIANGYING LI (Northwestern Polytechnical University, Xian, People's Republic of China) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 292-299. refs
Copyright

Three experimental schemes are presented for the active control of asymmetric force, a controllable rotating nose cone, a controllable nose jet, and a controllable strake, in low speed wind-tunnel models. Attention is given to control laws. The experimental results obtained indicate that the asymmetric forces generated at high angle-of-attack are significantly reduced in all

cases; the active control codes developed automatically limit the side force borne by the models to minimum magnitudes. Controllable jet-blowing and the controllable strake can be used to enhance lateral maneuverability. O.C.

A91-24345#
CONTROL LAW SYNTHESIS AND WIND TUNNEL TEST OF GUST LOAD ALLEVIATION FOR A TRANSPORT-TYPE AIRCRAFT
H. MATSUSHITA, T. UEDA, K. FUJII, Y. MIYAZAWA, M. HASHIDATE (National Aerospace Laboratory, Tokyo, Japan) et al. IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 399-407. refs
Copyright

In this paper, a systematic control law synthesis method for active control of an aeroelastic aircraft and dynamic wind tunnel test results using an active model-suspension system are described. A special model of a transport-type aircraft, which has a flexible wing with aeroelastic similarity, was designed and constructed. The math model was derived in the state space form based on finite element structural analysis coupled with boundary element aerodynamic analysis. Practical low order control laws for gust load alleviation were synthesized by applying the LQG optimal control law synthesis method with the order reduction procedure. The control law thus obtained was implemented in the digital computer and tested in the 6.5 m X 5.5 m low speed wind tunnel at the National Aerospace Laboratory. Using a newly developed active model-suspension system, the model was supported so as to give freedom of heaving and pitching motions. The test verified that the optimal reduced order control law could effectively suppress the rigid-body motion contribution, as well as the flexible wing contribution, to the wing bending moment. Author

A91-24346*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DESIGN, IMPLEMENTATION, SIMULATION, AND TESTING OF DIGITAL FLUTTER SUPPRESSION SYSTEMS FOR THE ACTIVE FLEXIBLE WING WIND-TUNNEL MODEL
BOYD PERRY, III, VIVEK MUKHOPADHYAY, SHERWOOD TIFFANY HOADLEY, STANLEY R. COLE, CAREY S. BUTTRILL, and JACOB A. HOUCK (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 408-418. refs
Copyright

Active flutter suppression control laws were designed, implemented, and tested on an aeroelastically-scaled wind-tunnel model in the NASA Langley Transonic Dynamics Tunnel. One of the control laws was successful in stabilizing the model while the dynamic pressure was increased to 24 percent greater than the measured open-loop flutter boundary. Other accomplishments included the design, implementation, and successful operation of a one-of-a-kind digital controller, the design and use of two simulation methods to support the projet, and the development and successful use of a methodology for online controller performance evaluation. Author

A91-24347#
WHIRL-FLUTTER SUPPRESSION IN ADVANCED TURBOPROPS AND PROPFANS BY ACTIVE CONTROL TECHNIQUES
F. NITZSCHE (Instituto Tecnologico de Aeronautica, Sao Jose dos Campos, Brazil) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 419-426. refs
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The feasibility of using the active control technique to suppress the whirl-flutter instability of advanced turboprops and propfans is analyzed. Aerodynamic vanes are incorporated at the engine nacelles to generate control airloads. The actuator system is driven by a control law derived from the linear quadratic regulator theory. The results demonstrate that the aeroservoelastic system provides enough controllability to prevent the whirl-flutter onset well beyond the design speed. The present study suggests that very efficient engine vibration isolation may be achieved by optimizing the engine-propeller suspension to attenuate unpleasant low frequencies without the risk of downgrading the required stability. Author

A91-24348#
IDENTIFICATION OF DYNAMIC RESPONSE, SIMULATION AND DESIGN OF A HIGHLY NONLINEAR DIGITAL LOAD ALLEVIATION SYSTEM FOR A MODERN TRANSPORT AIRCRAFT
G. ROLLWAGEN, H. ELLGOTH, and G. BEUCK (Deutsche Airbus GmbH, Hamburg, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 427-433. refs
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The objectives and the methods of Load Alleviation System design for the LOCKHEED L-1011 and the AIRBUS A320 are analyzed. A software design package for control system design and aircraft model development is presented. It carries out iterative parameter optimization by means of a vector performance index. The components of this index are the individual cost-functions or specifications dependent on parameters. This software is applied to identify dynamic response parameters during large, steep deflections and frequency sweeps of spoilers measured during flight test campaigns with AIRBUS A310/A320. Control law derivation for an aircraft with highly nonlinear operating systems is explained. A software-system simulating an aeroservoelastic aircraft incorporating highly nonlinear hydraulic and digital operating components is outlined. Author

A91-24366#
NONLINEAR FLUTTER ANALYSIS OF WINGS AT HIGH ANGLE OF ATTACK
ZHENG-YIN YE and LING-CHENG ZHAO (Northwestern Polytechnical University, Xian, People's Republic of China) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 602-606.
Copyright

Two methods are presented to analyze nonlinear flutter of wings with separated vortex at high angle of attack. One is a time integration method (TIM). Combined with the calculated unsteady aerodynamic forces for wings at high angle of attack, the structural dynamic equations of the wing are integrated by Runge-Kutta method in time domain, and the wing motion can be simulated at any flying speed. Another method is a describing function method (DFM). In the DFM, the nonlinear generalized aerodynamic forces are linearized by using the concept of describing function. Then, the structural dynamic equations of the wing are solved by conventional V-g method, and the critical flutter speed can be obtained. To verify the numerical methods, flutter tests for wings at high angle of attack are carried out in a low-speed wind tunnel. It is shown that the higher the basic angle of attack, the lower the critical flutter speed. The results calculated by the two methods are in agreement with the experiment. Author

A91-24367*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MODELING AND MODEL SIMPLIFICATION OF AEROELASTIC VEHICLES
MARTIN R. WASZAK, CAREY S. BUTTRILL (NASA, Langley Research Center, Hampton, VA), and DAVID K. SCHMIDT (Arizona State University, Tempe) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 606a-606j. refs
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The rigid-body degrees of freedom and elastic degrees of

freedom of aeroelastic vehicles are typically treated separately in dynamic analysis. Such a decoupling, however, is not always justified and modeling assumptions that imply decoupling must be used with caution. The frequency separation between the rigid-body and elastic degrees of freedom for advanced aircraft may no longer be sufficient to permit the typical treatment of the vehicle dynamics. Integrated, elastic vehicle models must be developed initially and simplified in a manner appropriate to and consistent with the intended application. This paper summarizes key results from the research aimed at developing and implementing integrated aeroelastic vehicle models for flight controls analysis and design. Three major areas will be addressed: (1) the accurate representation of the dynamics of aeroelastic vehicles, (2) properties of several model simplification methods, and (3) the importance of understanding the physics of the system being modeled and of having a model which exposes the underlying physical causes for critical dynamic characteristics. Author

A91-24369#
INTEGRATION - THE BASIS OF THE INTEGRATED APPROACH TO PASSENGER AIRCRAFT CONTROL SYSTEM DESIGN

S. P. KRIUKOV (Aviapribor Corp., Moscow, USSR) and V. V. SMIRNOV (Moscow Institute of Electromechanics, USSR) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 617-623.
Copyright

The paper discusses the necessity to integrate the airborne flight control equipment. It is pointed out that a problem of integration can be formulated both on the system design and the corresponding elements design levels. A method of systems integration expediency evaluation is proposed: interrelationship determination between the integrated systems taking into account the whole system fail safety. Integration on the computer system level gives a considerable benefit in the equipment volume, which is confirmed by the design results. The problem of fail safety should be considered as the basis for integration. The existing and advanced equipment estimate was obtained, based on the correlation between its computational power and volume. The analog and digital implementations are compared. The paper also discusses the main principles of the integrated system digital computer architecture. The block diagrams of the Il-96-300 and Tu-204 command/stability augmentation systems are presented; these systems are designed using the comprehensive approach described in this paper. Their comparative characteristics are also discussed. Author

A91-24394#
PREDICTION OF HIGH-ALPHA VEHICLE DYNAMICS

LARS E. ERICSSON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 858-869. refs
(Contract F33615-87-C-3607)
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The long slender nose of an advanced fighter aircraft, maneuvering at high angles of attack, experiences flow separations of various types, which not only generate large local aerodynamic forces but also can generate large downstream loads through the interaction by the shed vortices with wing and tail surfaces. The separation-induced local side force can exceed the local normal force and result in yawing moments well beyond the control capability of existing aircraft. The coupling between vehicle motion and forebody flow separation causes self-induced coning and nose-slice motions. Additionally, the interaction between separation-induced forebody vortices and downstream lifting surfaces can produce dynamic stability problems, resulting in excessive wing rock oscillations, as has been demonstrated in subscale wind tunnel and flight tests. The fluid dynamic processes causing these dynamic stability problems are described and a step-by-step process is outlined for the development of needed predictive capabilities. Author

A91-24420#
DEVELOPMENT OF LATERAL CONTROL ON AIRCRAFT OPERATING AT HIGH ANGLES OF ATTACK

N. J. WOOD (Bath, University, England) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1146-1153. refs
(Contract F49620-86-K-0020)
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The concept of tangential wall jet blowing for the control of separated vortical flows is presented. Experimental results for the development of rolling moment about a delta wing for both pre- and post-stall angles of attack with sideslip have been obtained. The unblown vortical flow present on the lee-side of a delta wing at post-stall angle of attack is shown to be sensitive to sideslip and to affect the efficiency of the blowing concept. An extension of the delta wing application to forebody flow control to provide yaw control at post-stall angles of attack is discussed. Author

A91-24421#
AN ALGORITHM FOR DECOUPLING VERTICAL/HORIZONTAL MOTIONS OF NON-SYMMETRIC ROLLING AIRCRAFT

EDUARDO MORGADO BELO (Sao Paulo, Universidade, Brazil) and PETER W. FORTESCUE (Southampton, University, England) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1154-1161. refs
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This paper deals with the vertical horizontal accelerations decoupling process of a rolling missile which is only nonsymmetric relatively to inertias. The consequence of rolling an aircraft is to prohibit the separation of its motion equations into independent lateral and longitudinal groups, and also to affect its stability. Many vehicles bank or roll to accomplish a maneuver which can result in the presence of high roll rates, producing cross-couplings and its effects. If the designer adopts the objective of decoupling the pitch/yaw channels of the rolling aircraft, he can gain from the fact that a demanded maneuver could start to be applied at the same time as the vehicle starts the roll orientation task, saving time and also avoiding stability complications. Thus, in this paper a decoupling technique for nonsymmetric aircraft is presented, which makes the global system (aircraft plus autopilot) behave and have the characteristics of an axisymmetric aircraft. The result is that one can then apply all the theory developed for decoupling axisymmetric aircraft, using the complex summation method as a useful tool. Author

A91-24440#
AN ANALYSIS OF REDUCED ORDER SYSTEM FOR AIRPLANE GUST ALLEVIATION

CHANG JIN (Northwestern Polytechnical University, Xian, People's Republic of China) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1361-1365. refs
Copyright

A method is presented which employs optimization techniques in the design of a reduced-order controller to minimize a performance index defined by a weighted sum of mean-square responses and control inputs. A truncated system is composed of key states of the original full-order system. The optimal feedback matrix and Kalman estimator gain matrix of the truncated system are chosen as the initial values of the controller design variables. This method was applied to the synthesis of a gust alleviation controller for a model of a transport aircraft. A reduced fourth-order control law is synthesized, and the responses at the center of gravity and wing tip are compared with the full-order optimal feedback control law. It is found that the responses of the fourth-order system are very close to the responses of the 25th-order optimal control law. L.K.S.

A91-24479#
MODELLING AND CLASSIFICATION OF HELICOPTER COMBAT MANOEUVRES
D. G. THOMSON and R. BRADLEY (Glasgow, University, Scotland) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1763-1773. refs
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The various types of maneuvers commonly used in helicopter military operations are categorized, and algorithms capable of defining them mathematically are developed. Several maneuvers were fully modeled; and by way of validation, flight-test data were used for comparisons with modeled flight paths and maneuver parameters. Methods for grading maneuvers are examined, and the choice of suitable mathematical functions is considered. Particular attention is given to the following types of maneuvers: popup, linear repositioning, level turn, and entry transient. B.J.

A91-24480#
LONGITUDINAL HANDLING IMPROVEMENTS OF PILATUS PC-9 ADVANCED TURBO TRAINER
A. B. CERVIA and A. TURI (Pilatus Aircraft, Ltd., Stans, Switzerland) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1774-1776.
Copyright

A theoretical analysis was performed with the aim of reducing the c.g. effect on the stick force per g and increasing the stick force per speed gradient on the Pilatus PC-9 Advanced Turbo Trainer. Based on this, a new elevator aerodynamic balance and control circuit design was designed and extensively flight-tested. The MIL-Spec. goals were achieved by further modifications based on comparisons of theory and flight test results. It was found that the requirement for low maneuver stick force per g gradient together with stick-free stability at high speeds can be obtained for wide c.g. excursions with a manually operated control by careful design of both the elevator aerodynamic balance and the longitudinal control circuit. B.J.

A91-24481#
AERODYNAMICS, PERFORMANCE AND CONTROL OF AIRPLANES IN FORMATION FLIGHT
MARKUS BEUKENBERG and DIETRICH HUMMEL (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1777-1794. refs
(Contract DFG-HU-254/5; DFG-HU-254/10)
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Different methods of theoretical aerodynamics are used to calculate the power reduction of flight formations. Methods using a simple horseshoe vortex model are compared with methods using a plane or rolled-up vortex sheet. In addition, it is shown that, in formations of two Do-28 aircraft, a maximum flight power reduction of about 15 percent can be achieved for the rear aircraft at very small lateral distances. Finally, the benefits of the application of a control system to the rear aircraft are demonstrated. B.J.

A91-24482#
STATUS OF AGILITY RESEARCH AT MCDONNELL AIRCRAFT COMPANY AND MAJOR FINDINGS AND CONCLUSIONS TO DATE
DAVID R. RILEY and MARK H. DRAJESKE (McDonnell Aircraft Co., Saint Louis, MO) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1795-1807. refs
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Agility research has been ongoing at McDonnell Aircraft Company for many years. The objective of this research has been to develop advanced capabilities that enhance the tactical effectiveness of fighter aircraft. Recent agility research, reported herein, has focused on defining the regions of the flight envelope where airframe agility requires improvement and determining the required level of agility to give pilots a significant tactical advantage. Flying qualities criteria have been developed and different command systems have been investigated for high angle of attack maneuvering. Ways to attain increased agility have been studied, along with studies of the pilot's ability to perform effectively in an agile motion environment. An agility working group has been formed at McDonnell Aircraft Company which has created a beneficial synergy and accelerated research efforts. Author

A91-24503#
POST STALL CHARACTERISTICS OF HIGHLY AUGMENTED FIGHTER AIRCRAFT
MOSHE MEDINA and MANUEL SHAHAF (Israeli Air Force, Tel Aviv, Israel) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1976-1983. refs
Copyright

The deep stall phenomenon and related post stall characteristics are described in considerable detail, including the various stages of departure from controlled flight. The problematics of deep stall characteristics in view of ever changing operational requirements and aircraft modifications are presented. The development of corresponding flight control laws in highly augmented fighter aircraft (General Dynamics F-16 and Israel Aircraft Industries LAVI) is outlined. Results of 6DOF digital simulations and flight test data (accumulated in recent IAF high AOA test program) of deep stalls and post departure phenomena are presented. The impact of configuration changes, pilot input coordination, and selected flight control system modifications are shown and discussed. Author

A91-24504#
A STUDY OF WING ROCK
H. GAO, Z. J. WANG, and S. G. ZHANG (Northwestern Polytechnical University, Xian, People's Republic of China) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1984-1989. refs
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Wing rock (WR) is investigated on the basis of a mathematical model which describes high-AOA aircraft flight. ODE qualitative theory indicates that WR is a Hopf bifurcation phenomenon of nonlinear dynamic systems. It is shown that, for aircraft with moderate sweptback wings, WR is mainly caused by the variation in roll damping moment with the AOA and sideslip angle. B.J.

A91-24505#
BIFURCATION THEORY IN FLIGHT DYNAMICS - AN APPLICATION TO A REAL COMBAT AIRCRAFT
P. GUICHETEAU (ONERA, Chatillon-sous-Bagneux, France) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1990-1998. Research supported by Service Technique des Programmes Aeronautiques. refs
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A methodology based on bifurcation theory has been developed to study the asymptotic behavior of nonlinear differential equations depending on the parameters. The application of this methodology to the Alpha-Jet is considered here, with emphasis on oscillatory motion and the sensitivity of spin behavior to various parameters. The existence of different spin modes for certain control deflections is shown, and it is found that the lack of a realistic nonlinear model may lead lead to difficulties for flight analysis when the motion is quasi-periodic or chaotic. Comparisons between predictions and flight tests are shown. B.J.

A91-24526#
THE REDUCTION OF RIGID-BODY RESPONSE OF STING SUPPORTED MODELS AT HIGH ANGLES OF INCIDENCE
D. G. MABEY, B. L. WELSH, and C. R. PYNE (Royal Aerospace Establishment, Bedford, England) IN: ICAS, Congress, 17th,

Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2192-2202. refs
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Techniques for controlling the low-frequency rigid-body motions of sting-mounted aircraft models during wind-tunnel testing at high Reynolds number and angle of attack are described and demonstrated with data on RAE model 2209, which has a thin highly swept wing mounted above a fuselage of almost square cross section. During initial tests at Mach 0.5 in the RAE 8 x 8-ft tunnel, both severe bending oscillations at angle of attack 27-29 deg and horizontal yawing oscillations at angle of attack about 35 deg were observed. Installation of an internal passive tuned damper and bump stops (to limit model lateral motion) was found to be effective in limiting these problems. Diagrams, drawings, and graphs are provided. D.G.

A91-24728#
EXPERIMENTAL STUDY ON MATCHING BETWEEN CHARACTERISTICS OF CONTROL-MANIPULATOR SYSTEM AND CONTROLLED ELEMENT DYNAMICS. I - THE CASE OF 1ST ORDER UNSTABLE CONTROLLED ELEMENT. II - THE CASE OF 3RD ORDER CONTROLLED ELEMENT
NAOHIRO YUHARA and SHINICHIRO HORIUCHI (Nihon University, Funabashi, Japan) Japan Society for Aeronautical and Space Sciences, Transactions (ISSN 0549-3811), vol. 33, Nov. 1990, p. 85-109. refs

A description is presented of an experimental study conducted with a fixed-base simulator in order to examine the matching between the characteristics of a control-manipulator system and both first-order and third-order unstable controlled elements. The first-order case represents the longitudinal dynamics of aircraft with relaxed static stability under the condition that the stability augmentation system is out of order; the third-order case represents the dynamics of the pitching motion of conventional aircraft. The manipulators used for the experiments are a control wheel and a fixed sidestick manipulator. With both the lag time and the lead time kept constant, and the dead time in the control system varied in several ways, the frequency responses of human operators performing single-axis manual control are obtained. Results are then presented for both the first-order and third-order cases. S.A.V.

A91-25793
SIMULATION STUDIES OF THE PILOT-HELICOPTER SYSTEM UNDER ABNORMAL CONDITIONS [BADANIA SYMULACYJNE UKLADU PILOT-SMIGLOWIEC W WARUNKACH TRANSGRESJI]
KAZIMIERZ SZUMANSKI (Instytut Lotnictwa, Warsaw, Poland) Rozprawy Inzynierskie (ISSN 0035-9408), vol. 37, no. 1, 1989, p. 3-39. In Polish. refs
Copyright

The paper is concerned with the dynamics of the system pilot-helicopter under extreme conditions, including cases where some consecutive limits have been exceeded. The aim of the study includes both estimation of helicopter loading and determination of the control methods under given conditions. The discussion covers simulation analyses using mathematical models, flight simulator tests, and actual flight tests. V.L.

A91-25846
THE EIGENVALUE SENSITIVITY ANALYSIS AND DESIGN FOR INTEGRATED FLIGHT/PROPULSION CONTROL SYSTEM
GONGZHANG SHEN, ZONGJI CHEN, and KEMAO PENG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 3, Nov. 1990, p. 277-284. refs
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In this paper, sensitivity approaches are used to analyze and design an integrated flight propulsion system where the interaction between subsystems directly affects the stability property and handling performances of the aircraft. The eigenvalue sensitivity approach is employed to study the effect of coupling parameters on system stability, and the gain sensitivity approach is used to direct the reduced-state-feedback suboptimal control-system design. Simulation results show that the integrated flight/propulsion control systems designed by sensitivity approaches have good performance. Author

A91-26134
EFFECT OF HINGELESS ROTOR AEROELASTICITY ON HELICOPTER LONGITUDINAL FLIGHT DYNAMICS
ROBERTO CELI (Maryland, University, College Park) American Helicopter Society, Journal (ISSN 0002-8711), vol. 36, Jan. 1991, p. 35-44. refs
(Contract DAAL03-88-C-002)
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This paper describes an aeroelastic stability and response analysis for helicopter rotor blades in forward flight that includes the modelign of hub motions. A special formulation of the aerodynamic and inertia loads substantially reduces the amount of algebraic manipulation necessary to formulate the equations of motion. No restrictions are placed on the amplitudes of the hub motions. Two techniques for solving simultaneously the helicopter trim problem and the blade aeroelastic response problem are presented and compared. The aeroelastic analysis is applied to an illustrative problem, focusing on the effect of blade torsional stiffness and chordwise offset of center of mass and aerodynamic center from the elastic axis on the longitudinal dynamics of a hingeless helicopter in forward flight. The results indicate the possibility of stabilizing the phugoid mode through an appropriate dynamic design of the rotor, and without additional stability augmentation systems. Author

A91-26626
CONTROLLER DESIGNS OF A GUST LOAD ALLEVIATION SYSTEM FOR AN ELASTIC RECTANGULAR WING
A. FUJIMORI, H. OHTA (Nagoya University, Japan), and P. N. NIKIFORUK (Saskatchewan, University, Saskatoon, Canada) IN: Automatic control in aerospace; IFAC Symposium, Tsukuba, Japan, July 17-21, 1989, Selected Papers. Oxford, England and New York, Pergamon Press, 1990, p. 153-158. Research supported by Ishida Foundation.
(Contract NSERC-A-5625; NSERC-A-1080)
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This paper proposes two design methods of reduced-order controllers for gust load alleviation (GLA) systems of an elastic wing, and examines the control performance using both simulation studies and wind-tunnel experiments. One of the methods is based on the use of the generalized Hessenbery representation in the time domain, and the other method is the one in the frequency domain termed the Nyquist frequency approximation. The former yields quasi-optimal controllers in the sense of minimizing quadratic performance indices, whereas the latter can yield controllers with increased stability margin. Applying these methods to the design of GLA systems of a cantilevered elastic rectangular wing, low-order controllers, the 1st- or the 2nd-order, can be constructed, and they showed as good performance as the LQG compensator. Author

A91-26634
INTEGRATED FLIGHT/PROPULSION CONTROL - REQUIREMENTS AND ISSUES
S. M. ROCK (Stanford University, CA) IN: Automatic control in aerospace; IFAC Symposium, Tsukuba, Japan, July 17-21, 1989, Selected Papers. Oxford, England and New York, Pergamon Press, 1990, p. 209-214. refs
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Thrust vectoring schemes, lift-augmentation configurations, and direct force/moment control methods in next-generation aircraft design require integrated control laws which overcome the intrinsic difficulty posed by the fundamental differences of the types of control appropriate to flight and to propulsion. In addition, control-design tasks relating to airframe and to engine safety have customarily been left to the respective manufacturers. Attention is presently given to a decentralized-hierarchical design approach

for integrated flight/propulsion control systems, emphasizing the distinctive control design requirements of such propulsion factors as compressor operational variables and transients. O.C.

A91-26720
AUTOMATIC CONTROL OF AIRCRAFT AND MISSILES (2ND REVISED AND ENLARGED EDITION)
JOHN H. BLAKELOCK Research supported by USAF,. New York, Wiley-Interscience, 1991, 361 p. refs
(Contract F33615-78-C-3145EE40)
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The fundamental principles of the automatic control of aircraft and missiles are presented in a systematic manner. In particular, attention is given to the derivation and solution of longitudinal equations, longitudinal autopilots, derivation of equations for the lateral stability derivatives, lateral autopilot configurations, systems for controlling an aircraft subject to inertial cross-coupling, and missile control systems. The book also covers guidance systems and their performance, integrated flight/fire control systems, multivariable control systems, structural flexibility, application of statistical design principles, and pilot modeling. V.L.

A91-26928
ACCOMMODATION OF FAILURES IN THE F-16 AIRCRAFT USING ADAPTIVE CONTROL
FARID AHMED-ZAID, PETROS IOANNOU (Southern California, University, Los Angeles, CA), KEN GOUSMAN, and ROBERT ROONEY (Lockheed Aeronautical Systems Co., Burbank, CA) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 11, Jan. 1991, p. 73-78. refs
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Surface and hardware failure affect the flight control system of the F-16 fighter aircraft. In the absence of failures and unpredictable changes, the controller, based on gain scheduling performs very well and exhibits a good degree of robustness, even for high angles of attack. In order to accommodate for possible failure and maintain good performance characteristics, the control system is augmented with a hybrid adaptive linear quadratic control scheme. The augmented adaptive flight control system has the online capability for learning and accommodating to drastic changes in the aircraft dynamics due to surface or hardware failure. The proposed flight control system has been tested on the nonlinear model of the F-16 aircraft, and the simulation results demonstrate its ability to accommodate control failures and maintain good performance. I.E.

A91-27114
ADAPTIVE CONTROLLER FOR WING FLUTTER WITH UNMEASURABLE EXCITATIONS AND UNMODELLED DYNAMICS
R. LIVNEH and G. L. SLATER (Cincinnati, University, OH) International Journal of Control (ISSN 0020-7179), vol. 53, Feb. 1991, p. 293-309. refs
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The problem of designing a robust simplified controller for the control of a wing flutter vibration is studied. The adaptive control algorithm developed by Bar-Kana et al. (1983) is extended to include independent excitations to both the input and the output of the plant. Those excitations are partitioned into measurable and unmeasurable parts, and are incorporated into the ideal trajectory and into the adaptive law. The stability of the adaptive law is proved using ultimate boundedness results. The 'almost strict positive realness' property of the plant is examined and related to the minimum phase property, to the output stabilizability, and to the steady-state solution of the Riccati equation. The numerical simulations of the wing flutter control problem demonstrate stability and robustness over a wide range of variations in both the plant and adaptation parameters. Author

N91-17561*# Boeing Commercial Airplane Co., Seattle, WA.
LIFE-CRITICAL DIGITAL FLIGHT CONTROL SYSTEMS
JAMES MCWHA *In* NASA, Langley Research Center, NASA Formal Methods Workshop, 1990 22 p Nov. 1990
Avail: NTIS HC/MF A22 CSCL 01/3

Digital autopilot systems were first used on commercial airplanes in the late 1970s. The A-320 airplane was the first air transport airplane with a fly-by-wire primary flight control system. On the 767-X (777) airplane Boeing will install all fly-by-wire flight controls. Activities related to safety, industry status and program phases are discussed. Y.S.

N91-17565*# SRI International Corp., Menlo Park, CA. Computer Science Lab.
WHAT FM CAN OFFER DFCS DESIGN
JOHN RUSHBY *In* NASA, Langley Research Center, NASA Formal Methods Workshop, 1990 30 p Nov. 1990
Avail: NTIS HC/MF A22 CSCL 09/2

The results of aircrafts and spacecrafts flight tests are reported. It is shown that the problems of Digital Flight Control Systems (DFCS) are the problems of systems whose complexity has exceeded the reach of the intellectual tools employed. It is also shown that intuition, experience, and techniques derived from mechanical and analog systems are insufficient for complex, integrated, digital systems. Formal Methods (FM) of computer science can offer DFCS systematic techniques for the construction of trustworthy software, including: techniques for the precise specification of requirements and the development of designs; systematic approaches to the design and structuring of distributed and concurrent systems; fault tolerance algorithms; and systematic methods of testing and analytic methods of verification. Y.S.

N91-17566*# Computational Logic, Inc., Austin, TX.
WHAT CAN FORMAL METHODS OFFER TO DIGITAL FLIGHT CONTROL SYSTEMS DESIGN
DONALD I. GOOD *In* NASA, Langley Research Center, NASA Formal Methods Workshop, 1990 38 p Nov. 1990
Avail: NTIS HC/MF A22 CSCL 09/2

Formal methods research begins to produce methods which will enable mathematic modeling of the physical behavior of digital hardware and software systems. The development of these methods directly supports the NASA mission of increasing the scope and effectiveness of flight system modeling capabilities. The conventional, continuous mathematics that is used extensively in modeling flight systems is not adequate for accurate modeling of digital systems. Therefore, the current practice of digital flight control system design has not had the benefits of extensive mathematical modeling which are common in other parts of flight system engineering. Formal methods research shows that by using discrete mathematics, very accurate modeling of digital systems is possible. These discrete modeling methods will bring the traditional benefits of modeling to digital hardware and hardware design. Sound reasoning about accurate mathematical models of flight control systems can be an important part of reducing risk of unsafe flight control. Author

N91-18115*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CANDIDATE CONTROL DESIGN METRICS FOR AN AGILE FIGHTER
PATRICK C. MURPHY, MELVIN L. BAILEY (Lockheed Engineering and Sciences Co., Hampton, VA.), and AARON J. OSTROFF Washington Mar. 1991 64 p
(NASA-TM-4238; L-16766; NAS 1.15:4238) Avail: NTIS HC/MF A04 CSCL 01/3

Success in the fighter combat environment of the future will certainly demand increasing capability from aircraft technology. These advanced capabilities in the form of superagility and supermaneuverability will require special design techniques which translate advanced air combat maneuvering requirements into design criteria. Control design metrics can provide some of these techniques for the control designer. Thus study presents an overview of control design metrics and investigates metrics for advanced fighter agility. The objectives of various metric users, such as airframe designers and pilots, are differentiated from the objectives of the control designer. Using an advanced fighter model,

metric values are documented over a portion of the flight envelope through piloted simulation. These metric values provide a baseline against which future control system improvements can be compared and against which a control design methodology can be developed. Agility is measured for axial, pitch, and roll axes. Axial metrics highlight acceleration and deceleration capabilities under different flight loads and include specific excess power measurements to characterize energy meneuverability. Pitch metrics cover both body-axis and wind-axis pitch rates and accelerations. Included in pitch metrics are nose pointing metrics which highlight displacement capability between the nose and the velocity vector. Roll metrics (or torsion metrics) focus on rotational capability about the wind axis. Author

N91-18116*# Boeing Co., Seattle, WA.
PERSONNEL LAUNCH SYSTEM AUTOLAND DEVELOPMENT STUDY Final Report
J. A. BOSSI, M. A. LANGEHOUGH, and J. C. TOLLEFSON Jan. 1991 168 p
(Contract NAS1-18762)
(NASA-CR-187495; NAS 1.26:187495) Avail: NTIS HC/MF A08 CSCL 01/3

The Personnel Launch System (PLS) Autoland Development Study focused on development of the guidance and control system for the approach and landing (A/L) phase and the terminal area energy management (TAEM) phase. In the A/L phase, a straight-in trajectory profile was developed with an initial high glide slope, a pull-up and flare to lower glide slope, and the final flare touchdown. The TAEM system consisted of using a heading alignment cone spiral profile. The PLS autopilot was developed using integral LQG design techniques. The guidance and control design was verified using a nonlinear 6 DOF simulation. Simulation results demonstrated accurate steering during the TAEM phase and adequate autoland performance in the presence of wind turbulence and wind shear. Author

N91-18117# National Aeronautical Lab., Bangalore (India).
PRECISION MECHANICS OF ACTUATORS IN AIRCRAFT AND ROCKETS
P. T. VARUTE Sep. 1990 114 p
(NAL-SP-9016) Avail: NTIS HC/MF A06

A lecture series is presented which is spread over the following six areas: (1) types of actuators; (2) the study and design of actuators; (3) basic requirements in actuator dynamic performance; (4) development and fabrication technology of actuators; (5) state-of-the-art in actuators; and (6) equipment and instruments required for development and testing of servo actuators in a laboratory. Author

N91-18118# Technische Univ., Munich (Germany, F.R.). Lehrstuhl fuer Flugmechanik und Flugregelung.
ELASTIC AIRPLANE GUST RESPONSE Ph.D. Thesis [ZUM BOEENVERHALTEN ELASTISCHER FLUGZEUGE]
JOHANN KRAMMER 1989 151 p In GERMAN
(ETN-91-98797) Avail: NTIS HC/MF A08

A new mathematical model for elastic airplane gust response, including measured or calculated natural oscillation magnitude, is presented. An airfoil process extended to an oscillating deflection system is used, in order to describe the unsteady aerodynamic forces, out of proper motion and gust disturbances. This system is proved advantageous, in relation to computation time and storage location need, on account of the partial analytical integration carried out. The frequency dependent loads were discussed for two airplanes, for harmonic gust disturbances and stochastic one and two dimensional turbulence models, in order to explain the performance of the model. ESA

09

RESEARCH AND SUPPORT FACILITIES (AIR)

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

A91-24302#
FLIGHT SIMULATION AND DIGITAL FLIGHT CONTROLS
D. CHATRENET (Aerospatiale, Toulouse, France) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. XL-XLIV.
Copyright

Various forms of flight control system simulation, including those involving a high degree of integration with actual aircraft components, have played a key role in the successful development of the A320 airliner's digital flight controls. A total of about 18,000 hours of simulator testing had been logged at the time of A320-200 certification, substantially enhancing the safety and effectiveness of flight testing by serving in a complementary capacity. Simulation methods for airline training purposes have been able to use digital flight controls to move representability-critical areas from 'aerodynamic model' accuracy levels to flight control system representation exactness. O.C.

A91-24305*# Lockheed Engineering and Sciences Co., Hampton, VA.
PREDICTING THE AEROELASTIC BEHAVIOR OF A WIND-TUNNEL MODEL USING TRANSONIC SMALL DISTURBANCE THEORY
WALTER A. SILVA (Lockheed Engineering and Sciences Co., Hampton, VA) and ROBERT M. BENNETT (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1-10. refs
Copyright

The CAP-TSD (Computational Aeroelasticity Program - Transonic Small Disturbance) code, developed at the NASA-Langley Research Center, is applied to the Active Flexible Wing (AFW) wind-tunnel model for prediction of the model's transonic aeroelastic behavior. Static aeroelastic solutions using CAP-TSD are computed. Dynamic (flutter) analyses are then performed as perturbations about the static aeroelastic deformations of the AFW. The accuracy of the static aeroelastic procedure is investigated by comparing analytical results to those from AFW wind-tunnel experiments. Dynamic results are presented in the form of root loci at different Mach numbers for a heavy gas and for air test mediums. The resultant flutter boundaries for both gases, and the effects of viscous damping and angle of attack on the flutter boundary in air, are also presented. Author

A91-24324#
THE WINDTUNNEL AS A TOOL FOR LAMINAR FLOW RESEARCH
A. ELSENAAR (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 174-185. refs
Copyright

Testing laminar airfoils or wings in the wind tunnel entails some specific experimental problems. These problems are discussed in the paper using the (limited) experience of laminar flow tests made in the High Speed Wind Tunnel HST of NLR. Special measurement techniques are required, like infrared imaging for transition detection and fast continuous wake rake traverses, for detailed drag assessment. Premature transition due to contamination of the airfoil surface appears to be a problem. It is unlikely that the transition

location in flight will be duplicated in the wind tunnel due to flow quality and Reynolds number differences. Therefore, a methodology is discussed to extrapolate the wind tunnel test result to flight conditions. Author

A91-24342#
STATUS OF ADAPTIVE WALL TECHNOLOGY FOR MINIMIZATION OF WIND TUNNEL BOUNDARY INTERFERENCES
STEPHEN W. D. WOLF (MCAT Institute, Moffett Field, CA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 352-362. refs
Copyright

This paper reviews the status of adaptive wall technology for improving wind tunnel simulations. This technology relies on making the test section boundaries adjustable, with a tunnel/computer system to control the boundary shapes. This paper briefly considers the significant benefits of adaptive wall testing techniques. A brief historical overview covers the development of these testing techniques from 1938 to present. Currently operational adaptive wall test sections (AWTSs) are detailed. The simplest AWTS design with 2 solid flexible walls is found to be most advantageous. A review of research experience with AWTSs shows the many advances in recent times. Requirements for operating AWTSs on a production basis are discussed. Adaptive wall technology is mature enough for general use in two-dimensional testing, even in cryogenic wind tunnels. In three-dimensional testing, this technology is not so advanced because of low priority development and misconceptions. Author

A91-24343#
PERFORMANCE OF THE NEW ROLL-IN ROLL-OUT TRANSONIC TEST SECTIONS OF THE NAE 1.5 M X 1.5 M BLOWDOWN WIND TUNNEL
L. H. OHMAN and D. BROWN (National Aeronautical Establishment, Ottawa, Canada) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 363-387. refs
Copyright

In an effort to improve the data-productivity and quality of the Canadian National Aeronautical Establishment's 1.5 x 1.5 m trisonic blowdown wind tunnel, a reconstruction program was instituted which has led to the construction of a two-dimensional and a three-dimensional modular test section. These modules are fitted into the original plenum chamber and are easily interchangeable; they feature perforated walls with 0.5-6.0 percent porosity variation. All holes are at 60 deg inclination. Results are presented from the calibration of these two test sections, and wall interference effects derived from model forces and boundary pressure measurements are analyzed. O.C.

A91-24344#
THE FFA T1500 INJECTION DRIVEN TRANSONIC WIND TUNNEL
LARS TORNGREN (Flygtekniska Forsoksanstalten, Stockholm, Sweden) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 388-398. refs
Copyright

A new high Reynolds number transonic wind tunnel has been built in Sweden for the Aeronautical Research Institute (FFA). The tunnel has a closed circuit with a 1.5 m x 1.5 m test section and is injector driven from an existing 250 bar air supply system. The Mach number range is 0.3 - 1.2 with a conventional contraction and a sonic second throat and 1.4 with a convergent-divergent contraction . The stagnation pressure range is 100-550 kPa at the lowest Mach number. This range decreases for increasing Mach numbers mostly because of practical restrictions as dynamic pressure and run time limits. Initial testing of different flow properties as Mach number distribution, flow angularity, turbulence intensity and pressure fluctuations has been performed and results are presented. The performance of the wind tunnel control system has also been checked regarding its ability to control Mach number and stagnation pressure. Author

A91-24453#
EFFECTS OF REYNOLDS NUMBER, MACH NUMBER AND STING GEOMETRY ON ROTARY BALANCE MEASUREMENTS
C. O. O'LEARY and B. WEIR (Royal Aeroscape Establishment, Bedford, England) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1485-1495. refs
Copyright

Although extensive assessments of the effects of Reynolds number, Mach number, and sting geometry have been made for static tests, there have been few similar studies for rotary tests. This paper describes the results of exploratory tests on the RAE HIRM 1 and HIRM 2 models. Effects on the lateral coefficients are assessed. Test Reynolds number and Mach number ranges were 0.7 x 10 to the 6th to 3.8 x 10 to the 6th and 0.2 to 0.8, respectively. Results showed that asymmetric forces could be generated, depending on Reynolds number and rate of roll. Reynolds number also affected the linearity and magnitude of side force, yawing moment, and rolling moment due to the rate of roll. Effects of rear sting geometry were most prominent at alpha = 40 deg. A dummy top-entry sting caused most interference to C(y) and C(n) at alpha = 40 deg and 60 deg but effects on C1 were confined to alpha = 40 deg. There was a reduction in roll damping for Mach number increases between 0.4 and 0.8. Author

A91-25847
A GROUND SIMULATION-INSPECTION SYSTEM FOR AVIONIC DEVICES
RENZHOU FAN, RUILIN CHEN, and XIMING ZHANG (Beijing University of Aeronautics and Astronautics, People's Republic of China) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 3, Nov. 1990, p. 285-293. refs
Copyright

This paper discusses the system function and hardware and software structure of a ground simulation testing system for airborne electronic devices. An example of a practical simulation and inspection system is given. The system connects different kinds of microcomputers (DIMENSION 68000. SDK86, and TP801) to form a distributed simulation and inspection network through an eight-terminal optical-fiber communication net. The system can imitate the signal of the radar of a moving object and the ARINC429 signal of the navigation subsystem and atmosphere subsystem. It can be directly connected to the airborne electronic devices, receiving and processing real-time data from airborne electronic devices, storing data, performing error analysis, drawing curves of the mobile objects, and printing tables of various test parameters. The system is easy to operate with perfect functions. Author

A91-26112*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TRANSONIC WIND-TUNNEL WALL INTERFERENCE PREDICTION CODE
PAMELA S. PHILLIPS and EDGAR G. WAGGONER (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Nov. 1990, p. 915, 916. Previously cited in issue 16, p. 2603, Accession no. A88-40722. refs
Copyright

A91-26927
A PREDICTIVE CONTROLLER FOR THE MACH NUMBER IN A TRANSONIC WIND TUNNEL
RONALD A. M. SOETERBOEK, HENK B. VERBRUGGEN, GERARD C. VAN LANGEN (Delft, Technische Universiteit, Netherlands), and ARTHUR F. PELS (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 11, Jan. 1991, p.

63-72. refs
Copyright

The use of the unified predictive controller in controlling the Mach number of a transonic wind tunnel is examined. It is shown, by means of simulations and experiments, that the unified predictive controller yields an overall performance improvement of 30-60 percent in comparison with the proportional-integral-derivative (PID) controller that is normally used to control the Mach number. The rejection by the unified predictive controller of disturbances caused by changing the angle of attack is a factor of four better than that of the PID controller. This makes it possible to change the angle of attack faster, so that the efficiency of the wind tunnel operation can be improved. It is believed that this is mainly due to the fact that knowledge about the disturbances can be incorporated into the predictive controller design. Simulations have shown that even better results can be expected; the results have not yet been verified by experiments. I.E.

A91-28095
USING IMPULSE WIND TUNNELS AT M LESS THAN 8 [PRIMENENIE IMPUL'SNYKH AERODINAMICHESKIKH TRUB PRI M LESS THAN 8]
V. I. ZVEGINTSEV (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Oct. 1990, p. 129-134. In Russian. refs
Copyright

A model gasdynamic system, capable of generating gas flows lasting 0.1 s at M 1-7, a pressure of 20 MPa, and temperatures up to 700 K, was used to investigate new impulse wind tunnel design concepts for operation at Mach numbers less than 8. Some problems associated with the design of such wind tunnels are examined, specific designs are discussed, and test results are presented. Attention is also given to the possibility of using impulse wind tunnels in the transonic velocity range. V.L.

A91-28096
STABILIZATION OF GAS PARAMETERS IN THE PLENUM CHAMBER OF A HYPERSONIC IMPULSE WIND TUNNEL [STABILIZATSIIA PARAMETROV GAZA V FORKAMERE GIPERZVUKOVOI IMPUL'SNOI AERODINAMICHESKOI TRUBY]
L. N. PUZYREV and M. I. IAROSLAVTSEV (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Oct. 1990, p. 135-140. In Russian. refs
Copyright

A wind tunnel is described which has all the advantages of an impulse wind tunnel (simplicity, low cost, high initial gas intensity, and wide range of stall parameters) while being capable of operating at constant stall parameters for 0.1-0.5 s without the forced cooling of the most thermally stressed components (plenum chamber, critical nozzle section, and models). The wind tunnel has a plenum chamber with a maximum volume of 8 sq dm and a test section diameter of 0.5 m; the range of the modeled Reynolds numbers is 7 x 10 to the 6th - 2 x 10 to the 8th; gas pressure stability is 2 percent for an operating cycle of 0.14 s. The operation of the wind tunnel is described with emphasis on the gas pressure stabilization system. V.L.

A91-28098
BLOWDOWN WIND TUNNELS [AERODINAMICHESKIE USTANOVKI KRATKOVREMENNOGO DEISTVIIA]
N. I. KHVOSTOV, N. S. ZUBAREV, and V. I. ZAIKA (Tsentral'nyi Aerogidrodinamicheskii Institut, Moscow, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Oct. 1990, p. 145-148. In Russian.
Copyright

A method for producing a dense high-temperature gas for blowdown wind tunnel testing is described which can be implemented in wind tunnels operated by a gas or mechanical piston. The general design and principle of operation of such wind tunnels, which use hydraulic damping and a Cowper blast air heater, are briefly described. Experimental results are presented in graphic form. V.L.

A91-28100
AN IMPULSE WIND TUNNEL WITH CHEMICAL HEATING [IMPUL'SNAIA AERODINAMICHESKAIA TRUBA S KHIMICHESKIM PODOGREVOM]
M. M. NOSOV and M. I. ANOSHIN (Nauchno-Issledovatel'skii Mashinostroitel'nyi Institut, Moscow, USSR) Akademiia Nauk SSSR, *Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki* (ISSN 0002-3434), Oct. 1990, p. 158-161. In Russian.
Copyright

The advantages of wind tunnels with chemical heating are briefly examined, and results of thermochemical calculations are presented for the combustion of propane-nitrous oxide-air mixtures. The general design and the main components of an implementation of a wind tunnnel with chemical heating are then described. It is shown that the properties of the working medium in a wind tunnel with chemical heating differ only slightly from those of standard 'dry' air and are practically similar to those of real air with high water vapor concentration. V.L.

N91-17065*# *Virginia Polytechnic Inst. and State Univ.*, Blacksburg. Center for Transportation Research.
RUNWAY EXIT DESIGNS FOR CAPACITY IMPROVEMENT DEMONSTRATIONS. PHASE 1: ALGORITHM DEVELOPMENT
A. A. TRANI, A. G. HOBEIKA, H. SHERALI, B. J. KIM, and C. K. SADAM Jun. 1990 166 p Sponsored by FAA, Washington, DC
(Contract NAS1-18471)
(NASA-CR-187955; NAS 1.26:187955; CTR-R-1-90-PHASE-1; DOT/FAA/RD-90/32-PHASE-1) Avail: NTIS HC/MF A08
CSCL 01/5

A description and results are presented of a study to locate and design rapid runway exits under realistic airport conditions. The study developed a PC-based computer simulation-optimization program called REDIM (runway exit design interactive model) to help future airport designers and planners to locate optimal exits under various airport conditions. The model addresses three sets of problems typically arising during runway exit design evaluations. These are the evaluations of existing runway configurations, addition of new rapid runway turnoffs, and the design of new runway facilities. The model is highly interactive and allows a quick estimation of the expected value of runway occupancy time. Aircraft populations and airport environmental conditions are among the multiple inputs to the model to execute a viable runway location and geometric design solution. The results presented suggest that possible reductions on runway occupancy time (ROT) can be achieved with the use of optimally tailored rapid runway designs for a given aircraft population. Reductions of up to 9 to 6 seconds are possible with the implementation of 30 m/sec variable geometry exits. Author

N91-18119# National Aeronautical Lab., Bangalore (India). Flight Mechanics and Controls Div.
DYNAMIC WIND TUNNEL TESTING OF A FLEXIBLE WING MODEL
M. S. RAJAMURTHY and S. BALAKRISHNA Oct. 1990 25 p Original contains color illustrations
(NAL-PD-FC-9010) Avail: NTIS HC/MF A03; 2 functional color pages

The current state-of-the-art in the design of modern combat aircraft is to use CCV (Control Configured Vehicles) concepts to obtain high performance at lower weight. This demands an unstable aerodynamic configuration with the stability provided artificially by the control system. This needs longitudinal servo-actuators of high bandwidth. With lower structural frequencies there is scope for interaction and aeroservoelastic problems could occur. A simple experimental study of servoelastically exciting wing to yield transfer function data is detailed. The aim of these experiments is to provide a vehicle for generating experimental data for validating

aeroservoelastic codes and to obtain insight of flutter/aeroservoelastic phenomena through scaled models. Author

N91-18120*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MECHANICAL PROPERTIES OF THE FIBERGLASS PREPREG SYSTEM USED FOR THE NATIONAL TRANSONIC FACILITY REPLACEMENT BLADE SET Technical Report, 1989 - 1990
CLARENCE P. YOUNG, JR. and JOHN W. WALLACE Feb. 1991 26 p
(NASA-TM-102756; NAS 1.15:102756) Avail: NTIS HC/MF A03 CSCL 14/2

The results are presented of mechanical and physical properties characterization testing for the fiber glass prepreg system used to fabricate 15 of the replacement set of 25 fan blades for the National Transonic Facility. The fan blades were fabricated to be identical to the original blade set with the exception that the 7576 style E glass cloth used for the replacement set has a different surface finish than the original 7576 cloth. The 7781 E glass cloth and resin system were unchanged. The data are presented for elevated, room, and cryogenic temperatures. The results are compared with data from the original blade set and evaluated against selected structural design criteria. Test experience is described along with recommendations for future testing of these materials if required. 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.

A91-24676
NAV 89 - SATELLITE NAVIGATION; PROCEEDINGS OF THE CONFERENCE, LONDON, ENGLAND, OCT. 17-19, 1989
Conference sponsored by Royal Institute of Navigation. London, Royal Institute of Navigation, 1989, 269 p. For individual items see A91-24677 to A91-24695.
Copyright

Recent advances in satellite-based navigation systems and their applications are discussed in reviews and reports. Sections are devoted to basic principles; current and future satellite systems; user and institutional plans; user equipment and its applications; differential systems; hybrid systems and receivers; and satellite-system coverage, availability, integrity, and monitoring. Extensive diagrams, graphs, and coverage maps are provided. D.G.

A91-25665
THE NATIONAL AEROSPACE PLANE PROGRAM - A REVOLUTIONARY CONCEPT
ROBERT R. BARTHELEMY (National Aero-Space Plane Joint Program Office, Wright-Patterson AFB, OH) Johns Hopkins APL Technical Digest (ISSN 0270-5214), vol. 11, July-Dec. 1990, p. 312-318.
Copyright

The National AeroSpace Plane program is aimed at developing and demonstrating hypersonic technologies with the goal of achieving orbit with a single-stage vehicle. This article describes the technological, programmatic, utilitarian, and conceptual aspects of the program. Author

A91-25738
OPTIMIZATION OF WAVERIDERS TO MAXIMIZE MISSION PERFORMANCE
DAVID L. BEUERLEIN (General Dynamics Corp., Fort Worth, TX) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 19 p. refs
Copyright

Factors other than the aerodynamics are examined in an attempt to determine the optimum waverider geometry required to satisfy specific mission constraints. The objective function to be optimized is not the on-design L/D ratio of the aircraft but rather the performance of the aircraft over a specified mission. The measure of merit used to evaluate mission performance is the weight of the aircraft when scaled to precisely satisfy mission requirements. The waverider design analysis and mission performance calculations have been integrated into the Mission Optimized Waverider computer code. V.L.

A91-25755*# Oklahoma Univ., Norman.
IDEALIZED TIP-TO-TAIL WAVERIDER MODEL
G. EMANUEL (Oklahoma, University, Norman) and H.-K. PARK IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 21 p. refs
(Contract NAG1-886)

The flow field of an idealized cone-derived waverider is axisymmetric. This forebody feature is preserved for the rest of the vehicle, including the inlet, cowl, combustor, and nozzle. There is thus an inviscid, tip-to-tail model in which both the external and internal flows are axisymmetric. The assumption of axial symmetry provides a major simplification for the analysis and allows for a systematic integration of the propulsion unit with the aerodynamics. The code is an initial formulation that provides only the most basic engineering data, such as lift, thrust, drag, and fuel consumption for a point-designed vehicle that may be cruising at a low hypersonic Mach number. The user may specify flight altitude and Mach number, a multiple shock configuration for the inlet, a few basic geometric parameter, H2 or CH4 as fuel, the fuel/air ratio, etc. A new design concept is used for the nozzle that avoids shock waves, minimizes the nozzle length, and may maximize its thrust. A general description of the model is provided with emphasis on the design of the nozzle and fins. Preliminary results are presented that compare the cruise flight range using H2 or CH4 as the fuel. Author

A91-25774
SAENGER THROTTLES UP
DIETRICH E. KOELLE and HERIBERT KUCZERA (MBB GmbH, Munich, Federal Republic of Germany) Space (ISSN 0267-954X), vol. 7, Jan.-Feb. 1991, p. 16-20.
Copyright

Saenger's first stage (the European Hypersonic Transport Vehicle) has completed its second design cycle, which has confirmed the configuration of this Mach 6.8 vehicle. A follow-on definition study for a hypersonic technology demonstrator has been started that should result in an aircraft capable of attaining Mach 5.5 for short periods. The main purpose of this study will be to verify CFD simulations and wind tunnel model test data. Mission and design requirements include a manned station supply capability of 3000 kg useful load with a crew of three, an unmanned payload capability of 7.5 Mg for a 200 km orbit, and a ground-to-orbit launch capability of 2300 kg. CFD investigations will continue with the new 52 cm model (scale 1:160). New wind tunnel tests are planned to investigate the efficiency of the aerodynamic control surfaces including the canards. The economic justification for a Saenger type space transport system is a substantially reduced cost per launch. R.E.P.

A91-26612* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
KALMAN FILTER BASED RANGE ESTIMATION FOR AUTONOMOUS NAVIGATION USING IMAGING SENSORS
B. SRIDHAR, V. H. L. CHENG (NASA, Ames Research Center, Moffett Field, CA), and A. V. PHATAK (Analytical Mechanics Associates, Mountain View, CA) IN: Automatic control in

aerospace; IFAC Symposium, Tsukuba, Japan, July 17-21, 1989, Selected Papers. Oxford, England and New York, Pergamon Press, 1990, p. 45-50. refs
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The ability to detect and locate obstacles using on-board sensors and modify the nominal trajectory is necessary for safe landing of an autonomous lander on Mars. This paper examines some of the issues in the location of objects using a sequence of images from a passive sensor, and describes a Kalman filter approach to improve the range estimation to obstacles. The filter is also used to track features in the images leading to a significant reduction of search effort in the feature extraction step of the algorithm. The lack of suitable flight imagery data presents a problem in the verification of concepts for obstacle detection. An experiment is designed to acquire a sequence of images along with sensor motion parameters and the range estimation results using this imagery are presented. Author

A91-26635
THE CASSINI TITAN PROBE'S ADAPTIVE DESCENT CONTROL
K. SCHILLING (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) and H. LEHRA (Dornier Luftfahrt GmbH, Friedrichshafen, Federal Republic of Germany) IN: Automatic control in aerospace; IFAC Symposium, Tsukuba, Japan, July 17-21, 1989, Selected Papers. Oxford, England and New York, Pergamon Press, 1990, p. 215-222. refs
Copyright

The Cassini Mission encompasses an orbiter and a probe which will land in Titan; the distance to earth is such that the descent of the probe will not be controllable by ground stations, and the Titan atmosphere is in any case sufficiently unknown to preclude accurate anticipation of probe reentry conditions. The descent profile's control will allow engagement of the requisite scientific instruments and guarantee the transmission of data obtained to the orbiter. Attention is presently given to the use of a continuous revision of atmospheric models according to measurements obtained during descent for autonomous probe trajectory improvement and power-resources allocation as required by emerging circumstances. O.C.

A91-27809#
SECOND-STAGE TRAJECTORIES OF AIR-BREATHING SPACE PLANES
R. W. STAUFENBIEL (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 27, Nov.-Dec. 1990, p. 618-622.
Copyright

Attention throughout the world has turned to the benefits that can be gained in space transportation by combining the features of aircraft and rockets. In the rocket-driven phase or stage, which follows the nearly horizontal air-breathing flight, a considerable change in the flight trajectory, a pullup maneuver, is necessary shortly before or after igniting the rocket engines. The change puts a burden on the first or the second stage and thereby reduces the payload. In this paper an optimal strategy for the rocket-propelled flight phase is developed that gives the smallest penalties on longitudinal acceleration and, therefore, on burnout mass. The strategy leads to a splitting of lift and thrust component normal to the flight direction. Two other control strategies are compared with the optimal procedure. Using a generic modeling of aerodynamic characteristics, the equations of motion are solved to assess the influence of initial conditions and of trajectory parameters on the burnout mass. Results of the study show the essential influence of the initial values of flight-path angle and Mach number on the rocket-propelled flight phase. Initial flight-path angle should not be lower than 5 deg. If a reasonable amount of payload and propellant for in-orbit operation should be carried, the dry-mass ratio of the second stage must come down to the range of 15 to 20, depending on the separation Mach number (5 to 6.5). Author

A91-28097
METHODS FOR THE COMPREHENSIVE STUDY OF STRESSES ACTING ON THE TAIL SECTION OF FLIGHT VEHICLES IN PISTON-TYPE WIND TUNNELS WITH POWERPLANT JET MODELING [METODY KOMPLEKSNOGO ISSLEDOVANIIA NAGRUZOK NA KORMOVYE CHASTI LETATEL'NYKH APPARATOV V PORSHNEVYKH GAZODINAMICHESKIKH USTANOVKAKH S MODELIROVANIEM STRUI DVIGATEL'NYKH USTANOVOK]
V. V. KISLYKH and I. A. RESHETIN (Tsentral'nyi Nauchno-Issledovatel'skii Institut Mashinostroeniia, Moscow, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), Oct. 1990, p. 141-144. In Russian.
Copyright

The currently used methods for studying a wide class of jet flows under realistic conditions are examined with particular reference to the use of piston-type gasdynamic testing facilities. The high efficiency of such wind tunnels is due to the possibility of generating high-energy flows of short duration at pressures up to 2000 atm. A method for the comprehensive study of loading of the tail section of flight vehicles is described which uses a two-chamber adiabatic compression system with a pressure regulator as a jet generator. Results obtained for a 1:100 scale model are presented. V.L.

N91-17021*# National Aeronautics and Space Administration, Washington, DC.
NATIONAL SPACE TRANSPORTATION SYSTEM (NSTS) TECHNOLOGY NEEDS
DAVID L. WINTERHALTER and KIMBERLY K. ULRICH *In its* Space Transportation Avionics Technology Symposium. Volume 2: Conference Proceedings p 5-18 Aug. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

The National Space Transportation System (NSTS) is one of the Nation's most valuable resources, providing manned transportation to and from space in support of payloads and scientific research. The NSTS program is currently faced with the problem of hardware obsolescence, which could result in unacceptable schedule and cost impacts to the flight program. Obsolescence problems occur because certain components are no longer being manufactured or repair turnaround time is excessive. In order to achieve a long-term, reliable transportation system that can support manned access to space through 2010 and beyond, NASA must develop a strategic plan for a phased implementation of enhancements which will satisfy this long-term goal. The NSTS program has initiated the Assured Shuttle Availability (ASA) project with the following objectives: eliminate hardware obsolescence in critical areas, increase reliability and safety of the vehicle, decrease operational costs and turnaround time, and improve operational capability. The strategy for ASA will be to first meet the mandatory needs - keep the Shuttle flying. Non-mandatory changes that will improve operational capability and enhance performance will then be considered if funding is adequate. Upgrade packages should be developed to install within designated inspection periods, grouped in a systematic approach to reduce cost and schedule impacts, and allow the capability to provide a Block 2 Shuttle (Phase 3). Author

N91-17030*# National Aeronautics and Space Administration, Washington, DC.
FLIGHT ELEMENTS SUBPANEL INTRODUCTION AND OVERVIEW
PAUL E. SOLLOCK *In its* Space Transportation Avionics Technology Symposium. Volume 2: Conference Proceedings p 305-338 Aug. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

Major objectives, milestones, key contacts, technology issues, accomplishments, and candidate programs are outlined. Topics addressed include: advanced avionics systems architectures; advanced information processing; avionics concepts; integrated Global Positioning System/guidance, navigation, and command concepts; advanced communication and telemetry; display and

control concepts; advanced sensors and instrumentation; fault detection and fault management; advanced electric power, distribution, and control; EMA/power systems; and in-flight crew training. This presentation is represented by viewgraphs only.
B.G.

N91-17134*# Loyola Coll., Baltimore, MD.
JTEC PANEL REPORT ON SPACE AND TRANSATMOSPHERIC PROPULSION TECHNOLOGY
DUANE SHELTON Aug. 1990 232 p Sponsored by NASA, Washington, DC; DARPA; and DOE
(Contract NSF ECS-89-02528)
(NASA-CR-187670; NAS 1.26:187670; PB90-215732) Avail: NTIS HC/MF A11 CSCL 21/8

An assessment of Japan's current capabilities in the areas of space and transatmospheric propulsion is presented. The report focuses primarily upon Japan's programs in liquid rocket propulsion and in propulsion for spaceplanes and related transatmospheric areas. It also includes brief reference to Japan's solid rocket programs, as well as to supersonic air-breathing propulsion efforts that are just getting underway. The results are based upon the findings of a panel of U.S. engineers made up of individuals from academia, government, and industry, and are derived from a review of a broad array of the open literature, combined with visits to the primary propulsion laboratories and development agencies in Japan.
GRA

N91-18182# Sandia National Labs., Albuquerque, NM. Transportation Div.
JUSTIFICATION FOR USING SCALE MODELS FOR IMPACT RESPONSE EVALUATION OF THE SST TRANSPORTATION SYSTEM
R. E. BERRY Dec. 1990 10 p
(Contract DE-AC04-76DP-00789)
(DE91-006100; SAND-90-2337) Avail: NTIS HC/MF A02

The validity of scale model impact evaluation of Supersonic Transportation System is acceptable based on Dimensional Analysis (Buckingham Pi Theorem) and the work of numerous programs that have evaluated the agreement among dimensional analysis, several different reduced-size models and full-scale impact test data. Excellent accuracy has been demonstrated between scale models and full-scale impact data when collected in conformance with the Buckingham Pi Theorem.
DOE

11

CHEMISTRY AND MATERIALS

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

A91-24416#
CHARACTERIZATION AND MODELLING OF THE ANISOTROPIC MECHANICAL BEHAVIOUR OF NICKEL-BASED SINGLE CRYSTAL SUPERALLOYS FOR TURBINE BLADES
P. POUBANNE (SNECMA, Moissy-Cramayel, France), P. CARON, and T. KHAN (ONERA, Chatillon, France) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1115-1121. Research supported by SNECMA. refs
Copyright

For a more reliable and rational utilization of nickel-based single-crystal superalloys, it is noted that an important requirement is the development of models permitting the prediction of the inelastic constitutive behavior of such anisotropic materials. The creep behavior of various alloys was examined between 760 and 1050 C by varying the crystallographic orientation and the microstructure of the tensile axis. It is shown that the creep strength at 750 MPa and 760 C of CMSX-2 is strongly anisotropic and that this anistropy is highly sensitive to the size of the strengthening gamma prime precipitates. A model is developed that describes the cyclic and monotonic behavior of the single crystal superalloy AM1 at 950 C.
R.E.P.

A91-24417#
HIGH-STRENGTH STRUCTURAL STEELS FOR LANDING GEAR PARTS
A. F. PETRAKOV, N. G. POKROVSKAIA, and O. K. REVIAKINA (Vsesoiuznyi Nauchno-Issledovatel'skii Institut Aviatsionnykh Materialov, Moscow, USSR) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1122-1125.
Copyright

A review is presented of high-strength medium alloy welding steels having an ultimate strength of 1400 to 2000 MPa that are used for main parts production; i.e., wheel axes, cylinders and damper rods, levels, truck rockers, and supporting struts that define landing gear weight efficiency. It is noted that the operational reliability of these materials relies on their sensitivity to stress concentration, due to geometry or part manufacturing processes, and fatigue crack propagation rate, which in turn determine the frequency of inspection and overhaul and parts service life. Details are provided on a comparison of high-strength steel properties, the melting technique effect on high-strength steel properties, BKC-9 steel weldment properties, and the phase-cold hardening effect on BKC-210 steel properties.
R.E.P.

A91-24438#
COMPACT RAMJET COMBUSTION INSTABILITY - AN OVERVIEW
GABRIEL D. ROY (U.S. Navy, Office of Naval Research, Arlington, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1340-1351. refs

A five year research program was sponsored by the U.S. Department of the Navy to address the fundamental physics of combustion instabilities in compact ramjets. The programs focused on the role of fuel characteristics, evaporation and microexplosion of droplets, and the flow structure/acoustic interactions in causing pressure oscillations. In liquid-fueled ramjets, the dynamics of the spray vaporization process has a major impact on the energy release pattern in the combustor and plays an important role in the driving mechanism of combustion instability. It is shown that the development of coherent flow structures and their breakdown into fine scale turbulence can lead to periodic heat release, which when in phase with the pressure oscillation, can lead to Rayleigh's criterion and cause instability. Understanding of the physical processes associated with the vortex breakdown led to the passive control of combustion instability. Non axisymmetrical nozzles and inlets, and acoustic forcing have been successfully employed to minimize pressure oscillations. Direct numerical simulations confirmed the flow field structure/acoustic interactions. Approximate analysis of the instability problem has been formulated and solutions obtained.
Author

A91-24500#
THE EFFECT OF ELECTRIC PROPERTIES OF ADVANCED COMPOSITES ON THE DESIGN OF MODERN AIRCRAFT
PO HSU (Chengdu Aircraft Corp., People's Republic of China) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1951-1957. refs
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The effects of the electric properties of advanced composites on the design of modern aircraft structures and on stealth capability were investigated. It is pointed out that the stealth capability has improved through the use of advanced composites, but that problems connected with electrostatic discharges and electromagnetic interference exist. The need for EMI shielding and

lightning protection for composite structures is addressed. Recent advances in the study of the electric properties of composites in China are reviewed. B.J.

A91-25893#
A REVIEW AND PROSPECT OF PULSATING COMBUSTION
CHUANJUN CAO, DENGFENG XU, CHANGHAIN ZHU, and YUE REN (Beijing University of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 6, Jan. 1991, p. 73-78. In Chinese, with abstract in English. refs

It is well known that pulsating combustion has advantages in fuel saving, pollutant suppression, enhancement of combustion intensity and efficiency, and increase of convective heat and mass transfer rates. The capital investment and operational costs of many systems and processes can be reduced if the pulsating combustion is applied. In this paper, the characteristics of the pulsating combustion are treated and a review with instructive comments on its application is given. The application of the pulsating combustion particularly in the areas of jet propulsion, gas turbine, boiler and heater, drying and ash cleaning is discussed. Author

A91-25898#
A REVIEW OF HIGH-PERFORMANCE THERMOPLASTIC RESINS AND THEIR COMPOSITES
S. BELAND, S. LEE, and R. F. SCOTT (National Aeronautical Establishment, Structures and Materials Laboratory, Ottawa, Canada) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 36, Dec. 1990, p. 202-212. Research supported by the National Research Council of Canada. refs

Recently, a range of commercial composites based on thermoplastic matrix resins has emerged for high-temperature structural applications. The replacement of metallic- and fiber-reinforced thermoset components with these novel materials is now occurring. This review discusses the performance of neat and continuous fiber-reinforced thermoplastic resins in terms of their properties and environmental and chemical resistance. The interrelationships between morphology and properties of semi-crystalline thermoplastic composites are addressed, as well as the factors influencing the morphology. Advantages and disadvantages of processing thermoplastic composites are presented and some examples of aircraft applications of thermoplastic composites are provided. Author

A91-26100
LIQUID HYDROGEN - AN ALTERNATIVE AVIATION FUEL?
ROBERT O. PRICE Aerospace Engineering (ISSN 0736-2536), vol. 11, Feb. 1991, p. 21-25.
Copyright

This paper examines the past and current activities concerning the development of liquid hydrogen as an alternative turbine engine aviation fuel, and also provides a look at the technical and market requirements that determine the viability of substitutes for conventional jet fuel. Alternative aviation fuels must address the following issues: availability, distribution, energy density, compatibility, economics, safety, handling, and quality control. Preliminary hardware demonstrations and analyses have shown that liquid hydrogen seems to be technically feasible, and may be eventually superior to petroleum-based jet fuel. Disadvantages include low ignition energy and a high flame velocity. From the environmental standpoint, hydrogen combustion in aircraft turbine engines can be expected to eliminate smoke emissions, hydrocarbon, and carbon monoxide. As to the marketing perspective, liquid hydrogen has broad applicability as a fuel in other transportation sectors that could allow multiindustry involvement in its development and commercialization. R.E.P.

A91-26176
BORON - STILL FLYING
FRANK COLUCCI Aerospace Composites and Materials (ISSN 0954-5832), vol. 3, Jan.-Feb. 1991, p. 9-11.
Copyright

An overview is presented of the development, applications, and production methods for boron fiber-reinforced composites. The F-14 and F-15 each have about 200 lbs of boron-epoxy skins: the center structure of the Space Shuttle Orbiter is mostly boron-aluminum; and the B-1B has primary structure reinforced with boron-epoxy. Boron filaments are manufactured by chemical vapor deposition. Fine tungsten wire is drawn through boron chloride gas. In structural repairs, boron fiber reinforced patches can have triple the modulus of aircraft aluminum in one-half to one-third the thickness. Bonded to the aircraft exterior, thin, low-drag doublers can be applied without tearing structures apart and without drilling holes that may concentrate stresses and endanger internal wiring and plumbing. Thus, boron can be used to extend fatigue life and can also be applied to enhance under-designed structures. R.E.P.

A91-28184
GENERAL PROCEDURES TO DETERMINE THE COMPOSITION OF COMMERCIAL, TWO-PART POLYSULFIDE AIRCRAFT SEALANTS
BRIAN C. ENNIS, PETER J. HANHELA, ROBERT H. E. HUANG, GEOFFREY J. LONG, and D. BRENTON PAUL (Department of Defence, Materials Research Laboratory, Ascot Vale, Australia) Journal of Applied Polymer Science (ISSN 0021-8995), vol. 41, 1990, p. 2837-2856. refs
Copyright

Procedures are developed to isolate and identify a range of additives in two-part commercial aircraft sealants of both the dichromate and manganese dioxide cure types. Solvents, curing agent dispersants, and cure-rate modifiers are separated chemically. Thermal analysis is demonstrated to provide a ready means to estimate carbon in fillers. The phenolic resin adhesion enhancers are conveniently determined using C-13-NMR spectroscopy and could also be identified using size-exclusion chromatography. It is shown that virtually no interaction occurred between polysulfide liquid polymers and phenolic resins following aging at 70 C for seven days. The most appropriate methods for determining curative levels are established, and new means of assessing thiol content of the polysulfides by both C-13-NMR and PMR spectroscopy are described. The significant aspects of the sealant formulations are discussed. S.A.V.

N91-17144# Air Force Materials Lab., Wright-Patterson AFB, OH. Structural Materials Branch.
THE EFFECT OF JET FUEL EXPOSURE ON ADVANCED AEROSPACE COMPOSITES 2: MECHANICAL PROPERTIES
Final Report, May - Dec. 1989
DAVID B. CURLISS and DIANA M. CARLIN Aug. 1990 26 p
(Contract AF PROJ. 2419)
(AD-A227529; WRDC-TR-90-4064) Avail: NTIS HC/MF A03
CSCL 21/4

The sensitivity of several advanced aerospace composite materials to military jet fuel, JP-4, was investigated in this study. The following commercially available fiber/matrix prepreg materials were used in this investigation: AS-4/3501-6; IM7/8551-7A; IM7/977-2 (1377-2T)/ IM7/5250-4; IM8HTA; and AS-4/PEEK(APC-2). The materials were chosen as representative state-of-the-art materials in their classes of standard epoxy, toughened epoxy, toughened BMI, and thermoplastic matrix composites respectively. The materials were processed into (+ or - 45)2S, (0)12T laminates using the manufacturer's recommended process cycle and standard quality assurance checks were performed on the panels. Standard geometry coupons were fabricated from the panels and divided into a control set and test set. The test coupons were immersed in JP-4 in a sealed pressure vessel at 180 F. The weight gain was recorded as a function of the square root of time and the jet fuel was exchanged each time the coupon weight was recorded. In general, the thermoset matrix composites did not pick-up significant levels of fuel in any lay-up examined; while the thermoplastics did absorb JP-4. The amount of JP-4 absorbed by the thermoplastic matrix composites was dependent on the lay-up. After 1680 hours of

total exposure time the mechanical properties of the coupons were evaluated. GRA

N91-17157*# Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics.
IMPACT RESPONSE OF COMPOSITE MATERIALS Progress Report, period ended 31 Jan. 1991
S. N. TIWARI and K. SRINIVASAN Feb. 1991 57 p
(Contract NAG1-569)
(NASA-CR-187896; NAS 1.26:187896) Avail: NTIS HC/MF A04 CSCL 11/4

Composite materials composed of carbon fibers and resin matrices offer great promise in reducing the weight of aerospace structures. However they remain extremely vulnerable to out of plane impact loads, which lead to severe losses in strength and stiffness. The results of an experimental program, undertaken to investigate the low velocity impact damage tolerance of composite materials is presented. The objectives were to identify key neat resin/composite properties that lead to enhancement of composite impact damage tolerance and to find a small scale test that predicts compression after impact properties of panels. Five materials were selected for evaluation. These systems represented different classes of material behavior such as brittle epoxy, modified epoxies, and amorphous and semicrystalling thermoplastics. The influence of fiber properties on the impact performance was also studied in one material, i.e., in polyether ether ketone (PEEK). Several 24 and 48 ply quasi-isotropic and 24 ply orthotropic laminates were examined using an instrumented drop weight impactor. Correlations with post impact compression behavior were made. Author

N91-17168 Florida State Univ., Tallahassee.
***CONFINED SUPERSONIC MIXING LAYERS: A COMPUTATIONAL INVESTIGATION OF INSTABILITY AND MIXING ENHANCEMENT* Ph.D. Thesis**
FANG QIANG HU 1990 130 p
Avail: Univ. Microfilms Order No. DA9027799

Hydrodynamic instability of a compressible shear mixing layer plays a very important role in controlling and promoting the mixing processes in supersonic combustion problems. At supersonic convective Mach numbers, the natural mixing rates of the shear layer are observed to be very small. The linear spatial instability problem of a supersonic shear mixing layer inside a rectangular channel is solved. A systematic way of calculating and classifying all the normal modes is developed. It is demonstrated that a vortex sheet at high supersonic convective Mach number, neutrally stable when unconfined, becomes unstable when confined. Extensive numerical computations indicate that two classes of unstable supersonic instability waves can be identified. In addition to unstable waves, two families of neutral acoustic waves can also be identified. The characteristics of the unstable waves as well as the neutral waves are determined. It is concluded that the new supersonic instabilities found in this study are the dominant instabilities of a confined mixing layer at high supersonic convective Mach numbers. Thus, they are very relevant to the supersonic combustion problem. The possibility of enhancing the rate of supersonic mixing by means of a periodic Mach wave system is explored. The stability of the periodic basic flow is analyzed numerically by the Floquet theory and the spectral-collocation method. The convergence of the numerical solutions is discussed. New secondary instabilities of the shear layer induced by the periodic Mach waves are found computationally. The growth rate of the new instabilities is found to vary nearly linearly with the ratio of the wavy wall amplitude to the wave length. Therefore, it is a potentially promising scheme for the enhancement of supersonic mixing. Dissert. Abstr.

N91-17244# Oak Ridge National Lab., TN. Metals and Ceramics Div.
CERAMIC TECHNOLOGY FOR ADVANCED HEAT ENGINES PROJECT Semiannual Progress Report, Oct. 1989 - Mar. 1990
Sep. 1990 507 p
(Contract DE-AC05-84OR-21400)
(DE91-005644; ORNL/TM-11586) Avail: NTIS HC/MF A22

This project was developed to meet the ceramic technology requirements of the OTT's automotive technology programs. Advanced heat engine programs have provided evidence that the operation of ceramic parts in high-temperature engine environments is feasible; however, these programs have also demonstrated that additional research is needed in materials and processing development, design methodology, and data base and life prediction before industry will have a sufficient technology base from which to produce reliable cost-effective ceramic engine components commercially. An assessment of needs was completed, and a five-year plan was developed with extensive input from private industry. The objective of the project is to develop the industrial technology base required for reliable ceramics for application in advanced automotive heat engines. The project approach includes determining the mechanisms controlling reliability, improving processes for fabrication existing ceramics, developing new materials with increased reliability, and testing these materials in simulated engine environments to confirm reliability. Although this is a generic materials project, the focus is on the structural ceramics for advanced gas turbine and diesel engines, ceramic bearings and attachments, and ceramic coatings for thermal barrier and wear applications in these engines. The main topics covered include: monolithics, ceramic composites, thermal and wear coatings, ceramic-metal joints, modeling, contact interfaces, structural qualification, time-dependent behavior; environmental effects; fracture mechanics; nondestructive evaluation development; and technology transfer. DOE

N91-18014# Wichita State Univ., KS. Dept. of Aerospace Engineering.
ENVIRONMENTAL EFFECTS ON DELAMINATION OF GRAPHITE EPOXY COMPOSITES
STEVE HOOPER *In its* Proceedings: Techfest 17 p 9-13 1991
Avail: NTIS HC/MF A03

Delamination is a significant, and frequently the critical, failure mode in advanced composite materials. Delaminations are important considerations in the design of composite structures since their presence results in reduced laminate stiffness, strength, and fatigue life. The development of free-edge delamination is generally attributed to the existence of singularities near the interfaces of the laminae in the region of a free edge. For the case of mechanical loading, the stress concentrations develop due to the mismatch in Poisson's ratio between the adjacent plies. For the case of thermal or hygroscopic loading, the singularities are developed as a result of the mismatch in the coefficients of thermal and/or hygroscopic expansion, as well as the mismatch in Poisson's ratio. The question of how a nonuniform moisture distribution affects delamination onset is studied. Tests were conducted on different laminates designs which were exposed to different types of fluids, such as water and jet fuels. The effects of a nonuniform moisture distribution on the total and mixed-mode strain energy release rates were analyzed using a modified theory analysis and a quasi-3D finite element method respectively. Both analyses employed a Fickian moisture diffusion model. Author

N91-18079# Department of National Defence, Ottawa (Ontario). Operational Research and Analysis Establishment.
EVALUATION OF A NEW FUEL WITH HIGHER ENERGY DENSITY
P. E. DESMIER and R. R. HASTINGS *In* AGARD, Progress in Military Airlift 17 p Dec. 1990
Copyright Avail: NTIS HC/MF A14; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

In order to increase the range and endurance of fighters operating in the far northern regions of Canada, and to extend maritime surveillance capability with existing aircraft assets, the Department of National Defence of Canada has pursued the development of an aviation fuel with a high energy density. The fuel selection criteria included: an energy increase of at least 10 percent by volume over current NATO F40/JP-4; acceptable performance and durability impact on aircraft systems; and large scale availability at reasonable cost. A description of the analysis

is provided which was used to determine the potential benefits to be derived from the use of a high energy density fuel. Mission analyses included discussions which cover fighter (CF-18), maritime surveillance (CP-140 Aurora), and tankers (CC-137 and KC-130), aircraft. The fuel characteristics which were perceived to have a potential impact on aircraft or engine military performance are discussed. The results of engine component rig tests are then briefly discussed to demonstrate how critical fuel blend factors were evaluated to ensure that an optimal energy/performance blend was determined. Finally, a description is provided on testing objectives for the subsequent full scale engine performance and durability testing as well as an outline of the final flight certification program for the High Density Fuel (HDF). The test results to date are most encouraging. There appears to be considerable potential for the introduction of HDF to military service. Author

N91-18227 Texas Univ., Arlington.
A NUMERICAL SIMULATION OF SHOCK-ENHANCED MIXING IN SUPERSONIC COMBUSTION Ph.D. Thesis
NEAL DAVID DOMEL 1990 180 p
Avail: Univ. Microfilms Order No. DA9033477

The development of supersonic combustion engines requires the ability to control fuel/air mixing with supersonic shear layers. The qualitative effect of an oblique shock impinging on a reacting shear layer of this type is examined. The Total Variation Diminishing (TVD) scheme is used in a Beam Warming approximate factorization numerical algorithm to solve the 2-D Navier-Stokes (N-S) equations and the species transport equations. The N-S solver is explicitly coupled to the chemistry package and allows for variable specific heats, molecular weights, and heat of formation. Also used is the algebraic turbulence model of Baldwin and Lomax. The TVD N-S solver is tested and validated with a series of nonreacting cases. The fully reacting turbulent flow is then numerically simulated. A comparison is made among five reacting cases. The numerical results of this model are compared to the experimental data of Burrows and Kurkov who ran wind tunnel tests on a combustion case with no shock impingement. The results of this analysis show that the impingement of an oblique shock does enhance the turbulent mixing and combustion. Dissert. Abstr.

N91-18285# Sandia National Labs., Albuquerque, NM.
DEVELOPMENT OF KEVLAR PARACHUTE WEBBINGS
R. H. ERICKSEN 1991 9 p Presented at the 11th AIAA Aerodynamic Decelerator Systems Technology Conference, San Diego, 9-11 Apr. 1991
(Contract DE-AC04-76DP-00789)
(DE91-007513; SAND-90-2306C; CONF-9104171-4) Avail: NTIS HC/MF A02

This paper describes the development of Kevlar webbings for parachute applications. Evaluation of existing webbings and a study of the effects of filling yarn denier and pick count on tensile and joint strength provided data for fabric design. Measurements of warp crimp as a function of filling denier and pick count demonstrated the relationship between warp crimp and strength. One newly developed webbing had higher strength efficiency and another had higher joint efficiency than comparable existing webbings. Both new webbings had overall efficiencies over 5 percent higher than values for existing webbings. DOE

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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.

A91-24331*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NASA PROGRAMS IN ADVANCED SENSORS AND MEASUREMENT TECHNOLOGY FOR AERONAUTICAL APPLICATIONS
BRUCE A. CONWAY (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 242-248. refs
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NASA involvement in the development, implementation, and experimental use of advanced aeronautical sensors and measurement technologies is presently discussed within the framework of specific NASA research centers' activities. The technology thrusts are in the fields of high temperature strain gages and microphones, laser light-sheet flow visualization, LTA, LDV, and LDA, tunable laser-based aviation meteorology, and fiber-optic CARS measurements. IR thermography and close-range photogrammetry are undergoing substantial updating and application. It is expected that 'smart' sensors will be increasingly widely used, especially in conjunction with smart structures in aircraft and spacecraft. O.C.

A91-24356#
THEORETICAL AND EXPERIMENTAL INVESTIGATION OF STRINGER PEELING EFFECTS AT STIFFENED SHEARLOADED COMPOSITE PANELS IN THE POSTBUCKLING RANGE
D. HACHENBERG and H. KOSSIRA (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 511-521. Research supported by Deutsche Airbus GmbH and BMFT. refs
Copyright

Results of an experimental and analytical study of the postbuckling behavior of stiffened graphite-epoxy panels loaded in pure shear are presented. The postbuckling response and failure characteristics of the panels are described. Panels with one and two stiffeners were tested. Failure of all panels originated in a skin-stiffener interface region. A method of computing the forces in the interface region between the skin and the stiffener, using a special contact element within a nonlinear finite element code is described. Analytical results correlate well with typical postbuckling test results up to failure. Typical stress distributions within the skin-stiffener interface region were determined analytically. A failure criterion for peeling delamination based on interlaminar forces is presented. Author

A91-24378#
COMPUTER AIDED FATIGUE AND DAMAGE TOLERANCE SIZING
HANS ANSELL (Saab-Scania, AB, Linkoping, Sweden) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 693-701.
Copyright

The software system for fatigue and damage tolerance sizing at Saab Aircraft Division is demonstrated. The need for fatigue and damage tolerance predictions in the design work of a new aircraft is emphasized. Computer programs for this purpose and

for the loads spectrum handling work are described through an example from the Saab JAS39 Gripen aircraft, all from a stressmans point of view. The sizing approach including prediction and verification of structural integrity through testing is described. Author

A91-24456#
ANALYSIS OF PRECISION SANDWICH STRUCTURES UNDER THERMAL LOADING
WILFRIED ELSPASS and MANFRED FLEMMING (Zuerich, Eidgenoessische Technische Hochschule, Zurich, Switzerland) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1513-1518.
Copyright

Analytical and finite element models have been developed to determine the thermoelastic constants of honeycombs as a homogeneous orthotropic material. It is pointed out that, since honeycomb is considered as a homogeneous orthotropic material, it can be modeled on the basis of knowledge of all nine elastic constants using solid elements in finite-element analysis. This approach simplifies the analysis of sandwich structures, thus improving the accuracy with respect to the in-plane stiffness of the core material. Results are summarized for a honeycomb type 3/16-5056-.001 with a core thickness of t(c) = 1 mm and rigid faceskins. B.J.

A91-24463#
RECENT DEVELOPMENTS IN CFD AT ARA
A. J. BOCCI (Aircraft Research Association, Ltd., Bedford, England) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1569-1585. Research supported by Ministry of Defence Procurement Executive, British Aerospace, PLC, and Dowty Rotol, Ltd. refs
Copyright

The paper discusses recent work in the Theoretical Division at the Aircraft Research Association Limited (ARA) on the modeling complex configurations, rotors, propulsion, and viscous flows. The general features of the ARA multiblock system, which provides a grid generation and Euler flow solution capability for complex configurations, are discussed. Although very successful, the system has various limitations, in particular the tendency for the grid quality to depend on configuration complexity and type. A new multiblock system is being developed which allows regions of unstructured grid to be included, giving increased flexibility in dealing with complex geometries, and other improvements. Work on rotors has included the development of a new Euler code for propellers, as a replacement for the code in current use. Improvements in flow solution offered by the new code are illustrated. In the propulsion field, the extension of a viscous-coupled Euler code for afterbody flows to a complete cowl unit is described briefly. The code is particularly relevant to the new generation of large civil turbofans. Work on Navier-Stokes methods for afterbody/nozzle flows is also discussed. Author

A91-24469*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INTEGRATED FLUID-THERMAL-STRUCTURAL ANALYSIS USING ADAPTIVE UNSTRUCTURED MESHES
PRAMOTE DECHAUMPHAI (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1655-1666. refs
Copyright

An integrated fluid-thermal-structural analysis approach using adaptive unstructured meshes is presented. The approach combines the finite-element method and an adaptive remeshing technique to solve the Navier-tokes equations for high-speed compressible flow, the energy equation for the thermal response of the structure, and the quasi-static equilibrium equations for the structural response. The analysis solution procedure and the adaptive unstructured remeshing technique are described. The effectiveness of the approach is evaluated with three application studies. The adaptive unstructured remeshing procedure and finite-element solution algorithms combine to yield increased accuracy and effiency over standard structured meshes. Author

A91-24477#
DEVELOPMENT OF STRUCTURAL STRENGTH FINITE-ELEMENT ANALYSIS TECHNIQUES
V. D. CHUBAN (Tsentral'nyi Aerogidrodinamicheskii Institut, Moscow, USSR) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1747-1754.
Copyright

The development and application of the finite-element method are reviewed in connection with work done at TsAGI and in the Soviet aircraft industry. Particular emphasis is placed on trends in the development of FEM software and in extension of its field of application. The TsAGI-developed MARS system is described, and examples of its application to the solution of Buran statics/dynamics problems are presented. B.J.

A91-24521*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
DYNAMIC RESPONSE OF ANISOTROPIC COMPOSITE PANELS TO TIME-DEPENDENT EXTERNAL EXCITATIONS
L. LIBRESCU and A. NOSIER (Virginia Polytechnic Institute and State University, Blacksburg) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 2134-2144. refs
(Contract NAG1-749)
Copyright

This paper deals with the dynamic response of anisotropic laminated composite flat panels exposed to sonic boom and explosive blast-type loadings. The pertinent governing equations incorporating transverse shear deformation, transverse normal stress, the higher order effects as well as the viscous structural damping are solved by using the integral-transform technique. The obtained results are compared with their counterparts obtained within the framework of the first order transverse shear deformation and the classical plate theories and some conclusions concerning their range of applicability are outlined. The paper also contains a detailed analysis of the influence played by the various parameters characterizing the considered pressure pulses as well as the material and geometry of the plate. Author

A91-24584#
FINITE ELEMENT METHOD FOR COMPUTING TURBULENT PROPELLER FLOW
DOMINIQUE PELLETIER, ANDRE GARON, and RICARDO CAMARERO (Montreal, Ecole Polytechnique, Montreal, Canada) AIAA Journal (ISSN 0001-1452), vol. 29, Jan. 1991, p. 68-75. Research supported by NSERC, Centre de Recherche Informatique de Montreal, and U.S. Navy. Previously cited in issue 07, p. 1001, Accession no. A88-22033. refs
Copyright

A91-24779* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A SYNCHRONOUS STROBED LASER LIGHT SHEET FOR HELICOPTER MODEL ROTOR FLOW VISUALIZATION
BRADLEY D. LEIGHTY, DAVID B. RHODES, STEPHEN B. JONES, and JOHN M. FRANKE (NASA, Langley Research Center, Hampton, VA) ISA Proceedings (ISSN 0227-7576), 1990, p. 9-22.
Copyright

A synchronous, strobed laser light sheet has been developed for use in flow visualization of a helicopter rotor model. The light sheet strobe circuit included selectable blade position, strobe duration, and multiple pulses per revolution for rotors having 2 to 9 blades. The flow was seeded with propylene glycol. Between

runs, a calibration grid board was placed in the plane of the laser sheet and recorded with the video camera at the position used to record the flow field. A slip-sync mode permitted slow motion visualization of the flow field over complete rotations of the rotor. The system was used to make two-dimensional flow field cuts of a four-bladed rotor operating at advance ratio of 0.37 at wind tunnel speeds up to 79.25 meters per second (260 feet per second). Author

A91-24810
A LOW COST CW CO2 LIDAR SYSTEM FOR LOW-LEVEL WIND SHEAR DETECTION
G. J. FETZER (Ophir Corp., Lakewood, CO) and M. J. POST (NOAA, Environmental Research Laboratory, Boulder, CO) IN: Laser radar V; Proceedings of the Meeting, Los Angeles, CA, Jan. 18, 19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 130-141. refs
(Contract DT-RS57-87-C-00111)
Copyright

A CW CO2 lidar sytem developed to determine the feasibility of using such a system for detecting and measuring low-level wind shear is discussed. The system was constructed from off-the-shelf components at a relatively low cost. Results of preliminary testing of the system are included. Wind shear measurements have been achieved but the capability of the system to measure large-scale microburst-generated wind shear has not been determined at this time. Author

A91-24847
SUPERPLASTIC FORMING - READY FOR THE 1990S
DAVID W. SCHULZ (Exotic Metals Forming Co., Kent, WA) Society of Manufacturing Engineers, Superplastic Forming Clinic, Los Angeles, CA, June 14, 15, 1990. 15 p. refs
(SME PAPER MS90-271) Copyright

The development of the superplastic-forming (SPF) process in 1980s is reviewed starting with the manufacturing methods used for production B1-B aircraft in the United States. Materials available for applications of the SPF process are listed, including titanium alloys, aluminum alloys, and titanium aluminide alloys, as well as metal matrix composite systems. Attention is given to tooling technology and tool materials. Tool inspection is considered, and SPF presses are discussed. Emphasis is placed on applications of SPF components in military and commercial hardware. Increase in dependence on single-sheet SPF manufacturing technology is seen for the 90s. It is pointed out that designers should take into consideration the advantages of the process and materials it offers. V.T.

A91-24848
ABRASIVE FLOW MACHINING OF TURBINE ENGINE COMPONENTS
LAWRENCE J. RHOADES (Extrude Hone Corp., Irwin, PA) Society of Manufacturing Engineers, International Manufacturing Technology Conference '90, Chicago, IL, Sept. 10, 1990. 13 p. refs
(SME PAPER FC90-392) Copyright

A technique used for improving the performance and durability of aircraft turbine engines by flowing abrasive media through critical components is described. The process is abrasive only where the flow is restricted: the extrusion area (the process is also known as extrusion honing). Process parameters including extrusion pressure and the volume of flow are presented, and the tooling and media are covered. The abrasive grains are mostly made of silicon carbide, although boron carbide, aluminum oxide, and diamond may also be used. Some abrasive-flow machining applications in aerospace involve removal of the thermal recast layer in the lasered cooling holes of blades and disks, deburring fuel spray nozzles, and polishing cast surfaces of blades, compressor wheels, and impellers. V.T.

A91-24850
WATERJET CUTTING AND HYDROBRASIVE MACHINING OF AEROSPACE COMPONENTS
DAVID F. WIGHTMAN (Ingersoll-Rand Co., Elmhurst, IL) Society of Manufacturing Engineers. 1990. 15 p. refs
(SME PAPER MR90-672) Copyright

The state-of-the-art manufacturing techniques of waterjet cutting and hydrobrasive machining of aerospace parts are presented. The history of these techniques is outlined, cutting principles are reviewed from the point of view of kinetic energy transfer, and material removal with a waterjet stream are discussed. Hydrobrasive machining adding the injection of abrasive into the cutting stream is described, as well as an alignable orifice head providing maximum stream energy. The importance of alignability is emphasized, and a bulk-abrasive transfer system is discussed along with a water intensifier, high-pressure tubing and fittings, and waterjet cutting nozzle. Applications including machining, near-net shaping, drilling, contouring, and deburring are outlined. V.T.

A91-25288
FORMATION OF ZONES OF ELEVATED PARTICLE CONCENTRATION DURING FOCUSED INJECTION IN A TWO-PHASE MEDIUM [OBRAZOVANIE ZONY POVYSHENNOI KONTSENTRATSII CHASTITS PRI SFOKUSIROVANNOM VDUVE V DVUKHFAZNOI SREDE]
IU. M. DAVYDOV (Nauchno-Issledovatel'skii Institut Avtomaticheskikh Ustroistv, Moscow, USSR) Akademiia Nauk SSSR, Doklady (ISSN 0002-3264), vol. 315, no. 4, 1990, p. 813-815. In Russian.
Copyright

The paper presents results of a numerical experiment on the formation of a p-layer (a layer of elevated particle concentration behind a shock wave in a two-phase medium) during focused two-phase injection from the frontal surface of a blunt body into a single-phase flow. The strong effect of the heterogenous injection on the character of flow past the body and on its aerodynamic characteristics is shown. The results are of interest in connection with the control of the aerodynamic characteristics of flight vehicles. L.M.

A91-25796
DAMAGE-TOLERANCE-BASED LIFE PREDICTION OF AEROENGINE COMPRESSOR DISCS. I - A DETERMINISTIC FRACTURE MECHANICS APPROACH
A. K. KOUL, N. C. BELLINGER, and A. FAHR (National Research Council of Canada, Institute for Aerospace Research, Ottawa) International Journal of Fatigue (ISSN 0142-1123), vol. 12, Sept. 1990, p. 379-387. Research supported by DND. refs
Copyright

This paper reports the results of a demonstration program carried out to determine the influence of the sensitivity and reliability of NDI techniques on the damage-tolerance-based life assessment of aeroengine compressor disks. The program was carried out on AM-355 compressor disks of an aeroengine. The safe inspection intervals (SII) for the disk are calculated using deterministic fracture mechanics (DFM) principles and different initial crack length, a(i); selection criteria. These calculations involve the use of the NDI data, finite-element analysis, and the experimental fatigue crack growth rate data generated on compact tension specimens machined from safe-life-expired disks. The results demonstrate that a sensitive eddy current and the ultrasonic leaky surface wave NDI techniques yield the largest SII values when the longest crack missed and the detectable crack sizes at 90 percent probability of detection (POD) and 90/95 POD are substituted for the a(i) values in the DFM calculations. In all cases, however, the SII values are too short for the damage-tolerance-based life cycle management procedure to be cost effective. Author

A91-25797
DAMAGE-TOLERANCE-BASED LIFE PREDICTION OF AEROENGINE COMPRESSOR DISCS. II - A PROBABILISTIC FRACTURE MECHANICS APPROACH
A. K. KOUL, N. C. BELLINGER, and G. GOULD (National Research Council of Canada, Institute for Aerospace Research, Ottawa) International Journal of Fatigue (ISSN 0142-1123), vol. 12, Sept.

1990, p. 388-396. Research supported by DND. refs
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A91-25844
NUMERICAL MODELING OF TURBULENT EVAPORATING GAS-DROPLET TWO-PHASE FLOWS IN AN AFTERBURNER DIFFUSOR OF TURBO-FAN JET ENGINES
LIXING ZHOU and JIAN ZHANG (Qinghua University, Beijing, People's Republic of China) Chinese Journal of Aeronautics (ISSN 1000-9361), vol. 3, Nov. 1990, p. 258-265. Research sponsored by the Ministry of Aerospace of People's Republic of China. refs
Copyright

Two-dimensional turbulent evaporating gas-droplet two-phase flows in an afterburner diffusor of turbofan jet engines are simulated here by a k-epsilon turbulence model and a particle trajectory model. Comparison of predicted gas velocity and temperature distributions with experimental results for the cases without liquid spray shows good agreement. Gas-droplet two-phase flow predictions give plausible droplet trajectories, fuel-vapor concentration distribution, gas-phase velocity and temperature field in the presence of liquid droplets. One run of computation with this method is made for a particular afterburner. The results indicate that the location of the atomizers is not favorable to flame stabilization and combustion efficiency. The proposed numerical modeling can also be adopted for optimization design and performance evaluation of afterburner combustors of turbofan jet engines. Author

A91-25887#
A RESEARCH ON CRACKED FAILURES OF FIR-TREE SERRATION IN AEROENGINE TURBINE DISC
HUAXING YAO and SHALIN YAN (Shenying Aeroengine Co., People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 6, Jan. 1991, p. 51-53. In Chinese, with abstract in English.

A lot of crack failures of fir-tree serration occurred in the second-stage turbine disk of a large number of certain types of aeroengines in service. In order to find out the cause for the crack failure, the vibrating stresses of the second-stage turbine blades on test benches and their vibrating strains in flight tests have been measured in conditions of high temperature and high rotational speed. The measured data indicate that several resonance zones really exist in the second stage turbine blades of type A and B engines. Some methods for elimination of the crack failures of fir-tree serration in the turbine disk are provided. Author

A91-26088#
MODELING COMPRESSIBLE TURBULENT FLOW IN PROPULSION - POSSIBILITIES, LIMITATIONS AND REQUIREMENTS [MODELISATION DES ECOULEMENTS TURBULENTS COMPRESSIBLES EN ENERGETIQUE - POSSIBILITES, LIMITES ACTUELLES ET BESOINS]
ELIANE RUIZ and DENIS DUTOYA (ONERA, Chatillon, France) ONERA, TP no. 1990-187, 1990, 28 p. In French. refs
(ONERA, TP NO. 1990-187)

An overview is presented of current models in use for the study of internal airflows in rockets, ramjets and turbine engines. Various modeling possibilities for studying compressibility effects are examined. Results of four tests of compressible flows conducted on the different engine types are presented. The majority of available turbulent flow models have focused on incompressibility and this paper, therefore, analyzes their capabilities and deficiencies in order to identify the origin of the defects. An attempt has been made to validate specified aerothermodynamic flow calculation codes. Finally, the question of which may be the best model to use for manufacturing calculations is discussed. R.E.P.

A91-26121*# Northwest Research Associates, Inc., Bellevue, WA.
MEASUREMENTS AND IMPLICATIONS OF VORTEX MOTIONS USING TWO FLOW-VISUALIZATION TECHNIQUES
DONALD P. DELISI (Northwest Research Associates, Inc., Bellevue, WA) and GEORGE C. GREENE (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Nov. 1990, p. 968-971. refs
(Contract N0014-88-C-0284; N00014-89-C-0030)
Copyright

The present comparative study of two different, but complementary flow-visualization techniques, which yield different interpretations of vortex-migration distance and lifetime, gives attention to the difficulty of determining vortex evolution and lifetime from flow-visualization measurements. The techniques involved the release of a fluorescent dye and of neutrally buoyant particles in a water-filled towing tank. Vortices are found to migrate farther, and last longer, when visualized with neutrally buoyant particles rather than with dyes. O.C.

A91-26228 National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ADVANCES AND TRENDS IN COMPUTATIONAL STRUCTURES TECHNOLOGY
A. K. NOOR (NASA, Langley Research Center; Virginia, University, Hampton) and S. L. VENNERI (NASA, Washington, DC) Computing Systems in Engineering (ISSN 0956-0521), vol. 1, no. 1, 1990, p. 23-36. refs
Copyright

The major goals of computational structures technology (CST) are outlined, and recent advances in CST are examined. These include computational material modeling, stochastic-based modeling, computational methods for articulated structural dynamics, strategies and numerical algorithms for new computing systems, multidisciplinary analysis and optimization. The role of CST in the future development of structures technology and the multidisciplinary design of future flight vehicles is addressed, and the future directions of CST research in the prediction of failures of structural components, the solution of large-scale structural problems, and quality assessment and control of numerical simulations are discussed. C.D.

A91-26328*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TURBULENT BOUNDARY LAYER SEPARATION OVER A REARWARD FACING RAMP AND ITS CONTROL THROUGH MECHANICAL EXCITATION
DANIEL J. MCKINZIE, JR. (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 27 p. refs
(AIAA PAPER 91-0253) Copyright

A vane which oscillates about a fixed point at the inlet to a two-dimensional, 20-deg rearward-facing ramp has been noted to effectively delay the separation of a turbulent boundary layer. A parametric study has been conducted to determine the variation of the maximum values of the static pressure recovery, measured close to the ramp exit as a function of the oscillation frequency of the vane. The resulting curves show a peak value in the maximum static pressure recovery as a function of the vane's oscillation frequency. For the excited cases, corona anemometer measurements in the inner wall regions of the boundary layer along the surface of the ramp show a large range of unsteadiness in the local velocities. Finally, a qualitative explanation of the phenomena of delay of separation is discussed which appears to be supported by the surface static pressure and flow field measurements obtained. O.C.

A91-26442
AMPLIFIERS IN THE RADIO-ELECTRONIC EQUIPMENT OF AIRCRAFT [USILITELI V RADIOELEKTRONNOM OBORUDOVANII VOZDUSHNYKH SUDOV]
VLADIMIR IA. KHOL'NYI Moscow, Izdatel'stvo Radio i Sviaz', 1990, 256 p. In Russian. refs
Copyright

The applications, classification, and technical specifications of airborne electronic amplifiers are discussed. Particular attention is given to the general design and principles of operation of single

amplification cascades and multicascade amplifiers, including dc, audio, and video amplifiers used as part of the radio-electronic equipment of modern aircraft. The discussion also covers the principal technical and performance characteristics of various amplifiers, their operating conditions, service, and repair. V.L.

A91-26444
FIXTURES FOR THE MANUFACTURE OF AIRCRAFT ENGINES (STRUCTURAL DESIGN) [PRISPOSOBLENIIA DLIA PROIZVODSTVA DVIGATELEI LETATEL'NYKH APPARATOV /KONSTRUKTSIIA I PROEKTIROVANIE/]
VASILII A. SHMANEV, ALEKSANDR P. SHULEPOV, and LEONID A. ANIPCHENKO Moscow, Izdatel'stvo Mashinostroenie, 1990, 256 p. In Russian. refs
Copyright

The theory and methods of the design of machine tool fixtures for the production of aircraft engines are examined. The general designs of fixture components are presented, as are methods of precision and cost effectiveness analyses for different levels of mechanization and automation. The types of fixtures considered include clamps, guides, indexers, and special fixtures for lathes, drills, milling machines, and multiple-purpose machine tools, including computer-controlled programmable machines. The principles of computer-aided design are discussed. V.L.

A91-26565#
THE NUMERICAL NAVIER-STOKES SOLUTION OF TWO-DIMENSIONAL FLOW WITH TRANSVERSE INJECTION
ZHENGHUA WANG and CHENGYAO WANG (National University of Defence Technology, People's Republic of China) Journal of Propulsion Technology (ISSN 1001-4055), Feb. 1991, p. 24-29. In Chinese, with abstract in English. refs

Injecting a jet stream into a supersonic external flow is a common technique for flight control of aerospace vehicles. In this paper, the MacCormack explicit scheme and the Baldwin-Lomax algebraic turbulence model are employed to solve the two-dimensional compressible Reynolds-averaged Navier-Stokes equations for supersonic and hypersonic external flow over a rearward-facing step with transverse injection. The velocity vector field and the pressure contour of the field are given to clarify the interaction phenomena. The interaction effects increase with the width of the slot, but are insensitive to the freestream Mach number. Adding the fourth-difference dissipation to a central difference scheme in shock-free regions can increase the convergence rate and is necessary for the hypersonic problem with transverse injection. Author

A91-26645
OPTIMIZATION: METHODS AND APPLICATIONS, POSSIBILITIES AND LIMITATIONS; PROCEEDINGS OF THE INTERNATIONAL SEMINAR, BONN, FEDERAL REPUBLIC OF GERMANY, JUNE 7, 8, 1989
H. W. BERGMANN, ED. (DLR, Institut fuer Strukturmechanik, Brunswick, Federal Republic of Germany) Seminar sponsored by DLR. Berlin and New York, Springer-Verlag (Lecture Notes in Engineering. Vol. 47), 1989, 151 p. For individual items see A91-26646 to A91-26650.
Copyright

Recent advances in optimization methods are discussed in a collection of review essays. Topics addressed include the 'three columns' approach to optimum structural design, mathematical optimization methods, multidisciplinary optimization for engineering systems, the optimization of axially compressed fiber-composite cylindrical shells, the structural optimization of aircraft, evolution strategies as nature's approach to optimization, computer-aided design of proteins, and the philosophical implications of technological optimization. T.K.

A91-26647
METHODS OF MATHEMATICAL OPTIMIZATION
G. N. VANDERPLAATS (Engineering Design Optimization, Inc., Santa Barbara, CA) IN: Optimization: Methods and applications, possibilities and limitations; Proceedings of the International Seminar, Bonn, Federal Republic of Germany, June 7, 8, 1989. Berlin and New York, Springer-Verlag, 1989, p. 22-41. refs
Copyright

The fundamental principles of numerical optimization methods are reviewed, with an emphasis on potential engineering applications. The basic optimization process is described; unconstrained and constrained minimization problems are defined; a general approach to the design of optimization software programs is outlined; and drawings and diagrams are shown for examples involving (1) the conceptual design of an aircraft, (2) the aerodynamic optimization of an airfoil, (3) the design of an automotive-engine connecting rod, and (4) the optimization of a 'ski-jump' to assist aircraft in taking off from a very short ship deck. T.K.

A91-26752
THE EFFECT OF SIDE LOADS ON THE ENERGY ABSORPTION OF COMPOSITE STRUCTURES
D. C. FLEMING and A. J. VIZZINI (Maryland, University, College Park) IN: American Society for Composites, Technical Conference, 5th, East Lansing, MI, June 12-14, 1990, Proceedings. Lancaster, PA, Technomic Publishing Co., Inc., 1990, p. 611-620. Research supported by U.S. Army. refs
Copyright

Slightly tapered truncated cones were manufactured from graphite/epoxy preimpregnated unidirectional tape and were loaded in compression. Different amounts of side loads were introduced by orienting the loading axis away from the central axis of the cone. The cones were crushed under quasi-static conditions, and their energy absorption was measured. For small amounts of side load, the energy absorbency was improved; however, as the amount of side load is increased further, the energy absorption capability of the structure is reduced significantly. Furthermore, a tendency for the specimen to topple is observed as a result of the moment induced by the side loads and reduces the energy absorption properties even further. Author

A91-26767* Virginia Polytechnic Inst. and State Univ., Blacksburg.
STATIC AND DYNAMIC RESPONSE OF GRAPHITE-EPOXY CURVED FRAMES
J. S. COLLINS (Pima Community College, Tucson, AZ) and E. R. JOHNSON (Virginia Polytechnic Institute and State University, Blacksburg) IN: American Society for Composites, Technical Conference, 5th, East Lansing, MI, June 12-14, 1990, Proceedings. Lancaster, PA, Technomic Publishing Co., Inc., 1990, p. 859-868. refs
(Contract NAG1-343)
Copyright

Experiments were conducted to measure the three-dimensional static and vibratory response of two graphite-epoxy, thin-walled, open section frames. The frames are semicircular with a radius of three feet. One specimen had an I cross section and the other had a channel cross section. The experimental data is used to evaluate a mixed finite element model of the frames that is based on Vlasov-type, thin-walled, open section curved beam theory. Author

A91-27368
SOME REMARKS ON THE THEORY OF IRREGULAR REFLECTION OF A SHOCK WAVE FROM A SURFACE
A. GALKOWSKI (Institute of Plasma Physics amnd Laser Microfusion, Warsaw, Poland) Archiwum Mechaniki Stosowanej (ISSN 0373-2029), vol. 41, no. 6, 1989, p. 837-855. refs
Copyright

Decay of the initial discontinuity is interpreted as a mechanism of passage from a regular to an irregular phase in the problem of nonstationary reflection of a shock wave from a surface. Modification of the Mach triple point theory resulting from the hypothesis presented is considered. Author

A91-27786#
INVESTIGATION OF INTELLIGENT MEASUREMENT SYSTEM FOR AERO-ENGINE EXPERIMENTS
WEISONG WANG (Gas Turbine Establishment, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, July 1990, p. 209-212. In Chinese, with abstract in English.

An intelligent aero-engine measurement system has been developed. The system is original and new in its global design. It integrates data acquisition, real-time calibration, displacement control, angle tracking, data processing, and table printing. The system has been used successfully in combustion and turbine testing; its technical and economic effectiveness has been proved remarkable. Author

A91-27791#
VIBRATION DIAGNOSIS AND VIBRATION SOURCE ANALYSIS OF AIRCRAFT ENGINE
XIFA LI, LUN QIU, JUAN YI, and ZHAOBING MENG (Air Force Research Institute No. 1, People's Republic of China) Journal of Aerospace Power (ISSN 1000-8055), vol. 5, July 1990, p. 229, 230. In Chinese, with abstract in English.

This paper reviews recent advances in aircraft-engine vibration monitoring and diagnosis in flight. An airborne vibration data acquisition unit, the ground analysis equipment, and the method for analyzing vibration signals are given. Applications prove that it is feasible to perform vibration signal recording and frequency spectrum analysis in flight. Author

A91-27911*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONDENSATION EFFECTS ON RAYLEIGH SCATTERING MEASUREMENTS IN A SUPERSONIC WIND TUNNEL
B. SHIRINZADEH, M. E. HILLARD, and R. J. EXTON (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 29, Feb. 1991, p. 242-246. refs
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Rayleigh and Raman scattering measurements have been performed in the 20-in., Mach 6 wind tunnel at the NASA Langley Research Center. Rayleigh results show signal levels much higher than expected for molecular scattering in the tunnel, whereas densities deduced from spontaneous Raman scattering of molecular nitrogen are in good agreement with the expected nitrogen densities in the facility. The apparent discrepancy in the Rayleigh result is attributed to cluster formation as a result of expansion in the tunnel. The dependence of the Rayleigh signal on the stagnation pressure and temperature is also discussed. Author

A91-28302
COMPARISON OF EXPERIMENTAL AND ANALYTICAL ESTIMATIONS FOR THE MODAL DENSITY OF A RING-STIFFENED CYLINDER
PAUL M. SERATI and STEVEN E. MARSHALL (Boeing Commercial Airplanes, Seattle, WA) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 2. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 1199-1202. refs
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The feasibility of applying to complex aircraft-type structures the relationship developed by Cremer et al. (1973) between the modal density of a structure and spatially averaged drive-point mobility measurements is demonstrated by using drive point mobility measurements to derive values of modal density for an aluminum ring-stiffened thin-walled cylinder. The dimensions of the cylinder were designed to simulate the dynamic behavior of a half-scale commercial aircraft fuselage. Experimental results showed good agreement with results obtained from an analytical mode-counting method, suggesting that the technique may be applied to both nonuniform and simple uniform structures. It was found that, in case of nonuniform stiffened structures, spatial averaging of measurements was necessary, due to the large range in the measured drive point mobility . I.S.

N91-17253# Army Cold Regions Research and Engineering Lab., Hanover, NH.
PREDICTING THE BEHAVIOR OF ASPHALT CONCRETE PAVEMENTS IN SEASONAL FROST AREAS USING NONDESTRUCTIVE TECHNIQUES Final Report
VINCENT C. JANOO and RICHARD L. BERG Nov. 1990 62 p
Sponsored by FAA, Washington, DC
(Contract DA PROJ. 4A7-62784-AT-42)
(CRREL-90-10; DOT/FAA/RD-90/33) Avail: NTIS HC/MF A04

Four different pavement test sections were subjected to freeze-thaw cycling in the Frost Effects Research Facility (FERF). The test sections, each 610 cm in length, consisted of 15.2 cm of asphalt concrete pavement over a clay subgrade; 15.2 cm of asphalt concrete over 10.2 cm of crushed gravel over a clay subgrade; 5.1 cm of asphalt over 17.8 cm of crushed gravel over 20.3 cm of clean sand over a clay subgrade; and 5.1 cm of asphalt concrete over 25.4 cm of crushed gravel over 12.7 cm of clean sand over clay subgrade. Thermocouples were imbedded throughout the pavement structure and subgrade. During the thawing periods, deflection measurements were made at four locations in each test section using a Dynatest Falling Weight Deflectometer (FWD). The results of the deflection measurement are presented here. An analysis was done to qualify the subgrade strength based solely on FDW measurements. It was also shown that a relationship existed between thaw depth and FWD measurement in the subgrade. Author

N91-17264# Massachusetts Inst. of Tech., Lexington. Lincoln Lab.
BEAM FILLING LOSS ADJUSTMENTS FOR ASR-9 WEATHER CHANNEL REFLECTIVITY ESTIMATES
CYNTHIA D. ENGHOLM and SETH W. TROXEL 23 Oct. 1990 57 p
(Contract DTFA01-L-83-4-10579)
(AD-A228654; ATC-177; DOT/FAA/NR-90/6) Avail: NTIS HC/MF A04 CSCL 17/9

The FAA is deploying over 100 new airport surveillance radars (ASR-9) across the country. In contrast to earlier ASRs, the ASR-9 utilizes a separate digital weather processing channel to provide air traffic controllers with timely, calibrated displays of precipitation intensity. The ASR-9 utilizes dual selectable fan shaped elevation beams designed to track aircraft over a large volume. As a consequence, weather echoes received from these fan shaped beams represent vertically averaged quantities. If the precipitation only partially or nonuniformly fills the beam, then the vertically integrated reflectivity may underestimate the actual intensity of the storm. The ASR-9 weather channel corrects for this by adjusting the range dependent six level reflectivity thresholds. The appropriateness of the currently implemented correction has not been carefully examined and may require modification to take into account regional and morphological variability in storm structure. The method used to derive new beam filling loss adjustments is discussed. An extensive database of volumetric pencil beam radar data were used in conjunction with the ASR-9 simulation facility to derive adjustments aimed at calibrating the precipitation intensity reports to the maximum perceived hazard. Results from this calibration indicate that a single correction is appropriate for all sites and intensities. The new corrections yield substantially improved results over the current corrections in producing these reflectivity reports. GRA

N91-17332 Tennessee Univ., Knoxville.
A STUDY OF JETS IN CROSSFLOW AND ITS APPLICATION ON WINGTIP BLOWING Ph.D. Thesis
ZHI SHI 1990 141 p
Avail: Univ. Microfilms Order No. DA9030735

The flowfield associated with jets in crossflow and their applications to the flowfield near the tip of a wing are studied both numerically and experimentally. The flowfields of different shaped jets oriented in crossflow were studied numerically. The predicted flow features generally agreed well with measurements and observations. Qualitatively, most of the basic flow physics were captured numerically, particularly for circular jet cases where

data is available for comparisons. Periodic vortex formations were captured both at the front and the rear bound shear layers of the jet plume. The well known counter-rotating vortex pair is symmetric for a symmetrically oriented jet but is asymmetric for asymmetric jet. The source of these vortices is the jet-pipe boundary-layer vorticity. For any shaped jet, a pair of vertical twin tornado-like wake vortices would always form behind the jet plume due to the lower pressure at that region. These wake vortices are asymmetric in position and different on size for an asymmetrically placed jet. The source of these vortices is the crossflow boundary-layer vorticity. An experimental investigation of discrete wingtip jets was also conducted in both water and wind tunnels as an important application. Careful flow visualization revealed that the local perturbation introduced by the wingtip jet closely resembles that of asymmetric jets blowing from a flat plate. All types of vortices observed in the latter flowfield were identified in the flowfield generated by the wingtip jet. It was reconfirmed that the wingtip jets effectively dispersed the tip vortex and that the individual jet location and blowing momentum are the major parameters. Wing surface pressure measurements indicated that wingtip jets affected the global surface pressure distribution over the wing and improved its lift. Dissert. Abstr.

N91-17421 Clemson Univ., SC.
ANALYSIS OF THE INTERLAMINAR STRESS COMPONENTS AT THE SKIN/STIFFENER INTERFACE OF AN ADVANCED-CONCEPT STIFFENED PANEL Ph.D. Thesis
JACOBUS FREDERIKUS M WIGGENRAAD 1990 225 p
Avail: Univ. Microfilms Order No. DA9033434

A grid-stiffened panel of fiber-reinforced composite material with a laminated skin and stiffeners of unidirectional material is investigated. The stiffeners are joined to the skin by a laminate which forms a wrap around the stiffeners. A numerical analysis of the interlaminar stress state at the interfaces of skin, stiffener, and wrap is presented. The influence of design parameters is evaluated. A procedure was developed to generate a finite element model of a generic grid-stiffened panel using shell elements, named Global Model. This procedure was used to design a grid-stiffened wing panel that satisfied specified design criteria, and to obtain its displacements at the design load via a nonlinear analysis. A second procedure was developed to generate a generic finite element model of a detailed skin-stiffener combination, utilizing three-dimensional finite elements, named Local Model. The interlaminar stress components were determined with the Local Model by applying displacements obtained previously with the Global Model. Author

N91-17428*# McDonnell-Douglas Helicopter Co., Mesa, AZ.
FINITE ELEMENT MODELING OF THE HIGHER HARMONIC CONTROLLED OH-6A HELICOPTER AIRFRAME
DOUGLAS FERG and MOSTAFA TOOSSI Oct. 1990 66 p
(Contract NAS1-17498)
(NASA-CR-187449; NAS 1.26:187449) Avail: NTIS HC/MF A04
CSCL 20/11

An MSC/NASTRAN finite element model of the higher harmonic control configured OH-6A helicopter fuselage was developed. This finite element model was verified by performing various model checkouts and correlation with results from a ground vibration test. Author

N91-18011# Wichita State Univ., KS. Dept. of Mechanical Engineering.
NEURAL NETWORKS IN FLAW DETECTION Abstract Only
BEHNAM BAHR and NABEEL TARABISHY *In its* Proceedings: Techfest 17 p 8 1991
Avail: NTIS HC/MF A03

Many non-destructive inspection methods such as vision system, ultrasonic, and eddy current may be used for flaw detection of aircraft structures. These method require a skilled technician to identify flaws. Human error was identified to be a major contributing factor in probability of detection of defects or false calls. A neural network and its usage for aiding the technician in detecting the defects are discussed. Author

N91-18015# Wichita State Univ., KS. Dept. of Mechanical Engineering.
USE OF NATURAL PARTICLES FOR THE REMOVAL OF PAINT FROM AERONAUTICAL COMPOSITE MATERIALS Abstract Only
THU-HA GUY, HAMID M. LANKARANI, and JORGE E. TALIA *In its* Proceedings: Techfest 17 p 14 1991
Avail: NTIS HC/MF A03

Paint removal by blasting and its effects on the surface morphology of aeronautical composite materials are investigated. An ideal combination of the parameters for mechanical paint removal by blasting such as particle type, size, velocity and angle of incidence yields a stripped aircraft skin substrate with minimal or no damage. Natural particles, specifically white corn flour, seem to be a good choice for paint removal by blasting. Since they are softer as well as smaller in size than other particles used for paint removal, they minimize the amount of damage to the surface of the composite. They are also cheaper and produce no harm to environment. The variation of the degree of surface roughness and the amount of broken fibers were correlated with some stripping parameters, such as particle impact angle and velocity. This defined an optimum environment for paint removal by blasting. Author

N91-18016# Wichita State Univ., KS. Dept. of Mechanical Engineering.
ANALYSIS OF RESIDUAL STRESS IN PLASTIC-MEDIA-BLASTED THIN ALUMINUM SKIN BY X-RAY DOUBLE CRYSTAL DIFFRACTOMETRY Abstract Only
J. CHAUDHURI, Y. M. TAN, and K. PATNI (Cessna Aircraft Co., Wichita, KS.) *In its* Proceedings: Techfest 17 p 15 1991
Avail: NTIS HC/MF A03

Plastic media blasting technique, also frequently called dry stripping, refers to the use of light weight lightly abrasive plastic grit to remove coatings by a combination of cutting and chipping actions. The x-ray double crystal diffractometry technique was used to measure residual stresses in plastic media blasted 0.032 in. thick Alclad 2024 aluminum sheet material, which is representative of the fuselage skin of most Cessna aircraft models. Among the blasting parameters, the velocity, angle-of-attack, and distance were varied in order to determine an optimum blasting condition. Author

N91-18025# Wichita State Univ., KS. Dept. of Aerospace Engineering.
COMPUTATIONAL FLUID DYNAMICS IN AEROSPACE ENGINEERING AT WICHITA STATE UNIVERSITY Abstract Only
STEVE KLAUSMEYER, S. REDDY, X. LUI, and M. PAPADAKIS *In its* Proceedings: Techfest 17 p 24 1991
Avail: NTIS HC/MF A03

A summary of recent research performed in the department of Aerospace Engineering of the Wichita State University in the field of Computational Fluid Dynamics is presented. Computer codes developed and solutions obtained for a variety of flow conditions are also presented. The following subject areas are covered: steady and unsteady free and impinging 2D jet flows; viscous and inviscid solutions for airfoils at subsonic, transonic, and supersonic speeds; the shock wave interaction evaluation for a complex geometry in hypersonic flow; and 3D flow about a delta wing. Y.S.

N91-18027# Wichita State Univ., KS. Dept. of Mechanical Engineering.
LDV MEASUREMENTS OF A JET IN A CROSSFLOW Abstract Only
JULIE A. MATHIS *In its* Proceedings: Techfest 17 p 26 1991
Avail: NTIS HC/MF A03

Measurements of the flow field created by a jet exhausting into a wind tunnel crossflow are obtained with laser Doppler velocimetry (LDV) techniques. Results are summarized and compared with predictions of a computational model, and the limitations of computational fluid dynamics as applied to turbulent flow fields are discussed. Analysis of the velocity time evolution

data collected provides information on the turbulent microstructure of the flow. The fractal dimension of the microstructures is estimated, and its relevance is discussed. Author

N91-18307*# Ohio State Univ., Columbus. Dept. of Electrical Engineering.
SATCOM ANTENNA SITING STUDY ON A P-3C USING THE NEC-BSC V3.1
D. BENSMAN and R. J. MARHEFKA Apr. 1990 326 p
(Contract NAG2-542)
(NASA-CR-187949; NAS 1.26:187949; ESL-TR-721711-2) Avail: NTIS HC/MF A15 CSCL 20/14

The location of a UHF SATCOM antenna on a P-3C aircraft is studied using the NEC-Basic Scattering Code V3.1 (NEC-BSC3). The NEC-BSC3 is a computer code based on the uniform theory of diffraction. The code is first validated for this application using scale model measurements. In general, the comparisons are good except in 10 degree regions near the nose and tail of the aircraft. Patterns for various antenna locations are analyzed to achieve a prescripted performance. Author

N91-18340# Federal Aviation Administration, Atlantic City, NJ.
CONTROLLER EVALUATION OF INITIAL DATA LINK TERMINAL AIR TRAFFIC CONTROL SERVICES Final Report
Jan. 1991 68 p
(Contract T2001E)
(DOT/FAA/CT-90/29) Avail: NTIS HC/MF A04

The results of the first Federal Aviation Administration (FAA) Technical Center investigation of the initial terminal air traffic control services were evaluated in order to identify service delivery methods which optimize controller acceptance, performance, and workload. Author

N91-18397*# Institute for Computer Applications in Science and Engineering, Hampton, VA.
APPLICATION OF A NEW K-TAU MODEL TO NEAR WALL TURBULENT FLOWS Final Report
S. THANGAM, R. ABID, and CHARLES G. SPEZIALE Feb. 1991 12 p Previously announced in IAA as A91-19383 Submitted for publication
(Contract NAS1-18605)
(NASA-CR-187518; ICASE-91-16; NAS 1.26:187518) Avail: NTIS HC/MF A03 CSCL 20/4

A recently developed K-tau model for near wall turbulent flows is applied to two severe test cases. The turbulent flows considered include the incompressible flat plate boundary layer with the adverse pressure gradients and incompressible flow past a backward facing step. Calculations are performed for this two-equation model using an anisotropic as well as isotropic eddy-viscosity. The model predictions are shown to compare quite favorably with experimental data. Author

N91-18398# National Aeronautical Lab., Bangalore (India). Propulsion Div.
PREDICTION OF FLOW WITHIN SUPERCRITICAL COMPRESSOR CASCADE USING A TIME MARCHING METHOD
H. GIRIGOSWAMI Sep. 1990 10 p
(NAL-PD-PR-9013) Avail: NTIS HC/MF A02

A semi-explicit time marching method is used to solve two dimensional Euler equations for a supercritical cascade which was designed by Garabedian and Korn, using complex characteristics. It is a time dependent damping surface method which gives a second order time accurate steady state solution. An H-type grid with finite volume formulation is adopted here. For a set of H-type grids, the computed surface Mach number distributions are compared with the design values. Smooth grids are observed to produce reasonable accurate solutions. Author

N91-18445*# McDonnell-Douglas Helicopter Co., Mesa, AZ.
PLAN, FORMULATE, AND DISCUSS A NASTRAN FINITE ELEMENT MODEL OF THE AH-64A HELICOPTER AIRFRAME
RICHARD A. CHRIST, DOUGLAS A. FERG, KEVIN A. KILROY, MOSTAFA TOOSSI, and RICHARD K. WEISENBURGER Oct. 1990 111 p
(Contract NAS1-17498)
(NASA-CR-187446; NAS 1.26:187446) Avail: NTIS HC/MF A06 CSCL 20/11

A discussion of modeling plan objectives, followed by a description of the AH-64A aircraft including all general features, major components, and primary and structure definitions are presented. Following the aircraft description, a discussion of the modeling guidelines and model checkout procedure are provided. The NASTRAN finite element analysis is set up to be suitable to predict both static internal loads and vibrations. Finally, the results, schedule, and planned versus actual manhours for this work are presented. Author

N91-18457# Technische Univ., Berlin (Germany, F.R.). Physikalische Ingenieurwissenschaft.
CONSEQUENCES OF FRICTION IN LENGTH COMPENSATION FOR PROPELLER SHAFTS WITH BENDING VIBRATIONS AND BEARING FORCES Ph.D. Thesis [ANSWIRKUNGEN DER REIBUNG IM LAENGENAUSGLEICH VON GELENKWELLEN AUF BIEGESCWINGUNDEN UND LAGERKRAEFT]
ALY EL-KAFRAWY 1989 232 p In GERMAN
(ETN-91-98783) Avail: NTIS HC/MF A11

The computerized examination of the consequences of friction in length compensation of propeller shafts showed that an influence of bending vibration behavior of propeller shafts is given. It is also acting on the dynamic loading of the propeller shaft itself, the piping, and the welding connections. It also has a notable effect on the trunnion loading. It is of importance to reduce to a minimum the oscillations and the additional loads of the main bearing and of the trunnion, on account of friction in length compensation. Great attention should be given to the machining and the lubrication, in order to reduce the frictional force. ESA

N91-18979*# Alabama Univ., Tuscaloosa. Dept. of Mechanical Engineering.
MECHANICAL DESIGN PROBLEMS ASSOCIATED WITH TURBOPUMP FLUID FILM BEARINGS
CHARLES R. EVCES *In its* Research Reports: 1990 NASA/ASEE Summer Faculty Fellowship Program 4 p Oct. 1990
(Contract NGT-01-002-099)
Avail: NTIS HC/MF A16 CSCL 13/11

Most high speed cryogenic turbopumps for liquid propulsion rocket engines currently use ball or roller contact bearings for rotor support. The operating speeds, loads, clearances, and environments of these pumps combine to make bearing wear a limiting factor on turbopump life. An example is the high pressure oxygen turbopump (HPOTP) used in the Space Shuttle Main Engine (SSME). Although the HPOTP design life is 27,000 seconds at 30,000 rpms, or approximately 50 missions, bearings must currently be replaced after 2 missions. One solution to the bearing wear problem in the HPOTP, as well as in future turbopump designs, is the utilization of fluid film bearings in lieu of continuous contact bearings. Hydrostatic, hydrodynamic, and damping seal bearings are all replacement candidates for contact bearings in rocket engine high speed turbomachinery. These three types of fluid film bearings have different operating characteristics, but they share a common set of mechanical design opportunities and difficulties. Results of research to define some of the mechanical design issues are given. Problems considered include transient strat/stop rub, non-operational rotor support, bearing wear inspection and measurement, and bearing fluid supply route. Emphasis is given to the HPOTP preburner pump (PBP) bearing, but the results are pertinent to high-speed cryogenic turbomachinery in general. Author

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GEOSCIENCES

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

A91-24627
CASE STUDY - THE APPLICATION OF A GEOGRAPHIC INFORMATION SYSTEM (GIS) IN THE IMPLEMENTATION OF A PART 150 NOISE COMPATIBILITY PROGRAM
GREGORY B. DARBY (Darby and Way, Inc., Pompano Beach, FL) IN: 1989 ASPRS-ACSM Fall Convention, Cleveland, OH, Sept. 17-21, 1989, ASPRS Technical Papers. Bethesda, MD, American Society for Photogrammetry and Remote Sensing, 1989, p. 1-6.
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An approach and methodology are presented, by way of a case study, of the specific benefits of using a geographical information system (GIS) in the planning and implementation of a Federal Aviation Regulation Part 150 Noise Compatibility Program. The particular case study here deals with the use of a Facilities Management and integrated GIS to effectively and economically handle the selection and acquisition of adjacent properties by an Airport Authority. Due to the value of the properties adjacent to the airport, a system is implemented that could accurately define the properties in question and provide an efficient method for their acquisition. The data base used in the GIS here is based on a Global Satellite Positioning system traverse and the Photogrammetric Digital Mapping project. The data collected includes topographical information, paving, utilities, and structures. The integration of data in this GIS allowed for orderly notices to be sent out, budgets prepared, acquisition plans developed for the purchase of property, and preparation of a Status Module of the acquisition program, as well as considerable savings in time and money. S.A.V.

A91-25478
SIMULATIONS OF THE CONCEPT OF USING A SMALL NONSCANNING DOPPLER RADAR FOR WIND SHEAR DETECTION
DOYLE T. PEED (Mitre Corp., McLean, VA) IN: IEEE 1990 International Radar Conference, Arlington, VA, May 7-10, 1990, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 467-472. refs
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The concept of using a small nonscanning Doppler radar, called the weather mini-radar, for automatically detecting and quantitatively measuring low-altitude wind shear along approach and departure paths to airport runways is introduced. This work focuses on the implementation of the weather mini-radar design on a general-purpose pulse Doppler radar computer simulation. This simulation uses microburst model data generated with the aid of a supercomputer as the input, and the output is used to test prototype automatic detection algorithms proposed for use with the weather mini-radar. Test results indicate that the weather mini-radar concept of automating wind shear detection and measurement is sound. I.E.

A91-26113*# Washington State Univ., Pullman.
DFW MICROBURST MODEL BASED ON AA-539 DATA
WALTER J. GRANTHAM, GUY G. ROETCISOENDER (Washington State University, Pullman), and EDWIN K. PARKS (Arizona, University, Tucson) Journal of Aircraft (ISSN 0021-8669), vol. 27, Nov. 1990, p. 917-922. refs
(Contract NCA2-216; NCC2-329)
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Analysis of the August 2, 1985 crash for an L-1011 jumbo jet (DL-191) on approach to the Dallas-Ft. Worth International Airport (DFW) in a thunderstorm indicates that the severe windshear microburst that caused the crash was composed not only of a strong downflow and outflow but also included several large-scale vortex rings entrained in the flowfield. This paper presents a detailed two-dimensional model of the DFW microburst based on data from the MD-80 (AA-539) that followed behind DL-191 and flew through the microburst about two minutes after the crash of DL-191. The model was developed using wind-vector and flight-path data reconstructed by NASA Ames Research Center and a combination of interactive graphics and least-squares error best fit between the modeled and measured wind vectors along the AA-539 flight path. The model indicates that the flowfield contains some significant elements and vortices not previously reported. The alternating direction of rotation of the vortices in the model suggests a microburst structure based on a von Karman vortex street rather than on a Kelvin-Helmholtz instability. The model also indicates that the reconstructed wind-vector data contain a time lag of at least one second in the horizontal winds. Author

A91-26114*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
WIND MEASUREMENTS FROM FOUR AIRLINERS IN 1988 DENVER MICROBURST
R. A. COPPENBARGER and R. C. WINGROVE (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 27, Nov. 1990, p. 923-928. Previously cited in issue 21, p. 3382, Accession no. A89-49058. refs
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A91-28198
THE EVOLUTION AND FINE-SCALE STRUCTURE OF A MICROBURST-PRODUCING CELL
WILLIAM P. MAHONEY, III and KIMBERLY L. ELMORE (NCAR, Boulder, CO) Monthly Weather Review (ISSN 0027-0644), vol. 119, Jan. 1991, p. 176-192. Research supported by NCAR, NSF, and FAA. refs
(Contract DTFA01-82-Y-10513)
Copyright

The structure and the evolution of a microburst-producing cell were examined using dual-Doppler data taken on the July 17, 1987, thunderstorm developed east of Denver. It was found that the storm produced two adjacent microbursts with different kinematic structures. One was associated with a strong horizontal rotor, while the other was associated with the rapid collapse of the cell. The data analysis indicates that the source region of air for the rotor-associated microburst was below cloud base and upwind of the precipitation shaft, while the source of air within the second microburst was well above cloud base. Features associated with this microburst included a descending reflectivity echo, convergence above cloud base, and the development and descent of strong vertical vorticity. I.S.

A91-28282* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AIRCRAFT NOISE INDUCED BUILDING VIBRATION AND EFFECTS ON HUMAN RESPONSE
CLEMANS A. POWELL and KEVIN P. SHEPHERD (NASA, Langley Research Center, Hampton, VA) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 567-572. refs
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The acoustic loads resulting from aircraft noise and sonic booms which can induce vibration in the structure and result in radiation of noise into its interior, rattling of items in contact with the structure, and the perception of the inhabitants that the structure is vibrating, are investigated. In particular, the response of buildings, particularly residential structures, to aircraft noise and the resulting effects on human response have been the subjects of considerable research at the NASA Langley Research Center. These studies are reviewed with particular emphasis on the response of houses to aircraft overflight noise and any increase in noise annoyance caused by the perception of vibration and rattling. L.K.S.

A91-28283
A REVIEW OF AIRCRAFT NOISE CONTROL MEASURES AT THE BURBANK AIRPORT
DWIGHT E. BISHOP (Acoustical Analysis Associates, Inc., Canoga Park, CA) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 643-648.
Copyright
A review of measures taken to alleviate aircraft noise disturbances in the communities surrounding the Burbank Glendale Pasadena Airport is presented. It is shown that, where there is a determined, firm airport policy to limit noise that is backed by accurate technical information and engineering procedures tailored to the airport needs, meaningful control of the airport noise can be achieved. Airport policies and engineering techniques are discussed. The major technical tool which is used to acquire information on actual noise levels, the permanent noise monitor system, is described, and the establishment of a noise budget based on these measurements is discussed. It is concluded that the simple noise budget procedure has proven easy to use and allows the noise impact of routine airline schedule changes to be evaluated by a relatively simple calculation. Noise factors for aircraft can thus be updated as needed from the noise monitor data base. L.K.S.

A91-28284
STAPLETON INTERNATIONAL AIRPORT - A CONTRAST IN NOISE ABATEMENT TECHNIQUES, PREFERENTIAL RUNWAY USE SYSTEM AND AIRCRAFT NOISE LIMITATION PROGRAM
STEVEN R. ALVERSON (Stapleton International Airport, Denver, CO) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 649-654. refs
Copyright
The aircraft-noise mitigation measures employed at the Stapleton International Airport near Denver (Colorado) are discussed. Special attention is given noise abatement techniques recommended by the Preferential Runway Use System (PRUS), initiated in the early 1940s, and by the Aircraft Noise Limitation Program (ANLP) implemented at this airport in 1987. The PRUS addresses the location and the intensity of aircraft noise impacts by specifying the best operational configuration for landing and departing aircraft. The ANLP was designed to provide techniques for limiting the overall airport noise exposure level. I.S.

A91-28285
FIFTEEN YEARS OF NOISE CONTROL AT LOGAN INTERNATIONAL AIRPORT
LARRY COLEMAN (Logan International Airport, Boston, MA) and KENNETH MCK. ELDRED (Ken Eldred Engineering, Concord, MA) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 655-660. refs
Copyright
Major actions concerning noise control which have been taken by Logan International Airport during the last 15 years are discussed. It is noted that in 1975 Massport installed a new management team and initiated a comprehensive Master Planning policy review of operations at Logan which included the establishment of a noise office in the Department of Aviation at Logan, promulgation of strict noise regulations, expansion of noise monitoring and complaint processing systems, and initiation of studies leading to improved flight tracks, runway preference rules, and sound proofing programs. It is noted that, as a result of these actions, the population residing in areas where the day-night sound level exceeds 65 dB has fallen an estimated 60 percent since the program began. L.K.S.

A91-28286
JOHN WAYNE AIRPORT - AN EXAMPLE OF NOISE CONTROL, THE METHODS AND THE RESULTS
VINCENT MESTRE (Mestre Greve Associates, Newport Beach, CA) and KAREN L. ROBERTSON (John Wayne Airport, Costa Mesa, CA) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 661-664.
Copyright
This paper discusses the mechanics and results of the commercial airline access plan that serves as an example of the affects of a comprehensive noise control program. Two particular aspects of this program are highlighted: all noise level criteria for the access plan are actual field measured noise levels based on John Wayne Airport's permanent noise monitoring system, encompassing nine permanent remote monitoring stations, and the airport does not use FAR Part 36 definitons of Stage I, II and III. It is shown that implementation of this access plan has resulted in a substantial reduction in aircraft noise levels even though the number of air carrier operations has increased. The principal reason for this noise reduction is shown to be the lowered noise levels associated with the new-generation aircraft. R.E.P.

A91-28287
LOW LEVELS OF AIRCRAFT NOISE FROM EXPANDED EAST COAST PLAN OPERATIONS
JAMES P. MULDOON (Port Authority of New York and New Jersey, Aviation Technical Services Div., New York) and ROBERT L. MILLER (Harris Miller, Miller and Hanson, Inc., Lexington, MA) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 665-670. refs
Copyright
A study was carried out with the aim of identifying the specific noise impacts attributable to the Expanded East Coast Plan (EECP), an extensive revision of air traffic control routes. Normal measures of noise exposure and the FAA compatibility guidelines failed to predict the degree of public response to the implementation of the plan. The community reaction, however, could be explained in terms of significant increases in noise levels (4 to 7 dB) experienced by some areas. The importance of considering the aircraft noise change patterns in future studies of this kind is emphasized. V.L.

A91-28289
NOISE INDUCED VIBRATION OF DWELLING CONSTRUCTION AROUND THE AIRPORT
YASUO TOKITA (Aircraft Nuisance Prevention Research Center, Tokyo, Japan) and HIROMASA OGAWA (Kobayashi Institute of Physical Research, Kokubunji, Japan) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 677-680. Research supported by Ministry of Transportation of Japan.
Copyright
Old style houses and buildings in Japan have roof tiles attached to the wood by clay, without the use of nails. Since the introduction of jet aircraft there have been complaints of dislodging of these tiles by vibration from noise. Vibration levels at seven houses were measured at several different points, including the roof tiles. The data show good correlation between structural vibrations and sound pressure level, but critical values could not be determined. To evaluate the impact on structures, the sound pressure with flat response will need to be measured, and the effect of long-term exposure to noise studied. A.F.S.

A91-28290
THE EFFECT OF AIR TRAFFIC INCREASE AND PHASING-OUT OF STAGE 2 AIRCRAFT ON THE NOISE EXPOSURE AROUND AIRPORTS
U. ISERMANN, K. MATSCHAT, E.-A. MUELLER (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, Federal Republic of Germany), and V. NITSCHE (Flughafen Duesseldorf GmbH, Federal Republic of Germany) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 681-684.
Copyright

While there has been an overall growth in air traffic at most commercial airports in recent years, the percentage of stage 2 aircraft has been decreasing and the percentage of less noisy stage 3 aircraft increasing. To find out if the net result will be more or less noise exposure around airports, the current situation at two airports is considered, along with two alternative future scenarios for each. In all four cases the effect of air traffic increase is found to be overcompensated by the phasing-out of stage 2 aircraft. A.F.S.

A91-28291
AIRPORT NOISE CONTROL - NEW ZEALAND'S RADICAL NEW APPROACH THE 'AIRNOISE BOUNDARY' PRINCIPLE
PHILIP DICKINSON (Department of Health, Wellington, New Zealand) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 685-690.
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The airnoise boundary principle suggests the elimination of the area around the Wellington, N.Z. airport within which there is to be no restriction on aircraft noise but mandatory strict compatible land use zoning. In this zone residential or noise sensitive development is prohibited. To meet the requirements of the standard the airlines have to arrange their flights balancing the aircraft types and their noise generation with time and direction of flights, so that their noise allocation is not exceeded on the airnoise boundary. The INM model for noise prediction is recommended. The strategy will make it possible to minimize the number of highly annoyed people and the effect of the aircraft noise on health, but it will cost airlines considerable sums of money for quieter aircraft. The digitally measured level of total average daily sound exposure is not permitted to exceed 109 Pa-squared sec (65 dB). O.G.

A91-28292
RESEARCH GOALS FOR IDENTIFICATION AND SUBSTANTIATION OF A RATIONAL AIRCRAFT-NOISE DESCRIPTOR SYSTEM RELEVANT TO HUMAN ANNOYANCE BY AIRCRAFT NOISE
MAURICE A. GARBELL (M.A.G. Associates, San Francisco, CA) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 691-694. refs
Copyright

This paper discusses the requirements of a rational internationally consistent aircraft-noise descriptor system that would express existing and predicted noise levels in terms that are closely correlated to the physiologically identifiable human annoyance criteria. A list of research goals for such a descriptor is proposed. It is emphasized that the measures and criteria established by the system must be valid at high and low emission levels and high and low ambient noise levels, for large and small numbers of noise events, and for outdoors and indoors. I.S.

A91-28295
CRITERIA FOR ACCEPTABLE AIRCRAFT NOISE EXPOSURES IN CLASSROOMS
JIM BUNTIN (Brown-Buntin Associates, Inc., Fair Oaks, CA) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 2. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 873-876. refs
Copyright

As part of the Noise Compatibility Program at the Port Columbus International Airport (Columbus, Ohio), interior-noise criteria were developed for acceptable noise exposures in schools located in the environs of the airport. A variety of noise-level descriptors that were developed which apply to the issues of intelligibility and interference with speech and learning. Recommendations are presented for noise levels that would provide sentence intelligibility of up to 99 for children and older adults, with up to 100 intelligibility for young adults, including the interior noise-level standards, the reverberation time in classrooms, and the background noise levels produced by classroom ventilation systems. I.S.

A91-28298
AIRCRAFT NOISE ANNOYANCE
TRULS GJESTLAND (Norwegian Institute of Technology, Trondheim, Norway) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 2. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 903-908. refs
Copyright

Results of recent studies of annoyance due to aircraft noise, assessed in different residential communities and different countries, are presented indicating that there may be a difference in the community reaction depending on the type of the noise source; it was shown that, for any given noise level, twice as many people will be annoyed by aircraft noise than by road traffic noise. A new study is described, which was initiated to perform an extensive survey of community reaction to aircraft noise around the Fornebu airport in Oslo. The results will be used to establish a new model for the aircraft-noise annoyance as well as new guidelines for the interpretation of the Norwegian zoning laws around major airports. I.S.

A91-28299
AIRPORT NOISE IMPACT ANALYSIS PROBLEMS
SAM R. LANE IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 2. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 909-912.
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Problems generally encountered in analyses and reports on the airport-noise impact on neighboring communities are discussed. These problems include uses of only CNEL as the only scale for noise evaluation, the erroneously low values of the aircraft-noise levels, and faulty data from malfunctioning noise monitor systems as well as discrepancies between published noise contours and the airport noise monitor data. The paper discusses the currently used noise-impact criteria and the existing scales (including aircraft event average noise level, LEQ; SENEL; the speech interference fractional impact, FI; and the sleep interference FI) and compares them with the CNEL and LDN scales. Results are presented for a single-event analysis, showing that, at the level of 15 average daily departures, the speech interference impact (in terms of FI) is just as great in the 45 dB CNEL zone as it is in the 665 dB CNEL zone. I.S.

A91-28303
USE OF FAA'S NATIONWIDE AIRPORT NOISE IMPACT MODEL
STEVEN R. ALBERSHEIM and KENNETH MCK. ELDRED (FAA, Office of Environment and Energy, Washington, DC) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 2. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 1249-1252.
Copyright

This paper describes the Nationwide Airport Noise Impact Model (NANIM), which makes it possible to make quick nationwide assessments of the number of people affected by aircraft noise. The model, developed on the basis of the Integrated Noise Model for determining the day-night average sound level (DNL) noise contours for aircraft operations, lends itself to the analysis of various policy alternatives which could be used to control and mitigate aircraft noise within the United States. The NANIM was validated by comparing its results with results obtained previously at 23 U.S. airports. It is estimated that, in 1985, there were 3,220,000 people within the 65 DNL contour. I.S.

N91-17436 Tennessee Univ., Knoxville.
REMOTE SENSING OF TURBULENCE USING DOPPLER LIDAR AND RADAR TECHNIQUES Ph.D. Thesis
DENNIS ALLEN FAULKNER 1990 128 p
Avail: Univ. Microfilms Order No. DA9030704

The idea of remotely sensing turbulence is not a new idea but has not been achieved to any level of reliability. Severe weather patterns are easy to spot with both Doppler and conventional radar systems. The clear air and otherwise undistinguishable turbulence is the type that has been receiving a lot of publicity lately due to the number of personal injuries suffered aboard the aircraft. The phenomenology and feasibility of remotely sensing and measuring small scale turbulence of this type is investigated. The remote sensing device of particular interest in this effort is the lidar. Data from two different field programs were used to research this effort. Some data were also reduced from a radar experiment conducted out west as a proof of concept. Wind fields were measured with ground based NASA Marshall Space Flight Center (NASA/MSFC), Huntsville, Alabama, lidar; NOAA Wave Propagation Laboratory (NOAA/WPL), Boulder Colorado, lidar; Stapleton International Airport, Denver, Colorado, Doppler radars; and with a NASA B-57B instrumented aircraft. The remotely sensed winds are compared in all cases with the in-situ aircraft measurement. Turbulence intensities measured by computing the lidar wind time history for each range gate and then calculating the rms value relative to the mean agree quite well with the aircraft intensities. Overall, the results of the research show general agreement between winds measured with Doppler lidars/radars and the B-57 instrumented aircraft. Dissert. Abstr.

N91-18490*# Atmospheric and Environmental Research, Inc., Cambridge, MA.
EFFECTS OF ENGINE EMISSIONS FROM HIGH-SPEED CIVIL TRANSPORT AIRCRAFT: A TWO-DIMENSIONAL MODELING STUDY, PART 2 Report, Jul. - Dec. 1989
MALCOLM K. W. KO, DEBRA K. WEISENSTEIN, NEIN DAK SZE, RUN-LIE SHIA, JOSE M. RODRIGUEZ, and CURTIS HEISEY Washington Mar. 1991 66 p Prepared for ST Systems Corp., Hampton, VA
(Contract NAS1-18460)
(NASA-CR-4346-PT-2; NAS 1.26:4346-PT-2) Avail: NTIS HC/MF A04 CSCL 13/2

The AER two-dimensional chemistry-transport model is used to study the effect of supersonic and subsonic aircraft operation in the 2010 atmosphere on stratospheric ozone (O3). The results show that: (1) the calculated O3 response is smaller in the 2010 atmosphere compared to previous calculations performed in the 1980 atmosphere; (2) with the emissions provided, the calculated decrease in O3 column is less than 1 percent; and (3) the effect of model grid resolution on O3 response is small provided that the physics is not modified. Author

N91-18495# Lawrence Livermore National Lab., CA. Atmospheric and Geophysical Sciences Div.
INFLUENCE OF PRESENT AND POSSIBLE FUTURE AIRCRAFT EMISSIONS ON THE GLOBAL OZONE DISTRIBUTION
DOUGLAS E. KINNISON and DONALD J. WUEBBLES Oct. 1990 7 p Presented at the 71st Annual Meeting of American Meteorological Society, New Orleans, LA, 13-18 Jan. 1991
(Contract W-7405-ENG-48)
(DE91-005422; UCRL-JC-104677; CONF-910143-2) Avail: NTIS HC/MF A02

This study has used the Lawrence Livermore National Laboratory (LLNL) two-dimensional model of the global atmosphere in an evaluation of the effects on global ozone concentrations from current subsonic aircraft emissions and from the emissions of possible future high speed civil transports (HSCT). The authors have attempted to include more realistic representations of emissions as a function of altitude and latitude in these scenarios than were included in previous sensitivity analyses. Major findings from this study are: (1) Current aircraft emissions may be having an impact on upper tropospheric ozone, leading to increasing concentrations of ozone in the upper troposphere. (2) A matrix of HSCT scenarios evaluated over a wide range of mean flight altitudes and magnitudes of NO(sub x) emissions confirmed previous analyses showing that ozone destruction becomes larger as the emissions of NO(sub x) increase and as the altitude of injection increases. (3) Model calculations indicate that a major reduction in emissions would allow the stratosphere to recover to unperturbed conditions in about a decade. (4) Sensitivity studies indicate that water vapor emissions have a moderate effect on the change in total ozone, while carbon monoxide emissions had a negligible effect. (5) Injection of NO(sub x) as HNO(sub 3) had a moderate effect on the change in total ozone. (6) The calculated change in ozone for the HSCT scenarios was very sensitive to the background atmosphere, particularly to the levels of stratospheric chlorine and concentrations of carbon dioxide, methane, and nitrous oxide. DOE

N91-18503# Lawrence Livermore National Lab., CA.
SENSITIVITY OF STRATOSPHERIC OZONE TO PRESENT AND POSSIBLE FUTURE AIRCRAFT EMISSIONS
DONALD J. WUEBBLES and DOUGLAS E. KINNISON Aug. 1990 18 p Presented at the German Aerospace Research Establishment Seminar on Air Traffic and the Environment, Bonn, Fed. Republic of Germany, 15-16 Nov. 1990
(Contract W-7405-ENG-48)
(DE91-007140; UCRL-JC-104730; CONF-9011178-1) Avail: NTIS HC/MF A03

The aircraft industry is showing renewed interest in the development of supersonic, high flying aircraft for intercontinental passenger flights. There appears to be confidence that such high-speed civil transports can be designed, and that aircraft will be economically viable as long as they are also environmentally acceptable. As such, it is important to establish the potential for such environmental problems early in the aircraft design. Initial studies with LLNL models of global atmospheric chemical, radiative, and transport processes have indicated that substantial decreases in stratospheric ozone concentrations could result from emissions of NO(x) from aircraft flying the stratosphere, depending on the fleet size and magnitude of the engine emissions. The purpose of this study is to build on previous analyses of potential aircraft emission effects on ozone in order to better define the sensitivity of ozone to such emissions. In addition to NO(x), the effects of potential emissions of carbon monoxide and water vapor are also examined. More realistic scenarios for the emissions as a function of altitude, latitude, and season are examined in comparison to prior analyses. These studies indicate that the effects on ozone are sensitive to the altitude and latitude, as well as the magnitude, of the emissions. DOE

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MATHEMATICAL AND COMPUTER SCIENCES

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

A91-24310#
APPLICATIONS OF THE STRUCTURAL OPTIMIZATION PROGRAM OPTSYS
TORSTEN BRAMA and RAGNAR ROSENGREN (Saab-Scania, AB, Linkoping, Sweden) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 40-44. refs
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Software tools for structural optimization are now gradually being introduced in the design process. The OPTSYS system is developed primarily for applications on aircraft, space and automotive structures. OPTSYS is a modular system combining the finite element method with mathematical programming methods. To illustrate the role of OPTSYS in recent projects, three real life applications are presented. A small shape optimization example in a separation system for satellites, a case of mixed shape and sizing optimization in the design of a car suspension component and a large optimization study on a composite wing of a fighter aircraft. The experience of using OPTSYS and the directions of current development are also commented. Author

A91-24330#
THE AEREL FLUTTER PREDICTION SYSTEM
VALTER J. E. STARK (Saab-Scania, AB, Linkoping, Sweden) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 232-241. Research supported by Swedish Defence Administration and Saab-Scania, AB. refs
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The AEREL system contains subprograms for determining analytical displacement modes, numerical values of aerodynamic transfer functions, analytical approximations to these, eigenvalues and eigenvalue derivatives. The approximations are combinations of simple functions fitted to given values, which can be calculated by programs based on the Advanced Doublet Element method, an extension of the Characteristic Box method, strip theory or piston theory or obtained in some other way. Eigenvalues are determined by Newton iteration for increasing flow density by using natural frequencies as initial approximations or a routine based on complex integration for determining these. Control laws may be included. Author

A91-24371*# Air Force Office of Scientific Research, Bolling AFB, Washington, DC.
THREE REAL-TIME ARCHITECTURES - A STUDY USING REWARD MODELS
J. A. SJOGREN (USAF, Office of Scientific Research, Washington, DC) and R. M. SMITH (Yale University, New Haven, CT) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 630-633.
(Contract NAG1-897)

Numerous applications in the area of computer system analysis can be effectively studied with Markov reward models. These models describe the evolutionary behavior of the computer system by a continuous-time Markov chain, and a reward rate is associated with each state. In reliability/availability models, upstates have reward rate 1, and down states have reward rate zero associated with them. In a combined model of performance and reliability, the reward rate of a state may be the computational capacity, or a related performance measure. Steady-state expected reward rate and expected instantaneous reward rate are clearly useful measures which can be extracted from the Markov reward model. The diversity of areas where Markov reward models may be used is illustrated with a comparative study of three examples of interest to the fault tolerant computing community. Author

A91-24409#
SOME NEW DEVELOPMENTS ON THE AIRCRAFT DESIGN AND ANALYSIS SYSTEM (ADAS)
C. BIL and J. MIDDEL (Delft, Technische Universiteit, Netherlands) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1043-1052. refs
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ADAS is a computer based-system developed at the Delft University of Technology for conceptual design and evaluation of aircraft configurations. This system has been integrated with a relational data base management system for design data information and storage. Then a procedure was developed to automatically generate a panel distribution for a conceptual aircraft model defined with ADAS. The ADAS has been converted to the UNIX operating system. A design study is presented where ADAS was applied to examine conventional, three-surface, and canard configurations employing the linear potential flow code NLRAERO. R.E.P.

A91-24418#
ROBUST CONTROL SYSTEM DESIGN WITH MULTIPLE MODEL APPROACH AND ITS APPLICATION TO FLIGHT CONTROL SYSTEM
YOSHIKAZU MIYAZAWA (National Aerospace Laboratory, Chofu, Japan) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1126-1135. refs
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In this paper, an approach to robust flight control system design is proposed and examined with a view to applying it to the flight control system for an in-flight simulator. Robustness of the control system is obtained by considering multiple models that represent an uncertain dynamical system. A delay element of uncertain delay time is used to introduce arbitrarily assigned bandwidths for a multiple intput control system. The quadratic performance index that is directly given from the design objective in a simple manner makes the system design straightforward. Constraint of output feedback is posed to introduce a practical control law. The design approach is applied to a robust model following flight control of an in-flight simulator, where precise flight control is necessary. Numerical results that were obtained for research airplanes of the National Aerospace Laboratory, Japan, are shown to demonstrate the feasibility of the approach. Author

A91-24451#
FOUR-DIMENSIONAL FUEL-OPTIMAL FLIGHTS INTO AND OUT OF THE TERMINAL AREA
H. G. VISSER (Delft, Technische Universiteit, Netherlands) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1468-1478. refs
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The problem of four-dimensional fuel-optimal flight into and out of a terminal area is studied using a reduced-order (energy state) system formulation. The Minimum Principle of Optimal Control Theory is employed to generate climb-out and descent extremals (turning and nonturning) in the form of a three-parameter family. Extremals that pass through specified end conditions at a specified time can be obtained by searching in the three-dimensional parameter-space. The trajectory-family structure allows significant insight into the energy management features of four-dimensional fuel-optimal flight. Numerical examples are given to illustrate these energy management features, as well as to quantify the penalties

in fuel consumption which result from operational (ATC) constraints. Author

A91-24461#
COMPUTING AERODYNAMICS ON PARALLEL COMPUTERS
S. C. GUPTA (Institute of Armament Technology, Poona, India) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1550-1556. refs
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Current problems in computational aerodynamics (CA) involve very large calculations, necessitating fast computations. Algorithms in computational aerodynamics can be provided with extensive parallelism. Computations can, therefore, be carried on computers with parallel architecture. Provisioning of parallelism in various computational algorithms, associated problems that arise and the requirement of computer hardware parallelism are brought out in this paper. Artificial intelligence (AI) in computational aerodynamics is described. Knowledge based expert system and symbolic manipulation make the characteristics of AI/CA system. Author

A91-27904*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
PATTERN RECOGNITION SYSTEM FOR AUTOMATIC IDENTIFICATION OF ACOUSTIC SOURCES
R. H. CABELL and C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 29, Feb. 1991, p. 180-186. Previously cited in issue 13, p. 2044, Accession no. A89-33751. refs
(Contract NAG1-762)
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N91-17036*# National Aeronautics and Space Administration, Washington, DC.
OPERATIONS MANAGEMENT SYSTEM
A. E. BRANDLI, R. E. ECKELKAMP, C. M. KELLY, W. MCCANDLESS, and D. L. RUE (TRW Electronics and Defense Sector, Redondo Beach, CA.) *In its* Space Transportation Avionics Technology Symposium. Volume 2: Conference Proceedings p 451-462 Aug. 1990
Avail: NTIS HC/MF A99 CSCL 12/2

The objective of an operations management system is to provide an orderly and efficient method to operate and maintain aerospace vehicles. Concepts are described for an operations management system and the key technologies are highlighted which will be required if this capability is brought to fruition. Without this automation and decision aiding capability, the growing complexity of avionics will result in an unmanageable workload for the operator, ultimately threatening mission success or survivability of the aircraft or space system. The key technologies include expert system application to operational tasks such as replanning, equipment diagnostics and checkout, global system management, and advanced man machine interfaces. The economical development of operations management systems, which are largely software, will require advancements in other technological areas such as software engineering and computer hardware. Author

N91-17559*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NASA FORMAL METHODS WORKSHOP, 1990
RICKY W. BUTLER, comp. Nov. 1990 504 p Workshop held in Hampton, VA, 20-23 Aug. 1990; sponsored by NASA, Washington
(NASA-CP-10052; NAS 1.55:10052) Avail: NTIS HC/MF A22 CSCL 09/2

The workshop brought together researchers involved in the NASA formal methods research effort for detailed technical interchange and provided a mechanism for interaction with representatives from the FAA and the aerospace industry. The workshop also included speakers from industry to debrief the formal methods researchers on the current state of practice in flight critical system design, verification, and certification. The goals were: define and characterize the verification problem for ultra-reliable life critical flight control systems and the current state of practice in industry today; determine the proper role of formal methods in addressing these problems, and assess the state of the art and recent progress toward applying formal methods to this area.

N91-17563*# Nebraska Univ., Lincoln. Dept. of Computer Science and Engineering.
MAFT: THE MULTICOMPUTER ARCHITECTURE FOR FAULT-TOLERANCE
ROGER M. KIECKHAFER *In* NASA, Langley Research Center, NASA Formal Methods Workshop, 1990 52 p Nov. 1990
Avail: NTIS HC/MF A22 CSCL 09/2

Multicomputer Architecture for Fault-Tolerance (MAFT) is a loosely coupled multiprocessor system designed to achieve an unreliability of less than 10(exp -10)/hr in flight-critical real time applications. The MAFT design objectives and architecture are presented. The fault-tolerance implementation of major functions in MAFT is also presented, including communication; task scheduling; reconfiguration; clock synchronization; and data handling and voting. The need for Byzantine agreement or approximate agreement in various functions is discussed. Different methods were selected to achieve agreement in various subsystems. These methods are illustrated by a more detailed description of the task scheduling and error handling subsystems. Author

N91-17564*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DESIGN FOR VALIDATION, BASED ON FORMAL METHODS
RICKY W. BUTLER *In its* NASA Formal Methods Workshop, 1990 19 p Nov. 1990
Avail: NTIS HC/MF A22 CSCL 09/2

Validation of ultra-reliable systems decomposes into two subproblems: (1) quantification of probability of system failure due to physical failure; (2) establishing that Design Errors are not present. Methods of design, testing, and analysis of ultra-reliable software are discussed. It is concluded that a design-for-validation based on formal methods is needed for the digital flight control systems problem, and also that formal methods will play a major role in the development of future high reliability digital systems. Y.S.

N91-17591# IBM Federal Systems Div., Gaithersburg, MD.
UPDATED APPLICATION BLUEPRINT DEFINITION FOR C3 FOR THE SOFTWARE TECHNOLOGY FOR ADAPTABLE, RELIABLE SYSTEMS (STARS) PROGRAM Final Report
J. PIOTROWSKI 30 Jun. 1990 58 p
(Contract F19628-88-D-0032)
(AD-A228471; CDRL-1490A-001) Avail: NTIS HC/MF A04 CSCL 12/5

Application blueprints serve as frameworks for designing new systems in an application domain, leading to reuse of design information and greater reuse of code. The term application blueprint is defined, its creation is described, and the benefits and drawbacks of this approach is this discussed. The appendix presents a generic specification and information about the initial domain analysis for creating an application blueprint for an air traffic control system. Future research on reusing analysis and design information may be based on this research. GRA

N91-17597# IBM Federal Systems Center, Gaithersburg, MD.
STARS STRUCTURE (DOD AAS IOM DOCUMENT VERSION 1.3) FOR THE SOFTWARE TECHNOLOGY FOR ADAPTABLE, RELIABLE SYSTEMS (STARS) PROGRAM Final Report
WILLIAM H. ETT 11 May 1990 284 p
(Contract F19628-88-D-0032)
(AD-A228479) Avail: NTIS HC/MF A13 CSCL 12/7

Information Object Modeling is a technique for developing specification models for systems. The techniques for building Information Object Models were adapted from techniques of real-time structured analysis and the Foxboro company's experience in specifying and developing real-time process control systems. An information object Model (IOM) is organized to provide

levels of information for different audiences, so that one document can meet the needs of different people. A mission statement is provided which describes the scope of the system. An overview of the system describes the major functional objects. Finally, each functional object is discussed in detail. The modeling techniques for an IOM use the graphical techniques real-time structured analysis, including transformation diagrams (data flow plus control flow), state transition diagrams, and entity relationship diagrams. Transformation diagrams, however, are applied in a different manner, representing the communication of objects organized hierarchically rather than a functional decomposition of processes. This document describes a specification model for an air traffic control system prepared using Real Time Structured Analysis. It shows Foxboro's concept of specification packaging and can serve as an alternative to MIL-STD-2167A. GRA

N91-17609# Federal Aviation Administration, Atlantic City, NJ.
NAS (HOST/ARTS 3A) TO VME MODEM INTERFACE ATC INTERFACE. HARDWARE MANUAL
LEO J. WAPELHORST Oct. 1990 115 p
(DOT/FAA/CT-TN90/46) Avail: NTIS HC/MF A06

Reference materials for personnel using the National Airspace System (NAS) (HOST or ARTS IIIA) Air Traffic Control (ATC) Interface Subsystem is given. The material was originally developed to be part of the Data Link Test and Analysis System (DATAS) in order to provide an interface between the NAS and the Ground Data Link Processor (GDLP). Author

N91-17612*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
GCS PROGRAMMER'S MANUAL
DOUGLAS S. LOWMAN, B. EDWARD WITHERS, ANITA M. SHAGNEA, LESLIE A. DENT (Research Triangle Inst., Research Triangle Park, NC.), and KELLY J. HAYHURST Dec. 1990 28 p
(NASA-TM-102721; NAS 1.15:102721) Avail: NTIS HC/MF A03 CSCL 09/2

A variety of instructions to be used in the development of implementations of software for the Guidance and Control Software (GCS) project is described. This document fulfills the Radio Technical Commission for Aeronautics RTCA/DO-178A guidelines, 'Software Considerations in Airborne Systems and Equipment Certification' requirements for document No. 4, which specifies the information necessary for understanding and programming the host computer, and document No. 12, which specifies the software design and implementation standards that are applicable to the software development and testing process. Information on the following subjects is contained: activity recording, communication protocol, coding standards, change management, error handling, design standards, problem reporting, module testing logs, documentation formats, accuracy requirements, and programmer responsibilities. Author

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PHYSICS

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

A91-24317*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AEROACOUSTICS OF ADVANCED PROPELLERS
JOHN F. GROENEWEG (NASA, Lewis Research Center, Cleveland, OH) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 108-126. Previously announced in STAR as N90-26635. refs
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The aeroacoustics of advanced, high speed propellers (propfans) are reviewed from the perspective of NASA research conducted in support of the Advanced Turboprop Program. Aerodynamic and acoustic components of prediction methods for near and far field noise are summarized for both single and counterrotation propellers in uninstalled and configurations. Experimental results from tests at both takeoff/approach and cruise conditions are reviewed with emphasis on: (1) single and counterrotation model tests in the NASA Lewis 9 by 15 (low speed) and 8 by 6 (high speed) wind tunnels, and (2) full scale flight tests of a 9 ft (2.74 m) diameter single rotation wing mounted tractor and a 11.7 ft (3.57 m) diameter counterrotation aft mounted pusher propeller. Comparisons of model data projected to flight with full scale flight data show good agreement validating the scale model wind tunnel approach. Likewise, comparisons of measured and predicted noise level show excellent agreement for both single and counterrotation propellers. Progress in describing angle of attack and installation effects is also summarized. Finally, the aeroacoustic issues associated with ducted propellers (very high bypass fans) are discussed. Author

A91-24318#
INCREASED NOISE EMISSION OF PROPELLERS AND PROPFANS DUE TO PUSHER INSTALLATION
G. NEUWERTH, TH. LOELGEN, and R. STAUFENBIEL (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 127-138. refs
Copyright

The inflow to propellers and propfans, installed as aft-mounted pushers at the fuselage of airplanes, is distorted by wakes of pylons or wings. The increase of the radiated noise because of this installation is investigated theoretically and in experiments for take off and landing configurations. A system of computer codes has been developed to predict the emitted noise fields starting with the distorted flow and calculating steady and unsteady blade forces as a function of the radial position. For the experimental investigations, a rotor test set was built up in the open test section of a wind tunnel which simulates the flight speed. The numerous influences on the noise are treated by a parameter study. Measurements of the noise power and spectrum are in good agreement with the theoretical predictions. Various means for a reduction of the radiated noise have been investigated. Author

A91-24319#
REDUCING FLYOVER NOISE OF PROPELLER-DRIVEN AEROPLANES BY SUPERPOSITION OF PROPELLER- AND EXHAUST-NOISE
M. KALLERGIS (DLR, Institut fuer Entwurfsaerodynamik, Brunswick, Federal Republic of Germany) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 139-150. refs
Copyright

Propeller farfield-noise attenuation is presently accomplished by means of a superimposition of piston-engine exhaust noise on the propeller-generated noise in order to produce destructive interference. This objective may be efficiently accomplished by adjusting the relative circumferential position of the propeller blades to the crankshaft. This concept has been theoretically and experimentally verified for an apparatus in which a flange was inserted between the propeller and the driveshaft; this flange can be rotated in steps to shift the sound-wave phase of the propeller relative to the engine exhaust. O.C.

A91-24337#
ON THE EFFECTS OF SHEAR FLOW ON SOUND TRANSMISSION ACROSS BOUNDARY LAYERS
L. M. B. C. CAMPOS and P. G. T. A. SERRAO (Lisboa, Universidade Tecnica, Lisbon, Portugal) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC,

American Institute of Aeronautics and Astronautics, Inc., 1990, p. 307-315. Research supported by Junta Nacional de Investigacao Cientifica e Tecnologica and Instituto Nacional de Investigacao Cientifica. refs
Copyright

The present effort to ascertain sound-transmission characteristics across a boundary layer leads to an exact solution of the acoustic wave equation in an exponential shear flow. There exists a critical level whose function is that of an acoustic valve, amplifying outward-propagating waves while attenuating inward-propagating sound. Although the sound fields near a critical level cannot be adequately described by ray theory, the critical level absorption may be the physical mechanism by means of which sound-attenuation in a boundary layer significantly exceeds ray-theory predictions. O.C.

A91-24340*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ROTORCRAFT BLADE/VORTEX INTERACTION NOISE - ITS GENERATION, RADIATION, AND CONTROL
J. S. PREISSER, T. F. BROOKS, and R. M. MARTIN (NASA, Langley Research Center, Hampton, VA) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 333-343. refs
Copyright

Recent results are presented from several research efforts aimed at the understanding of rotorcraft blade-vortex interaction noise generation, directivity, and control. The results are based on work performed by researches at the NASA Langley Research Center, both alone and in collaboration with other research organizations. Based on analysis of a simplified physical model, the critical parameters controlling the noise generation are identified. Detailed mapping of the acoustic radiation field reveals the extreme sensitivity of directivity to rotor advance ratio and disk attitude. A means of controlling blade-vortex interaction noise by higher harmonic pitch control is discussed. Author

A91-24754* General Electric Co., Schenectady, NY.
THE RADIATION OF SOUND FROM A PROPELLER AT ANGLE OF ATTACK
R. MANI (General Electric Co., Schenectady, NY) Royal Society (London), Proceedings, Series A - Mathematical and Physical Sciences (ISSN 0080-4630), vol. 431, no. 1882, Nov. 8, 1990, p. 203-218. Research supported by NASA. Previously announced in STAR as N90-21602. refs
Copyright

The mechanism by which the noise generated at the blade passing frequency by a propeller is altered when the propeller axis is at an angle of attack to the freestream is examined. The measured noise field is distinctly non axially symmetric under such conditions with far field sound pressure levels both diminished and increased relative to the axially symmetric values produced with the propeller at zero angle of attack. Attempts have been made to explain this non axially symmetric sound field based on the unsteady (once per rev) loading experienced by the propeller blades when the propeller axis is at non zero angle of attack. A calculation based on this notion appears to greatly underestimate the measured azimuthal asymmetry of noise for high tip speed, highly loaded propellers. A new mechanism is proposed; namely, that at angle of attack, there is a non axially symmetric modulation of the radiative efficiency of the steady loading and thickness noise which is the primary cause of the non axially symmetric sound field at angle of attack for high tip speed, heavily loaded propellers with a large number of blades. A calculation of this effect to first order in the crossflow Mach number (component of freestream Mach number normal to the propeller axis) is carried out and shows much better agreement with measured noise data on the angle of attack effect. Author

A91-24759
SCATTERING BY A SEMI-INFINITE SANDWICH PANEL PERFORATED ON ONE SIDE
C. MAIR A. JONES (Imperial College of Science, Technology, and Medicine, London, England) Royal Society (London), Proceedings, Series A - Mathematical and Physical Sciences (ISSN 0080-4630), vol. 431, no. 1883, Dec. 8, 1990, p. 465-479. Research supported by SERC. refs
Copyright

The scattering of sound waves propagating in an inviscid compressible fluid in irrotational motion by the edge of a semiinfinite perforated elastic sandwich panel clamped to a semiinfinite rigid screen is investigated analytically. The problem formulation is outlined; traveling-wave solutions are derived; and the resulting mixed boundary-value problem is analyzed using a Wiener-Hopf procedure. In the limit as tau goes to zero, the sound field is found to be similar to that described by Cannell (1975) for a semiinfinite elastic plate in air, implying that indirect edge scattering can be an important energy-conversion mechanism in aerodynamic flows. The relationship between this theoretical problem and the acoustic design of helicopters is indicated. T.K.

A91-24873
AIRBORNE TELESCOPE WITH LARGE APERTURE
O. PADE and Y. NACHSHON (Rafael Armament Development Authority, Haifa, Israel) IN: Propagation of high-energy laser beams through the earth's atmosphere; Proceedings of the Meeting, Los Angeles, CA, Jan. 15-17, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 414-424. refs
Copyright

The detailed calculations presented for the optical quality of a large-aperture airborne telescope, whose open-fuselage platform aircraft will cruise at high altitude and at near-sonic speed, give attention to the optical degradation of telescope performance by the aerodynamic and flight-dynamic environment. It is established that, while phase degradation is not severe, the aircraft boundary layer acts to tilt the beam to a degree that is not negligible. The mechanical torques acting on the telescope are strong, and may affect system performance to a degree requiring careful preventive design of the telescope structure. O.C.

A91-25826
SOUND AND VIBRATION PRODUCED BY AN AIRFOIL TIP IN BOUNDARY LAYER FLOW OVER AN ELASTIC PLATE
M. S. HOWE (BBN Laboratories, Cambridge, MA) Journal of Sound and Vibration (ISSN 0022-460X), vol. 144, Jan. 22, 1991, p. 229-245. refs
(Contract N00167-87-C-0021)
Copyright

A theoretical model is analyzed to estimate the structural and acoustic noise produced when boundary layer turbulence impinges on the tip region of an airfoil, such as a rotor blade in a turbomachine. The airfoil has rectangular planform and its tip is immersed in the turbulent boundary layer on a wall modeled by a thin elastic plate. Numerical results are presented for a rigid airfoil adjacent to a steel plate in water. These indicate that the tip behaves as an acoustically bright source of sound, the intensity of which typically exceeds by 30 dB or more that which would be produced by the turbulence in the region of the tip when the airfoil is removed. Similarly, flexural motions induced in the wall (structure-borne sound) are shown to be substantially increased by the presence of the airfoil. This is important because structural waves may be scattered by surface discontinuities at remote points of the wall, resulting in an overall increase in the radiated sound. Author

A91-28254
SUBSONIC AXIAL FLOW FAN NOISE AND INFLOW VELOCITY DISTURBANCE
WEN-SHYANG CHIU and GERALD C. LAUCHLE (Pennsylvania State University, State College) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control

Foundation, 1989, p. 133-138. Research supported by IBM Corp. refs
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A91-28255
NOISE REDUCTION EFFORTS ON VANEAXIAL COOLING FANS USED IN AIRCRAFT
ANDREW L. BOGGESS, JR. (EG&G Rotron, Custom Products Div., Woodstock, NY) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 147-150. refs
Copyright

A91-28260
QUANTIFYING THE SOUND POWER GENERATED BY A HELICOPTER MAIN TRANSMISSION ON A REGENERATIVE TEST STAND
WM. MARK HARDESTY and BENJAMIN HUDSON (McDonnell Douglas Helicopter Co., Flight Technology Dept., Mesa, AZ) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 217-220.
Copyright

A91-28261* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ADVANCED TURBOPROP AIRCRAFT FLYOVER NOISE ANNOYANCE
DAVID A. MCCURDY (NASA, Langley Research Center, Hampton, VA) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 221-226. refs
Copyright

Results from recent laboratory experiments in which human subjects were exposed to synthetic sounds simulating the flyover noise emitted by advanced turbofan aircraft engines are briefly summarized. The Aircraft Noise Synthesis System described by McCurdy et al. (1987) is used to simulate the noise from (1) a conventional turboprop engine, (2) a jet engine, (3) a single-rotating turbofan engine, and counterrotating turbofans with (4) equal or (5) unequal numbers of blades on the two rotors. The measured annoyance levels are compared with effective perceived noise levels in a graph. For a given noise level, the annoyance levels for (3) are shown to be slightly lower than those for all the other engine types, especially if the tone/broadband noise ratio is relatively high. T.K.

A91-28262
EXTERIOR NOISE OF THE MCDONNELL DOUGLAS UHB DEMONSTRATOR
D. N. MAY and J. P. MEADE (Douglas Aircraft Co., Long Beach, CA) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 227-232.
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A91-28263
DUAL SHAKERS FOR SIMULATION OF PROPELLER INDUCED STRUCTURE-BORNE NOISE TRANSMISSION
JAMES F. UNRUH (Southwest Research Institute, San Antonio, TX) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 233-236. refs
Copyright

A91-28271
ACOUSTICAL PHENOMENA OF GROUND RUN-UP NOISE IN COMBINATION WITH SCREENS
WILLEM M. SCHULLER and FOKKE D. VAN DER PLOEG (Adviesbureau Peutz and Associes, Nijmegen, Netherlands) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 361-366.
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A91-28276
A NOISE SUPPRESSOR USING CO-AXIAL PERFORATED TUBES
KUNISATO SETO (Saga University, Japan) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 421-424.
Copyright

A91-28281
MECHANISMS OF NOISE REDUCTION IN ENCLOSED CYLINDRICAL SOUND FIELDS BY ACTIVE VIBRATION CONTROL
HENRY R. HALL and JAMES D. JONES (Purdue University, West Lafayette, IN) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 1. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 559-562. refs
Copyright

It is shown that active vibration control can provide substantial noise reduction when the sound field is created by a point force driving the shell wall or an exterior monopole. The acoustic field inside an infinite cylindrical shell has been analyzed by modal decomposition. Because only a few shell modes couple well with the interior acoustic modes, it has spatially averaged noise reduction on the order of 17 dB for a primary source that is either a point force or a monopole. The location of the control source need not be exactly aligned with the primary source. Good control was achieved at small angular offsets as well as at the other antinodes of the primary mode to be controlled. This shows some promise for the use of point force actuators to control sound in aircraft fuselages, especially when the primary source is an applied fuselage. Control spillover in the shell is generally more severe when controlling the primary point force. L.K.S.

A91-28293
LOW FREQUENCY NOISE AND VIBRATION FROM SONIC BOOMS
LOUIS C. SUTHERLAND (Wyle Laboratories, El Segundo, CA) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 2. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 847-852. refs
Copyright

The effects of sonic booms on the degree of discomfort for humans residing in the vicinity of an airport are examined with special consideration given to the role of the secondary noise and vibration from rattle generated by sonic booms in surrounding structures. Data obtained on the subjective response of human subjects indoors to actual or simulated sonic booms strongly suggest that the rattle noise could contribute significantly to perceived annoyance. Estimates of structural response show that the high probability for the rattle response occurred at peak sonic boom overpressures of the order of 1 psf. Structural velocity is identified as the critical response parameter which can be used to predict rattle occurence and to estimate rattle noise levels. I.S.

A91-28294
A-WEIGHTING - IT DOES NOT WORK INDOORS FOR HELICOPTER OR LARGE GUN NOISES; NOISES WITH LOW FREQUENCIES AND LARGE AMPLITUDES
PAUL D. SCHOMER and BRIAN D. HOOVER (U.S. Army, Construction Engineering Research Laboratory, Champaign, IL) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 2. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 853-858.
Copyright

Possible methods for correcting the measurements of high-amplitude 'impulsive' noise sources (such as noise from a helicopter or from a large gun) are discussed with special attention given to establishing a measure for these high-amplitude sounds. The concept of an impulsive sound is defined, and it is shown that the A-weighting schemes used widely to measure noise does not work for these impulsive noise sources. The reasons are as follows: (1) in the presence of a noticeable rattle generated by a helicopter sound, the A-weighted sound exposure level (ASEL) greatly underestimates the annoyance experienced indoors by up to 13 dB; (2) there is a structure/sound interaction whereby ASEL underestimates general helicopter noise annoyance indoors by 8 to 10 dB, and (3) detectability may well be a factor in the helicopter-noise annoyance. I.S.

A91-28300
THE USE OF MULTISPECTRUM IN DETERMINING AIRPORT NOISE SOURCES
ROBERT BRONSDON (Bruel and Kjaer Instruments, Inc., Marlborough, MA) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 2. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 939-942.
Copyright

An airport noise measuring system is described which uses a digital filter analyzer to process the input signals continuously rather than blockwise (as is done by an FFT analyzer. Moreover, this system detects the difference between the airport noise events caused by air traffic and those caused by other noise sources. In addition, significantly less data are needed for this system than when for an FFT analyzer or when actual aural recordings are used. I.S.

A91-28301
UNATTENDED MONITORING AND SOURCE IDENTIFICATION OF AIRCRAFT NOISE
I. YAMADA, J. IGARASHI (Kobayashi Institute of Physical Research, Kokubunji, Japan), and N. HAYASHI (Rion Co., Ltd., Kokubunji, Japan) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 2. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 1133-1136.
Copyright

This paper describes an automatic continuously operating aircraft-noise-monitoring system, which conforms to the description in the 'Manual for Aircraft Noise Monitoring and Measurement' of the Japan's Environmental Protection Agency. Particular attention is given to the principles of operation, the system's configuration and salient design features, the site-selection criteria, and the procedure for identifying the aircraft-noise source. The cross-correlation method of Ono et al. (1979) was successfully applied to automatically identify an aircraft fly-over noise, as distinguished from that made by an arriving aircraft. I.S.

N91-17671*# Sverdrup Technology, Inc., Brook Park, OH.
INFLUENCE OF VANE SWEEP ON ROTOR-STATOR INTERACTION NOISE
EDMANE ENVIA and EDWARD J. KERSCHEN (Arizona Univ., Tucson.) Dec. 1990 168 p
(Contract NAG3-357)
(NASA-CR-187052; NAS 1.26:187052) Avail: NTIS HC/MF A08
CSCL 20/1

The influence of vane sweep in rotor-stator interaction noise is investigated. In an analytical approach, the interaction of a convected gust representing the rotor viscous wake, with a cascade of cascade of finite span swept airfoils, representing the stator, is analyzed. The analysis is based on the solution of the exact linearized equations of motion. High frequency convected gusts for which noise generation is concentrated near the leading edge of airfoils is considered. In a preliminary study, the problem of an isolated finite span swept airfoil interacting with a convected gust is analyzed. Results indicate that sweep can substantially reduce the farfield noise levels for a single airfoil. Using the single airfoil model, an approximate solution to the problem of noise radiation from a cascade of finite span swept airfoils interacting with a convected gust is derived. A parametric study of noise generated by gust cascade interaction is carried out to assess the effectiveness of vane sweep in reducing rotor-stator interaction noise. The results show that sweep is beneficial in reducing noise levels. Rotor wake twist or circumferential lean substantially influences the effectiveness of vane sweep. The orientation of vane sweep must be chosen to enhance the natural phase lag caused by wake lean, in which case rather small sweep angles substantially reduce the noise levels. Author

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A91-26694#
PAR-WIG (POWER-AUGMENTED-RAM WING-IN-GROUND) - SOME CONSIDERATIONS FOR CONCEPTUAL DESIGN OF PAR-WIG EFFECT VEHICLE
SHIGENORI ANDO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 38, no. 443, 1990, p. 676-683. In Japanese, with abstract in English. refs

Investigations have indicated that PAR-WIG has almost twice the range capability of conventional aircraft due to higher L/D and lower empty weight fraction. This paper analyzes empty weight based on the available data, comparing this data with various other types. The synthetic effect of the wing aspect ratio on operational efficiency is examined. R.E.P.

A91-27828
AIRLINE DEREGULATION AND LAISSEZ-FAIRE MYTHOLOGY - ECONOMIC THEORY IN TURBULENCE
PAUL STEPHEN DEMPSEY (Denver, University, CO) Journal of Air Law and Commerce (ISSN 0021-8642), vol. 56, Winter 1990, p. 305-412. refs
Copyright

The effect of airline deregulation on the airline industry, its customers, and on the U.S. air transportation system is examined. The actual experience of the last decade is compared with the promises that were made by those who successfully promoted the Airline Deregulation Act of 1978. It is shown that, after a decade of airline deregulation, concentration of national and regional market power is greater, routes are more circuitous, service is poorer, labor-management relations have deteriorated, and air travel is less safe. A legislative agenda for reform is proposed which attempts to steer a middle course between heavy-handed regulation and laissez-faire. The agenda includes the establishment of an independent Federal Transportation Commission, the prohibition of a single airline maintaining a dominant position at

more than a single airport, price regulation to prevent price gouging and predatory pricing, and laws aimed at eliminating price discrimination. C.D.

A91-27830
RECENT CASES AND DEVELOPMENTS IN AVIATION LAW. II
GEORGE S. PETKOFF Journal of Air Law and Commerce (ISSN 0021-8642), vol. 56, Winter 1990, p. 491-556. refs
Copyright

A survey is presented of recent developments in aviation law. The topics addressed include: the Federal Tort Claims Act, indemnification, negligence, evidence, insurance, airports, FAA regulations, passenger actions against air carriers, contractual claims, and handicapped passengers. The results of the most significant cases in each area are summarized and discussed. C.D.

A91-27831
THE PROPRIETY OF CLASS ACTIONS IN MASS AVIATION DISASTER LITIGATION
MARK W. HARRIS Journal of Air Law and Commerce (ISSN 0021-8642), vol. 56, Winter 1990, p. 559-587. refs
Copyright

Some of the issues surrounding the use of class action suits in mass air disaster litigation are examined. The scope of Federal Rule of Civil Procedure 23, which provides for the maintenance of federal class action suits, is addressed. The various factors surrounding the prevailing judicial hesitancy to certify class actions in mass air disaster litigation are considered. Several alternative methods of adjudication that the courts have used in mass air disaster cases are analyzed, and it is concluded that the class action, despite its limitations, is ultimately a superior method of litigating the numerous claims which arise out a mass air disaster. C.D.

A91-27832
THE 1992 EUROPEAN UNIFICATION - EFFECTS IN THE AIR TRANSPORT INDUSTRY
MONICA L. LUEBKER Journal of Air Law and Commerce (ISSN 0021-8642), vol. 56, Winter 1990, p. 589-639. refs
Copyright

The effect of the plan for European unification in 1992 on the air tranport sector in both Member and nonmember states is addressed. The general concepts behind the unification are explained, and it is shown how airlines fit within the purview of the Treaty Establishing the European Economic Community. Resistance to a common policy exhibited by some Member States is examined. Arguments both for and against a deregulated airline system in Europe are illustrated, and concerns about deregulation held by the United States airline industry are analyzed. C.D.

A91-27833
FREEDOM OF THE PRESS - DOES THE MEDIA HAVE A SPECIAL RIGHT OF ACCESS TO AIR CRASH SITES?
KAREN S. PRECELLA Journal of Air Law and Commerce (ISSN 0021-8642), vol. 56, Winter 1990, p. 641-687. refs
Copyright

The development of the fundamental view that the right of the press to have access to air crash sites does not exceed that of the general public is reviewed along with modern cases that imply a special right of access. Disaster and accident cases are then examined to determine both the trend of such decisions as well as the method of analysis which they utilize. Finally, the identified standard of review is incorporated into some general guidelines that may be used to evaluate if and when the press should have a special right of access to crash sites. C.D.

A91-28296
URBAN PLANNING OF INDUSTRIAL AND COMMERCIAL SITES INSIDE AIRCRAFT NOISE INFLICTED AREAS OF AIRPORTS
LOTHAR G. S. PRANG (ASI Buero fuer Architektur-Staedtebau-Infrastruktur, Kaarst, Federal Republic of Germany) IN: Inter-noise 89 - Engineering for environmental noise control; Proceedings of the International Conference on Noise Control Engineering, Newport Beach, CA, Dec. 4-6, 1989. Vol. 2. Poughkeepsie, NY, Noise Control Foundation, 1989, p. 881-886.
Copyright

Problems involved in the control of the aircraft noise in residential and commercial cites in the vicinity of airports are discussed. It is pointed out that, usually, air traffic control (ATC) regulations in densely populated regions, based on international agreements, do not coincide with the local aircraft noise abatement policy, causing difficult situations for urban planning. It is suggested that, to obtain a profitable, economical, and ecological land-use compatibility in the airport vicinity, the competing demands for the noise abatement measures and for safe ATC, a critical evaluation by urban and regional planning authorities must be carried out. This evaluation should include the assessment of the exterior aircraft noise effects as well as the indoor professional and working noise degrees. I.S.

N91-18022# Wichita State Univ., KS. National Inst. for Aviation Research.
AN OVERVIEW OF INFORMATION RESOURCES IN AVIATION Abstract Only
THOMAS G. DEPETRO *In its* Proceedings: Techfest 17 p 21 1991
Avail: NTIS HC/MF A03

Information resources in aviation are produced by many organizations, including publishing companies, government agencies, professional associations, research institutes, and colleges and universities. Topics in aviation include management, government regulation, air transport, engineering, technology, research and development, and applied sciences. Information is available in a number of formats including books, periodicals, maps, charts, government documents, technical reports, professional papers, microfiche, and, more recently, audio and video cassette tapes and CD-ROM and on-line computer databases. Author

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GENERAL

A91-25666
THE BEGINNING OF HYPERSONIC RAMJET RESEARCH AT APL
HAROLD E. GILREATH (Johns Hopkins University, Laurel, MD) Johns Hopkins APL Technical Digest (ISSN 0270-5214), vol. 11, July-Dec. 1990, p. 319-335. refs
Copyright

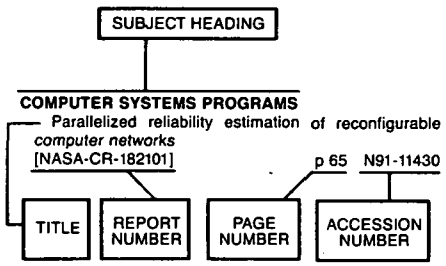
An overview is presented of research that has been conducted on future applications for ramjet engines in long-range high-speed transports, air defense missiles, and nuclear-powered aircraft capable of almost unlimited supersonic flight close to sea level. It is noted that for flight in the atmosphere for ranges greater than 100 miles and speeds over Mach 3, a ramjet would be the only practical propulsion system. It is pointed out, however, that if sustained hypersonic flight is to become possible, a way around the thermal barrier must be found. Various programs that have evolved in this field of research are discussed, including the Talos propulsion project, the X-airplane research program that led to the development of the liquid-rocket-powered X-15, the first ground test of a complete hydrogen-fueled supersonic-combustion ramjet engine, and the hypersonic transport aircraft. R.E.P.

N91-18966*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RESEARCH AND TECHNOLOGY 1990, LANGLEY RESEARCH CENTER

Feb. 1991 247 p Original contains color illustrations
(NASA-TM-4243; L-16860; NAS 1.15:4243) Avail: NTIS HC/MF
A11; 28 functional color pages CSCL 05/4

The mission of NASA-Langley is to increase the knowledge and capability of the U.S. in a full range of aeronautics disciplines and in selected space disciplines. This mission will be executed by performing innovative research relevant to national needs and agency goals, transferring technology to users in a timely manner, and providing development support to other U.S. government agencies, industry, and other NASA centers. Highlights are presented of the major accomplishments and applications that were made during the past year. The highlights illustrate both the broad range of the research and technology activitives at NASA-Langley and the contributions of this work toward maintaining U.S. leadership in aeronautics and space research. Author

Typical Subject Index Listing



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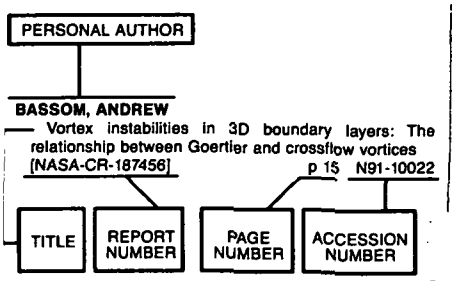

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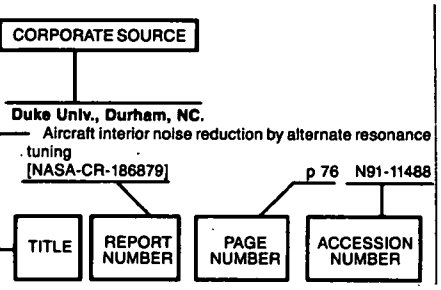

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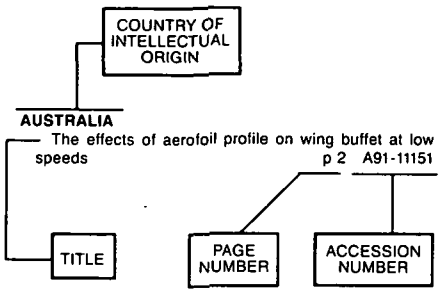

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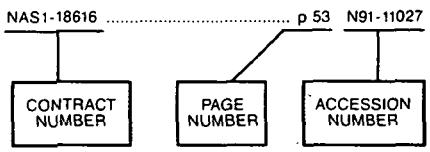

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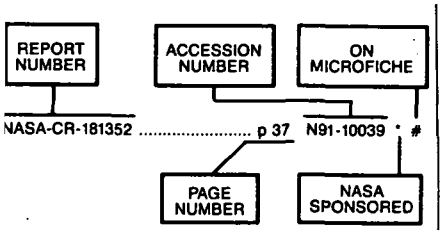

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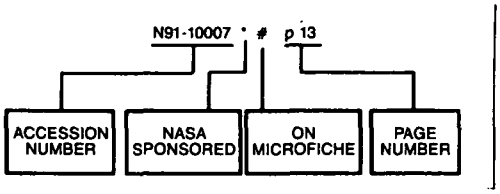

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