NASA SP-7037 (323)
November 1995

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AERONAUTICAL ENGINEERING

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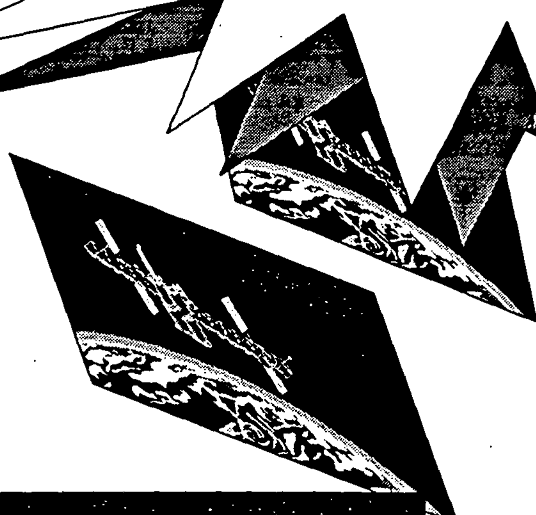

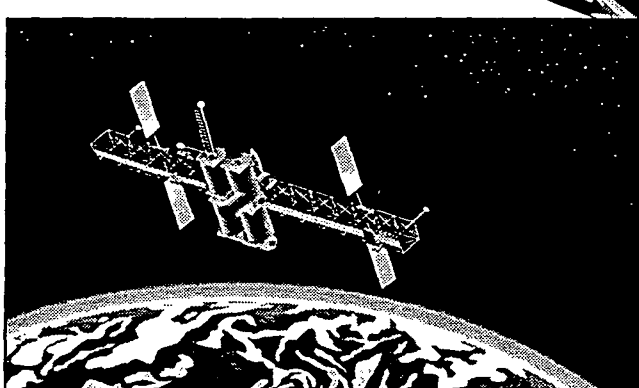

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INTRODUCTION

This issue of *Aeronautical Engineering — A Continuing Bibliography with Indexes* (NASA SP-7037) lists 518 reports, journal articles, and other documents recently announced in the NASA STI Database.

Accession numbers cited in this issue include:

Scientific and Technical Aerospace Reports (STAR) (N-10000 Series)	N95-30358 — N95-32372
Open Literature (A-60000 Series)	A95-92371 — A95-95938

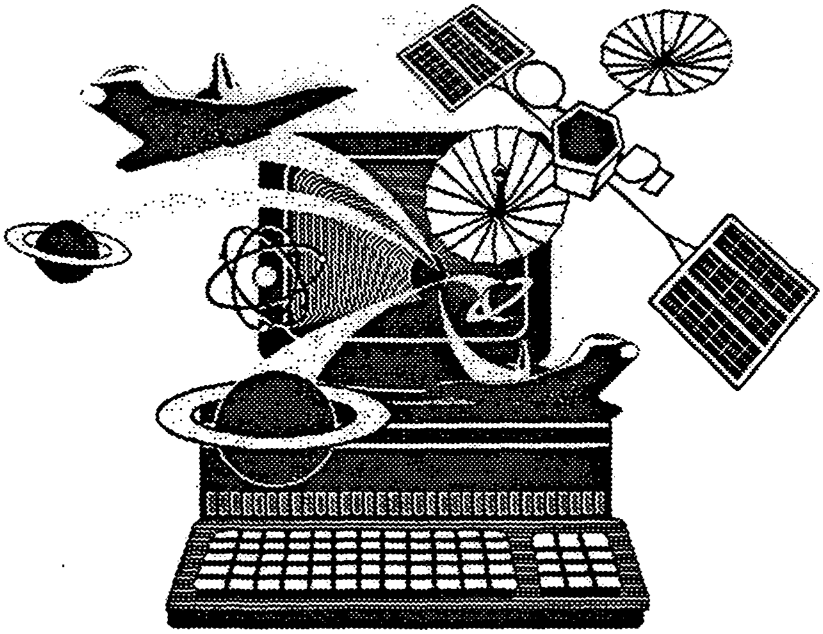
The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, 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 1995 will be published in early 1996.

The NASA CASI price code table, addresses of organizations, and document availability information are located at the back of this issue.



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10/95

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TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED
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ACCESSION NUMBER → N95-10318*# Dow Chemical Co., Midland, MI. ← CORPORATE SOURCE
TITLE → **NOVEL MATRIX RESINS FOR COMPOSITES FOR AIRCRAFT PRIMARY STRUCTURES, PHASE 1 Final Report, Apr. 1989 - Mar. 1992**
AUTHORS → EDMUND P. WOO, P. M. PUCKETT, S. MAYNARD, M. T. BISHOP, K. J. BRUZA, J. P. GODSCHALX, AND M. J. MULLINS Aug. 1992 ← PUBLICATION DATE
164 p
CONTRACT NUMBERS → (Contracts NAS1-18841; RTOP 510-02-11-02)
REPORT NUMBERS → (NASA-CR-189657; NAS 1.26:189657) Avail: CASI HC A08/MFA02 ← AVAILABILITY AND PRICE CODE

The objective of the contract is the development of matrix resins with improved processability and properties for composites for primarily aircraft structures. To this end, several resins/systems were identified for subsonic and supersonic applications. For subsonic aircraft, a series of epoxy resins suitable for RTM and powder prepreg was shown to give composites with about 40 ksi compressive strength after impact (CAI) and 200 F/wet mechanical performance. For supersonic applications, a thermoplastic toughened cyanate prepreg system has demonstrated excellent resistance to heat aging at 360 F for 4000 hours, 40 ksi CAI and useful mechanical properties at greater than or equal to 310 F. An AB-BCB-maleimide resin was identified as a leading candidate for the HSCT. Composite panels fabricated by RTM show CAI of approximately 50 ksi, 350 F/wet performance and excellent retention of mechanical properties after aging at 400 F for 4000 hours. Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

ACCESSION NUMBER → A95-60192* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA. ← CORPORATE SOURCE
TITLE → **AERODYNAMIC INTERACTIONS BETWEEN A ROTOR AND WING IN HOVER**
AUTHORS → FORT F. FELKER NASA. Ames Research Center, Moffett Field, CA, US and JEFFREY S. LIGHT NASA. Ames Research Center, Moffett Field, CA, US ← AUTHOR'S AFFILIATION
Journal of the American Helicopter Society ← JOURNAL TITLE
PUBLICATION DATE → 2 Jun. 1986 p. 53-61
REPORT NUMBER → (HTN-94-00714) Copyright

An experimental investigation of rotor/wing aerodynamic interactions in hover is described. The investigation consisted of both a large-scale and a small-scale test. A 0.658-scale V-22 rotor and wing was used in the large-scale test. Wing download, wing surface pressure, rotor performance, and rotor downwash data from the large-scale test are presented. A small-scale experiment was conducted to determine how changes in the rotor/wing geometry affected the aerodynamic interactions. These geometry variations included the distance between the rotor and wing, wing incidence angle, wing flap angle, rotor rotation direction, and configurations both with the rotor axis at the tip of the wing (tilt rotor configuration) and with the rotor axis at the center of the wing (compound helicopter configuration). Author (Herner)

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 323)

November 1995

01 AERONAUTICS (GENERAL)

A95-93617

DEVELOPMENT OF AN INTELLIGENT TOOL-CONDITION MONITORING SYSTEM FOR FMS

R. D. JAMES University of Hull, UK and D. R. AITCHISON University of Hull, UK 1991 8 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 32: Manufacturing Technology)

Contract(s)/Grant(s): (BREU-0066-C (MB))

(CONGRESS PAPER C428-32-012; HTN-95-21186) Copyright

Cutting tool management is a important aspect of Flexibe Manufacturing Systems (FMS). However, the number of tools and their relative complexity means that the tasks involved in meeting this objective are not trivial, particularly in the context of metal cutting FMS for the aerospace industry. The current work relates to the development of an intelligent laser-based system for monitoring the condition of cutting tools either in the context of a computer-controlled centralized tool-room or as a localized facility at a Computer Numerically Controlled (CNC) machining station. The condition-monitoring methodology is described and its integration within the framework of a BRITE/EURAM trans-national academic and industrial collaborative program discussed. Author (Herner)

A95-93618

NON-CONTACT CALIBRATION OF A CNC RIVETTING MACHINE

T. R. CROSSLEY University of Salford, UK 1991 6 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 32: Manufacturing Technology)

(CONGRESS PAPER C428-32-075; HTN-95-21187) Copyright

The non-contact calibration of a five-Axis Computer Numerically Controlled (CNC) riveting machine is described. The calibration was carried out in order to assess the accuracy and repeatability of the machine when used to drill and rivet aircraft panels. The equipment used was a Kern-Theodolite ECDS measuring system. The analysis of the calibration indicated that the repeatability of the machine was well within specification, and that look-up tables compensating for small machine inaccuracies can be developed. In consequence, it is entirely feasible to build an off-line part-programming system for the CNC riveting machine. This should enable aircraft panels to be drilled and riveted with sufficient confidence and to use the machine part program repeatedly for identical panels. Author (Herner)

A95-93619

TOOLING - A SOURCE OF PRODUCTIVITY

J. HARGREAVES and R. W. SHANKS 1991 3 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 32: Manufacturing Technology)

(CONGRESS PAPER C428-32-017; HTN-95-21188) Copyright

By embracing computer technologies to help design and manufacture cutting tools with performance capabilities to match the needs of aerospace companies, Sandvik Coromant is filling an important role and helping the industry to raise productivity. The following is an overview of these technologies and how they have effected productivity. Author (Herner)

A95-93682

INTEGRATED TEST SYSTEM SINGLE POINT CONTROL OF AIRCRAFT CHECKOUT

STEVE MYERS (ISSN 0148-7191) 1993 6 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993

(SAE PAPER 931417; HTN-95-21251) Copyright

Integration, checkout and test of a multi-discipline complex system like the B-2 involves concurrent operation of many scattered interactive resources. Potential unplanned conflicts involving high energy equipment can threaten the safety of operators and equipment. Tests can be run serially to aviod conflicts, however, this adds considerable time to the process and cannot support rate production. Manual operation of the equipment can be coordinated, to a limited extent, using communication devices such as intercoms, but that is slow, imprecise, labor intensive and subject to operator error. A systems approach was needed to effectively integrate and control the test resources to sustain the throughput and provide the safety necessary for production operation. An Integrated Test System was developed to link the resources, provide single point access and control, and automate the process. Author (Herner)

A95-94036

LEAN MANUFACTURING FOR LEAN TIMES

JAMES D. LANG F-15 Integrated Product Definition and PAUL B. HUGGE Aerospace America (ISSN 0740-722X) vol. 33, no. 5 May 1995 7 p

(BTN-95-EIX95302730538) Copyright

In times of reduced budget pressure of global competition, the U.S. aerospace industry are advised to adopt the concept of lean manufacturing. Lean manufacturing implies thorough understanding of both customer requirements and companies' manufacturing processes to enable companies to make major strides in productivity, quality and cost containment. Although a lot of techniques and tools have been associated with the concept of lean design and manufacturing, they prove to be futile unless they are integrated with thorough understanding of the manufacturing processes, redefinition of the currently adopted processes and multidisciplined teams assigned to implement changes. EI

A95-94056* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

EVALUATION OF A MULTIGRID-BASED NAVIER-STOKES SOLVER FOR AEROTHERMODYNAMIC COMPUTATIONS

VEER N. VATSA National Aeronautics and Space Administration Langley Research Cent, Hampton, VA, United States Journal of Spacecraft and Rockets (ISSN 0022-4650) vol. 32, no. 2 March-April 1995 p. 193-199 refs

(BTN-95-EIX95302694459) Copyright

A multigrid acceleration technique developed for solving the three-dimensional Navier-Stokes equations is used for computing high-Mach-number flows over configurations of practical interest. An explicit multistage Runge-Kutta time-stepping scheme is used as the basic algorithm.

Solutions are presented for a spherically blunted cone at Mach 10 and a modified Shuttle orbiter at Mach 6. The computed surface heat-transfer distributions are shown to compare well with the experimental data. Effect of grid refinement on computed heat-transfer distributions is also examined to assess the numerical accuracy of the computed solutions. The rapid convergence rate associated with multigrid schemes in previous applications at transonic speeds is observed at the higher-Mach-number flows investigated here. Author (EI)

A95-94468
PREDICTION OF AIRPLANE STATES
AMNON KATZ Univ of Alabama, Tuscaloosa, AL, United States and KENNETH GRAHAM Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 563-569 refs
(BTN-95-EIX0619952748174) Copyright

Methods for extrapolation of airplane flight trajectory and orientation history that exploit coordinated flight and other airplane specific grounds are derived and applied. They include extraction of orientation from trajectory with angle-of-attack (AOA) correction, closed-form trajectory extrapolation based on constant longitudinal and transverse acceleration, and a 'phugoid scheme' for six degrees-of-freedom extrapolation at constant AOA in coordinated flight. A metric well known in connection with networked simulation shows an advantage of up to a factor of 3 for the new methods. Author (EI)

A95-94469
STATISTICAL DISCRETE GUST-POWER SPECTRAL DENSITY METHODS OVERLAP-HOLISTIC PROOF AND BEYOND
ROBERT P. CHEN Allied-Signal Aerospace Co, Torrance, CA, United States Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 570-576 refs
(BTN-95-EIX0619952748175) Copyright

The statistical discrete gust (SDG)-power spectral density overlap of gamma (bar) = 10.4A(bar) claimed by J. G. Jones, and verified by B. Perry III, A. S. Pototzky, and J. A. Woods, does exist. The analytical results consist of numerical substantiation of specific aircraft models. The claim is valid up to approximately +/- 10% about the 10.4 factor. This article presents a mathematically rigorous proof from basic principles without specific aircraft models and very restricted gust shapes. By invoking Chebyshev's inequality, the extension to gamma-bar(max) = 25 - 150 A-bar for true design gust loads becomes a reality to complete the holistic proof. This article also introduces the all-encompassing fractal geometry representation of turbulence that uses their respective Hausdorff (fractal) dimensions to derive all known spectral shapes. A sample case explains the obvious impacts from these different shapes on gust load exceedance. A two-tier approach proposes concrete changes in FAR 25 requirements. Realistic assessment of SDG method's role in gust load analysis points out some of its shortcomings and virtues. Author (EI)

N95-31000*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PATTERNS IN THE SKY: NATURAL VISUALIZATION OF AIRCRAFT FLOW FIELDS
JAMES F. CAMPBELL and JOSEPH R. CHAMBERS 1994 162 p Original contains color illustrations
(NASA-SP-514; NAS 1.21:514) Avail: CASI HC A08/MF A02; 118 functional color pages

The objective of the current publication is to present the collection of flight photographs to illustrate the types of flow patterns that were visualized and to present qualitative correlations with computational and wind tunnel results. Initially in section 2, the condensation process is discussed, including a review of relative humidity, vapor pressure, and factors which determine the presence of visible condensate. Next, outputs from computer code calculations are postprocessed by using water-vapor relationships to determine if computed values of relative humidity in the local flow field correlate with the qualitative features of the in-flight condensation patterns. The photographs are then presented in section 3 by flow type and subsequently in section 4 by aircraft type to demonstrate the variety of condensed flow fields that was visualized for a wide range of aircraft and flight maneuvers. Author

N95-31598# Federal Aviation Administration, Washington, DC. Office of Aviation Policy and Plans.
FAA AVIATION FORECASTS: FISCAL YEAR 1995-2006
Mar. 1995
(AD-A293682; FAA-APO-95-1) Avail: CASI HC A11/MF A03

This report contains the Fiscal Years 1995-2006 Federal Aviation Administration (FAA) forecasts of aviation activity at FAA facilities. These include airports with FAA control towers, air route traffic control centers, and flight service stations. Detailed forecasts were made for the major users of the National Aviation System: air carriers, air taxi/ commuters, military, and general aviation. The forecasts have been prepared to meet the budget and planning needs of the constituent units of the FAA and to provide information that can be used by state and local authorities, the aviation industry, and the general public. The outlook for the 12-year forecast period is for moderate economic growth, stable real fuel prices, modest inflation, and continued moderate to strong growth in the demand for aviation services. Based on these assumptions, aviation activity is forecast to increase by 19.7 percent at FAA towered airports (352 airports) and 26.0 percent at air route traffic control centers. The general aviation active fleet is forecast to decline by 0.8 percent during the forecast period but increased utilization (hours flown by aircraft) results in a 12.0 percent increase in general aviation hours flown during same period. Scheduled domestic revenue passenger miles (RPM's) are forecast to increase 60.5 percent, scheduled international RPM's are forecast to increase by 97.2 percent, and regional/commuter RPM's are forecast to increase by 154.1 percent. DTIC

N95-32164# Lawrence Livermore National Lab., Livermore, CA.
MAPPING HIDDEN AIRCRAFT DEFECTS WITH DUAL-BAND INFRARED COMPUTED TOMOGRAPHY
NANCY K. DELGRANDE and PHILIP F. DURBIN 3 Apr. 1995 14 p Presented at the Conference on Nondestructive Evaluation of Aging Infrastructure, Oakland, CA, 6-8 Jun. 1995
Contract(s)/Grant(s): (W-7405-ENG-48)
(DE95-011531; UCRL-JC-120546; CONF-9506126-2) Avail: CASI HC A03/MF A01

Infrared computed tomography (IRCT) is a promising, non-contact, nondestructive evaluation tool used to inspect the mechanical integrity of large structures. We describe on-site, proof-of-principle demonstrations of IRCT to inspect defective metallic and composite structures. The IRCT system captures time sequences of heat-stimulated, dual-band infrared (DBIR) thermal maps for flash-heated and naturally-heated targets. Our VIEW algorithms produce co-registered thermal, thermal inertia, and thermal-timegram maps from which we quantify the percent metal-loss corrosion damage for airframes and the defect sites, depths, and host-material physical properties for composite structures. The IRCT method clarifies the type of defect, e.g., corrosion, fabrication, foreign-material insert, delamination, unbond, void, and quantifies the amount of damage from the defect, e.g., the percent metal-loss from corrosion in metal structures, the depth, thickness, and areal extent of heat damage in multi-layered composite materials. Potential long-term benefits of IRCT technology are in-service monitoring of incipient corrosion damage, to avoid catastrophic failure and production-monitoring of cure states for composite materials. DOE

N95-32194# General Accounting Office, Washington, DC. National Security and International Affairs Div.
REPORT TO THE CHAIRMAN, LEGISLATION AND NATIONAL SECURITY SUBCOMMITTEE, COMMITTEE ON GOVERNMENT OPERATIONS, HOUSE OF REPRESENTATIVES. C-17 AIRCRAFT PROGRAM: IMPROVEMENTS IN INITIAL PROVISIONING PROCESS

21 Jan. 1994 11 p
(GAO/NSIAD-94-63; B-255832) Avail: CASI HC A03/MF A01; GAO, PO Box 6015, Gaithersburg, MD 20877 HC

This GAO report is an updated review of the Air Force's initial provisioning of spare parts for the C-17 military transport aircraft. Since 1989, when it began initial provisioning for the C-17 aircraft program, the Air Force has frequently ordered spare parts prematurely. As of July 1993, the Air Force had $111.2 million of C-17 spare parts on order. These premature procurements were made under a DOD policy that called for maximizing procurement of support items for the provisioning period. Within the framework of this policy, this report finds that premature ordering occurred because the Air Force: used inaccurate and outdated information to determine how many spare parts to buy and when to buy them; bought quantities of spare parts that were higher than computed stockage levels justified; and failed to follow regulations that governed the initial provisioning process. DOD has recently revised its provisioning guidance to stress the need to limit the initial procurement of spare parts, thereby minimizing cost. Derived from text

N95-32198# General Accounting Office, Washington, DC. National Security and International Affairs Div.

REPORT TO CONGRESSIONAL COMMITTEES. MILITARY AIRLIFT: C-17 SETTLEMENT IS NOT A GOOD DEAL

15 Apr. 1994
(GAO/NSIAD-94-141; B-256721) Avail: CASI HC A03/MF A01; GAO, PO Box 6015, Gaithersburg, MD 20877 HC

This report deals with the status of the C-17 program, with emphasis on DoD's proposed settlement agreement with McDonnell Douglas, the prime contractor on the C-17 aircraft. It also discusses DOD's efforts to identify alternatives to the C-17 program. Rising program costs, less than anticipated performance, and lengthy delays in this concurrent acquisition program raise serious doubts about the C-17's cost-effectiveness and undermine the program's credibility. Despite these problems, DOD has proposed a settlement with McDonnell Douglas that, in our opinion, is not in the best interest of the government. Although the true cost is not known, the settlement identifies the cost to the government and the contractor as $348 million and $454 million, respectively. Under the proposed settlement, DOD would delay the decision on the number of C-17's to be procured until November 1995; it would also, in effect, delay the decision on the most cost-effective mix of aircraft for meeting its airlift requirements until that time. Most of the benefits of the contractor's management and productivity improvements called for in the settlement will not be realized until 1996 or beyond. We are also concerned that DOD has not established specific cost, schedule, and performance criteria to evaluate McDonnell Douglas' performance and to decide whether to purchase more than 40 aircraft. CASI

02 AERODYNAMICS

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

A95-93392

MODELLING REQUIREMENTS IN FLIGHT SIMULATION

A. G. BARNES Aeronautical Journal (ISSN 0001-9240) vol. 98, no. 980 December 1994 p. 395-404
(HTN-95-C0004) Copyright

The models used in flight simulation have changed dramatically in the past thirty years. The extent of modeling has been dictated entirely by computing equipment limitations. Now, other factors, such as the control of software and other documentation, are beginning to intrude. There have always been more concerns about the data used in the model, and about the computer implementation, than about the model itself. The paper highlights the many choices open to the modeler, in selecting a level of modeling appropriate to the application of the simulator. Modeling a complex entity such as an aircraft and its enviroment requires severe compromises. Two parameters which allow these compromises to be seen are the bandwidth of components of the model, and the extent of the cross-coupling between components. Author (revised by Herner)

A95-93393

MODELLING 2D SEPARATION FROM A HIGH LIFT AEROFOIL WITH A NON-LINEAR EDDY-VISCOSITY MODEL AND SECOND-MOMENT CLOSURE

F. S. LIEN Institute of Science and Technology, Manchester, UK and M. A. LESCHZINER Institute of Science and Technology, Manchester, UK Aeronautical Journal (ISSN 0001-9240) vol. 99, no. 984 April 1995 p. 125-143 Research sponsored by British Aerospace (CAL), Defence Research Agency, Commission of the European Communities
(HTN-95-C0005) Copyright

A computational study is presented, which examines the performance of variants of second-moment closure and non-linear eddy-viscosity models when used to predict attached and separated flows over a high lift aerfoil for a range of incidence angles. The capabilities of both model types, especially in respect of resolving the onset of suction-side separation at high incidence, are contrasted with those of a low Reynolds number K-epsilon model based on the linear Boussinesq stress-strain relationship.The second-moment model contains a conventional linear approximation of the pressure straining process; a cubic variant has been investigated in an earlier study and found to offer no advantages. The quadratic eddy-viscosity model features coefficients which are sensitised to the strain and vorticity invariants. While both models, in the form originally proposed, are superior to the linear eddy-viscosity variant, neither performs well in respect of resolving separation, unless modified so as to return the requisite low level of shear stress in the boundary layer approaching separation. Once separation is resolved with sufficient realism, the near wake aft of the trailing edge is also well represented. All models return poor representations of the far wake which is characterized by low levels of turbulence production to dissipation ratio. Author (Herner)

A95-93394

AUTONOMOUS HELICOPTER HOVER POSITIONING BY OPTICAL TRACKING

G. BOUWER DLR Institut fur Flugmechanik, Braunschweig, Germany, C.-H. OERTEL DLR Institut fur Flugmechanik, Braunschweig, Germany, and W. VON GRUNHAGEN DLR Institut fur Flugmechanik, Braunschweig, Germany Aeronautical Journal (ISSN 0001-9240) vol. 99, no. 984 April 1995 p. 145-149
(HTN-95-C0006) Copyright

The design of control systems for helicopters in hover and at low speed is a requirement for the extension of mission profiles and new mission demands. A special task for various applications is the position hold under wind and gust conditions above a ground fixed or moving target, like a shipboard reference, or a small vessel or lifeboat in rescue missions. For the solution of this problem a controller concept was developed and the feasibility was proven and successfully demonstrated in flight tests. The integrated system of optical position sensor and control computer enables the helicopter to hover automatically above a defined target in constant altitude and with constant heading. Flight tests above a moving car under wind and gust conditions underline the future potential of the overall system to be used under operational conditions. Author (revised by Herner)

A95-93395

A THREE-DIMENSIONAL MOVING MESH METHOD FOR THE CALCULATION OF UNSTEADY TRANSONIC FLOWS

A. L. GAITONDE University of Bristol, Bristol, UK and S. P. FIDDES University of Bristol, Bristol, UK (ISSN 0001-9240) vol. 99, no. 984 April 1995 p. 150-160 Research sponsored by British Aerospace (Airbus) Limited and Lloyds of London Tercentenary Foundation

(HTN-95-C0007) Copyright

A three-dimensional moving mesh method for solving the Euler equations describing the compressible flow about a wing undergoing arbitrary motions and deformations is described. A finite-volume formulation is chosen where the volumes distort as the wing moves or defoms. By using transfinite interpolation, a technique for generating the required sequence of grids has been developed. Furthermore, as the speeds of the grid at the vertices of the finite volumes are required by the flow solver, transfinite interpolation is also used to obtain these by interpolation of the boundaary speeds. A two-dimensional version ofthe method has also been developed and results for both two- and three-dimensional transonic flows are presented and compared with experimental data where available. Author (Herner)

A95-93396* National Aeronautics and Space Administration, Wash., DC.
SCRAMJET THRUST MEASUREMENT IN A SHOCK TUNNEL
A. PAULL University of Queenstand, Brisbane, Australia, R. J. STALKER University of Queenstand, Brisbane, Australia, and D. J. MEE University of Queenstand, Brisbane, Australia Aeronautical Journal (ISSN 0001-9240) vol. 99, no. 984 April 1995 p. 161-163 Research sponsored by Australian Research Council and NASA
Contract(s)/Grant(s): (NAGW-674)
(HTN-95-C0008) Copyright

This note reports tests in a shock tunnel in which a fully integrated scamjet configuration produced net thrust. The experiments not only showed that impluse facilities can be used for assessing thrust performance, but also were a demonstration of the application of a new technique to the measurement of thrust on scramjet configurations in shock tunnels. These two developments are of significance because scramjets are expected to operate at speeds well in excess of 2 km/s, and shock tunnels offer a means of generating high Mach number flows at such speeds. Author (Herner)

A95-93647
A PERSPECTIVE OF RAREFIED GAS FLOW PROBLEMS RELEVANT TO HIGH ALTITUDE FLIGHT
K. S. NAGARAJA Wright-Patterson Air Force Base, OH, US and K. D. MACH Wright-Patterson Air Force Base, OH, US (ISSN 0148-7191) 1993 12 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993
(SAE PAPER 931366; HTN-95-21216) Copyright

High altitude, high speed flight will push vehicles into regions wherein the density of the surrounding medium is so low that vehicle aerodynamics cannot be described on the basis of a continuum equations of fluid motion. Typical flight trajectories and the characteristic flow regions they traverse are illustrated, and the prediction techniques based on molecular flow physics are outlined. Some analytical, experimental, and flight test results which clearly illustrate the importance of low density effects on the flight performance of vehicles - particularly lift, drag, and moment - are discussed. The data presented bring out some fundamental physical principles of molecular interactions in the definitions of aerodynamic behavior, and some of the underlying physical mechanisms are discussed. molecule-to-molecule interaction is only one of the processes which determine flow field characteristics. Molecule-to-surface interaction becomes important at some Knudsen numbers and at high Mach numbers, real gas effects caused by the high temperatures also becomes important. These are also illustrated. Among the various theoretical and computational approaches which are vigorously pursued today, Monte Carlo methods and the Burnett equations are extensively applied. The bases of these methods are outlined and some of their results are discussed in the paper. Author (Herner)

A95-93648
X-29 HIGH AOA FLIGHT TEST RESULTS: AN OVERVIEW
W. SMITH Wright-Patterson Air Force Base, OH, US (ISSN 0148-7191) 1993 12 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993
(SAE PAPER 931367; HTN-95-21217) Copyright

An extensive high angle-of-attack (AOA) flight testing prograam has been performed with the X-29-2 (AF 82-0049) forward swept wing research aircraft. The high AOA envelope expansion phase cleared the aircrat to fly in a broad flight regime and produced important data on the high AOA clearance process and data analysis. Lessons learned during the military utility phase on the tactical advantages and disadvantages associated with high AOA maneuvering are impacting programs such as the X-31, HARV, and F-22. Insight on the critical forebody flow-field of the X-29 at high AOA was gained using on-surface flow visualization during the aerocharacterization phase. The Vortex Flow Control (VFC) experiment conducted on the X-29 sucessfully proved the viability of a pneumatic blowing device manipulating forebody vortices to act as an aircraft controller, an historical first. Finally throughout the aircraft #2 flight test program, important data concerning the aircraft's air data system, digital flight control system, vertical tail, engine, and subsystems operating in a high AOA environment were gathered. Author (Herner)

A95-93649
PRIMARY AND SECONDARY VORTEX STRUCTURES OVER ACCELERATED-DECELERATED AIRFOILS AT HIGH ANGLES OF ATTACK
FATHI FINAISH University of Missouri-Rolla, MO, US and JACOPO FRIGERIO University of Missouri-Rolla, MO, US (ISSN 0148-7191) 1993 6 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993
(SAE PAPER 931368; HTN-95-21218) Copyright

An experimental study is conducted to investigate the vortex developments over high angles of attack flat plate airfoils in an accelerated-decelerated flow. To perform the required experiments, a new experimental system was developed and incorporated into an open return subsonic wind tunnel. The system was employed to visualize the details of vortex structures and processes over and downstream of the airfoils for an angle of attack range between 30 deg and 90 deg. While flow acceleration encouraged flow separation and vortex convection, flow deceleration delayed the convection of the primary vortex structures as well as the reverse flow reattachment and shredding. The details provided in the article may help in developing control possibilities of vortical flow over vehicles or structures subjected to accelerating-decelerating motions. Further, the study presents guidelines to develop unsteady flow experimental arrangements suitable for incorporation into steady flow subsonic wind tunnels. Author (Herner)

A95-93660
A DESIGN TRADE STUDY USING CFD MODELING OF REACTION JETS FOR AERODYNAMIC CONTROL
CLINTON HOUSH (ISSN 0148-7191) 1993 6 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993
(SAE PAPER 931384; HTN-95-21229) Copyright

The use of external jets issuing normal to the surface of a body for aerodynamic control has received attention in the past due to experimental observations of favorable interactions between the free stream flow and the jet wake which, in effect, augment the force produced by the jet. The purpose of this study was to preform preliminary trades to determine the effect of variables such as reaction jet location, free stream Mach number, reaction jet stagnation pressure, and reaction jet exit Mach number on augmentation factors for a representative lifting body cruise missile configuration. A computational fluid dynamic analysis, solving the Euler equations, was used to preform the trades listed above. It is shown that the reaction jet augmentation factors are greater, hence the reaction jet is more effective, at higher free stream dynamic pressures in the subsonic regime. It is also shown that the augmentation factors are essentially independent of reaction jet stagnation pressure for choked nozzles with jet to free stream stagnation pressure ratios between 1.24 and 3.0. Additionally it is shown that increasing the jet exit Mach number decreases the reaction jet augmentation factor. Finally, the strong influence of reaction jet placement and body geometry on augmention factors is discussed and the need for this level of analysis is justified. Author (Hemer)

A95-93662

HYBRID LAMINAR FLOW OVER WINGS ENHANCED BY CONTINUOUS BOUNDARY LAYER SUCTION

BASHAR S. ABDUL NOUR and MARC K. MUELLER University of Wyoming, WY, US (ISSN 0148-7191) 1993 8 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993

(SAE PAPER 931386; HTN-95-21231) Copyright

The numerical analysis of continuous boundary-layer suction on a flat plate at zero angle of attack is the focus of this study. A uniform flow is prescribed upstream of the plate. The governing equations, the Navier-Stokes and continuity equations are presented by the vorticity-stream function formulation. A transformation is made from the physical to the computational domain and the ressulting equations are solved numerically by the ADI and SOR methods, respectively. Reynolds numbers from 10(exp 3) to 10(exp 4) are considered. A second-order upwinding scheme is employed to numerically stabilize the solution. A comparison is made between flows with and without suction. Preliminary results are presented for the solution behavior as a function of such parameters as Reynolds number, grid resolution and numerical representation of the boundary conditions. Author (Hemer)

A95-93736

ON CONTROLLING THE TIP VORTEX FLOW OF A LIFTING WING

JAIN-MING JAMES WU The Univ. of Tennessee Space Inst., Tullahoma, TN, US *In* Developments in theoretical and applied mechanics; Southeastern Conference on Theoretical and Applied Mechanics, 16th, Nashville, TN, April 12-14, 1992. A95-93700 Tullahoma, TN The Univ. of Tennessee Space Inst. (SECTAM, Vol. 16) 1992 p. II.14.52-II.14.61

(ISBN 1-879921-01-4) Copyright

First, a brief summary of review of the so called wingtip vortex wake flow, its formulation, consequence and complexity is introduced. Then, the various means to reduce or alleviate this tip vortex are presented which includes leading edge and wingtip modifications; solid end-plate; winglets; delta-wing-fences; multiple fins; jet-sheet; discrete jets blowing. Finally, some of our unpublished works at University of Tennessee Space Institute (USTI) on fins, various jet(s) from the tip and leeside surface of the wing are presented and its effectiveness discussed. Author (Hemer)

A95-93747* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

THE APPLIATION OF POTENTIAL CFD METHODS TO HELICOPTER HOVER FLOWS

F. X. CARADONNA NASA. Ames Research Center, Moffett Field, CA, US, C. TUNG NASA. Ames Research Center, Moffett Field, CA, US, and K. RAMACHANDRAN Flow Analysis, Inc., Moffett Field, CA, US *In* Developments in theoretical and applied mechanics; Southeastern Conference on Theoretical and Applied Mechanics, 16th, Nashville, TN, April 12-14, 1992. A95-93700 Tullahoma, TN The Univ. of Tennessee Space Inst. (SECTAM, Vol. 16) 1992 p. III.II.1-III.I.14

(ISBN 1-879921-01-4) Copyright

Fixed-wing code development is now aimed primarily at the solution of problems dominated by separation--based on the assumptions that the ability to solve such problems implies the ability to solve all other problems and that present inviscid method are already adequate for most other problems. Neither of the above assumptions are correct for rotary wing problems. This is because of the unique and overriding importance of wake modeling to rotor problems and also due to the well-known numerical diffusion problems which convectional Eulerian Computational fluid dynamics (CFD) method encounter when called on to convect strong vortical regions for long distances. The need for accurate wake analyses is probably the most fundamental difference between rotory and fixed-wing aerodynamics. In addition, rotary wing complexity requires a much more intimate relationship between test and analysis than is common in fixed-wing work. With these issues in mind, this paper will review some of our recent experience in using a unique-Eulerian-Lagrangian Computational fluid dynamics (CFC) method for the solution of a critical rotor-wake problem--the prediction of hover performance. Author (Hemer)

A95-93748

A THREE-DIMENSIONAL NAVIER-STOKES / FULL-POTENTIAL COUPLED ANALYSIS FOR ROTOR BLADES

FU-LIN TSUNG Georgia Tech, GA, US and L. N. SANKAR Georgia Tech, GA, US *In* Developments in theoretical and applied mechanics; Southeastern Conference on Theoretical and Applied Mechanics, 16th, Nashville, TN, April 12-14, 1992. A95-93700 Tullahoma, TN The Univ. of Tennessee Space Inst. (SECTAM, Vol. 16) 1992 p. III.II.15.III.II.23 Research sponsored by McDonnel Douglas Corp.

(ISBN 1-879921-01-4) Copyright

An efficient technique for the prediction of three-dimensional steady and unsteady viscous flows past arbitrary configurations is described. The flowfield is partitioned into an inner zone adjacent to the solid surface and an outer zone away from the solid surface. The solution procedure uses a three-dimensional compressible Navier-Stokes solver in the inner vortical region, and a three-dimensional unsteady full potential flow solver in the outer irrotational region. These two solvers are tightly coupled and simultaneously integrated in time. Computational results are compared with experimental and other Computational fluid dynamics (CFC) data. The present coupled analysis reduces the CUP requirements about 50% when compared to standard Navier-Stokes analysis. Author (Hemer)

A95-93749

NUMERICAL SOLUTIONS OF THREE DIMENSIONAL VISCOUS FLOWS

JAMES WU, C. Georgia Inst. of Tech., GA, US and CLIN M. WANG Georgia Inst. of Tech., GA, US *In* Developments in theoretical and applied mechanics; Southeastern Conference on Theoretical and Applied Mechanics, 16th, Nashville, TN, April 12-14, 1992. A95-93700 Tullahoma, TN The Univ. of Tennessee Space Inst. (SECTAM, Vol. 16) 1992 p. III.II.24-III.II.31 Research sponsored by the Army Research Office

(ISBN 1-879921-01-4) Copyright

A numerical approach based on the velocity-vorticity formulation and a velocity integral representation is presented for three-dimensional viscous flow problems. Several new techiques unique to three-dimensional viscous flows are developed and implemented. Steady and unsteady flow solutions around rectangular wings are presented and discussed. Author (Hemer)

A95-93750* National Aeronautics and Space Administration, Washington, DC.

NUMERICAL STUDY OF MULTI-ELEMENT AIRFOIL AERODYNAMICS

CLIN M. WANG Georgia Inst. of Tech., GA, US and CHEE TUNG *In* Developments in theoretical and applied mechanics; Southeastern Conference on Theoretical and Applied Mechanics, 16th, Nashville, TN, April 12-14, 1992. A95-93700 Tullahoma, TN The Univ. of Tennessee Space Inst. (SECTAM, Vol. 16) 1992 p. III.II.32-III.II.39

(ISBN 1-879921-01-4) Copyright

Unsteady flowfields around oscillating Boeing VR7 airfoil with and without a leading-edge slat were numerically investigated by a novel zonal method using a conformal mapping technique. Numerical aero-dynamic hysteresis loops show that the leading-edge slat prevents the airfoil dynamic stall at reduced frequency of 0.15, Reynolds number of 1 million, and the oscillation range of 5 deg to 25 deg. Author (Hemer)

A95-93751

A KUTTA CONDITION CONSCIOUS PERTURBATION STREAM FUNCTION BOUNDARY ELEMENT ALGORITHM FOR 2-D POTENTIAL AERODYNAMICS

G. S. IANNELLI Univ. of Tennessee, TN, US, C. GRILLO Univ. of Pal-

ermo, Italy, and L. TULUMELLO Univ. of Palermo, Italy *In* Developments in theoretical and applied mechanics; Southeastern Conference on Theoretical and Applied Mechanics, 16th, Nashville, TN, April 12-14, 1992. A95-93700 Tullahoma, TN The Univ. of Tennessee Space Inst. (SECTAM, Vol. 16) 1992 p. III.II.40-III.II.47
(ISBN 1-879921-01-4) Copyright

An analytical perturbation stream function procedure is established for potential flows about lifting airfoils, which provides for a natural venue to impose the fundamental Kutta condition. Using Green's identity, this formulation is transformed into an equivalent boundary integral equation. A boundary finite element discretization of this equation then yields a linear system for the efficient determination of the airfoil surface tangential velocity and associated lift. Author (Herner)

A95-93752
A ONE-DIMENSIONAL INVISCID NONEQUILIBRIUM FLOW SOLVER
R. W. TRAMEL Calspac Corp./AEDC Operations, TN, US, S. L. KEELING Calspac Corp./AEDC Operations, TN, US, and J. H. FOX Calspac Corp./AEDC Operations, TN, US *In* Developments in theoretical and applied mechanics; Southeastern Conference on Theoretical and Applied Mechanics, 16th, Nashville, TN, April 12-14, 1992. A95-93700 Tullahoma, TN The Univ. of Tennessee Space Inst. (SECTAM, Vol. 16) 1992 p. III.II.48-III.II.55
(ISBN 1-879921-01-4) Copyright

A new one-dimensional inviscid flow solver has been developed that has the capability of providing flow-field properties for high-temperature flows in which nonequilibrium chemistry effects are important. Changing chemistry models is a simple task because the code was implemented in a modular fashion to take advantage of an existing set of nonequilibrium chemical, thermodynamic, and transport property routines. The new code uses a simple algorithm that is easy to understand and use. Excellent agreement was obtained in comparisons of results from the new flow solver with solutions obtained from existing state-of-the-art solvers for high-temperature air. Author (Herner)

A95-93758* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ANALYTIC SOLUTION OF THE THICKNESS PROBLEM OF A RECTANGULAR WING IN STEADY SUBSONIC FLOW
N. ULBRICH The Univ. of Tenessee Space Inst., TN, US *In* Developments in theoretical and applied mechanics; Southeastern Conference on Theoretical and Applied Mechanics, 16th, Nashville, TN, April 12-14, 1992. A95-93700 Tullahoma, TN The Univ. of Tennessee Space Inst. (SECTAM, Vol. 16) 1992 p. IV.S1.8-IV.S1.16
Contract(s)/Grant(s): (NAG2-733)
(ISBN 1-879921-01-4) Copyright

An analytic solution of the thickness problem of a rectangular wing with parabolic airfoil section in three-dimensional flow is presented. The free-air solution is obtained by integrating the equation of the axial perturbation velocity. The Prandtl-Glauert rule can be used to derive the subsonic solution. Parts of the free-air solution are verified by taking the limit of the axial peturbation velocity on the model surface as the wing span goes to infinity. Pressure coefficients are studied for a selected wing geometry in the flow field. The solution of the thickness problem of a rectangular wing in a rectangular wind tunnel is derived using the free-air solution and the method of images. Author (Herner)

A95-94065
AERODYNAMIC INTERFERENCE FOR SUPERSONIC LOW-ASPECT-RATIO MISSILES
H. F. NELSON Univ of Missouri - Rolla, Rolla, MO, United States and BRENT W. BOSSI Journal of Spacecraft and Rockets (ISSN 0022-4650) vol. 32, no. 2 March-April 1995 p. 270-278 refs
(BTN-95-EIX95302694469) Copyright

Interference factors K(sub W(B)), K(sub B(W)), and K(sub phi) are used in preliminary design in the equivalent-angle-of-attack method. An Euler code is used to numerically evaluate K(sub W(B)), K(sub B(W)), and K(sub phi) for low-aspect-ratio, cruciform wing-bodies with clipped delta fins for Mach numbers from 3 to 4 and angles of attack up to 20 deg. The ratios of fin span to body radius (S/R) range from 1.3 to 2, so that aspect ratios vary from 0.05 to 4 and taper ratios vary from 0 to 0.975. Euler results compare well with experimental data. At low angle of attack K(sub W(B)) is of the order of 1.5 for low-aspect-ratio fins. K(sub W(B)) decreases as the angle of attack increases and can be less than 1 at large angles of attack. Shock and expansion waves from the fin interact with the body and strongly influence K(sub B(W)). The afterbody length beyond the fin trailing edge also contributes to K(sub B(W)). As the aspect ratio decreases from 4 to 0.05, K(sub B(W)) increases to a maximum value and then (1) decreases for small angles of attack and (2) remains fairly constant for large angles of attack. K(sub phi) is calculated for sideslip angles of +/- 3 deg. Euler predictions of K(sub phi) are larger than slender-body predictions, because of vortex effects. K(sub phi) is also influenced by shock and expansion waves from adjacent fins. At small angles of attack K(sub phi) is larger for negative sideslip than it is for positive sideslip. At large angles of attack K(sub phi) becomes independent of the sign of sideslip angle. Author (EI)

A95-94454
NUMERICAL INVESTIGATION OF HIGH INCIDENCE FLOW OVER A DOUBLE-DELTA WING
J. A. EKATERINARIS Naval Postgraduate Sch, Monterey, CA, United States, R. L. COUTLEY, LEWIS B. SCHIFF, and M. F. PLATZER Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 457-463 refs
(BTN-95-EIX0619952748160) Copyright

The vortical flowfield over a double-delta wing configuration, consisting of a sharp leading-edge 76-deg sweep strake and a 40-deg sweep wing section is investigated numerically. The governing equations are solved with a partially upwind, finite difference, two-factor algorithm. The leeward-side vortex system resulting from the strake and wing vortices is investigated for a subsonic freestream speed of M(sub infinity) = 0.22, high Reynolds number turbulent flow at various angles of incidence. At low angles of attack the strake and wing vortices remain separate over the wing section, whereas for flows at higher angles of attack the two vortices merge and vortex breakdown develops. Vortex breakdown appears initially in the trailing-edge region of the wing section. As the angle of attack increases, bursting occurs further upstream closer to the strake section. The effect of numerical grid density is investigated, and the solutions are compared with available experimental data. The computed surface pressures are in good agreement with the experimental measurements for the lower angles of attack, but the agreement deteriorates as the angle of attack increases. Author (EI)

A95-94455* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
QUANTIFIABLE VORTEX FEATURES OF F-106B AIRCRAFT AT SUBSONIC SPEEDS
JOHN E. LAMAR National Aeronautics and Space Administration Langley Research Cent, Hampton, VA, United States, JAY BRANDON, and THOMAS D. JOHNSON, JR. Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 464-470 refs
(BTN-95-EIX0619952748161) Copyright

Quantifiable vortex features and separated-flow origins have been determined on an F-106B aircraft at 1-g subsonic speeds using the vapor-screen technique coupled with image enhancement, photogrammetry, and computer graphics. In particular, the spatial location of vortex cores, their tracks over the wing, and the approximate reattachment locations have been determined as a function of angle of attack and Reynolds number. Increasing the Reynolds number generally delays or suppresses large-scale separation and promotes the formation of multiple vortices, whereas increasing the angle of attack generally promotes the formation of a single vortex system. The multiple vortices observed may likely be

attributed to small surface distortions in the wing leading-edge region. Comparisons of off-surface determined vortex core location and reattachment point approximation from the vapor-screen technique are made with those from the on-surface techniques of static pressure and oil flow and show generally good agreement. A comparison between quantified vortex features from flight and wind tunnel showed reasonably good agreement over the forward part of the wing for angles of attack from 16 to 20 deg.
Author (EI)

A95-94456

AERODYNAMIC APPLICATIONS OF UNDEREXPANDED HYPERSONIC VISCOUS JETS

V. V. RIABOV Worcester Polytechnic Inst, Worcester, MA, United States Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 471-479 refs

(BTN-95-EIX0619952748162) Copyright

The transonic and hypersonic regions of underexpanded viscous jets, their diffusion and rotational-translational nonequilibrium processes are analyzed, and the jet theory is applied to hypersonic aerodynamic research. Using the method of deformable coordinates, the asymptotic solutions are found for jet parameters in transonic and hypersonic regions. Rotational-translational relaxation is analyzed by the numerical solutions of the Navier-Stokes equations in terms of classical and quantum concepts. The aerodynamic characteristics of wedges and plates are investigated. Fundamental laws for the characteristics and similarity parameters are discussed.
EI

A95-94459

SPECTRAL MAPPING OF QUASIPERIODIC STRUCTURES IN A VORTEX FLOW

JAMES P. HUBNER Georgia Inst of Technology, Atlanta, GA, United States and NARAYANAN M. KOMERATH Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 493-500 refs

(BTN-95-EIX0619952748165) Copyright

Steady vortex flows over highly swept wings develop quasiperiodic velocity fluctuations. The nature of such fluctuations was explored extensively using a 59.3-deg cropped delta wing at 25-deg incidence in a low-speed wind tunnel. Additional single point tests were conducted over a range of incidences (16-32 deg) and Reynolds numbers (1.2 x 10(exp 5) to 5.6 x 10(exp 5)) based on the root chord. Cross-spectral analysis of velocity fluctuations, sensed by two hot-wire sensors, was used to track these phenomena to the region of their origin as well as study the evolution and growth of the fluctuations. Results show the existence of narrow, dominant frequency bands containing the majority of the fluctuation energy. At 25 deg the quasiperiodicity originates near the 30% span region and the intensity amplifies downstream as the corresponding peak frequency decreases. Further downstream the frequency levels off while the intensity peaks, then decreases. Coherence trajectory mapping displays a helical path around the core of the vortex system. At a fixed location relative to the model, the product of the Strouhal number and the nominal wake scale was relatively constant with respect to freestream speed.
Author (EI)

A95-94460

ANALYSIS OF SOME INTERFERENCE EFFECTS IN A TRANSONIC WIND TUNNEL

GIOVANNI LOMBARDI Univ of Pisa, Pisa, Italy and MAURO MORELLI Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 501-509 refs

(BTN-95-EIX0619952748166) Copyright

The effects of the walls of a test section on a model in transonic flow were investigated by using the AGARD Calibration Model B. Tests were carried out in a closed-circuit pressurized tunnel, with a confined square test section of 1.5 m width, with tapered slots giving a 5% porosity. Two models with different dimensions were used, with 0.85 and 0.056% blockage ratios. Longitudinal aerodynamic characteristics were analyzed by means of measurements performed at varying angles of attack (up to 24 deg) and Mach numbers from 0.3 to 1.2. In some flow conditions wall interference effects were probably present. However, the forces and moments dependent on the pressure distribution were likely to be related to the same factors, and therefore, the above effects tended to disappear when longitudinal stability and lift-dependent drag were analyzed as a function of lift characteristics. The drag rise Mach number evaluation seems be fully free from blockage effects. The dimensions of the tested larger model can be considered to be the largest reasonable ones for industrial applications, but, probably, not sufficiently small when high accuracy is required.
Author (EI)

A95-94461* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

COMPARISON OF THE PREDICTIVE CAPABILITIES OF SEVERAL TURBULENCE MODELS

CHRISTOPHER L. RUMSEY National Aeronautics and Space Administration Langley Research Cent, Hampton, VA, United States and VEER N. VATSA Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 510-514 refs

(BTN-95-EIX0619952748167) Copyright

Four turbulence models are evaluated for transonic separated flows using two well-established solvers, one upwind and one central difference. The equilibrium model of Baldwin-Lomax predicts separated-flow shock locations too far aft. The effects of several modifications to the half-equation model of Johnson-King are explored in detail, and different versions of the model are compared. Good results for two- and three-dimensional flows can be obtained using two different versions of this model. The one-equation models of Baldwin-Barth and Spalart-Allmaras perform well for airfoil flows, but can predict the shock too far forward at the outboard stations of a separated wing. The effects of numerical truncation error are assessed using grid-refinement studies in combination with varying the numerical dissipation levels in both codes.
Author (EI)

A95-94463

CORRELATION OF UNSTEADY PRESSURE AND INFLOW VELOCITY FIELDS OF A PITCHING ROTOR BLADE

MIHIR K. LAL Georgia Inst of Technology, Atlanta, GA, United States, S. G. LIOU, G. A. PIERCE, and N. M. KOMERATH Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 520-528 refs

(BTN-95-EIX0619952748169) Copyright

Predictions from four different analytical methods are compared with measurements of unsteady inflow velocity and surface pressure distributions on a pitching rotor blade in hover. The test case is a stiff two-bladed teetering rotor constructed from full-scale tail rotor blades, subjected to n/rev simple harmonic pitch oscillations under incompressible flow conditions. The chordwise distributions of unsteady pressure at three radial locations on the blade are compared with Theodorsen's and Loewy's two-dimensional incompressible unsteady aerodynamic theories and with Kaladi's pulsating doublet distribution method. Inflow velocity is predicted successfully using Peters' modal theory for steady as well as dynamic pitch conditions. The effect of dynamic inflow on rotor unsteady surface pressure is studied. At inboard radial locations, Loewy's two-dimensional theory for even harmonics of forcing frequency and Theodorsen's two-dimensional theory for odd harmonics provide efficient and reliable predictions of unsteady blade surface pressure. At outboard radial locations, panel or modal methods have to be used to predict amplitude and phase of unsteady pressure. Tip effects, mean pitch angle effects, and effects of rotation have been demonstrated.
Author (EI)

A95-94464* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

IN-FLIGHT PRESSURE MEASUREMENTS ON A SUBSONIC TRANSPORT HIGH-LIFT WING SECTION

LONG P. YIP National Aeronautics and Space Administration Langley Research Cent, Hampton, VA, United States, PAUL M. H. W. VIJGEN,

JAY D. HARDIN, and C. P. VAN DAM Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 529-538 refs
(BTN-95-EIX0619952748170) Copyright

The NASA Langley Transport Systems Research Vehicle (B737-100 aircraft) was used to obtain in-flight flow characteristics including surface pressures and surface shear stresses for a full-chord wing section, including the slat, main-wing, and triple-slotted, Fowler-flap elements. Chordwise pressure distributions were obtained at the 58% semispan station using thin pressure belts. Flow characteristics observed in the chordwise pressure distributions included leading-edge regions of high-subsonic flows, leading-edge attachment-line locations, slat and main-wing cove-flow separation and reattachment, and trailing-edge flow separation. In addition, surface shear-stress measurements were made using Preston-tube probes on each element. Computational analysis of the in-flight pressure measurements using two-dimensional, viscous-flow, multielement methods and simple-sweep theory showed reasonable agreement. However, overprediction of the suction pressures on the flap elements indicates a need for more detailed (off-surface) measurements of the flow and the in-flight flap geometry to aid modeling of the complex three-dimensional flowfield. Author (EI)

A95-94465

COOLING OF AEROSPACE PLANE USING LIQUID HYDROGEN AND METHANE

AHMED Z. AL-GARNI King Fahd Univ of Petroleum and Minerals, Dhahran, Saudi Arabia, AHMET Z. SAHIN, BEKIR S. YILBAS, and SAAD A. AHMED Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 539-546 refs
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This work studies the active cooling for aerospace plane, using liquid hydrogen and liquid methane. The ascending optimized trajectory to minimize the heat load in the hypersonic part is used to perform the study. The study includes the cooling for the stagnation point, the leading edges for wings and engine and other parts of the aerospace plane that are close to the leading edges. Laminar flow for the stagnation point and both laminar and turbulent flow for the leading-edge heating have been considered. The amount of heat rate (total, radiative, and convective) and the mass of liquid coolant needed for cooling are calculated. A design of minimum inlet-outlet areas for the amount of liquid needed for cooling is made with the consideration of the coolant's physical constraints in liquid and gaseous states. The study shows that the ratio of masses of coolant to the initial total mass (initial total mass of the vehicle including fuel and coolant masses) are in the limit of the reachable range, which requires about 20% or less of initial total mass for cooling in the worst case. Comparison of liquid hydrogen and liquid methane shows that liquid hydrogen is a clearly superior candidate for coolant and it saves 10% of the initial total mass as compared to methane. The study shows that there are no fundamental barriers for the cooling system of the vehicle in terms of its coolant mass and area size for coolant passage. Author (EI)

A95-94466

NONLINEAR AERODYNAMIC ANALYSIS OF GRID FIN CONFIGURATIONS

JOHN E. BURKHALTER Auburn Univ, Auburn, AL, United States, ROY J. HARTFIELD, and TODD M. LELEUX Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 547-554 refs
(BTN-95-EIX0619952748172) Copyright

An aerodynamic analysis of generalized grid fin configurations has been completed for subsonic flow. Grid fins are lifting surface devices that may be used as control surfaces for general missile configurations. A preprocessor code has been developed that designs the grid fin from general geometric input. Designs that are not practical are rejected and graphical drawings of the configuration under consideration are displayed for review purposes. The theoretical analysis is fundamentally based on a vortex lattice overlay of the lifting elements that produces adequate modeling for small angles of attack. For higher angles of attack, empirical equations are used for the body and fin aerodynamic coefficients. Good agreement between experimental data and theoretical predictions are obtained for the grid fins considered up to angles of attack of about 45 deg. For other grid fin designs, the agreement between the theory and experimental results has not yet been determined. Author (EI)

A95-94473

FLOW PHYSICS OF CRITICAL STATES FOR ROLLING DELTA WINGS

LARS E. ERICSSON American Inst of Aeronautics and Astronautics, Inc, Mountain View, CA, United States Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 603-610 refs
(BTN-95-EIX0619952748180) Copyright

A delta wing rolling at high flow inclination has two well-documented critical states. One occurs when the breakdown of the leeside leading-edge vortex passes over the trailing edge, and the other when the breakdown of the windward vortex reaches the apex. The flow physics associated with those critical states are described for a sharp-edged 65-deg delta wing rolling around an axis inclined 30 deg to the freestream. It is shown how the measured, extremely nonlinear, unsteady aerodynamics result from the roll-rate-induced camber effect in conjunction with convective flow time lag effects. Author (EI)

A95-94475

NAVIER-STOKES APPLICATIONS TO HIGH-LIFT AIRFOIL ANALYSIS

WALTER O. VALAREZO McDonnell Douglas Aerospace, Long Beach, CA, United States and DIMITRI J. MAVRIPLIS Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 618-624 refs
(BTN-95-EIX0619952748182) Copyright

This article presents applications of a compressible Reynolds-averaged Navier-Stokes method to the calculation of flows about a transport-type multielement airfoil. The unstructured-mesh method used utilizes multigrid techniques for computational efficiency and includes a selection of turbulence models. The airfoil used to benchmark the computational capability is a three-element airfoil configured for landing for which extensive experimental data have been acquired both on and off the airfoil surface at high Reynolds numbers. Comparisons of computational results vs experimental data shown here include traditional airfoil performance calculations due to configuration changes. Also discussed are detailed comparisons of computational results and experimental data obtained in the flap well region to assess the applicability of existing turbulence models to the flap slot flow. Performance comparisons are conducted for configurations tested at chord Reynolds numbers of 5 x 10(exp 6) and 9 x 10(exp 6) and the flap well study is based on data obtained on a similar airfoil at a chord Reynolds number of 5 x 10(exp 5). Author (EI)

A95-94476

ANALYSIS OF LOW REYNOLDS NUMBER AIRFOIL FLOWS

J. A. EKATERINARIS Naval Postgraduate Sch, Monterey, CA, United States, M. S. CHANDRASEKHARA, and M. F. PLATZER Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 625-630 refs
(BTN-95-EIX0619952748183) Copyright

Compressible steady and unsteady flowfields over a NACA 0012 airfoil at transitional Reynolds numbers are investigated. Comparisons with recently obtained experimental data are used to evaluate the ability of a numerical solution based on the compressible thin layer Navier-Stokes approximation, augmented with a transition model, to simulate transitional flow features. The discretization is obtained with an upwind-biased, factorized, iterative scheme. Transition onset is estimated using an empirical criterion based on the computed mean flow boundary-layer quantities. The transition length is computed from an empirical formula. The incorporation of transition modeling enables the prediction of the experimentally observed leading-edge separation bubbles. Results for steady airfoil flows at fixed angles of attack and for oscillating airfoils are presented. Author (EI)

A95-94479* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
LIFT-ENHANCING TABS ON MULTIELEMENT AIRFOILS
JAMES C. ROSS National Aeronautics and Space Administration Ames Research Cent, Moffett Field, CA, United States, BRUCE L. STORMS, and PAUL G. CARRANNANTO Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 649-655 refs
(BTN-95-EIX0619952748187) Copyright

The use of flat-plate tabs (similar to Gurney flaps) to enhance the lift of multielement airfoils is extended here by placing them on the pressure side and near the trailing edge of the main element rather than just on the furthest downstream wing element. The tabs studied range in height from 0.125 to 1.25% of the airfoil reference chord. In practice, such tabs would be retracted when the high-lift system is stowed. The effectiveness on the concept was demonstrated experimentally and computationally on a two-dimensional NACA 63(2)-215 Mod B airfoil with a single-slotted, 30%-chord flap. Both the experiments and computations showed that the tabs significantly increase the lift at a given angle of attack and the maximum lift coefficient of the airfoil. The computational results showed that the increased lift was a result of additional turning of the flow by the tab that reduced or eliminated flow separation on the flap. The best configuration tested, a 0.5%-chord tab placed 0.5% chord upstream of the trailing edge of the main element, increased the maximum lift coefficient of the airfoil by 12% and the maximum lift-to-drag ratio by 40%. Author (EI)

A95-94481
EFFECT OF LEADING-EDGE EXTENSION FENCES ON THE VORTEX WAKE OF AN F/A-18 MODEL
SHESHAGIRI K. HEBBAR Naval Postgraduate Sch, Monterey, CA, United States, MAX F. PLATZER, and WILLIAM D. FRINK, JR. Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 680-682 refs
(BTN-95-EIX0619952748192) Copyright

The vortex wake downstream of a 3% scale model of the YF-17 at high AOAS was examined by conducting a low-speed wind tunnel investigation. Both the hot-wire and power spectrum measurements were carried out in the velocity range of 10-50 m/s with and without the LEX fences. Based from the results, it was concluded that the maximum turbulent fluctuation at a near downstream station just after of the model occurred with the model oriented at 25-deg AOA, and that the addition of LEX fences increased the spectral levels and shifted the power spectrum toward higher frequencies. EI

A95-94482
TURBULENT EFFECTS ON PARACHUTE DRAG
MAYER HUMI Worcester Polytechnic Inst, Worcester, MA, United States Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 682-684 refs
(BTN-95-EIX0619952748193) Copyright

The value of the drag coefficient is regarded to be one of the key indicators to measure the overall performance of fully deployed parachutes. In this study, the time-independent NSE was simulated to obtain time-averaged values for the drag. The results obtained were found to be in good agreement with the experimental value when the compliant nature of the body used in the experiment is considered. However, based on physical arguments and results obtained with the use of the vortex method, it is assumed that dynamical time-dependent effects can make crucial contributions to the understanding of parachute performance and design. EI

A95-94483
ESTIMATION OF SUPERSONIC LEADING-EDGE THRUST BY A EULER FLOW MODEL
C. DE NICOLA Univ of Naples, Naples, Italy, R. TOGNACCINI, P. VISINGARDI, and L. PAPARONE Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 684-686 refs
(BTN-95-EIX0619952748194) Copyright

The applicability of the Euler equations based flow servers to the aerodynamic design and analysis of supersonic transport aircraft configurations at cruise conditions is addressed. Previously, Carlson and Mann showed that the strongly nonlinear phenomenon of the leading-edge thrust is a key problem when it comes to the design of supersonic wings. In the present work, results obtained using a multiblock structured Euler flow simulation system demonstrated the capability of the Euler flow model to predict the leading-edge thrust for sharped wings at a good level of accuracy. EI

A95-94484
COMPUTATION OF VORTEX BREAKDOWN ON A ROLLING DELTA WING
RAYMOND E. GORDNIER U.S. Air Force Wright Lab, Wright-Patterson Air Force Base, OH, United States Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 686-688 refs
(BTN-95-EIX0619952748195) Copyright

This discussion focuses on the dynamically induced vortex breakdown of the upward-moving edge vortex during a portion of the roll maneuver. The occurrence of breakdown is first tackled. Then, the factors that contribute to vortex breakdown are presented. EI

A95-95440
NAVIER-STOKES COMPUTATIONS AROUND A REALISTIC FIGHTER CONFIGURATION
TORSTEN BERGLIND Aeronautical Research Inst. of Sweden, Bromma, Sweden and PETER ELIASSON Aeronautical Research Inst. of Sweden, Bromma, Sweden *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 651-658
Copyright

A general approach to the generation of efficient Navier-Stokes grids around complex geometries is presented. The method starts from an Euler grid and the specification of its topology. An O-O grid is generated in a sublayer around the configuration covering the estimated boundary layer and its vicinity. The sublayer grid is thereafter merged with the original Euler grid. The result is a Navier-Stokes grid with a new topology. An application of the method on the new Swedish fighter JAS demonstrates the viability of the methid. Flow computations around the fighter configuration are performed with the EURANUS-code, a general purpose multiblock/multigrid code for solving Euler and Navier-Stokes equations. Euler and laminar Navier-Stokes equations are solved for transonic cases. A computation of the C(sub p)-contours for the Euler and the Navier-Stokes solutions at a low angle of attack shows, as expected, good agreement. This example serves as a first verification of the method's ability to generate efficient Navier-Stokes grids around complex configurations.
Author (Herner)

A95-95451
MULTIGRID/MULTIBLOCK METHOD FOR TRANSONIC POTENTIAL FLOW AROUND WING/BODY/NACELLE CONFIGURATIONS INCLUDING A SLIPSTREAM
DIEQIAN WANG Aeronautical Research Inst. of Sweden, Bromma, Sweden and SVEN G. HEDMAN Aeronautical Research Inst. of Sweden, Bromma, Sweden *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 733-740
Copyright

A potential flow code has been developed for simulation of transonic flow around wing/body/nacelle configurations and for predictions of propeller/airframe interference. The propeller is modeled as an actuator disk and the effect of the slipstream is approximately considered. The wing/body/nacelle flow solver has been developed from the MATRICS wing/body code. The computational space is divided into two blocks, with one inboard and one outboard of the nacelle. The resulting algorithm developed for the two blocks is fully implicit not only in all three coordinate directions but also between the two blocks. It is uniformly stable for all regions in the field. The method uses almost the same Central Processing Unit (CPU) time as the one block solver for wing/body configurations. Hence, it is a very robust algorithm and the method is cost effctive. Applications will be shown for three cases simulating propeller driven airplanes in subsonic climb and transonic cruise. Comparisons are made with data from windtunnel tests and from Euler code calculations. In general the agreement is very good with a tendency of the potential flow code to slightly overpredict the effect of the propeller slipstream on the wing pressure distributions. Author (Hemer)

N95-30448 University of Southern California, Los Angeles, CA.
FLOW MODELS FOR THE DESIGN OF A HYPERSONIC IODINE VAPOR WIND TUNNEL NOZZLE WITH CHEMICAL AND VIBRATIONAL NONEQUILIBRIUM EFFECTS Ph.D. Thesis
MARTY KEITH BRADLEY 1994
Avail: Issuing Activity (Univ. of Southern California, Doheny Library, Micrographics Dept., Los Angeles, CA 90089-0182)

A hypersonic iodine wind tunnel facility (H.I.T.) is being built at the University of Southern California (U.S.C.) to study hypersonic nonequilibrium flow. A detailed model for iodine nozzle flow with vibrational as well as chemical nonequilibrium has been developed to assess the impact of vibrational nonequilibrium in the wind tunnel nozzle. Each discrete vibrational level is treated as a separate species and reaction rate expressions are developed for vibration-vibration (V-V), vibration-translation (V-T), and dissociation reactions using various reaction rate models. Vibrational equilibrium, harmonic oscillator, SSH, and modified SSH thermodynamic and reaction rate models have been developed for iodine. One-dimensional and two-dimensional finite-rate chemistry nozzle calculations have been made using the LPP (Liquid Performance Program) nozzle analysis code. In the SSH and modified SSH models, V-T transitions were found to be dominant when compared to V-V transitions, and population inversions were created downstream in the nozzle in vibrational levels above about ten for the harmonic oscillator, SSH, and modified SSH models. Results from these calculations have been compared to data from an iodine freejet test. The sensitivity of the wind tunnel nozzle exit flow profile to the various nonequilibrium flow models has also been determined. Based on these results and considering the effects of vibrational nonequilibrium and boundary layer state, a nozzle contour has been designed that will produce near-uniform flow properties for the first H.I.T. nozzle, despite any uncertainties present in the chemistry, vibration, or boundary layer flow models. Dissert. Abstr.

N95-30611*# United Technologies Research Center, East Hartford, CT.
DEVELOPMENT OF A LINEARIZED UNSTEADY EULER ANALYSIS FOR TURBOMACHINERY BLADE ROWS Final Contractor Report
JOSEPH M. VERDON, MATTHEW D. MONTGOMERY, and KENNETH A. KOUSEN Jun. 1995 107 p
Contract(s)/Grant(s): (NAS3-25425; RTOP 505-62-10)
(NASA-CR-4677; E-9575; NAS 1.26:4677; R95-970293) Avail: CASI HC A06/MF A02

A linearized unsteady aerodynamic analysis for axial-flow turbomachinery blading is described in this report. The linearization is based on the Euler equations of fluid motion and is motivated by the need for an efficient aerodynamic analysis that can be used in predicting the aeroelastic and aeroacoustic responses of blade rows. The field equations and surface conditions required for inviscid, nonlinear and linearized, unsteady aerodynamic analyses of three-dimensional flow through a single, blade row operating within a cylindrical duct, are derived. An existing numerical algorithm for determining time-accurate solutions of the nonlinear unsteady flow problem is described, and a numerical model, based upon this nonlinear flow solver, is formulated for the first-harmonic linear unsteady problem. The linearized aerodynamic and numerical models have been implemented into a first-harmonic unsteady flow code, called LINFLUX. At present this code applies only to two-dimensional flows, but an extension to three-dimensions is planned as future work. The three-dimensional aerodynamic and numerical formulations are described in this report. Numerical results for two-dimensional unsteady cascade flows, excited by prescribed blade motions and prescribed aerodynamic disturbances at inlet and exit, are also provided to illustrate the present capabilities of the LINFLUX analysis. Author

N95-30638# Technische Univ., Delft (Netherlands). Inst. for Wind Energy.
AXIAL LOADS ON YAWED ROTORS
G. J. W. VANBUSSEL Nov. 1993 28 p
(PB95-214193; IW-93073R) Avail: CASI HC A03/MF A01

Under the assumption of incompressible, inviscid and irrotational flow, it can be shown that the pressure perturbation in the complete flow field is given by a Laplace equation and acts as an acceleration potential function. The rotor blades are represented in the model as discrete surfaces on which a pressure discontinuity is present. Spanwise and chordwise pressure distributions are present, which are composed of analytical asymptotic solutions for the Laplace equation. This model is implemented in the PREDICHAT and PREDICDYN computer code series for steady and dynamic inflow cases respectively. Dynamic inflow concerns with large scale unsteady rotor aerodynamics, such as coherent wind gusts, collective blade pitch and rotor speed variations. PREDICDYN is at present extended for the investigation of yawed flow. Axial induction velocities and axial load distributions are determined with this method and compared with yawed flow momentum theory extensions. NTIS

N95-30704*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
VALIDATION OF THE NPARC CODE FOR NOZZLE AFTERBODY FLOWS AT TRANSONIC SPEEDS
JAMES R. DEBONIS, NICHOLAS J. GEORGIADIS, and CRAWFORD F. SMITH (NYMA, Inc., Brook Park, OH.) Jul. 1995 28 p Presented at the 31st Joint Porpulsion Conference and Exhibit, San Diego, CA, 10-12 Jul. 1995; sponsored by AIAA, ASME, SAE, and ASEE
Contract(s)/Grant(s): (NAS3-27186; RTOP 537-02-00)
(NASA-TM-106971; E-9732; NAS 1.15:106971; AIAA PAPER 95-2614) Avail: CASI HC A03/MF A01

The NPARC code, a Reynolds-averaged full Navier-Stokes code, was validated for nozzle afterbody (boatail) flow fields at transonic speeds. The flow fields about three geometries were studied: an axisymmetric nozzle with attached flow; an axisymmetric nozzle with separated flow: and a two-dimensional (rectangular) nozzle with separated flow. Three turbulence models, Baldwin-Lomax, Baldwin-Barth, and Chien k-epsilon, were used to determine the effect of turbulence model selection on the flow field solution. Static pressure distributions on the nozzle surfaces and pitot pressure measurements in the exhaust plume were examined. Results from the NPARC code compared very well with experimental data for all cases. For attached flow fields, the effect of the turbulence models showed no discernable differences. The Baldwin-Barth model yielded better results than either the Chien k-epsilon or the Baldwin-Lomax model for separated flow fields. Author

N95-30712*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
TRANSONIC AERODYNAMIC CHARACTERISTICS OF A PROPOSED WING-BODY REUSABLE LAUNCH VEHICLE CONCEPT
A. M. SPRINGER Washington Mar. 1995 111 p
(NASA-TM-108489; NAS 1.15:108489) Avail: CASI HC A06/MF A02

A proposed wing-body reusable launch vehicle was tested in the NASA Marshall Space Flight Center's 14 x 14-inch trisonic wind tunnel during the winter of 1994. This test resulted in the vehicle's subsonic and transonic, Mach 0.3 to 1.96, longitudinal and lateral aerodynamic characteristics. The effects of control surface deflections on the basic vehicle's aerodynamics, including a body flap, elevons, ailerons, and tip fins, are presented. Author

N95-30788*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

FLIGHT TEST EVALUATION OF THE STANFORD UNIVERSITY/ UNITED AIRLINES DIFFERENTIAL GPS CATEGORY 3 AUTOMATIC LANDING SYSTEM

DAVID N. KAUFMANN and B. DAVID NCNALLY Jun. 1995 475 p
Contract(s)/Grant(s): (RTOP 505-64-13)
(NASA-TM-110354; A-950066; NAS 1.15:110354) Avail: CASI HC A20/MF A04

Test flights were conducted to evaluate the capability of Differential Global Positioning System (DGPS) to provide the accuracy and integrity required for International Civil Aviation Organization (ICAO) Category (CAT) 3 precision approach and landings. These test flights were part of a Federal Aviation Administration (FAA) program to evaluate the technical feasibility of using DGPS based technology for CAT 3 precision approach and landing applications. A United Airlines Boeing 737-300 (N304UA) was equipped with DGPS receiving equipment and additional computing capability provided by Stanford University. The test flights were conducted at NASA Ames Research Center's Crows Landing Flight Facility, Crows Landing, California. The flight test evaluation was based on completing 100 approaches and autolandings; 90 touch and go, and 10 terminating with a full stop. Two types of accuracy requirements were evaluated: 1) Total system error, based on the Required Navigation Performance (RNP), and 2) Navigation sensor error, based on ICAO requirements for the Microwave Landing System (MLS). All of the approaches and autolandings were evaluated against ground truth reference data provided by a laser tracker. Analysis of these approaches and autolandings shows that the Stanford University/United Airlines system met the requirements for a successful approach and autolanding 98 out of 100 approaches and autolandings, based on the total system error requirements as specified in the FAA CAT 3 Level 2 Flight Test Plan. Author

N95-30814# National Aerospace Lab., Amsterdam (Netherlands).

MULTIGRID CONVERGENCE ACCELERATION FOR THE 2D EULER EQUATIONS APPLIED TO HIGH-LIFT SYSTEMS

K. M. J. DECOCK 6 Jul. 1993 35 p Sponsored by Nederlands Inst.
Contract(s)/Grant(s): (NIVR-01308N)
(PB95-198081; NLR-TP-93301-U) Avail: CASI HC A03/MF A01

In this paper, a multigrid convergence acceleration technique for the two-dimensional Euler equations will be described. Applications to high-lift flows are made. The multigrid method is tested for this type of flow. NTIS

N95-30837# Technische Univ., Delft (Netherlands).

NUMERICAL INVESTIGATION INTO VORTICAL FLOW ABOUT A DELTA-WING CONFIGURATION UP TO INCIDENCES AT WHICH VORTEX BREAKDOWN OCCURS IN EXPERIMENT

J. I. VANDENBERG, H. W. M. HOEIJMAKERS, and F. J. BRANDSMA 11 Nov. 1993 21 p
Contract(s)/Grant(s): (NIVR-07302N)
(PB95-198024; NLR-TP-93511-U) Copyright Avail: CASI HC A03/MF A01

To contribute to the development and validation of Euler methods for complete fighter configurations, numerical investigations are carried out into the flow for two generic configurations. Results are presented about a wing-alone and a wing-body configuration with a sharp-edged cropped delta wing for incidences in the range at which vortex breakdown occurs in experiment. Above the aft part of the wing-alone configuration, the structure of the vortex core undergoes a remarkable change, i.e., there is a switch-over in the sign of the vorticity vector as well as a sharp reduction of the axial velocity component, in a way similar to what occurs during vortex breakdown in experiment. For the wing-body configuration similar flow features are found, but only in the near wake. NTIS

N95-30843 Stanford Univ., CA.

COMPUTATION OF HIGH-ALTITUDE HYPERSONIC FLOW-FIELD RADIATION Ph.D. Thesis

STEPHANE MOREAU 1994 438 p
Avail: Univ. Microfilms Order No. DA9422110

Accurate calculations of radiation on and from transatmospheric flight vehicles are currently a challenge to computational aerodynamicists. Due to combined effects of low density and hypersonic flight conditions, the gas in the shock-layer is in a state of thermal and chemical nonequilibrium. The present work aims at gathering existing ideas together about how such flows should be modeled and comparing them to recent, more accurate experiments that probe the separate energy modes of the different species of the gas in a more direct way than previously reported. Two recent Bow-Shock-Ultra-Violet flight experiments, and two recent shock-tube experiments are used to test the validity of the flow-field models implemented in the current state-of-the-art numerical codes. They involve highly non-equilibrium flow regimes in nitrogen and air with negligible ionization and provide detailed spectra emitted by the hot gas. A recent plasma torch experiment at Stanford, and the Cochise experiments at the Geophysics Directorate laboratories, have been the ideal experimental counterpart to test and improve the radiation calculation in the UV-visible spectral range and the IR region respectively. Each spectral region is used to probe several different aspects of the thermal and chemical non-equilibrium. A hierarchy of flow-field codes has been developed in conjunction with a greatly enhanced radiation code, termed NEQAIR2, to simulate these experiments. The flow-field codes involve axisymmetric Navier-Stokes and Burnett simulations around blunt-nose cones for the flight experiments and quasi-ID Euler simulations for the shock-tube experiments. They include between 5 and 8 chemical species and between 3 and 6 separate internal energy modes. The corresponding system of conservation equations are solved with finite volume, flux split algorithms. Gauss-Siedel line relaxation is used to increase efficiency of the fully-implicit method and exact numerical jacobians have been derived to increase the rate of convergence. The radiation code involves a collisional-radiative model based on a quasi-steady-state (QSS) approximation and a detailed line-by-line calculation for several atomic systems and molecular band systems. Comparisons of numerical spectra with the flight data show good agreement at the lower altitudes but the predictions are only within an order of magnitude at higher altitudes. Dissert. Abstr.

N95-30885# Lockheed Corp., Fort Worth, TX.

UNSTEADY TRANSONIC WIND TUNNEL TEST ON A SEMISPAN STRAKED DELTA WING, OSCILLATING IN PITCH. PART 1: DESCRIPTION OF THE MODEL, TEST SETUP, DATA ACQUISITION, AND DATA PROCESSING Final Report, Mar. 1989 - Dec. 1993

A. M. CUNNINGHAM, JR., R. G. DENBOER, C. S. DOGGER, E. G. GEURTS, and A. P. RETEL Dec. 1994 93 p
Contract(s)/Grant(s): (F33657-84-C-0247)
(AD-A293113; NLR-CR-93570L; WL-TR-94-3094) Avail: CASI HC A05/MF A01

A wind tunnel investigation was conducted in 1992 to investigate the unsteady aerodynamic aspects of transonic high incidence flows over a simple straked wing model. This test was designed to show how low speed vortex type flows evolve into complicated shock vortex interacting flows at transonic speeds. Requirements for this test were based on a low speed test conducted in 1986 on a full span model in the NLR Low Speed Tunnel. The transonic model was a semispan version of the low speed model with some modifications. It was equipped with a three-component semispan balance to measure total wing loads, seven rows of high response pressure transducers to measure unsteady pressures, and 15 vertical accelerometers to measure model motion and vibrations. The model was oscillated sinusoidally in pitch at various amplitudes and frequencies for mean model incidences varying from 4 to 48 deg. In addition, maneuver type transient motions of the model were tested with amplitudes of 16 and 30 deg total rotation at various starting angles. The test was conducted in the NLR HST in the Mach range of 0.225 to 0.90 with some preliminary vapor screen flow visualization data taken at M = 0.6 and 0.9. This part of the report presents a description of the model, test setup, data acquisition, and data processing. DTIC

N95-30929# Naval Surface Warfare Center, Silver Spring, MD.
HYPERVELOCITY WIND TUNNEL NUMBER 9, HIGH MACH NUMBER DEVELOPMENT PROGRAM Final Report
MELISSA A. LEDERER 5 Dec. 1994 85 p
(AD-A289934; NSWCDD/TR-94/96) Avail: CASI HC A05/MF A01

This report describes the results of the high Mach Number Development program performed at the White Oak, Maryland site of the Dahlgren Division, Naval Surface Warfare Center. The goal of this program was to expand the capabilities of the Hypervelocity Wind Tunnel Number 9 (Tunnel 9) to include operation at Mach 18. The constraints of this program involved using the existing Mach 14 setup with as little modification as necessary. There were two major areas of interest for this program, the heater and the nozzle. The required supply temperature for Mach 18 operation is above the current capabilities of the Tunnel 9 Mach 14 heater. Utilizing supercooled flow conditions lowered the required supply temperature to within the Mach 14 heater capability. The current Mach 14 nozzle was used and the throat section was replaced with a new hardware set designed to achieve the correct nozzle throat-to-exit area ratio to obtain the higher Mach number. Forty-one runs were carried out in Tunnel 9 in support of this program. The Mach number capability in Tunnel 9 has been extended to Mach 16.5. For this condition the flow has a 30-inch test core with Pitot pressure deviations of -1.1% to + 1.3% and 3.5 seconds of good run time. A Mach 18 capability has also been investigated. Research efforts to achieve acceptable Mach 18 conditions are continuing. DTIC

N95-31715# National Aerospace Lab., Tokyo (Japan). Aeroengine Div.
EFFECTS OF CAVITY BLEED AND ITS CONFIGURATION ON AERODYNAMIC CHARACTERISTICS OF SUPERSONIC INTERNAL FLOW
AKIRA MURAKAMI, SIGEMI SHINDO, FUMIO KOMIYAMA (Japanese Patent Office, Tokyo, Japan.), and KIMIO SAKATA Sep. 1994 18 p In JAPANESE Original contains color illustrations (ISSN 0389-4010)
(NAL-TR-1247) Avail: CASI HC A03/MF A01

This paper presents experimental results of the effects of cavity bleed and its configuration on the supersonic internal flow field and the aerodynamic characteristics. The experiments were conducted in the supersonic heat transfer test facility of NAL using the partial model to simulate the supersonic internal compression passage of the mixed compression air-intake. The pressure recovery characteristics of five cavity configurations was obtained for the bleed mass flow rates. It was found that the cavity bleed was effective for the starting of the air-intake but the excessive cavity bleed aggravated the pressure recovery. The cavity configuration affected the characteristics of the pressure in the cavity bleed plenum for the bleed mass flow rates. Therefore, the optimum bleed mass flow rates for the maximum pressure recovery depended on the cavity configuration. Author

N95-31984*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AFTERBODY/NOZZLE PRESSURE DISTRIBUTIONS OF A TWIN-TAIL TWIN-ENGINE FIGHTER WITH AXISYMMETRIC NOZZLES AT MACH NUMBERS FROM 0.6 TO 1.2
DAVID J. WING May 1995 214 p
Contract(s)/Grant(s): (RTOP 505-59-30-04)
(NASA-TP-3509; L-17438; NAS 1.60:3509) Avail: CASI HC A10/MF A03

Distributions of static pressure coefficient over the afterbody and axisymmetric nozzles of a generic, twin-tail twin-engine fighter were obtained in the Langley 16-Foot Transonic Tunnel. The longitudinal positions of the vertical and horizontal tails were varied for a total of six aft-end configurations. Static pressure coefficients were obtained at Mach numbers between 0.6 and 1.2, angles of attack between 0 deg and 8 deg, and nozzle pressure ratios ranging from jet-off to 8. The results of this investigation indicate that the influence of the vertical and horizontal tails extends beyond the vicinity of the tail-afterbody juncture. The pressure distribution affecting the aft-end drag is influenced more by the position of the vertical tails than by the position of the horizontal tails. Transonic tail-interference effects are seen at lower free-stream Mach numbers at positive angles of attack than at an angle of attack of 0 deg. Author

N95-32188*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NUMERICAL SOLUTION OF THE FULL POTENTIAL EQUATION USING A CHIMERA GRID APPROACH
TERRY L. HOLST Jul. 1995 33 p
Contract(s)/Grant(s): (RTOP 505-59-53)
(NASA-TM-110360; A-950082; NAS 1.15:110360) Avail: CASI HC A03/MF A01

A numerical scheme utilizing a chimera zonal grid approach for solving the full potential equation in two spatial dimensions is described. Within each grid zone a fully-implicit approximate factorization scheme is used to advance the solution one interaction. This is followed by the explicit advance of all common zonal grid boundaries using a bilinear interpolation of the velocity potential. The presentation is highlighted with numerical results simulating the flow about a two-dimensional, nonlifting, circular cylinder. For this problem, the flow domain is divided into two parts: an inner portion covered by a polar grid and an outer portion covered by a Cartesian grid. Both incompressible and compressible (transonic) flow solutions are included. Comparisons made with an analytic solution as well as single grid results indicate that the chimera zonal grid approach is a viable technique for solving the full potential equation. Author

N95-32193*# MCAT Inst., San Jose, CA.
CONTROL OF UNSTEADY SEPARATED FLOW ASSOCIATED WITH THE DYNAMIC STALL OF AIRFOILS Final Report
M. C. WILDER 31 Jan. 1995 41 p Original contains color illustrations
Contract(s)/Grant(s): (NCC2-637)
(NASA-CR-198972; NAS 1.26:198972; MCAT-95-09) Avail: CASI HC A03/MF A01; 1 functional color page

An effort to understand and control the unsteady separated flow associated with the dynamic stall of airfoils was funded for three years through the NASA cooperative agreement program. As part of this effort a substantial data base was compiled detailing the effects various parameters have on the development of the dynamic stall flow field. Parameters studied include Mach number, pitch rate, and pitch history, as well as Reynolds number (through two different model chord lengths) and the condition of the boundary layer at the leading edge of the airfoil (through application of surface roughness). It was found for free stream Mach numbers as low as 0.4 that a region of supersonic flow forms on the leading edge of the suction surface of the airfoil at moderate angles of attack. The shocks which form in this supersonic region induce boundary-layer separation and advance the dynamic stall process. Under such conditions a supercritical airfoil profile is called for to produce a flow field having a weaker leading-edge pressure gradient and no leading-edge shocks. An airfoil having an adaptive-geometry, or dynamically deformable leading edge (DDLE), is under development as a unique active flow-control device. The DDLE, formed of carbon-fiber composite and fiberglass, can be flexed between a NACA 0012 profile and a supercritical profile in a controllable fashion while the airfoil is executing an angle-of-attack pitch-up maneuver. The dynamic stall data were recorded using point diffraction interferometry (PDI), a noninvasive measurement technique. A new high-speed cinematography system was developed for recording *interferometric images. The system is capable of phase-locking with the* pitching airfoil motion for real-time documentation of the development of the dynamic stall flow field. Computer-aided image analysis algorithms were developed for fast and accurate reduction of the images, improving interpretation of the results. Author

03
AIR TRANSPORTATION AND SAFETY

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

A95-92626
REACTION-TIME RESPONSE OF AIRCRAFT CRASH
H. ABBAS Aligarh Muslim Univ (AMU), Aligarh, India, D. K. PAUL, P. N. GODBOLE, and G. C. NAYAK Computers and Structures (ISSN 0045-7949) vol. 55, no. 5 June 3 1995 p. 809-817 refs
(BTN-95-EIX95292721296) Copyright

The safety related structures of a nuclear power plant (NPP) are required to be designed for the impact of aircraft. The reaction-time response is usually obtained assuming the target to be rigid. The assumption is claimed to be conservative in the case of stiff structures. The effect of target yielding has been studied by considering an aircraft crash upon the outer containment of an NPP. It has been observed in this investigation that the assumption of a rigid target is unconservative for some of the cases. It is usually assumed that variation in crushing strength has very little effect on the reaction from the target. However, the sensitivity analysis for reaction-time response indicates that both linear mass density and crushing strength are sensitive in affecting the reaction from the target, depending upon the characteristics of the aircraft and the striking velocity. The concept of confidence level has been investigated in relation to inclined targets also and confidence curves are obtained for aircraft. Author (EI)

A95-93390
THE WORLD OF REGIONAL AIRCRAFT - CHALLENGES AND OPPORTUNITIES
P. H. SUMMERFIELD Aeronautical Journal (ISSN 0001-9240) vol. 98, no. 980 December 1994 p. 367-387
(HTN-95-C0002) Copyright

The regional air transport industry is slowly emerging from the ravages of a prolonged structural recession. Long term survival in an industry which has traditionally traded in one of the world's most aggressive market places, will impose enormous demands upon everyone involved. Those regional aircraft manufacturers and operators who are brave enough to take advantage of emerging technologies, adjust to new processes and develop highly-skilled and motivated people will be best equipped to meet the global demands of the marketplace in an ever-changing world. The actions and achievement of Avro International Aerospace, a division of British Aerospace, with its Regional Avroliner family of aircraft provides an example through which to identify the key components in this process. Author (Herner)

A95-93554
LEE WAVES BENIGH AND MALIGNANT
MORTON G. WURTELE UCLA, Los Angeles, CA, US, ANINDITA DATTA UCLA, Los Angeles, CA, US, and ROBERT D. SHARMAN UCLA, Los Angeles, CA, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 469
Copyright

The flow of an incompressible, stratified fluid over an obstacle will produce an oscillation in which buoyance is the restoring force, called a gravity wave. For disturbances of this scale, the atmosphere may be treated as incompressible; and even the linear approximation--i.e., for small disturbances--the theory will explain a great many of the orographic phenomena observed in the atmosphere. These phenomena we are calling benign, as offering no hazard to aircraft or lee surface areas. However, nonlinear 'malignancies' arise in three ways: (1) through the large (scaled) size of the mountain, and (2) from dynamically singular levels in the fluid field; and (3) by amplification of the disturbance arising out of the decrease of mean density with altitude. These effects produce a complicated array of phenomena--large departures of the streamlines from their equilibrium levels, high winds, wave-breaking, generation of small-scale disturbances, turbulence,etc.--that present hazards, possibly severe, to aircraft and to lee surface areas. The nonlinear disturbances also interact with the larger-scale flow in such a manner as to impact global weather forecasts and the climatological momentum balance. If there is no dynamic barrier, these waves can penetrate vertically into the middle atmosphere (30-80 km altitude), where the process (3) becomes effective in their breakdown. Recent observations (from radar, shuttle data, and limb soundings) show disturbances in the middle atmosphere to be of length scales that require the coriolis force in their modeling. At these altitudes, the phenomena must be studied with a view to their potential impacts on high-performance aircraft, including the projected National Aerospace Plane (NASP). Author (Herner)

A95-93598
EXTERNAL VIEWING AIRBORNE CCTV SYSTEM
P. A. WOODBURN, J. S. MCILVEEN, and G. SELVES 1991 4 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 25: Airworthiness-New Ideas)
(CONGRESS PAPER C428-25-172; HTN-95-21167) Copyright

Recent technology now makes it possible to place miniature closed circuit television cameras (CCTV) external to the aircraft. The paper describes the British Airways CCTV trial installation on a B747 aircraft of three externally-looking miniature video cameras plus associated viewing and recording equipment. The purpose of the trial is to evaluate system performance throughout the spectrum of environmental and climatic conditions encountered by an aircraft in airline operation. The trial may be extended to introduce a monitor into the cockpit, to introduce internal cameras and to explore the possibility of enhanced vision (infra red). The exercise will give British Airways the opportunity to evaluate a future fleet fit of a CCTV system and the CAA the opportunity to evaluate possible future applications. Author (Herner)

A95-93599
DEVELOPMENT OF AN AIRCRAFT CABIN WATER SPRAY SYSTEM
D. N. BALL Kidde-Graviner Ltd, UK, D. P. SMITH Fire and Safety International, UK, and D. J. SPRING Fire and Safety International, UK 1991 7 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 25: Airworthiness-New Ideas)
(CONGRESS PAPER C428-25-030; HTN-95-21168) Copyright

Following the Manchester Airport Boeing 737 fire in August 1985, there has been considerable interest in water spray systems to delay the ingress of an external fire and its harmful effects into aircraft cabins. The effectiveness of systems comprising arrays of selected nozzles was assessed by means of a multistage program of research. The results of these studies were utilized in the design of a system offering minimum weight and optimum performance for full scale fire trials on a Boeing 707 fuselage, for which findings are presented. Aspects of design architecture are also discussed. Author (Herner)

A95-93600
AIRCRAFT CABIN WATER SPRAY SYSTEMS - RESEARCH AND REGULATORY ISSUES
H. R. F. DUFFELL Civil Aviation Authority, UK 1991 7 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 25: Airworthiness-New Ideas)
(CONGRESS PAPER C428-25-150; HTN-95-21169) Copyright

The Civil Aviation Authority has the responsibility, placed upon it by Parliament, of making professional judgements on safety matters. These

judgements are necessary for the Authority to set the standards for United Kingdom airlines, which are designed to maintain and where possible improve the safety of passengers. This is a responsibility necessitating careful evaluation of the issues and requiring decisions to be taken only after all relevant factors have been considered. Greater emphasis is being placed on improving passenger survivability in the rare event of an accident and steady progress had been made, partcularly in the field of fire prevention and containment. This paper presents an overview of the results of recent research and discusses regulatory issues that are relevant if such systems are to be installed on passenger aircraft.
Author (revised by Herner)

A95-93601
CIVIL AIRCRAFT PERFORMANCE - DEVELOPMENTS FOR IMPROVED SAFETY
J. WILES 1991 3 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 25: Airworthiness-New Ideas) (CONGRESS PAPER C428-25-175; HTN-95-21170) Copyright

Some regulatory changes and technological developments which relate to aircraft performance may influence aviation safety. Recent proposals of new standards and regulations will cause changes to airline operations, with resulting economic effects. Some new technology will also affect aircraft performance. How should the regulators and the airline industry adjust to such changes? Author (Herner)

A95-95083
ORGANIZATIONAL ERGONOMICS AND AVIATION SAFETY
ALAN E. DIEHL U.S. Air Force Safety Agency, CA, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 309-312
Copyright

This paper describes organizational factors which appear to be associated with recent aviation accidents. The primary focus is what can be done at aviation organizations to reduce the frequency of 'human error'. The U.S. Government asked the author to provide a confidential report on how the relative accident potential of airline and air-taxi organizations could be evaluated from human factors standpoint. The paper contains his views on that subject. Author (revised by Herner)

A95-95192
PSYCHO-SOCIAL SAFETY PERCEPTIONS: HELICOPTERS AS A CASE STUDY
RICHARD J. ADAMS Advanced Aviation Concepts, Inc., Jupiter, FL, US, PETER V. HWOSCHINSKY FAA, Washington, DC, US, and THOMAS E. BAILEY Univ. of Tennessee Space Inst., Tullahoma, TN, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 945-950
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The paper presents helicopter safety issues from an objective, quantitative perspective. The actual risks to neighborhoods, businesses, and the population in areas where helicopters operate are quantified. Second, accident rates for various missions are examined so that citizens can intelligently differentiate between high and low risk types. Finally, the accident risk exposure near takeoff and landing facilities is analyzed to determine the risks to residential and commercial buildings, vehicles and people on ground. The quantitative accident data is in turn compared to the results of a detailed survey of citizens' attitudes toward the helicopter and its operation, and toward heliports. The survey, based on a large sample of considerable variety, produced a list of 'concerns' including a number of community problem areas and psychosocial factors. This more detailed understanding of the specific concerns is used in conjunction with the accident data to suggest actions which would be helpful in projecting the level of satety required for future helicopter operations.
Author (Herner)

A95-95198
GENERAL AVIATION LANDING INCIDENTS AND ACCIDENTS: A REVIEW OF ASRS AND AOPA RESEARCH FINDINGS
ROWENA MORRISON, KAMIL ETEM, and BETTY HICKS *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 975-980
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Specific researh objective were as follows: (1) Identify the results and operational causes of landing incidents in a study set of 150 aviation safety reporting system (ASRS0 reports, and compare these with landing accident results and causes identified by the aircraft owners and pilots association (AOPA) Foundation; (2) Determine the key human and environmental factors contributing to landing incidents, and compare these with key accident factors identified by the Foundation; (3) Evaluate the hypothesis that training activities contribute to a significant number of landing incidents; (4) Drawing on collective ASRS/AOPA research findings, identify key safety issues in landing operations and potential solutions to these problems. Author (Herner)

A95-95201* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EMS HELICOPTER INCIDENTS REPORTED TO THE NASA AVIATION SAFETY REPORTING SYSTEM
LINDA J. CONNELL NASA. Ames Research Center, Moffett Field, CA, US and WILLIAM D. REYNARD NASA. Ames Research Center, Moffett Field, CA, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 1001-1008
Copyright

The objectives of this evaluation were to: Identify the types of safety-related incidents reported to the Aviation Safety Reporting System (ASRS) in Emergency Medical Service (EMS) helicopter operations; Describe the operational conditions surrounding these incidents, such as weather, airspace, flight phase, time of day; and Assess the contribution to these incidents of selected human factors considerations, such as communication, distraction, time pressure, workload, and flight/duty impact. Author (Herner)

A95-95203* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EMERGENCY MEDICAL SERVICE (EMS): A UNIQUE FLIGHT ENVIRONMENT
R. JAY SHIVELY NASA. Ames Research Center, Moffett Field, CA, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 1016-1019
Copyright

The EMS flight environment is unique in today's aviation. The pilots must respond quickly to emergency events and often fly to landing zones where they have never been before. The time from initially receiving a call to being airborne can be as little as two to three minutes. Often the EMS pilot is the only aviation professional on site, they have no operations people or other pilots to aid them in making decisons. Further, since they are often flying to accident scenes, not airports, there is often complete weather and condition information. Therefore, the initial decision that the pilot must make, accepting or declining a flight, can become very difficult. The accident rate of EMS helicopters has been relatively high over the past years. NASA-Ames research center has taken several steps in an attempt to aid EMS pilots in their decision making and situational awareness. A preflight risk assessment system (SAFE) was developed to aid pilots in their decision making, and was tested at an EMS service. The results of the study were promising and a second version incorporating the lessons learned is under development. A second line of research was the development of a low cost electronic chart display (ECD). This is a digital map display to help pilots maintain geographical orientation.

Another thrust was undertaken in conjunction with the Aviation Safety Reporting System (ASRS). This involved publicizing the ASRS to EMS pilots and personnel, and calling each of the reporters back to gather additional information. This paper will discuss these efforts and how they may positively impact the safety of EMS operations. Author (Hemer)

N95-31061# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Vehicle Integration Panel.
FLIGHT VEHICLE INTEGRATION PANEL WORKSHOP ON PILOT INDUCED OSCILLATIONS [ATELIER SUR LE POMPAGE PILOTE]
Feb. 1995 117 p Workshop on Pilot Induced Oscillations of the Symposium on Active Control Technology, Turin, Italy, May 1994
(AGARD-AR-335; ISBN-92-836-1013-X) Copyright Avail: CASI HC A06/MF A02

Instability of the pilot/airframe combination has been a problem of manned flight. Rapid advances made in aviation following World War 2 greatly increased the incidence of PIO problems and the amount of research and development work aimed at understanding and mitigating these difficulties. Criteria and requirements were developed to be used in design to obtain satisfactory PIO qualities, but, in spite of all this work and the great flexibility in available modern control design technologies, PIO problems still often occur with new aircraft. It is clear that a universal solution of the PIO problem still evades the engineering community. The cost of these problems financially and in program delay is significant. This AGARD Flight Mechanics Workshop summary report contains presentations and discussions that aim toward the elimination and avoidance of PIO's by increasing the knowledge of PIO's and the problems associated with them. For individual titles, see N95-31062 through N95-31072.

N95-31062*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
PIO: A HISTORICAL PERSPECTIVE
DUANE T. MCRUER (Systems Technology, Inc., Manhatten Beach, CA.) and R. E. SMITH *In* Advisory Group for Aerospace Research and Development, Flight Vehicle Integration Panel Workshop on Pilot Induced Oscillations 4 p Feb. 1995
Copyright Avail: CASI HC A01/MF A02

These problems relating to Pilot Induced Oscillations have manifested themselves since the earliest days of manned flight. The earliest recorded examples of PIO date back to the Wright brothers first aircraft. The earliest filmed records date back to just prior to World War 2, with the XB-19 aircraft which suffered a pitch PIO just prior to touchdown. Four classes of PIO have been identified, into which all of the known incidents can be grouped. These are: (1) Essentially Single Axis, Extended Rigid Body Effective Vehicle Dynamics; (2) Essentially Single Axis, Extended Rigid Body with Significant Feel-System Manipulator Mechanical Control Elements; (3) Multiple Axis, Extended Rigid Body Effective Vehicle Dynamics; and (4) PIO's Involving Higher Frequency Modes.
Derived from text

N95-31063*# National Aeronautics and Space Administration, Washington, DC.
THE PROCESS FOR ADDRESSING THE CHALLENGES OF AIRCRAFT PILOT COUPLING
RALPH AHARRAH *In* Advisory Group for Aerospace Research and Development, Flight Vehicle Integration Panel Workshop on Pilot Induced Oscillations 3 p Feb. 1995
Copyright Avail: CASI HC A01/MF A02

The term 'Pilot Induced Oscillation' is misleading in that it places an undue emphasis on the role of the pilot in the process. Clearly, the phenomenon cannot occur in the absence of the pilot, but the term PIO suggests that the pilot is in some way responsible for the occurrence. He is not. The phenomenon may be better described by the title 'Aircraft-Pilot Coupling', or A-PC. This may be considered to better describe what is actually occurring when the pilot is trying to perform his normal function, i.e., that of controlling the aircraft which he is flying. For a designer, the objective should be to ensure that there is no possibility of A-PC occurring. Associated with this, the goal should also be to achieve Level 1 handling qualities. The key is to understand the Process involved in design and test and to ensure that this is exercised to achieve the objective. This has to be set alongside the management goals of better, faster and cheaper, in order that the manufacturer can remain competitive in the market. Derived from text

N95-31064# High Plains Engineering, Tehachapi, CA.
OBSERVATIONS ON PIO
RALPH H. SMITH *In* Advisory Group for Aerospace Research and Development, Flight Vehicle Integration Panel Workshop on Pilot Induced Oscillations 9 p Feb. 1995
Copyright Avail: CASI HC A02/MF A02

Comparison of the handling characteristics of a Porsche with those expected from a modern combat type aircraft indicate that we accept significantly poorer handling performance with the aircraft than we would with a high performance road vehicle. The work which led to the evolution of the Smith-Geddes criteria stems from work performed for the USAF in relation to the F-15 aircraft. The logic that arrived at the criteria stemmed from a belief that the existing handling qualities criteria were inadequate for assessing the Pilot Induced Oscillation (PIO) susceptibility of an aircraft, and that the only successful way to test for this was to use the methods of Handling Qualities During Tracking (HQDT). The work which was performed was offered for the update of Mil 1797, but was not incorporated. This presentation concentrated on the understanding of PIO and the process by which it originates, using a simple model to demonstrate the characteristics which are inherent. The presentation also provided an explanation of the Smith-Geddes criteria, without resorting to the detail of the theories which support the criteria. The major thrust relates to the application to the assessment of PIO susceptibility and includes a commentary on the state of the control law development, together with the associated flight test technology. Derived from text

N95-31066# Gibson (J. C.), Saint Annes (England).
LOOKING FOR THE SIMPLE PIO MODEL
JOHN C. GIBSON *In* Advisory Group for Aerospace Research and Development, Flight Vehicle Integration Panel Workshop on Pilot Induced Oscillations 11 p Feb. 1995
Copyright Avail: CASI HC A03/MF A02

Eighteen years after the Tornado PIO (Pilot induced Oscillation) was successfully resolved, it seems inexplicable that similar PIO problems can still occur. For whatever reason, current formal methods are not working. The Vista F-16 is a powerful tool which should be put to use in establishing a universally acceptable set of criteria for the prevention of PIO by design. It should do this by determining the PIO qualities of a sufficiently wide range of linear and non-linear dynamic qualities, both in pitch and in roll, to establish a customer-defined set of Level boundary limits on whatever parameters are found best to quantify PIO. Only by doing this will it be possible to resolve the claims of the many competing criteria and guarantee a PIO-free future for all. It is not particularly difficult to identify the means. Derived from text

N95-31067# McDonnell-Douglas Aerospace, Long Beach, CA. Transport Aircraft Unit.
THE RELATION OF HANDLING QUALITIES RATINGS TO AIRCRAFT SAFETY
JOHN HODGKINSON *In* Advisory Group for Aerospace Research and Development, Flight Vehicle Integration Panel Workshop on Pilot Induced Oscillations 3 p Feb. 1995
Copyright Avail: CASI HC A01/MF A02

The main theme of this presentation, is that of relating the handling qualities issues, and specifically the PIO, to aircraft safety. It is essential that the programme managers recognize that PIO is safety critical in that it is loss of control, and that when it is encountered, it is as dangerous as a structural failure of the airframe. Derived from text

N95-31068# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. fuer Flugmechanik.
SCARLET: DLR RATE SATURATION FLIGHT EXPERIMENT
JENNIFER R. MARTIN and JOERG J. BUCHHOLZ *In* Advisory Group for Aerospace Research and Development, Flight Vehicle Integration Panel Workshop on Pilot Induced Oscillations 6 p Feb. 1995
Copyright Avail: CASI HC A02/MF A02

The time delay which arises due to rate limiting in a control system has been identified as a contributing factor to the occurrence of pilot induced oscillations (PIO's). Recent discussions concerning PIO prevention measures have proposed the elimination of this time delay through an alternate control scheme. In response to this proposal, the SCARLET (Saturated Command And Rate Limited Elevator Time delay) project was initiated in order to study the effects of both the time delay and the elimination scheme on the handling qualities of a contemporary fly-by-wire aircraft. A flight experiment was carried out in 1992 using DLR's ATTAS In-Flight Simulator. The flight test included runs with two different control laws: a conventional control scheme and the alternate control scheme (ACS). Results of the experiment demonstrated both the negative effect of rate saturation and the effectiveness of ACS to reduce the equivalent time delay and improve tracking performance. In order to further validate the concept of an alternate control scheme, the algorithms were adapted for use with a model-following control system. Pilot-in-the-loop simulations have shown improved performance through the use of ACS during rate saturated conditions. A second flight test will be performed this year in order to further evaluate the use of the alternate control scheme to eliminate the rate limit induced time delay and reduce the danger of PIO.
Derived from text

N95-31069# Saab-Scania, Linkoeping (Sweden). Flight Control.
SAAB EXPERIENCE WITH PIO
E. KULLBERG and PER-OLOV ELGERONA *In* Advisory Group for Aerospace Research and Development, Flight Vehicle Integration Panel Workshop on Pilot Induced Oscillations 9 p Feb. 1995
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The past experience in Sweden with PIO is reviewed, which had been so publicly witnessed with the second accident to the JAS-39 aircraft at the Stockholm Water Festival. Prior to commencing on the JAS-39 project, SAAB's experience of the PIO phenomenon had commenced with the J-35 aircraft. This aircraft had high stick sensitivity combined with a linear gearing of the stick to elevon. Following the PIO, the solution devised was to add a nonlinear gearing and improve the stability augmentation of the system. For the next aircraft project, the AJ-37 Viggen, significant work was performed on the handling qualities and resistance to PIO, based upon new information received during the 1960's from Ashkenas, McRuer, and A'Harrah. By 1963, Sweden had developed its own specification for flight control system design and for handling qualities. The latest versions of this AJ-37 aircraft have a digital flight control system. The AJ-37 Viggen has never experienced a problem with PIO in its service to date. The JAS-39 flight control system originated from demonstration work performed by SAAB on a FBW AJ-37 Viggen aircraft. This aircraft had been flown with instability levels of up to 4 percent chord at low Mach Number. This was the limit for this aircraft. Although this aircraft was reported to have experienced Level 2 or 3 handling, due to excessive time delays within the flight control system, it never experienced rate limiting or PIO. On this basis, it was deemed that there was sufficient knowledge and confidence to proceed with the JAS-39 aircraft project, and the JAS-39 specification was written around this experience, with a demanding handling qualities requirement. Derived from text

N95-31070# Department of the Air Force, California City, CA.
AEROELASTIC PILOT-IN-THE-LOOP OSCILLATIONS
W. J. NORTON *In* Advisory Group for Aerospace Research and Development, Flight Vehicle Integration Panel Workshop on Pilot Induced Oscillations 14 p Feb. 1995
Copyright Avail: CASI HC A03/MF A02

Pilot-induced oscillation (PIO) is an unwanted and inadvertent closed-loop coupling between the pilot and one or more independent response variables of an aircraft. PIO typically results when the pilot attempts to perform a high gain tracking task using the usual cues of acceleration or attitude. Control system and aircraft characteristics within the bandwidth in which the pilot is active can contribute to a coupling between the pilot response and aircraft dynamics. The result is a neutrally damped or undamped out-of-control condition in which the pilot is often making intentional extreme and repetitive inputs in an effort to damp the motion but only serves to enhance it. Pilot-augmented oscillation (PAO) is an unintentional closed-loop coupling which does not involve a tracking task. Another aircraft variable which may lead to PIO or PAO is aeroelastic deformation of the vehicle structure. This elastic response can produce pilot cues or aircraft rigid body motion which can be enhanced when the pilot attempts to damp the oscillation and PIO results. Or, the elastic oscillations alone may lead to PAO. The potential for aeroelastic pilot-in-the-loop coupling is not widely recognized, and this can mean resources expended in ineffectual or nonoptimal solutions to the problem until the aeroelastic source is recognized. This paper will characterize the aeroelastic/pilot coupling phenomena without reproducing the fundamental research which has already been published on more general PIO. Examples of aeroelastic PIO and PAO will be provided to illustrate the various ways in which the phenomena can manifest itself, including recent experiences with the C-17A and the V-22. An examination of the potential for predicting this coupling will also be provided. Lastly, recommendations for flight test methodology to uncover and investigate aeroelastic pilot-in-the-loop coupling will be provided. Author

N95-31072# Chalk (Charles R.), Williamsville, NY.
CALSPAN EXPERIENCE OF PIO AND THE EFFECTS OF RATE LIMITING
CHARLES R. CHALK *In* Advisory Group for Aerospace Research and Development, Flight Vehicle Integration Panel Workshop on Pilot Induced Oscillations 12 p Feb. 1995
Copyright Avail: CASI HC A03/MF A02

The experience of PIO within the Calspan Corporation is considerable, following a long standing interest in the subject. During this experience, the major concern that has been uncovered is that of the attitude towards the pilot following a PIO incident. There is still a tendency in many areas of aviation to consider a PIO as a failure of the pilot, whereas it must be properly regarded as a failure of the control system and its design process. Over a period of some years, the Calspan Corporation has undertaken a series of experiments with the NT-33A and Lear Jet aircraft to examine the effects of rate limiting compensating devices. The notes which follow summarize the presentation given on some of the aspects which have been investigated both analytically and experimentally in flight tests. Derived from text

N95-31428# Federal Aviation Administration, Cambridge, MA.
AVIATION CAPACITY ENHANCEMENT PLAN 1994
1 Oct. 1994 364 p Limited Reproducibility: Document partially illegible
(AD-A292758; DOT/FAA/ASC-94-1) Avail: CASI HC A16/MF A03

A comprehensive review of Federal Aviation Administration programs intended to improve the capacity of the National Air Transportation System. The Plan identifies the causes and extent of capacity and delay problems currently associated with air travel in the U.S. and outlines various planned and ongoing FAA projects with the potential to reduce the severity of the problems in the future. The major areas of discussion are: (1) Airport Development; (2) Airport Capacity; (3) Airspace Capacity; (4) New Instrument Approach Procedures; (5) Technology for Capacity Improvement; and (6) Marketplace Solutions. DTIC

N95-31454# Naval Research Lab., Monterey, CA.
ENVIRONMENTAL SUPPORT OF NAVAL AVIATION Final Report
SAM BRAND and STEVEN B. DRESKSLER Feb. 1995 64 p
(AD-A292873; NRL/MR/7543-94-7218) Avail: CASI HC A04/MF A01

A two-pronged approach to providing environmental support to Navy aviation is described. One approach focuses on flight safety and efficiency, and the other focuses on support to the tactical mission planner. Products are discussed in terms of requirements and the technical issues associated with the development or implementation of the products. This insight should be useful not only to the operational, tactical, and environmental communities, but to the R&D community as well. DTIC

N95-31512# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
PATIENT/AIRCRAFT FORECASTING FOR THE STRATEGIC AEROMEDICAL EVACUATION LIFT-BED PROCESS M.S. Thesis
DONALD F. KIMMINAU Mar. 1995 90 p
(AD-A293902; AFIT/GOA/ENS/95M-04) Avail: CASI HC A05/MF A01

The goal of this research is to develop a tool for the Global Patient Movement Requirements Center (GPMRC) to efficiently forecast Aeromedical Evacuation (AE) aircraft and schedule patients in the lift-bed process. During a contingency, GPMRC is responsible for requesting required airlift, and providing lift-bed candidates to the Theater Patient Movement Requirements Center. The objective is to evacuate all waiting patients while minimizing the number of C-141 aircraft which must to be dedicated to the AE mission. In the solution process, a short-term forecast of patient movement requirements is input, including number of patients, bed and aircraft availability, and hub preferences. A mixed integer linear program is formulated, and solved. Upon reaching optimality or a user-specified node limit, the user analyzes the solution and determines if the search will be continued. At process completion, a solution file is produced which contains a feasible schedule which minimizes the number of dedicated C-141s required. The programs developed to assist the solution process were tested with 16 data sets. While optimal solutions are not guaranteed to be found for every case, the process quickly produces good, feasible solutions and provides timely, valuable information to GPMRC so it can request airlift and provide lift-bed candidates to appropriate agencies. DTIC

N95-31569# Federal Aviation Administration, Atlantic City, NJ.
CHEMICAL OPTIONS TO HALONS FOR AIRCRAFT USE Final Report
ROBERT E. TAPSCOTT Feb. 1995 62 p
(AD-A293741; DOT/FAA/CT-95/9) Avail: CASI HC A04/MF A01

This report contains a summary of available fire suppression agents, their properties, and their applicability in the various aircraft applications. Classes of agents, with presently available agents listed, are recommended for use in the development of test protocols. The test protocol developed for a class of agents can be used, with minor modifications, to test all agents belonging to that class. DTIC

N95-31667# Arnold Engineering Development Center, Arnold AFS, TN.
ICING SIMULATION IN THE AEROPROPULSION SYSTEMS TEST FACILITY PROPULSION DEVELOPMENT TEST CELL C-2 Final Report, 13 - 23 May 1994
C. S. BARTLETT Jan. 1995 49 p
(AD-A293039; AEDC-TR-94-12) Avail: CASI HC A03/MF A01

The AEDC Propulsion Development Test Cell C-2 has been modified to provide simulated altitude icing conditions. Spray droplet clouds with droplet mass median diameters simulating natural icing clouds are produced with calibrated water atomizing spray nozzles. The proper amount of liquid water ingested by an engine in flight through icing clouds is simulated by injection of the proper water content into the airstream that enters a test engine. The addition of the icing simulation spray system provides the opportunity to conduct simulated icing testing in the large engine test cell. The system is capable of providing icing testing of large engines, inlets, windshields, wings, and other full-scale test articles. The results of system activation testing have been summarized. The system can be used to initiate clouds and reach steady controlled spray operation within 10 sec. The system is capable of varying the liquid water content (LWC) over a five-to-one range within 10 sec. The simulation spray can be terminated within 5 sec. The uniformity of the distribution of the supercooled water at the test section has been determined. The transient response of the spray system and the ability to operate at extreme cold conditions for icing testing are improvements beyond previous AEDC icing simulation system capabilities. DTIC

N95-31687# Mitre Corp., McLean, VA. Center for Advanced Aviation System Development.
EFFECTS OF CIVIL TILTROTOR SERVICE IN THE NORTHEAST CORRIDOR ON EN ROUTE AIRSPACE LOADS Final Report
WILLIAM W. TRIGEIRO, XAVIER P. SZEBRAT, and STEPHANIE B. FRASER Oct. 1994 70 p Prepared in cooperation with NYMA, Inc.
Contract(s)/Grant(s): (DTFA01-93-C-0001)
(AD-A293586; MTR-94W0000150; DOT/FAA/AOR-100/94/008) Avail: CASI HC A04/MF A01

This report documents an analysis of the effects of the introduction of civil tiltrotor (CTR) service on en route airspace loads. The analysis is intended as one in a set of analyses designed to provide information to senior decision makers and other interested parties on the potential effects of CTR service on National Airspace System performance. The analysis uses a demand scenario that addresses the introduction of CTR services into the Northeast Corridor of the United States using several simplifying assumptions. This report also includes an update on the previously published report 'Civil Tiltrotor Northeast Corridor Delay Analysis (Based on the Demand Scenario Described in Civil Tiltrotor and Applications Phase 2: The Commercial Passenger Market).' This document is based on briefing materials developed to report on the results of this analysis. These briefing materials have not been expanded to the full text more typical of technical reports. Instead, this document contains copies of the briefing slides and the associated briefing text. DTIC

N95-31712# National Transportation Safety Board, Washington, DC.
ANNUAL REVIEW OF AIRCRAFT ACCIDENT DATA: US GENERAL AVIATION CALENDAR YEAR 1993
12 May 1995 84 p
(PB95-215828; NTSB/ARG-95/01) Avail: CASI HC A05/MF A01

This report presents a statistical compilation and review of general aviation accidents which occurred in 1993 in the United States, its territories and possessions and in international waters. The accidents reported are all those involving U.S. registered aircraft not conducting operations under 14 CFR 121, 14 CFR 127, or 14 CFR 135. This report is divided into five sections: All Accidents; Fatal Accidents; Serious Injury Accidents; Property Damage Accidents; and Midair Collision Accidents. Several tables present accident parameters for 1993 accidents only, and each section includes tabulations which present comparative statistics for 1993 and for the nine-year period 1984-1992. Author

N95-31845# Federal Aviation Administration, Oklahoma City, OK. Civil Aeromedical Institute.
AIRCRAFT EVACUATIONS THROUGH TYPE-3 EXITS I: EFFECTS OF SEAT PLACEMENT AT THE EXIT Final Report
G. A. MCLEAN, M. H. GEORGE, C. B. CHITTUM, and G. E. FUNKHOUSER Jul. 1995 13 p
(DOT/FAA/AM-95/22) Avail: CASI HC A03/MF A01

Simulated emergency egress from Type 3 over-wing exits was studied to support regulatory action by the FAA. Passageway width and seat encroachment distance adjacent to the Type-3 exit were the major variables of interest. Two subject groups of differing mean ages were employed in a repeated-measures evaluation of different passageway widths leading to the exit in the CAMI aircraft cabin evacuation facility. Main effects of passageway width and seat encroachment distance on egress rates were determined using analysis of variance (ANOVA). Main effects were found for passageway width (p less than.001), seat encroachment distance (p less than.001), and subject group (p less than.001). The passageway width resulted from slowed egress at 6 and 10 inch wide passageway relative to 13, 15, and 20 inch passageways; seat encroachment effects were found for maximum seat encroachments but not midpoint and minimum encroachment distances. The subject group effects were found to result from a general increase in egress time for the older subject group. The placement of seat assemblies at the Type-3 exit has significant effects on passenger egress through the exit opening. Narrow passageways and/or large encroachments of the seat into the area of the exit opening delay egress significantly. Relative to the younger subjects, older subjects were found to have a general increase in egress times at all seat placement configurations that did not appear to worsen as the access route to the exit was made more restrictive.

Author

04
AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

A95-93613

THE USE OF SATELLITES FOR AERONAUTICAL COMMUNICATIONS, NAVIGATION AND SURVEILLANCE

I. C. FEREBEE 1991 4 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 30: Avionic Systems)

(CONGRESS PAPER C428-30-159; HTN-95-21182) Copyright

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

Author (Herner)

A95-94044

GPS MODELING FOR DESIGNING AEROSPACE VEHICLE NAVIGATION SYSTEMS

JOHN J. DOUGHERTY TRW Systems Integration Group, San Bernardino, CA, United States, HOSSNY EL-SHERIEF, DANIEL J. SIMON, and GARY A. WHITMER IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251) vol. 31, no. 2 April 1995 p. 695-705 refs

(BTN-95-EIX95302731223) Copyright

The complexity of the design of a Global Positioning System (GPS) user segment, as well as the performance demanded of the components, depends on user requirements such as total navigation accuracy. Other factors, for instance the expected satellite/vehicle geometry or the accuracy of an accompanying inertial navigation system, can also affect the user segment design. Models of GPS measurements are used to predict user segment performance at various levels. Design curves are developed which illustrate the relationship between user requirements, the user segment design, and component performance.

Author (EI)

A95-94046

MODELING AND ANALYSIS FOR THE GPS PSEUDO-RANGE OBSERVABLE

WEIHUA ZHUANG Univ of Waterloo, Waterloo, Ont, Canada and JAMES TRANQUILLA IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251) vol. 31, no. 2 April 1995 p. 739-751 refs

(BTN-95-EIX95302731227) Copyright

In this paper, a digital system for the Global Positioning System (GPS) pseudo-range observable is modeled and analyzed theoretically. The observable is measured in a GPS receiver by accurately tracking the pseudorandom noise (PRN) code phase of the input GPS signal using a digital energy detector and a digital delay lock loop (DDLL). The following issues are presented: (1) mathematical modeling of the digital PRN code acquisition and tracking system, (2) the closed-form expression derivation for the detection and false-alarm probabilities of the acquisition process and for the variance of code phase tracking error, and (3) the linear and nonlinear performance analysis of the DDLL for optimizing the receiver structures and parameters with tradeoff between the tracking errors due to receiver dynamics and due to input noise.

Author (EI)

A95-95085

FUTURE ATC SYSTEM INTEGRATION: TOOLS FOR DEVELOPING A SHARED VISION

RUSSELL A. BENEL MITRE Corp., McLean, VA, US and DAVID A. DOMINO MITRE Corp., McLean, VA, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 313-317

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This paper identifies an approach to solve a significant, emerging problem in the definition and development of future air traffic control (ATC) system enhancements. Previously, system elements were well understood and could be successfully specified, designed, built, tested, and fielded with little regard for interoperability among components. Now, we have the opportunity to develop systems with greater levels of capability, but with higher levels of complexity in the interaction among system elements (including the human). This reveals the potential for unintended consequences to reduce the effectiveness of the integrated system. Prototyping at the system level will support the FAA in its development process, and facilitate enlisting the active involvement of system users. The key difference between this effort and previous, existing prototyping is the integration of concepts, models and system elements within a system context as opposed to prototyping of individual elements. This approach allows operational personnel, systems developers, and program managers to develop a shared vision of the future and guide development. At each step the resulting information will be used to support the FAA's efforts to establish and maintain: (1) a future system definition; and (2) relevant research and development programs to achieve enhanced efficiency for the end-users, system resources, and operational personnel.

Author (Herner)

A95-95090

INTEGRATED VOICE AND DATA COMMUNICATIONS FOR AIR TRAFFIC SERVICE APPLICATIONS

MICHAEL D. JENKINS MITRE Corp., McLean, VA, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 341-346

Copyright

This paper has been prepared in support of a Federal Aviation Administration (FAA) sponsored Mission Oriented Investigation and Experimentation (MOIE) project. The main purpose of the project was twofold. First, to demonstrate the operational benefits of integrated digital voice and data applications that will enhance air traffic control (ATC) and air traffic services (ATS). Second, to demonstrate the operational benefits of discrete addressing and call queucing - capabilities provided by a future VHF digital air/ground radio concept. The project included establishing a testbed and assessing the technical impact of introducing enhanced features into the next-generation National Airspace System (NAS) communications system. Simulated airborne aircraft scenarios were developed to highlight the benefits of these features. Benefits demonstrated included enhancement of ATC voice and data call management capabilities, enhancement of communications with rescue coordination centers, added support provided by a national data base, and reduction of channel contention problems.

Author (Herner)

A95-95091
EVALUATING THE EFFECTS OF AIR TRAFFIC CONTROL AUTOMATION
CAROL A. MANNING FAA Civil Aeromedical Inst., Oklahoma City, OK, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 347-351
Copyright

The Federal Aviation Administration (FAA) will introduce increasingly sophisticated levels of automation into air traffic control facilities over the next 20 years. This paper will discuss the need to evaluate each stage of air traffic control (ATC) automation. Current plans for automating the air traffic control system, reasons for evaluating new programs, and proposals for evaluation will be discussed. Author (Herner)

N95-30486 Columbia Univ., New York, NY.
QUALITATIVE ENVIRONMENTAL NAVIGATION: THEORY AND PRACTICE Ph.D. Thesis
IL-PYUNG PARK 1994 173 p
Avail: Univ. Microfilms Order No. DA9421385

In this thesis we propose and investigate a new model for robot navigation in large unstructured environments. Current models which depend on metric information contain inherent mechanical and sensory uncertainties. Instead we supply the navigator with qualitative information. Our model consists of two parts, the map-maker and the navigator. Given a source and a goal, the map-maker derives a navigational path based on the topological relationships between landmarks. A navigational path is generated as a combination of 'parkway' and 'trajectory' paths, both of which are abstractions of the real world into topological data structures. Traversing within a parkway enables the navigator to follow visible landmarks. Traversing on a trajectory enables the navigator to move reliably into a homogeneous space, based on shapes formed by visible landmarks that are robust to positional and orientational errors. Reliability measures of parkway and trajectory traversals are defined by appropriate error models that account for the sensory errors of the navigator, the motor errors of the navigator, and the population of neighboring objects. Error detection and error recovery methods are also encoded into the generated path. The optimal path is further abstracted into a 'custom map,' which consists of a list of verbal directional instructions, the vocabulary of which is defined by our environmental description language. Based on the custom map generated by the map-maker, the navigating robot looks for events that are characterized by spatial properties of the environment. The map-maker and the navigator are implemented using two cameras, an IBM 7575 robot arm and PIPE (Pipelined Image Processing Engine). Various experiments show the effectiveness of navigation 'in the large' using the proposed methods. Dissert. Abstr.

N95-30597# Norwegian Inst. for Air Research, Kjeller (Norway).
RESULTS FROM TESTS OF THE HONEYWELL INTEGRATED FLIGHT MANAGEMENT UNIT
B. JALVING 8 Jan. 1995 48 p
Contract(s)/Grant(s): (PROJ. FFIE/633/131.1)
(PB95-211355) Avail: CASI HC A03/MF A01

The Norwegian Defense Research Establishment (NDRE) has tested Honeywell Military Avionics' Integrated Flight Management Unit (IFMU) as part of a program for investigating alternative technologies and vendors for the new antiship missile for the Royal Norwegian Navy. The HG1700 Inertial Measurement Unit (IMU) considered for use in the missile contains the same GG1308 ring laser gyros and Sundstrand RBA 500 accelerometers as the IFMU. Among the tests carried out were static navigation, gyro compassing, dynamic navigation, and impact of vibrations. It was observed that the performance was dependent upon the flight profile. Gyro biases, accelerometer biases, and random walk coefficients have been estimated. Additionally, the applicability of the IMU navigation data for seeker stabilization has been investigated. The HG1700 unit is suitable for the new antiship missile. NTIS

N95-30815# National Aerospace Lab., Amsterdam (Netherlands).
DEVELOPMENT OF ADVANCED APPROACH AND DEPARTURE PROCEDURES. FAILURE SCENARIOS
L. J. J. ERKELENS and J. H. VANDRONKELAAR 15 Sep. 1994 18 p
(PB95-198123; NLR-TP-93348-U) Avail: CASI HC A03/MF A01

Under a joint contract awarded by the Federal Aviation Administration (FAA) and the Netherlands Department of Civil Aviation (RLD), a flight simulator program was carried out on National Aerospace Laboratory's (NLR's) Research Flight Simulator (RFS) with 19 airline crews to evaluate various test scenarios concerning curved approaches and departures. The test program was flown under full Microwave Landing System (MLS) guidance with a simulated Boeing 747-200 aircraft. The scenarios included procedures for both to New York Area (John F. Kennedy International and La Guardia Airports) and Amsterdam International Airport Schiphol. Four curved approaches and two MLS departures have been evaluated. Crew ability to detect insidious failures and to respond to them were investigated. Crew performance and perception data were also measured in case of a simulated failure of the flight management computer during execution of a curved approach. The workload during a one-engine inoperative flight was also evaluated. NTIS

N95-31013# Federal Aviation Administration, Atlantic City, NJ.
A NASPAC-BASED ANALYSIS OF THE DELAY AND COST EFFECTS OF THE WESTERN-PACIFIC REGION PRELIMINARY RESECTORIZATION EFFORT OF 1993 Technical Note
JOSEPH M. RICHIE and DOUGLAS BAART Nov. 1994 145 p
(AD-A288696; DOT/FAA/CT-TN94/49; FAA-AOR-100-94-012) Avail: CASI HC A07/MF A02

This report contains the findings and analysis of the effects of the Western-Pacific Region (AWP) Preliminary Resectorization Plan of 1993 on local (AWP airports) and system-wide traffic delays. The National Airspace System Performance Analysis Capability (NASPAC) was used to perform this task, and calculates the local and system-wide delays with and without the AWP Resectorization Plan. Cost of delay was derived using the Cost of Delay Module based on these delays, on passenger cost, and on airline and aircraft specific cost. The results indicate that the proposed resectorization will reduce the operational delay in years 1995 and 2000 at most AWP airports and system-wide with the maximum benefit occurring in the year 2000. On the other hand, resectorization does not favor the passengers for the future years modeled. However, in year 2000, the increase in passenger delay is less than for year 1995. DTIC

N95-31433# Minnesota Univ., Minneapolis, MN.
EMERGING APPLICATIONS IN PROBABILITY (SENSOR MANAGEMENT) Final Technical Report, May 1994 - Jan. 1995
AVNER FRIEDMAN and KEITH KASTELLA 22 Feb. 1995 2 p
Contract(s)/Grant(s): (F49620-94-1-0275)
(AD-A292781) Avail: CASI HC A01/MF A01

This grant from the Air Force Office of Scientific Research supported research in Sensor Management related to the IMA 1993-94 academic year program 'EMERGING APPLICATIONS OF PROBABILITY'. It provided partial support for residency of Keith Kastella, an industrial researcher at Unisys Government Systems, to pursue research on the use of discrimination gain optimization for sensor management in Air Traffic Control. Manufacturing, Robotics, Remote Sensing and Defense Applications. Grant AF/F49620-94-1-0275 supported the publication of a technical research report submitted by Dr Kastella for inclusion in the IMA Preprint Series. This paper has been submitted to the IEEE Transactions on Systems, Man and Cybernetics. DTIC

N95-31520# Massachusetts Inst. of Tech., Cambridge, MA.
AN EXPLORATORY SURVEY OF INFORMATION REQUIREMENTS FOR INSTRUMENT APPROACH CHARTS Final Report, Nov. 1990
R. J. HANSMAN, JR. and MARK MYKITYSHYN Mar. 1995 126 p
Contract(s)/Grant(s): (DTRS57-88-C-0078)

(AD-A293882; DOTVNTSC-FAA-95/2) Avail: CASI HC A07/MF A02

This report documents a user centered survey and interview effort conducted to analyze the information content of current Instrument Approach Plates (IAP). In the pilot opinion survey of approach chart information requirements, respondents indicated their preferences for approach information and at what phase of the approach they preferred to see this information. Both precision and non-precision IAP formats were examined. In addition to the survey, focused interviews were conducted with pilots who represent the full spectrum of operational IAP user communities from major domestic air carriers to general aviation. DTIC

N95-31521# Massachusetts Inst. of Tech., Lexington, MA.

INTEGRATED TERMINAL WEATHER SYSTEM (ITWS) DEMONSTRATION AND VALIDATION OPERATIONAL TEST AND EVALUATION

DIANA L. KLINGLE-WILSON 13 Apr. 1995 81 p

Contract(s)/Grant(s): (DTFA01-91-Z-02036)

(AD-A293932; ATC-234) Avail: CASI HC A05/MF A01

During summer 1994, MIT Lincoln Laboratory conducted the Operational Test and Evaluation Demonstration and Validation (Dem Val) of the Federal Aviation Administration's Integrated Terminal Weather System (ITWS). The purpose of the demonstration was to obtain user feedback on products and to prove that the ITWS products and concept were sufficiently mature to proceed with procurement. Dem Val was conducted at the Memphis international Airport from 23 May through 22 July and at the Orlando International Airport form 11 July through 19 August. Products were delivered to users at the Memphis Airport Traffic Control Tower (ATCT) and TRACON (Terminal Radar Approach Control), at the Memphis Air Route Traffic Control Center (ARTCC), at the Orlando international ATCT and TRACON, and at the Jacksonville ARTCC. in addition, ITWS displays were available to the National Weather Service forecast offices at Memphis, TN, and Melbourne, FL; to Northwest Airlines in Minneapolis, MN; and to Delta Airlines in Orlando, FL. This report documents the technical performance of the product generation algorithms. Each algorithm is described briefly, including the product operational and display concepts. The techniques by which the technical performance is assessed and the results of the assessment are presented. The performance of the algorithms is measured against the Minimum Operational Performance Requirements (MOPR), which products must meet to be considered operationally useful by the ATC user community. DTIC

N95-31572# Federal Aviation Administration, Cambridge, MA.

GUIDELINES FOR THE DESIGN OF GPS AND LORAN RECEIVER CONTROLS AND DISPLAYS Final Report

M. S. HUNTLEY, JR. Mar. 1995 128 p

(AD-A293753; DOT-VNTSC-FAA-95-7; DOT/FAA/RD-95-7) Avail: CASI HC A07/MF A02

Long range navigation (Loran) and global positioning system (GPS) receivers are widely used in aviation. The Loran and GPS receivers are similar in size and function but derive their navigation signals from different sources. The design of the controls, displays, and computer logic is usually similar for the two types of receivers from a single manufacturer, but differs substantially among manufacturers. Some or all of the designs may provide a suboptimal human-computer interface, which may result in simple time delays or in serious risks if the pilot cannot use the system effectively and efficiently. The design variations also make it difficult to certify receivers for different applications. As a result, the Volpe National Transportation Systems Center has sponsored a program of research to address issues in Loran and GPS receiver design. This report first reviews the literature on user experiences with Loran and GPS receivers and other types of similar, automated equipment. Second, the report reviews the major human factors references, texts, and individual journal articles that are relevant to the regulatory requirements for the receivers. Finally, specific human factors principles and guidelines are proposed for the design and certification of GPS and Loran receiver controls, displays, and control-display integration. DTIC

N95-31581# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.

ANALYSIS AND MODELING OF AN AIRPORT DEPARTURE PROCESS M.S. Thesis

JOSEPH E. HEBERT Mar. 1995 137 p

(AD-A293782; AFIT/GOA/ENS/95M-02) Avail: CASI HC A07/MF A02

This study analyzes departure delays at a major airport using probability models to represent this nonhomogeneous process. The models developed in this study expand on the Markovian models presently used by employing the method of stages to represent some of the model processes. This technique improves the user's ability to achieve a close fit for the service time probability distribution while maintaining the advantages of the Markovian model. The three types of models developed and compared all assume a Markovian system entry process. The first model uses an exponential distribution to model the service process. The second uses an Erlang distribution. The third models employs a unique server absence process to explicitly represents the periods of time when the server is unavailable to service departing aircraft. All three models generate results which correlate well with the delays actually observed. However, the Erlang model is preferred. Its results have lower variability than the exponential service time model. In addition, it generates solutions much faster than a typical application of the absence model. This model should be useful for improving capacity estimation and take-off delay prediction. DTIC

N95-32022# Federal Aviation Administration, Cambridge, MA.

INTEGRATION OF AIR TRAFFIC DATABASES: A CASE STUDY Final Report, Oct. - Nov. 1994

CHARLES T. PHILLIPS Mar. 1995 62 p

(AD-A293691; DOT-VNTSC-FAA-94-29; DOT/FAA/AOR-100/95-01) Avail: CASI HC A04/MF A01

This report describes a case study to show the benefits from maximum utilization of existing air traffic databases. The study demonstrates the utility of integrating available data through developing and demonstrating a methodology addressing the issue of airport performance. The study utilized data bases which addressed the factors of airport capacity and aircraft delay, and focused on the single airport of Philadelphia International. Since avoidable delays impose major costs to the nation's airlines, the study objective was to better understand the conditions under which delays occur and their causal factors. This will provide guidance for decisions on airport investments which are justified with well-defined benefits. The report presents quantitative measures of average delay, number of delayed flights, and total delay. As expected, there were more delayed flights and longer average delays under poor weather conditions than under better weather conditions. However, total delay under good weather conditions considerably outweighs the total delay experienced under poor weather conditions. The report also demonstrates a quantitative relationship between average delay and the demand/capacity ratio at the airport. This should prove to be especially useful in the investment analyses of airport improvements. DTIC

N95-32186# Tulsa Univ., OK. Dept. of Psychology.

CONTROLLER RESOURCE MANAGEMENT: WHAT CAN WE LEARN FROM AIRCREWS? Final Report

CHARMINE HAERTEL and GUENTHER F. HAERTEL (Colorado State Univ., Fort Collins, CO.) Jul. 1995 41 p

Contract(s)/Grant(s): (DTFA02-93-P-7913)

(DOT/FAA/AM-95/21) Avail: CASI HC A03/MF A01

This paper provides an overview of the scientific literature regarding Crew Resource Management (CRM). It responds to tasking from the Office of Air Traffic Program Management to conduct studies addressing the application of team training models such as CRM for air traffic operational and administrative tasks. The authors report that there is no single model for CRM per se. They formulate a model by integrating common dynamic elements found in many CRM programs. The literature reviewed points out that current CRM research: (a) is primarily focused on flight deck CRM; (b) is insufficient to establish the superiority of CRM training over other team training alternatives; (c) has not identified the critical components of CRM team training; and (d) is limited in part by weaknesses in assessment methods and outcome criteria. The authors identify alternative assessment methods and performance criteria currently being explored by behavioral scientists. Finally, the authors discuss potential CRM techniques for enhancing Air Traffic Control Specialists operational tasks. Author

N95-32197# General Accounting Office, Washington, DC. Resources, Community, and Economic Development Div.

FACT SHEET FOR CONGRESSIONAL COMMITTEES. AIR TRAFFIC CONTROL: STATUS OF FAA'S MODERNIZATION PROGRAM

15 Apr. 1994 80 p

(GAO/RCED-94-167FS; B-247729) Avail: CASI HC A05/MF A01; GAO, PO Box 6015, Gaithersburg, MD 20877 HC

This fact sheet is the fifth annual review of the Federal Aviation Administration's (FAA) comprehensive effort to modernize the nation's air traffic control system by acquiring new equipment, such as radars, computers, and communications systems. The fact sheet provides information on the status of modernization, giving special emphasis to 12 of the largest projects: Advanced Automation System, Air Route Surveillance Radar-4, Airport Surface Detection Equipment-3, Airport Surveillance Radar-9, Automated Weather Observing System, Central Weather Processor, Flight Service Automation System, Microwave Landing System, Mode Select, Radar Microwave Link Replacement and Expansion, Terminal Doppler Weather Radar, and Voice Switching and Control System. Derived from text

N95-32199# General Accounting Office, Washington, DC. Resources, Community, and Economic Development Div.

REPORT TO THE CHAIRMAN, SUBCOMMITTEE ON TRANSPORTATION AND RELATED AGENCIES, COMMITTEE ON APPROPRIATIONS, HOUSE OF REPRESENTATIVES. AIR TRAFFIC CONTROL: STATUS OF FAA'S PLANS TO CLOSE AND CONTRACT OUT LOW-ACTIVITY TOWERS

12 Sep. 1994 27 p

(GAO/RCED-94-265; B-257854) Avail: CASI HC A03/MF A01; GAO, PO Box 6015, Gaithersburg, MD 20877 HC

The objectives are (1) to determine the reasonableness of FAA's plans to close level 1 (low-activity) air traffic control towers and contract out the operations of other level 1 towers, (2) to assess the reasonableness of the potential savings that could result from such actions, (3) to identify the factors that could impede FAA's plans to close and contract out towers, and (4) to identify steps that FAA can take to enhance its strategy for reassigning controllers from closed or contracted out level 1 towers. Of the 151 level 1 towers, 36 do not meet FAA's benefit-cost criteria for continued operations. FAA is planning to permanently close 23 of these towers within the next 3 years, saving as much as $5 million annually. Of the remaining 127 towers, 32 are currently contracted out. FAA estimates that it could save as much as $120 million (in constant 1994 dollars) if it contracts out the operation of the remaining level 1 towers by fiscal year 1997. FAA will not realize immediate savings primarily because of the short-term costs to relocate controllers to other facilities. Several factors may affect FAA's efforts to close or contract out level 1 towers quickly. First, according to FAA program management officials, the agency is receiving mixed signals from the Congress regarding level 1 towers. Second, FAA cannot contract out towers until the Department of Labor completes its wage determinations for each tower location. The FAA does not have a strategy for reassigning controllers from towers to be closed or contracted out to higher level facilities after fiscal year 1994. Also, since a number of controllers at level 1 towers have not been able to perform required duties at other facilities, FAA could incur significant costs to relocate controllers a second time if they do not succeed at higher-level facilities. CASI

05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A95-93615

PROGRESS AND EXPERIENCE WITH HELICOPTER HEALTH AND USAGE MONITORING

A. C. GORDON 1991 19 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 31: Airworthiness-Progress & Development

(CONGRESS PAPER C428-31-151; HTN-95-21184) Copyright

This paper starts with the reasons why Bristow Helicopters as an operator are at the forefront of putting together an Integrated Health and Usage Monitoring package. Bristows identifies its long history of design wrok introducing onto helicopters various major modifications culminating in the IHUMS program. The paper goes on to deal with the need for health monitoring which is really the outcome of the Helicopter Airworthiness Review Panel (HARP) report. It discusses the trials that were conducted in three phases for the Civil Aviation Authority (CAA) and which led Bristows to believe they could package an integrated CVR/FDR and health monitoring system together in time to meet the CAA's mandated FDR. The practical specification for the system is discussed and the argument for the need to integrate the system with flight data recording and cockpit voice recording. The operation of the system is then discussed in some detail indicating how the generic nature of the system is accomplished and introducing the vital role of the ground station and the interface in the ground station between the pilot and the engineer and the system as a whole. The paper goes on to discuss the problems of certification and of gaining manufacturers acceptance of the system on their aircraft, without which of course monitoring would never reacfh its full pontential. The paper finishes with some ideas of future potential and the direction which Bristows believe IHUMS will develop. Author (Herner)

A95-93616

IMPROVING THE FIRE RESISTANCE OF AIRCRAFT STRUCTURES

L. A. JONES 1991 9 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 31: Airworthiness-Progress & Development

(CONGRESS PAPER C428-31-152; HTN-95-21185) Copyright

Potential fire hazards associated with the operation of commercial aircraft are addressed. The basic problem areas are detailed and the ongoing reseach programs, to give a greater understanding to the fire problem and hence to establish solutions, are outlined. Aircraft fire safety covers all aspects of technology which will provide a safer environment for the traveling public and cover both fire prevention and fire control. It is a wide ranging topic which incorporates a large number of disciplines during design manufacture and operation. These cover structural design, systems design, material choice, maintenance activities, airworthiness and certification and so on. Author (Herner)

A95-93626

VARIABLE CAMBER GEOMETRY FOR TRANSPORT AIRCRAFT WINGS

J. J. SPILLMAN 1991 4 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 35: Active Controls)

(CONGRESS PAPER C428-35-061; HTN-95-21195) Copyright

Consideration of the geometry required to obtain variable camber for a transport aircraft wing has shown that trailing edges which rotate about centers well below the chordline are essential. To keep the profiles smooth and continuous requires panels which are flexible and can extend. If the wing is swept the junctions between the spanwise segments providing the variable camber are not parallel to the free stream

and can lead to diffficulties if not designed to minimize this effect.
Author (Herner)

A95-93627

LOAD ALLEVIATION FOR CIVIL TRANSPORT AIRCRAFT

D. M. JOHNSON 1991 3 p. AeroTech 92; The Aerospace & Airport Tech-nology Exhibition & Congress, UK, 1992, (Seminar 35: Active Controls)

(CONGRESS PAPER C428-35-057; HTN-95-21196) Copyright

During aircraft maneuvers and when turbulence is encountered, the forces acting on the aircraft wings may be greatly increased resulting in high stresses in the wing structure. By deflecting control surfaces on the wing, it is possible to redistribute the loads to reduce stressess and hence allow reductions in structural strength and weight. This paper examines the methods used to alleviate structural loads with particular reference to the Gust Load Alleviation (GLA) development on the Airbus A320. This example and others demonstrate how, with a fly-by-wire system, load alleviation can be incorporated without excessive system modification.
Author (Herner)

A95-93650

AN EXPERIMENTAL INVESTIGATION OF FORWARD-SWEPT WINGS AT LOW REYNOLDS NUMBERS

SCOTT A. RANDLE Wichita State University, US and L. SCOTT MILLER Wichita State University, US (ISSN 0148-7191) 1993 10 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993

(SAE PAPER 931370; HTN-95-21219) Copyright

The aerodynamic properties of a forward-swept wing were tested at low Reynolds numbers. The investigation was performed in a low-speed wind tunnel using a reflection plane model. Tunnel balance, model pressure taps, and flow visualization results were utilized to characterize the wing behavior over a range of Reynolds numbers from 0.25 x 10(exp 6) - 0.75 x 10(exp 6). In addition, the experimental data is compared to results using a recently developed computer program known as WING3D. This modified Non-Planar Vortex Lattice Method can calculate total wing lift and surface pressure distributions. The forward-swept wing has good aerodynamic qualities, in addition, the flow, on the outboard sections of the wing, remains attached beyond stall. The comparison of WING3D and experimental surface pressure distributions is good. The investigation results add to the experimental data base for forward-swept wings at low Reynolds numbers, assist in the evaluation of analysis/design tools, and can be used for low Reynolds number unmanned air vehicle applications.
Author (Herner)

A95-93656

CONCEPTS FOR AIRCRAFT SUBSYSTEM INTEGRATION

ALAN H. BURKHARD and WILLIAM L. HASKINS (ISSN 0148-7191) 1993 9 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993

(SAE PAPER 931377; HTN-95-21225) Copyright

The Air Force has an initiative entitled, Subsystem Integration Technology (SUIT) to develop and demonstrate integration technology as applied to the traditional aircraft utility subsystems. The SUIT program has the objective of developing and demonstrating design data and assessment capability for a truly integrated subsystem suite. Novel concepts for a utility suite have emerged from recently completed concept studies conducted by several contract teams. These concept studies showed that significant flight vehicle performance benefits appear to be possible via the utility suite approach as a result of the use of common or shared hardware and fluids to perform required functions, use of waste energy, and better overall energy management. The utility suite appproach reduces weight by having less standby hardware, reduces the acquisition and support cost via hardware commonality, provides for graceful degradation, and better energy management. Author (Herner)

A95-93657

SUIT: THE INTEGRATION OF AIRCRAFT SUBSYSTEMS

DAVID E. BLANDING, JOSE F. ALDANA, and DONALD W. SCHLUNDT (ISSN 0148-7191) 1993 13 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993

(SAE PAPER 931381; HTN-95-21226) Copyright

During Phase 1 of the Air Force Study Contract SUIT (SUbsystem Integration Technology), Rockwell identified the significant aircraft impprovements attainable through the collaborative design, integration, and control of the utility subsystems. A systematic integration design methodology was implemented during Phase 1 to identify and then integrate common subsystem functions and common parameters. From this study approach, a new integrated utility subsystem suite was generated that included important key technology advantages, six critical functions, and six major subsystems. The following functional integration technologies make up the core integrated baseline suite: (1) integrated closed environmental control. (2) integrated hydraulic power, (3) shared electrical power-vehicle power management, (4) integrated secondary power, (5) integrated fuel and thermal management, and (6) integrated utility subsystem control. This paper gives an overview of the integration methodology utilized to assess the subsystem design process and describes the integration technologies that were defined during SUIT Phase 1.
Author (Herner)

A95-93658

A SUBSYSTEM INTEGRATION TECHNOLOGY CONCEPT

H. (NICK) CARTER, III, DAN S. MATULICH, and CARL F. WEISS (ISSN 0148-7191) 1993 8 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993

(SAE PAPER 931382; HTN-95-21227) Copyright

McDonnell Douglas Aerospace teamed with Pratt & Whitney and AlliedSignal Aerospace Company for the Subsystem Integration Technology (SUIT) program to examine the opportunities for improvement in subsystem integration and to identify a new integration concept. This concept integrates all aircraft and engine power and cooling systems into a Thermal and Energy Management Module (T/EMM); combines gas separation and usage systems; integrates fuel pumping systems; and integrates utility subsystem controls. The T/EMM is the heart of the concept. It is powered by engine bleed air, rejects heat to engine bypass air, powers airframe and engine subsystems, and provides airframe cooling. The T/EEM can operate autonomously in emergencies or for ground operations. Performance analyses confirmed the feasibility of the T/EEM concept and demonstrated a 40% reduction in the number of components and a 1,000 lbs reduction in subsystem weight. The weight savings combined with increased energy efficiency reduce vehicle take-off gross weight by 10%. These reductions in equipment and vehicle size translate into significant acquisition and support cost savings. Author (Herner)

A95-93670

AIRCRAFT LANDING GEAR DYNAMICS PRESENT AND FUTURE

WILLIAM E. KRABACHER Wright-Patterson AFB, OH, US (ISSN 0148-7191) 1993 4 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993

(SAE PAPER 931400; HTN-95-21239) Copyright

This paper reviews the current state-of-the-art in aircraft landing gear dynamics and presents recommendations for new areas of research in this field. The paper begins by reviewing some of the shortcomings the author has experienced in conducting shimmy investigations on various aircraft. Included in this review are the problems associated with obtaining both landing gear structural parameters and the aircraft tire parameters. Some discussion is also made of the problems with current landing gear dynamics mathematical models. On the basis of all of these problems, recommendations are then made for future reseach. The main content of these recommendations are to develop three documents that will completely define a general landing gear dynamics mathematical/computer model that will be able to analyze the problems of gear walk, shimmy, dynamic response to rough runways, antiskid brake induced oscillations, tire-out-of-round, and wheel imbalance. The overall aim of the paper is to develop a unified, consistant approach to the design of landing gear systems. Author (Herner)

A95-93672
MODELLING AND ANALYSIS OF A DUAL-WHEEL NOSEGEAR: SHIMMY INSTABILITY AND IMPACT MOTIONS
G. X. LI (ISSN 0148-7191) 1993 15 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993
(SAE PAPER 931402; HTN-95-21241) Copyright

This paper studies landing gear stabiity and shimmy behavior of cantilevered dual-independent-wheels nosegear through modeling, analysis and numerical simulation. The landing gear model includes key features of nonlinearities such as freeplay and nonlinear damping in the steering system, dry friction between the piston and cylinder, as well as spring hardening effects of the bending and torsional stiffness. The shock strut is treated as a flexible beam described by a lateral displacement and a rotational angle. The trail arm and axel are considered as rigid bodies. Interaction between the tire and the runway surface is considered as a single point at any instant, and thus the cornering force is treated as linearly proportional to the tire slip angle and its time derivative. For fixed system parameters, the gear may become unstable and subsequently develop shimmy as the aircraft taxiing velocity is incresed beyond the critical point. Thereafter, due to the existance of torsional freeplay, the amplitude of the resulting oscillatory motion will keep growing until the collar starts impacting with the steering damper. The stability properties of the system are also conducted in a parameter space by varying a few key parameters individually. Time curves are used to verify the analytical results and to illustrate the nature of motion at different parameter values. Author (Herner)

A95-93673* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN ELECTRORHEOLOGICALLY CONTROLLED SEMI-ACTIVE LANDING GEAR
ZHENG LOU University of Michigan, MI, US, ROBERT D. ERVIN University of Michigan, MI, US, CHRISTOPHER B. WINKLER University of Michigan, MI, US, and FRANK E. FILISKO University of Michigan, MI, US (ISSN 0148-7191) 1993 9 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993
Contract(s)/Grant(s): (NAG1-1410)
(SAE PAPER 931403; HTN-95-21242) Copyright

This study is to explore the application of electrorheology (ER) to the real-time control of damping forces that are transmitted through the nose landing gear for an F-106B aircraft. The main part of the landing gear is a strut that consists of a pneumatic spring and an ER controlled damper that is situatted on the strut centerline and applies a force directly opposing the vertical displacement of the nose wheel. The damping element rotates in response to strut displacement, employing a co-axial arrangement of stator and rotor plates connected to the opposing electrodes in the control circuit. The vertical displacement is conveted into rotation of the damper through a screw-nut mechanism. The ER fluid between the electrodes is thus engaged in shear along circumferential lines of action. This design results in a fast time response and a high ratio of strut forces achieved under Er-vs. zero-field control. Compact size and simplicity in fabrication are also attained. The analysis shows that when using an ER fluid of a yield stress of 7kPa, the energy absorption efficiency of the landing gear can reach almost 100% at various sink rates. Author (Herner)

A95-93731
EFFECT OF INITIAL CONDITIONS ON THE RESPONSE OF NONLINEAR DYNAMICAL SYSTEMS WITH THE APPLICATION TO HELICOPTER ROTOR DYNAMICS
GRZEGORZ KAWIECKI The Univ. of Tennessee, Knoxville, TN, US, NITHIAM TI SIVANERI West Virginia Univ., Morgantown, WV, US, and TADEUSZ JANIK The Univ. of Tennessee, Knoxville, TN, US *In* Developments in theoretical and applied mechanics; Southeastern Conference on Theoretical and Applied Mechanics, 16th, Nashville, TN, April 12-14, 1992. A95-93700 Tullahoma, TN The Univ. of Tennessee Space Inst. (SECTAM, Vol. 16) 1992 p. II.13.1-II.13.8
(ISBN 1-879921-01-4) Copyright

Response of a simple flag-lag helicopter rotor blade model has been analyzed using marching in time and imposed periodicity algorithms. Generally, a discrepancy between the solutions obtained using these two types of algorithms has been observed. Also, the marching-in-time methods indicated a period of 4 pi for lead-lag response. These observations were confirmed by the results of a simple, mass-damper-spring system response analysis. Author (Herner)

A95-93746
ANALYSIS AND TESTING OF A GRAPHITE-EPOXY SANDWICH SHELL FUSELAGE TEST STRUCTURE
JOHN C. MCWHORTER, III Mississippi State Univ., Mississippi State, MS, US *In* Developments in theoretical and applied mechanics; Southeastern Conference on Theoretical and Applied Mechanics, 16th, Nashville, TN, April 12-14, 1992. A95-93700 Tullahoma, TN The Univ. of Tennessee Space Inst. (SECTAM, Vol. 16) 1992 p. III.I.52-III.I.61
(ISBN 1-879921-01-4) Copyright

This paper presents comparison between strains computed by finite element analysis and strains measured by electrical resistance straingages for three regions on a full scale graphite-epoxy honeycomb sandwich shell fuselage test structure under internal pressure. The three regions are: (1) around the intersections of a flat plate bulkhead and the shell; (2) around the intersection of a hemispherical dome and the shell; (3) and around a window opening in the shell. Comparisons are generally good for most points and poor for some. The poor comparisons arise where there is insufficient model detail to pick up complex three dimensional effects. Author (Herner)

A95-94127
AUTOMATIC GRID GENERATION PROCEDURE FOR COMPLEX AIRCRAFT CONFIGURATIONS
SUSUMU TAKANASHI Natl Aerospace Lab, Tokyo, Japan and MASAMI TAKEMOTO Computers & Fluids (ISSN 0045-7930) vol. 24, no. 4 May 1995 p. 393-400 refs
(BTN-95-EIX95302729765) Copyright

An automatic grid generation procedure based on a hybrid elliptic-parabolic method for complex aircraft configurations is presented. The grid system consists of inner and outer grids. The inner grid near the body surface is generated by a parabolic equation with a second-order dissipation term. On the other hand, the outer grid with an arbitrarily specified outer boundary is generated by an elliptic method based on the electrostatic theory. This hybrid method is shown to be applicable to any types of surface grids including unstructured (triangular) ones. The Navier-Stokes simulation for an aircraft configuration was carried out using the block structured grid generated by the present hybrid method. Author (EI)

A95-94458
COMPUTATION OF DELTA-WING ROLL MANEUVERS
RAYMOND E. GORDNIER U.S. Air Force Wright Lab, Wright-Patterson Air Force Base, OH, United States Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 486-492 refs
(BTN-95-EIX0619952748164) Copyright

This article presents computations of delta-wing roll maneuvers for an 80-deg sweep delta-wing at 30-deg angle of attack. Three constant roll-rate maneuvers are considered. Two of the maneuvers consist of a roll from 0 to 45 deg at nondimensional roll rates of Phi = 0.0233 and 0.0467. The third roll maneuver computed starts at a 45-deg roll angle and rolls back to a -45-deg roll angle at a roll rate Phi = -0.0467. The governing equations are the unsteady, three-dimensional Navier-Stokes equations. The equations are solved using the implicit, approximately-factored, diagonal form of the Beam-Warming algorithm. Subiterations are used to provide a more accurate means of implementing the diagonal form of the algorithm for unsteady flows. The effects of roll-rate and differing initial roll angles on the dynamical behavior of the vortices positions and strengths as well as their corresponding effect on surface pressure and roll moment coefficient are described. Author (EI)

A95-94470

FUNDAMENTALS OF CATASTROPHIC FAILURE PREVENTION BY THRUST VECTORING

B. GAL-OR Technion-Israel Inst of Technology, Haifa, Israel, V. SHERBAUM, and M. LICHTSINDER Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 577-582 refs

(BTN-95-EIX0619952748176) Copyright

The authors' proposal to convert military thrust vectoring flight control (TVFC) technologies into civil transport applications, translates combat-agility capabilities into unprecedented flight-safety standards. Dealing with the latter, this article compares future vectored-aircraft safety potentials and classes with current unsafe flight standards dictated by conventional flight control (CFC). A few simplified analytical results are presented to illustrate new classes and fundamentals of catastrophic failure prevention when TVFC replaces partial or complete loss of CFC in future civil and fighter aircraft. Author (EI)

A95-94471* National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.

OPERATIONAL AND RESEARCH ASPECTS OF A RADIO-CONTROLLED MODEL FLIGHT TEST PROGRAM

GERALD D. BUDD National Aeronautics and Space Administration Dryden Flight Research Cent, Edwards, CA, United States, RONALD L. GILMAN, and DAVID EICHSTEDT Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 583-589 refs

(BTN-95-EIX0619952748177) Copyright

The operational and research aspects of a subscale, radio-controlled model flight-test program are presented. By using low-cost free-flying models, an approach was developed for obtaining research-quality vehicle performance and aerodynamic information. The advantages and limitations learned by applying this approach to a specific flight-test program are described. The research quality of the data acquired shows that model flight testing is practical for obtaining consistent and repeatable flight data. Author (EI)

A95-94474

ASSESSMENT OF TECHNOLOGY FOR AIRCRAFT DEVELOPMENT

J. S. SHANG U.S. Air Force Wright Lab, Wright-Patterson Air Force Base, OH, United States Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 611-617 refs

(BTN-95-EIX0619952748181) Copyright

An assessment of analysis and design tools for aircraft technology has been accomplished. By addressing the limitations of computational and experimental techniques for aircraft performance simulation, the critical and basic topics for improvement have been identified as turbulence, laminar-turbulent transition, aerodynamic bifurcation, and vortex interaction. Specific areas of future emphasis are also highlighted. Author (EI)

A95-94477

FLIGHT TEST CERTIFICATION OF PRIMARY CATEGORY AIRCRAFT USING TP101-41E SPORTPLANE DESIGN STANDARD

M. W. ANDERSON Federal Aviation Administration, Des Plaines, IL, United States Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 631-635 refs

(BTN-95-EIX0619952748184) Copyright

This article discusses certification standards, flight testing, and type certification of a primary category aircraft using the Transport Canada TP101-41E Ultra-Light Design Standard as the certification basis. For many years manufacturers maintained that certification standards were overly restrictive with regard to small aircraft of simple design, and therefore, restrict growth and innovation in the small airplane industry. Government agencies in conjunction with industry set forth to design a streamlined certification standard for these type aircraft. The primary category rule for type certification of aircraft of simple design intended for pleasure or personal use was adopted. Presented is an overview of certification and flight test of the Quicksilver GT 500 aircraft that was certified under the primary rule using the Transport Canada TP101-41E Ultra-Light Design Standard. Certification flight test plans and flight test techniques used to gather data are presented. Flight test data and compliance with TP101-41E are discussed. Noncompliant findings are discussed. The Quicksilver GT 500, the first aircraft certified in the primary category, was awarded a provisional-type certificate on August 1, 1993. Author (EI)

A95-94480

OPTIMAL TRAJECTORIES FOR AN UNMANNED AIR-VEHICLE IN THE HORIZONTAL PLANE

JOSEPH Z. BEN-ASHER Taas-Israel Industries, Ltd, Ramat-Hasharon, Israel Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 677-680 refs

(BTN-95-EIX0619952748191) Copyright

Several modern computational techniques were used to investigate the time-optimal trajectories in the horizontal plane for DELILAH, an actual unmanned air-vehicle (UAV). Minimum-time maneuvering problem in the horizontal plane was studied in three steps: (1) the minimum principle and the associated two-point boundary-value problem (TPBVP) were formulated and numerically solved using a multiple shooting algorithm; (2) the Jacobi test was conducted by a technique based on singular-value decomposition; and (3) an approximation scheme in which constant flight was assumed along the trajectories was considered. The results obtained were found to be satisfactory. EI

N95-30497 Virginia Polytechnic Inst., Blacksburg, VA.

A GENERAL INVERSE DESIGN PROCEDURE FOR AERODYNAMIC BODIES Ph.D. Thesis

MICHAEL LAWRENCE PAPAY 1994 103 p

Avail: Univ. Microfilms Order No. DA9425587

A general inverse design procedure has been developed to use optimization techniques and generic surface descriptions for the purpose of aerodynamic shape design. A variety of flow regimes are examined from 2D inviscid, subsonic cases to 3D turbulent, supersonic problems. Surface descriptions have been generalized through the use of B-splines to model a variety of curves and shapes with a minimum of parameters. The process uses a computational fluid dynamics program, GASP (the General Aerodynamic Simulation Program), and several iterative and optimization techniques to examine bodies of interest. A 2D inviscid, subsonic airfoil test case demonstrates the ability of the procedure to solve problems governed by elliptic equations. A 3D, viscous, compressible flow over a forebody/canopy model of a supersonic fighter and its comparison to test data establishes the ability of the method to solve practical problems of interest. Several other test cases are performed, including an axisymmetric power law body and a 3D elliptic cone. Unconstrained multiparameter optimizations have been quite successful in matching target pressure coefficients and reproducing target body shapes. Dissert. Abstr.

N95-30646*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

MOVING BASE SIMULATION OF AN INTEGRATED FLIGHT AND PROPULSION CONTROL SYSTEM FOR AN EJECTOR-AUGMENTOR STOVL AIRCRAFT IN HOVER

WALTER MCNEILL, E., WILLIAM W. CHUNG, and MICHAEL W. STORTZ Jun. 1995 31 p

Contract(s)/Grant(s): (RTOP 505-68-32)

(NASA-TM-108867; A-950046; NAS 1.15:108867) Avail: CASI HC A03/MF A01

A piloted motion simulator evaluation, using the NASA Ames Vertical Motion Simulator, was conducted in support of a NASA Lewis Contractual study of the integration of flight and propulsion systems of a STOVL aircraft. Objectives of the study were to validate the Design Methods for Integrated Control Systems (DMICS) concept, to evaluate the handling qualities, and to assess control power usage. The E-7D ejector-augmentor STOVL fighter design served as the basis for the simulation. Handling-qualities ratings were obtained during precision hover and shipboard landing tasks. Handling-qualities ratings for these tasks ranged from satisfactory to adequate. Further improvement of the design process to fully validate the DMICS concept appears to be warranted. Author

N95-30827*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A WIND TUNNEL INVESTIGATION OF THE EFFECTS OF MICRO-VORTEX GENERATORS AND GURNEY FLAPS ON THE HIGH-LIFT CHARACTERISTICS OF A BUSINESS JET WING M.S. Thesis
MICHELLE THERESE MARTUCCIO Aug. 1994 129 p
(NASA-TM-110626; NAS 1.15:110626) Avail: CASI HC A07/MF A02

A study of a full-scale, semi-span business jet wing has been conducted to investigate the potential of two types of high-lift devices for improving aircraft high-lift performance. The research effort involved low-speed wind-tunnel tests of micro-vortex generators and Gurney flaps applied to the flap system of the business jet wing and included force and moment measurements, surface pressure surveys and flow visualization on the wing and flap. Results showed that the micro-vortex generators tested had no beneficial effects on the longitudinal force characteristics in this particular application, while the Gurney flaps were an effective means of increasing lift. However, the Gurney flaps also caused an increase in drag in most circumstances. Author

N95-30838# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
VALIDATION OF THE HELICOPTER ROTOR CODE HERO
J. BOSSCHERS 11 Oct. 1993 23 p
(PB95-198040; NLR-TP-93418-U) Avail: CASI HC A03/MF A01

Some improvements are shown for the helicopter rotor code HERO. The code is based on a blade element method using relative simple inflow models and is presently being improved with respect to aerodynamic modeling. Experimental results are used to validate the performance characteristics and the inflow modeling. Calculations with the unsteady aerodynamics model of Leishman & Beddoes are shown. A preliminary empirical formula is presented to take rotational effects into account. The formula is implemented in a semi-empirical dynamic stall program, and a dynamic stall loop showing the influence of rotation is presented. NTIS

N95-30923# Continuum Dynamics, Inc., Princeton, NJ.
A NOVEL INSTRUMENTATION SYSTEM FOR MEASUREMENT OF HELICOPTER ROTOR MOTIONS AND LOADS DATA, PHASE 1 Final Report, 10 Aug. 1994 - 10 Mar. 1995
ROBERT MCKILLIP, JR. Apr. 1995 61 p
Contract(s)/Grant(s): (N00600-94-C-3087)
(AD-A293309; CDI-95-03) Avail: CASI HC A04/MF A01

Results of a Phase-1 SBIR study directed at a novel instrumentation system for the measurement of helicopter rotor motion and loads are described. Background into the requirements and needs of the measurement system are provided, along with a summary of past activities in this area. Consideration is then given to a novel scheme that incorporates blade-mounted accelerometer sensors with a simplified signal processing scheme to extract both rotor motion measurements, and to a limited extent, blade loading information. Issues regarding sensitivity of the system to modeling errors, nonlinearities and sensor bias errors are examined through detailed simulation and analysis. Also, a demonstration of the system performance for reconstructing flapping motion measurements is provided using Froude-scaled model rotor test results. Finally, implementation issues are discussed, and a plan for continued work leading to prototype development for this system is outlined. DTIC

N95-30927# Naval Postgraduate School, Monterey, CA.
PROBABILISTIC RELIABILITY MODELING OF FATIGUE ON THE H-46 TIE BAR M.S. Thesis
JOHN C. OCONNOR Sep. 1994 84 p
(AD-A289926) Avail: CASI HC A05/MF A01

The H-46 helicopter has experienced early in-service failures in its tie bar. The tie bar is a multi-component system that is a critical part of the linkage, which attaches the rotor blade to the rotating hub of the helicopter. This research developed methodology to predict the life of the tie bar under nominal operational flight loads. A probability model is indispensable because a revised design has yet to accumulate field data, and laboratory testing can never be sufficiently extensive for non-parametric reliability prediction. An algorithm was developed for three and four component systems that will generate the probability of system failure based on the probability of failure in its components. Finite element analysis was conducted on the tie bar to determine stress on each component for all possible damage configurations of the tie bar. A given set of flight loads was resolved into boundary conditions for the stress analysis. A methodology was developed to determine the probability of failure of each component using an idealized load history, based on the expected stress-life (S-N) relation of the component at the stress levels experienced by the component. The result is a prediction method that can fortify laboratory results to predict the probability of failure of a system given the system load history. This model will be verified using the early in-service failure statistics of the current design and can be used to assess revised designs. The model will provide a prediction of the failure distributions, (the bell-shaped distribution) as a fabrication of flight hours, or one, two, three, and four elements of failures within the leaves of the tie bar. DTIC

N95-31065# Hoh Aeronautics, Inc., Lomita, CA.
UNIFIED CRITERIA FOR ACT AIRCRAFT LONGITUDINAL DYNAMICS
ROGER H. HOH *In* Advisory Group for Aerospace Research and Development, Flight Vehicle Integration Panel Workshop on Pilot Induced Oscillations 9 p Feb. 1995
Copyright Avail: CASI HC A02/MF A02

This paper reports research done by USAF to adequately predict the susceptibility to pilot induced oscillation (PIO) and AGARD's response to the research. It discusses different criteria and characteristics that help to analyze PIO: the concept of phase delay, triggers, the effects of rate limiting, response characteristics and appropriate analysis techniques, and feel system influence. From the evidence presented by USAF, AGARD concludes that there is sufficient evidence that a PIO could be predicted, as could the effects of the bobweight. However, the impact of the actuation behavior may have had a dominant effect on the overall behavior of the aircraft. CASI

N95-31416# Department of Defense, Fort Meade, MD.
UNMANNED AERIAL VEHICLES. 1994 MASTER PLAN
31 May 1994 132 p Original contains color illustrations
Avail: CASI HC A07/MF A02

This 1994 Unmanned Aerial Vehicle (UAV) Master Plan is the sixth submission to Congress, providing the acquisition and technology strategies, management, and program plans for nonlethal UAVs. The UAV Joint Project Office is the single Department of Defense organization charged with management responsibility for UAV's; the United States Navy was designated as the Executive Service for nonlethal UAV programs. This plan is comprised of the following sections: executive summary; management; supporting the user; programs; commonality and interoperability; technology; analysis and simulation; integrated logistics support (ILS), training, and human systems integration (HSI); test and evaluation; international programs; resources; needs rationale; UAV characteristics; dual use of UAV's; and points of contact. CASI

N95-31451# Virginia Polytechnic Inst. and State Univ., Blacksburg, VA.
COMPUTATIONAL METHODS FOR CONTROL AND OPTIMAL DESIGN OF AEROSPACE SYSTEMS Final Technical Report, 1 Jan. 1992 - 31 Mar. 1994
J. A. BURNS and E. M. CLIFF 31 May 1994 16 p
Contract(s)/Grant(s): (F49620-92-J-0078)
(AD-A292861; ICAM-94-06-03) Avail: CASI HC A03/MF A01

This final technical report contains a summary of the research funded by AFOSR under Grant F49620-92J-0078, titled Computational Methods for Control and Optimal Design of Aerospace Systems, for the period 1 January 1992 to 31 March 1994. During this period, the investigators concentrated on five problems; optimal design of forebody simulators, control of highly maneuverable aircraft, control of fluid flows, modeling and identification of smart materials, and robust control of nonlinear conservation laws. A new sensitivity equation method was developed for shape optimization and flow tailoring. This method was transitioned into software at the Arnold Engineering Development Center and at Virginia Tech. A new mathematical model for aircraft agility was used to investigate feedback control laws for time optimal maneuvers. New vortex shedding patterns were discovered for unsteady flows about rotating cylinders. The work on smart materials produced new models and computational methods for the dynamics of shape memory alloys. In addition, robust control theory was applied to nonlinear conservation laws yielding a new approach to sensor location. The report contains a complete list of papers produced during this period. DTIC

N95-31525# Air Force Environmental Tech. App. Center, Scott AFB, IL.
ARTIFICIAL INTELLIGENCE TECHNIQUES FOR FLIGHT TEST PLANNING, PHASE 1 Final Report
RICHARD H. STOTTIER 28 Mar. 1995 52 p Limited Reproducibility: Document partially illegible
Contract(s)/Grant(s): (N00600-94-C-2972)
(AD-A293962; FR001) Avail: CASI HC A04/MF A01

We found that several AI techniques would be applicable to the development of a system to aid flight test engineers. Flight test engineers reported that test plan and test report creation to be their most time-consuming activities and that they often made informal use of similar plans and reports. Based on the requirements of the flight test engineers, we developed the design for the Automated Flight Test Engineering System (AFTES). To prove its feasibility we implemented and demonstrated critical portions in three Phase 1 prototypes. AFTES is feasible and will benefit the Navy substantially when it is implemented. The three prototypes showed that the most critical aspects could be implemented. Furthermore, the very positive response we received from flight test engineers over both the AFTES designs and the Phase 1 prototypes indicates that AFTES will be utilized when its implemented. Finally, the fact that the productivity of flight test engineers will markedly improve is based on the fact that AFTES was designed with precisely this purpose, along with improving the quality of the plans and reports produced. For example, the test plan produced in a a few minutes by the prototype can take some less-experienced flight test engineers several days to produce. DTIC

N95-31544# Defence Science and Technology Organisation, Canberra (Australia).
PREPARATION OF S-70A-9 BLACK HAWK HELICOPTER FOR FLIGHT TESTS TO INVESTIGATE CAUSE OF CRACKING OF INNER FUSELAGE PANEL
D. C. LOMBARDO, A. K. PATTERSON, P. FERRAROTTO, S. A. DUTTON, and I. G. POWLESLAND Feb. 1995 50 p
(AD-A293891; DSTO-TN-0004; DODA-AR-009-205) Avail: CASI HC A03/MF A01

An Australian Army Black Hawk helicopter has been fitted with suitable flight test instrumentation at the Aeronautical and Maritime Research Laboratory to enable an investigation of the cause of cracking in an internal fuselage skin panel. Nine accelerometer channels and 46 strain gauge channels have been provided. Reasons for the choice of measurement type and location are provided together with details of the measuring system installed. Plans for the conduct of suitable flight tests and for the evaluation of the collected data are provided. DTIC

N95-31578# Naval Postgraduate School, Monterey, CA.
A CASE STUDY OF THE TEAMING CONCEPT IN THE PROCUREMENT OF THE V-22 AIRCRAFT M.S. Thesis
RICHARD D. COLVARD Dec. 1994 68 p
(AD-A293770) Avail: CASI HC A04/MF A01

This thesis is a case study of the V-22 Osprey program. It examines dual-sourcing of major weapon systems which was the original acquisition strategy for the V-22. It examines the history of the V-22 program management. The chronology of the program is presented from the birth of the Joint Services Aircraft Program in 1981 through the engineering, manufacturing, and development phase in 1994. The focus of this thesis is to look at the relationship between the Joint Program Office, the parent companies of Bell Helicopter, Inc. and Boeing Helicopter, Inc., and the Government. The thesis also looks at other strategies that have been used in major weapon systems procurements such as the F/A-18 aircraft program which is being procured sole-source with the prime/subcontractor arrangement. This thesis concludes that the acquisition of the V-22 has not been efficient and that Bell and Boeing Aircraft Companies, operating under a teaming concept, have not presented a single face to the Government. DTIC

N95-31579# Naval Postgraduate School, Monterey, CA.
MODELING F/A-18 FLIGHT HOUR PROGRAM COSTS USING REGRESSION ANALYSIS M.S. Thesis
LARRY E. ARKLEY Dec. 1994 123 p
(AD-A293771) Avail: CASI HC A06/MF A02

This thesis is an in depth analysis of cost variance in Naval Air Reserve units flying the McDonnell Douglas F/A-18. The purpose of the thesis is to identify, analyze, and quantify the effect of variances in the cost per flight hour of the Naval Air Reserve's Flying Hour Program. The study begins with a review of the planning, programming, and budgeting system which is used to justify and fund the Flying Hour Program. Then three different methods of determining Flying Hour Program requirements are described. The four components of cost per hour within the Flying Hour Program (fuel, organizational maintenance activity, intermediate maintenance activity, and aviation depot level repairables) are defined. Finally, using regression analysis techniques, these four components of F/A-18 cost data are analyzed on the basis of the intensity of aircraft utilization: flight hours. The analysis includes a regression model to provide budgeters at the headquarter or squadron level the means for predicting aircraft maintenance and fuel costs given a utilization rate. The thesis concludes with areas recommended for further research. DTIC

N95-31602# Virginia Polytechnic Inst. and State Univ., Blacksburg, VA.
PERFORMANCE IMPROVEMENT OF COMPOSITE WINGS THROUGH AEROELASTIC TAILORING AND MODERN CONTROL Final Report, 1 Sep. 1991 - 31 Aug. 1994
LEONARD MEIROVITCH 23 Jan. 1995 110 p
Contract(s)/Grant(s): (AF-AFOSR-0351-91)
(AD-A293689; AFOSR-95-0326TR) Avail: CASI HC A06/MF A02

The research has been carried out simultaneously on three aspects of aircraft wings performance optimization, as follows: (1) Structural tailoring and modern control of thin-walled model of composite aircraft wings; (2) Structural tailoring of a low-aspect ratio plate model of composite aircraft wings; and (3) Integrated structural design and vibration control by multiobjective optimization. Significant progress has been made on all fronts. DTIC

N95-32003# Wright Lab., Wright-Patterson AFB, OH. Flight Dynamics Directorate.
FLIGHT EVALUATION OF FOREBODY VORTEX CONTROL IN POST-STALL FLIGHT
LAWRENCE A. WALCHLI *In* AGARD, Active Control Technology:

Applications and Lessons Learned 10 P Jan. 1995
Copyright Avail: CASI HC A02/MF A04

Loss of directional stability in a post-stall flight environment has become a major design issue for future fighter aircraft. Numerous studies have addressed this issue, either from an aerodynamics perspective or through use of propulsive forces generated by vectoring exhaust nozzles. The X-29 aircraft, with its forward swept wing and other advanced technologies, suffers loss of directional power above 40 degrees angle of attack (AOA). An exploratory development program was undertaken on this configuration to regain the lost stability through use of a pneumatic system on the aircraft nose which influenced the external flow field, generating significant side forces useful for control. Wind tunnel test results were inserted into the X-29 flight simulator at NASA Dryden Flight Research Facility and the simulator was used to support a critical flight experiment of this technology. This experiment is the subject of this paper. Author

N95-32007# Air Force Flight Test Center, Edwards AFB, CA.
FLIGHT TEST RESULTS OF THE F-16 AIRCRAFT MODIFIED WITH AXISYMMETRIC VECTORING EXHAUST NOZZLE
D. KIDMAN and D. VANHOY *In* AGARD, Active Control Technology: Applications and Lessons Learned 19 p Jan. 1995
Copyright Avail: CASI HC A03/MF A04

This paper presents results from flight testing an F-16 aircraft modified with the Axisymmetric Vectoring Exhaust Nozzle (AVEN). This includes an assessment of the AVEN nozzle and the modified F-16 flight control system to provide stability and control power in an expanded maneuvering envelope, an assessment of flying qualities, and an overall assessment of tactical utility. Also included are lessons learned regarding the testing and implementations of active control technology. Author

N95-32008# Dassault Aviation, Saint-Cloud (France).
CATAPULT-LAUNCHING OF THE RAFALE DESIGN AND EXPERIMENTATION [CATAPULTAGE DU RAFALE CONCEPTION ET EXPERIMENTATION]
D. FLEYGNAC and L. LEQUEUX *In* AGARD, Active Control Technology: Applications and Lessons Learned 12 p Jan. 1995 In FRENCH
Copyright Avail: CASI HC A03/MF A04

The RAFALE program was conceived from the beginning to define, develop and produce a general-purpose aircraft meeting the future needs of the State - the Army, Air Force, and Navy. The Navy version is intended to equip the French naval air forces by the end of the decade. It will operate starting from the conventional propulsion Foch and the Charles De Gaulle nuclear aircraft carrier. Furnished with a numerical flight control system, the RAFALE M01 prototype is the first aircraft with delta canards to be catapulted from an aircraft carrier (April 1993). It is also the first naval aircraft to use the original method of catapult-assisted dihedral launching. The study of naval aircraft catapult launching combines the technical disciplines implicit in the design of fighter aircraft: aerodynamics, structure, flight control, and aircraft systems. In the framework of this conference, the discussion has particularly focused on flight dynamics. It covers: the specifications of the RAFALE naval launching; some related aspects at the aircraft catapult design: flight control system, improved performance systems (dihedral launch, high-energy recovery rate); the ground tests; and the tests at sea. Transl. by CASI

N95-32013# Deutsche Aerospace A.G., Munich (Germany). Military Aircraft Div.
X-31: A PROGRAM OVERVIEW AND FLIGHT TEST STATUS
H. ROSS and U. NEUBERGER *In* AGARD, Active Control Technology: Applications and Lessons Learned 7 p Jan. 1995
Copyright Avail: CASI HC A02/MF A04

The objective of the X-31 program (the first international US/German experimental program) was to develop a new fighter that can execute tactical maneuvers up to an angle of attack (AOA) of 70 degrees (which is far beyond the stall AOA) without the pilot losing control of the aircraft (poststall capability, PST). This capability extends aircraft performance with respect to deceleration capability, turn rate and radius, and pointing capability for weapon firing considerably and results in a distinctive improvement of the tactical advantages in close-in combat. The prerequisite for these capabilities is the use of thrust vector control to boost or even replace the aerodynamic controls which lose their effectiveness at low speeds and in the poststall regime. The technical development of the PST capability requires the application of new technologies in the areas of aerodynamics (separated vortex flow), propulsion (inlet aerodynamics and jet deflection) and in particular, flight control (unstable configurations, digital flight control systems, integrated thrust vector control). Flight test results of the X-31 showed that the four important basic maneuvers (safe flight and maneuvering at 70 deg. AOA, 360 deg. rolls about the velocity at 70 deg. AOA, poststall maneuvers at high load factors, and the 180 deg. J (or Herbst) turn with extremely small turn radii and high turn rates) have been successfully demonstrated. In Nov./Dec. 1993 the flight envelope was extended into the supersonic and flights with a helmet mounted display (HMD) were conducted. This paper gives an overview of the X-31 program and the results of the test flights. CASI

N95-32196# General Accounting Office, Washington, DC. National Security and International Affairs Div.
REPORT TO THE CHAIRMAN, LEGISLATION AND NATIONAL SECURITY SUBCOMMITTEE, COMMITTEE ON GOVERNMENT OPERATIONS, HOUSE OF REPRESENTATIVES. UNMANNED AERIAL VEHICLES: PERFORMANCE OF SHORT-RANGE SYSTEM STILL IN QUESTION
15 Dec. 1993 19 p
(GAO/NSIAD-94-65; B-229489) Avail: CASI HC A03/MF A01; GAO, PO Box 6015, Gaithersburg, MD 20877 HC

The Department of Defense (DOD) is acquiring the Short-Range Unmanned Aerial Vehicle (UAV) at an estimated cost of $4.1 billion to meet the needs of the military services for reconnaissance, surveillance, target acquisition, and intelligence missions. The Short-Range UAV's performance capability as demonstrated in recent testing is evaluated. Although DOD considered the short-range system's preproduction test results to be sufficient to justify its low-rate production, the detailed test results showed deficiencies that could jeopardize the system's capability to meet military requirements. In addition, several important performance requirements were either not tested or were tested under unrealistic conditions. Thus, DOD has committed to acquiring an unproven and possibly deficient system. This condition occurred because DOD allowed the Short-Range UAV program to be driven by schedule requirements rather than by demonstrated accomplishments, as required by DOD's stated policy. CASI

06
AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A95-92513
PASSIVE MILLIMETER WAVE CAMERA FOR AIRCRAFT LANDING IN LOW VISIBILITY CONDITIONS
MERIT SHOUCRI TRW Space and Electronics Group, Redondo Beach, CA, United States, ROGER DAVIDHEISER, BRUCE HAUSS, PAUL LEE, MICHAEL MUSSETTO, STEVE YOUNG, and LARRY YUJIRI
IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985) vol. 10, no. 5 May 1995 p. 37-42 refs
(BTN-95-EIX95292721321) Copyright

Fog and low visibility conditions have hampered aviation since its inception. Fog-related accidents are numerous, and canceled take-offs and landings due to fog and low visibility conditions (Cat III) have significant economic impact on airlines, parcel carriers and general aviation. Millimeter waves have good propagation properties in weather and give adequate spatial resolution when used to image the forward scene. Passive millimeter wave focal plane array cameras are new sensors which, integrated into future guidance and landing systems, promise to be an effective aid, or alternative, to existing technology for aircraft landings and take-offs under Cat III conditions. They can produce visual-like radiometric images at real time frame rates (up to 30 Hz), and are directly amenable to image fusion with infrared and visible images. TRW has been actively involved in developing and productizing this technology both at the hardware and the system levels. Author (EI)

A95-93612
AIRBORNE INTEGRATED COMMUNICATIONS SYSTEM
G. VONGAS 1991 6 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 30: Avionic Systems)
(CONGRESS PAPER C428-30-162; HTN-95-21181) Copyright

It is widely accepted that future military and civil airborne communications will require an increased range of functions such as multiple, simultaneously operating channels, advanced data links, reduction in crew workload, automatic communications management, improved logistics and availability. This paper examines the methods and possible architectures for integrating the various radio systems covering frequencies from HF to UHF, also addresses some of the issues of integrating the communications sub-system within the aircraft avionics system. Author (Herner)

A95-93620
DESIGN TRENDS IN PROPULSION CONTROL SYSTEMS
M. J. JOBY 1991 12 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 33: Propulsion 4 - Power & Control)
(CONGRESS PAPER C428-33-123; HTN-95-21189) Copyright

High bypass ratio turbofan engines entered civil airline service in the late 1960's. Since that time families of engines have evolved through a process of continuous improvement, leading to the achievement of unprecedented levels of fuel economy and operational reliability. This process has been accompanied by major parallel developments in engine control systems. Future trends indicate further growth in control system requirements. These requirements, which may include sophisticated control laws and diagnostics, significant additional sensing, actuation and data processing functions, higher reliability, lower volume and cost, will provide a major challenge for the system designer. Author (Herner)

A95-93621
CHINOOK GOES FADEC
J. F. MARRIOT and T. MORRISON 1991 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 33: Propulsion 4 - Power & Control)
(CONGRESS PAPER C428-33-078; HTN-95-21190) Copyright

Full Authority Digital Engine Contol (FADEC) is being introduced onto the latest versions of the Chinook helicopter for the RAF and the US Army Special Operational Force (SOF). These applications will be the first introduction of a modem technology electronic control on the Chinook and will replace the conventional hydromechanical control that has been in service for over thirty years. Hawker Siddley Dynamics Engineering in collaboration with Chandler Evans have produced a FADAC to control the Textron Lycoming T55 turboshaft engines on these aircraft. Author (Herner)

A95-93622
SURGE RECOVERY AND COMPRESSOR WORKING LINE CONTROL USING COMPRESSOR EXIT MACH NUMBER MEASUREMENT
G. D. DADD and M. J. PORTER 1991 12 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 33: Propulsion 4 - Power & Control)
(CONGRESS PAPER C428-33-210; HTN-95-21191) Copyright

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

A95-93628
FLIGHT CONTROL SYSTEMS/STRUCTURAL COUPLING BAE WARTON EXPERIENCE IN AERO-SERVO ELASTICITY
B. CALDWELL 1991 13 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 35: Active Controls)
(CONGRESS PAPER C428-35-059; HTN-95-21197) Copyright

The structural coupling problem, associated with interaction between the flexible structure of the aircraft and its flight control system (FCS), is not as widely appreciated within the aircraft industry as the two disciplines on the fringes of which it lies; FCS design and Flutter. This paper is intended to provide a physical 'handle' on the topic, rather than an in depth mmathematical analysis. The approach to the problem solution developed at BAe Warton for flight clearance of the EAP Demonstrator aircraft is outlined, together with some of the recent development work which will lead into the EFA program. Author (Herner)

A95-93634
ASTRA - A SAFE, SIMPLEX, FLY-BY-WIRE AIRCRAFT CONTROL SYSTEM
D. A. WILLIAMS Cranfield Institute of Technology, UK 1991 9 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 37: Airworthiness-Composites and Fly by Wire)
(CONGRESS PAPER C428-37-218; HTN-95-21203) Copyright

The subject of this paper is a digital fly-by-wire control system designed and implemented by Cranfield Institute of Technology under contract to the United Kingdom Ministry of Defence. The system is installed in the Advanced Systems Training Aircraft (ASTRA), a BAe HAWK T MK, 1 operatd by the Empire Test Pilot's School, Boscombe Down. System design requirements and implementation issues are discussed with particular emphasis on flight safety requirements of a system which can be configured to yield, in the limit, an uncontrollable aircraft. Author (Herner)

A95-93642
CONDITION MONITORING FOR HELICOPTERS: 3303 AIRBORNE VIBRATION MONITORING SYSTEM
RONALD W. CAULKINS (ISSN 0148-7191) 1993 8 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993
(SAE PAPER 931360; HTN-95-21211) Copyright

This paper discusses the use of a sixteen (16) channel vibration monitoring and analysis system permanently mounted on the aircraft. Aircraft vibrations are measured by accelerometers placed at various locations around the airframe, analyzed to obtain frequency information and compared to predetermined vibration limits. FFT'd data is downloaded to a ground based computer for trending to reveal component wear, component faults or assembly/maintenance errors. Continuous monitoring for catastrophic events and rotor track and balance calculators are also considered. Author (Herner)

A95-93681
MODULAR AVIONICS: TAKING TODAY'S AIRCRAFT INTO TOMORROW
JOHN R. THEDENS (ISSN 0148-7191) 1993 5 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993
(SAE PAPER 931416; HTN-95-21250) Copyright

The use of advanced technology is essential to meeting the mission requirements of present as well as future aircraft. Modular avionics are being introduced into next generation aircraft, as a means of achieving higher levels of performance, including reduced volume and improved adaptability, maintainability, and expandability. The reduction in military spending may result in a stretch out of these programs, delaying their availability. This will require that aircraft presently in inventory remain in service beyond their original design lifetime. These platforms must also continue to improve their capability if they are to cope with the threats of the 21st century. Therefore, it is important to apply technology improvements like modular avionics to existing aircraft. The government has started this effort through the establishment of the Modular Avionics System Architecture (MASA) program, created to promote the retrofit application of modular concepts to government program managers and industry avionics suppliers through study programs, sponsorship of public forums and establishment of a Modular Avionics Handbook. The purpose of this paper is to aid the application of modular avionics to today's aircraft. It discusses the status of present modular avionics standards and identifies several areas throughout the equipment life cycle where traditional approaches must be reexamined. Author (Herner)

A95-95044
DESIGN OF HEAD-UP DISPLAY SYMBOLOGY FOR RECOVERY FROM UNUSUAL ATTITUDES
DIVYA CHANDRA Univ. of Michigan, MI, US and DANIEL J. WEINTRAUB Univ. of Michigan, MI, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 58-63
Copyright

Accident statistics show that spatial disorientation is a significant factor in military aviation mishaps. The 'Augie vector' symbology is designed to aid pilots flying with head-up displays (HUD) in recovering from unusual attitudes induced by spatial disorientation. The original concept of the Augie vector has now been elaborated and refined into an 'Augie display.' The results of a simulation that implemented variations of the Augie display are presented in this report. Subjects performed two types of tasks: initiation of recovery and execution of the full recovery. Pilots with instrument-flight experience and college students with computer-game flight-simulation experience were tested. Pilots showed a steeper learning curve than students, but performance between groups did not differ overall. Completion times for the full-recovery task were not diagnostic. Recovery initiation times indicated that command Augie displays were superior to status Augie displays. However, performance with the Augie display was not appreciably faster than performance without the display. The surprising result can be explained by a subject-reported strategy that yields interesting insights about the design of the HUD pitch ladder. Author (Herner)

A95-95194
ASRS PROBLEMS INVOLVING AIR CARRIER GROUND DEICING/ANTI-ICING
ROBERT L. SUMWALT, III Battelle's Aviation Safety Reporting Syst. Prgm Offc., Mountain View, CA, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 954-959
Copyright

The Aviation Safety Reporting System (ASRS) Office shares the FAA's and the Industry's desire to increase aviation safety through improved airline ground deicing/anti-icing procedures. This study focused on the human factors associated with air carrier ground deicing/anti-icing. We sought to determine psychological and physical factors that affect a person's ability to properly detect ice, remove ice, and assure that the aircraft critical surfaces are free of ice before takeoff. Psychological factors evaluated included (but were not limited to) judgement and decision making, perceptual aspects, motivational, and attentional factors. Physical factors that we evaluated were (but were not limited to) difficulties trying to inspect and/or remove ice from wings that are high off the ground, and procedural design issues. The ultimate goal of this research project was to identify specific deicing/anti-icing issues for which worthwhile safety recommendations could be made. Author (Herner)

A95-95210
AIRBORNE AIR TRAFFIC CONTROL: AN APPLICATION OF DISTRIBUTED PROCESSING IN THE AIR TRAFFIC CONTROL ENVIRONMENT
JOSHUA LEE DOWNS Ohio State Univ., Columbus, OH, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2 Columbus, OH Ohio State University April 1993 p. 1049-1057
(HTN-95-12417) Copyright

The author discuss an application of distributed processing in the air traffic control environment as a means for providing multiply redundant error checking and processing support that will fit in nicely with the new Advanced Automation System (AAS). He introduces an example of an integrated flight environment that could provide an added measure of fault correction and failure protection for the new system. Although the ultimate configuration of the system is a bit utopian, the idea of integrating air traffic control with the flight environment by using a distributed processing architecture has and should continue to be closely evaluated.
Author (revised by Herner)

N95-31180 Department of the Navy, Washington, DC.
APPARENT SIZE PASSIVE RANGE METHOD Patent
WALTER L. HARRIMAN, inventor (to Navy) 13 Dec. 1994 8 p Filed 15 Jul. 1993
(AD-D017360; US-PATENT-5,373,318; US-PATENT- APPL-SN- 094663; US-PATENT-CLASS-348-117) Avail: US Patent and Trademark Office

A method and apparatus provides instantaneous passive range measurement onboard an aircraft for determining the range between the aircraft and a target. The target may either be stationary or a slower moving vehicle. Calculation of the desired range is achieved using the formula: Range = (S/S')V(Cos a)(Cos b) where S = apparent target size; S' = rate of change of apparent size; V = round velocity; a = azimuth angle from aircraft eading to target; and b = elevation angle from the aircraft heading to the target. The apparatus consists of an automatic video tracker, a video camera, and a servo controlled aiming platform. The video tracker provides target size data. Resolvers on the aiming platform are utilized to determine the azimuth and elevation angles from the aircraft axis to the target. The azimuth angle is added to the aircraft drift angle to determine the total azimuth angle from the aircraft heading to the target. The drift angle and ground velocity are obtained from the aircraft inertial system. DTIC

N95-31584# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
ANALYSIS OF HEADS-UP DISPLAY QUICKENING VERSUS HANDLING QUALITIES M.S. Thesis
Mar. 1995 133 p
(AD-A293797; AFIT/GAE/ENY/95M-01) Avail: CASI HC A07/MF A02

This study investigated an analytical means of selecting the quickening time constant for the standardized heads-up display flight path marker. The theoretically determined time constant allowed a faster, less resource intensive means of selecting the quickening time constant. The theoretically best time constant for pilot-aircraft handling qualities was equal to the airframe pitch attitude high frequency zero time constant, T(sub theta 2). Flight test indicated an empirical, more labor intensive method yielded better handling qualities, even though paper analysis indicated the theoretical method was better. The theoretically determined time constant gave slightly lower handling qualities, but was less costly to implement than the empirical method. DTIC

N95-31655# Honeywell Technology Center, Minneapolis, MN.
SYNTHETIC TERRAIN IMAGERY FOR HELMET-MOUNTED DIS-

PLAY. VOLUME 2: SOFTWARE DESIGN DOCUMENT Final Report, 1 Jun. 1992 - 1 Mar. 1995
RAND WHILLOCK, BILL CORWIN, and JEFF GROAT 15 Nov. 1994 106 p
Contract(s)/Grant(s): (F33615-92-C-3601)
(AD-A293611; WL-TR-95-3026) Avail: CASI HC A06/MF A02

The software that has been developed as part of the Synthetic Terrain Imagery (STI) Helmet-Mounted Display program is written in C and is designed to execute on a Silicon Graphics VGX Workstation. This software was developed for purposes of evaluating the utility of synthetically derived representations of the local terrain presented on a helmet mounted display. DTIC

N95-31656# Honeywell Technology Center, Minneapolis, MN.
SYNTHETIC TERRAIN IMAGERY FOR HELMET-MOUNTED DISPLAY, VOLUME 1 Final Report, 1 Jun. 1992 - 1 Mar. 1995
BILL CORWIN, RAND WHILLOCK, and JEFF GROAT 15 Nov. 1994 77 p
Contract(s)/Grant(s): (F33615-92-C-3601)
(AD-A293612; WL-TR-95-3025) Avail: CASI HC A05/MF A01

In order to aggressively maneuver an aircraft at low altitude, the pilot must be aware of his attitude as well as the elevation of the surrounding terrain. Low altitude tactical maneuvering is difficult during day operations but becomes nearly impossible at night without an effective night attack system. A system that generates a terrain image from onboard data without the use of sensors would be valuable day or night under all weather conditions. Having a terrain image produced on a Helmet-Mounted Display (HMD) will provide a terrain reference wherever the pilot is looking, thus allowing for more aggressive tactical maneuvering at night. Therefore, with the advent of HMD technology, along with the ability to store a digital terrain data base on tactical aircraft, this capability can be realized. The overall objective of this program is to enhance tactical operations by utilizing a digital terrain system data base to generate a Synthetic Terrain Image(STI) on an HMD. DTIC

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.

A95-92589
APPLICABILITY OF ELECTRICALLY DRIVEN ACCESSORIES FOR TURBOSHAFT ENGINES
M. S. JARVIS General Electric Aircraft Engines, Lynn, MA, United States, W. J. OSTERGREN, and B. SMITH Journal of Engineering for Gas Turbines and Power, Transactions of the ASME (ISSN 0742-4795) vol. 117, no. 2 April 1995 p. 221-226 refs
(BTN-95-EIX95292721153) Copyright

Improved electrical power generation and actuation systems offer new design approaches for performing the engine control and accessory functions in helicopter propulsion systems. Present helicopter technology utilizes turboshaft engines with mechanically driven accessories. These accessories perform the functions of starting, fuel and lube pumping, variable stator actuation, and inlet particle separation. This paper discusses the applicability of replacing the mechanically driven accessories with their electrically driven counterparts. An electric accessory system is defined, which includes a switched reluctance starter/generator and its associated control unit; an electric pumping and actuation system; and the engine mounting for the starter/generator. A comparison between the mechanically and electrically driven accessory systems is performed on the basis of cost, weight, and reliability. Experience to date with switched reluctance machines and electrically driven turboshaft accessory systems is summarized. The benefits of electrically driven accessories are shown and recommendations for future activity for this important technology are discussed. Author (EI)

A95-92590
CONDENSATION IN JET ENGINE INTAKE DUCTS DURING STATIONARY OPERATION
J. B. YOUNG Univ of Cambridge, Cambridge, United Kingdom Journal of Engineering for Gas Turbines and Power, Transactions of the ASME (ISSN 0742-4795) vol. 117, no. 2 April 1995 p. 227-236 refs
(BTN-95-EIX95292721154) Copyright

The condensation of moist air in very long intake ducts of engines during stationary operation was analyzed. The analysis demonstrated the occurrence of homogeneous condensation, for moderate values of relative humidity, in an outer annulus adjacent to the intake cooling if the local flow Mach number is about 1.0. For Mach Number of 0.8, homogeneous condensation would unlikely to occur. However, heterogeneous condensation on foreign particles would likely occur if the intake duct is long enough. The effects of condensation on test engine were found to the two folds: (1) increase in entropy which resulted in loss of total pressure in intake duct; and (2) acceleration of flow approaching the engine due to mass and energy transfer between phases during the condensation process. EI

A95-93605
MANUFACTURE TECHNOLOGY
A. J. S. PRATT 1991 4 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 27: Propulsion 3 - Materials and Manufacture)
(CONGRESS PAPER C428-27-088; HTN-95-21174) Copyright

Design requirements are often constrained by the available manufacturing technology. This paper reviews how current and future aircraft engine designs are supported by manufacturing technology. This includes developments in new materials, processes and inspection, as well as the impact of computer based information systems on the relationship between the designer and the manufacturer. Author (Herner)

A95-93606
THE ROLE OF MATERIAL BEHAVIOUR MODELLING IN STRESSING AND LIFE ASSESSMENT OF MODERN AERO-ENGINE COMPONENTS
G. F. HARRISON 1991 10 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 27: Propulsion 3 - Materials and Manufacture)
(CONGRESS PAPER C428-27-127; HTN-95-21175) Copyright

Aircraft engine components evolve through an iterative process involving the creation of the basic design to meet the performance requirements and the stress analyses and subsequent life evaluation of the individual components. A progressive increase in stage loading has resulted in more parts experiencing time as well as cycle dependent damage processes. The influence of cyclic softening in quantifying this effect is discussed. The implications of a fracture mechanics based on damage tolerance approach in determining the lives of service discs is examined. The role of three dimensional creep analysis, including the influence of transient thermal stress, in identifying critical areas in highly cooled rotor blades is discussed. Finally an approach for modeling anisotropic single crystal materials is illustrated. Author (Herner)

A95-93631
THE AUXILIARY AND EMERGENCY POWER SUPPLY ON THE SAAB JAS39 GRIPEN AIRCRAFT
I. MCFARLANE 1991 10 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 36: Aircraft Power Generation & Mgmt.)
(CONGRESS PAPER C428-36-192; HTN-95-21200) Copyright

The Gripen aircraft employs a highly unstable canard, tail-first, configuration to optimize aerodynamic and performance benefits. Synthetic stability is imposed by fly-by-wire control technology throughout the flight envelope, with control laws embodied in computer software ensuring optimum control surface configuration using hydraulic and electrical power sources. During normal operation secondary power is provided by hydraulic pumps and a generator driven by the main (single) engine. Since even a momentary interruption can result in the loss of the aircraft and the pilot, a self-contained system of high reliability with immediate response is required to back up the main engine. Traditionally conventional batteries, auxiliary air power units (APU) or emergency hydrazine power units have been used. however, batteries are heavy and need maintenance, APUs have altitude limitations and hydrazine in any of its forms, presents considerable environmental hazards. Author (Herner)

A95-93664

A DETAILED POWER INVERTER DESIGN FOR A 250 KW SWITCHED RELUCTANCE AIRCRAFT ENGINE STARTER/GENERATOR

ARTHUR RADUN and EIKE RICHTER (ISSN 0148-7191) 1993 15 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993

Contract(s)/Grant(s): (F33615-90-C-2052)

(SAE PAPER 931388; HTN-95-21233) Copyright

The design results for a 250kW switched reluctance aircraft engine starter/generator system power inverter are presented. The starter/generator employs a single switched reluctance machine and a generating system architecure that produces two separate 270 Vdc buses from that single switched reluctance machine. The machine has six phases with three of the phases connected to one inverter supplying 125 kW to one 270 Vdc bus while the other three phases are connected to a second inverter supplying 125 kW to the other 270 Vdc bus. Each bus has its own electromagntic interference (EMI) filter and control in addition to its own inverter. Two types of inverters have been developed, one type employs metal oxide semicondutor (MOS) Controlled Thyristors (MCTs) for the controlled switches and the other type employs Insulated Gate Bipolar Tranistors (IGBTs). high-current 500 A peak turn-off MCT modules were specifically developed for the MCT inverters. Two of these modules are placed in parallel to form the required 1000 A switches. Safe operating area issues and special considerations related to employing the MCT switches are described. The IGBT inverters use two commercial 400 A 600 V IGBT modules for each switch. The link capacitor bank for each inverter employs multilayer ceramic capacitors to meet the starter/generators temperature requirements. These same multilayer ceramic capacitors are also used in the EMI filters. Performance predictions and results for inverters are presented. Author (Herner)

A95-93665

DETAILED DESIGN OF A 250-KW SWITCHED RELUCTANCE STARTER/GENERATOR FOR AN AIRCRAFT ENGINE

C. A. FERREIRA and EIKE RICHTER (ISSN 0148-7191) 1993 12 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993

Contract(s)/Grant(s): (F33615-90-C-2052)

(SAE PAPER 931389; HTN-95-21234) Copyright

The work reported in this paper has been conducted by General Electric Company and Sundstrand Corporation as part of a contract sponsored by the United States Air Force (USAF) Wright Laboratories, and Wright-Patterson Air Force Base (WPAFB). The objective of this contract is to prove the feasibility of an integral starter/generator (IS/G) through the preliminary design stage and demonstrate the starter/generator technology in the externally-mounted version (EIS/G) using switched reluctance (SR) machine technology. This paper reports on the detailed design and analysis of the EIS/G. The analysis and design encompassed definition of requirements and constraints, electromagnetic design, thermal analysis, mechanical stress and fit analysis, bearing and critical speed analysis, and mechanical layout and packaging, the results show that when properly designed the SR machine has a very competitive power density when compared to existing aircraft secondary power generator, and that the machine is capable of meeting the application performance requirements. Author (Herner)

A95-93667

PROPULSION EDUCATION AT CARLTON UNIVERSITY

H. I. H. SARAVANAMUTTOO Carleton University, Canada and S. A. SJOLANDER Carleton University, Canada (ISSN 0148-7191) 1993 12 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993

(SAE PAPER 931391; HTN-95-21236) Copyright

Although a relatively small industrial nation, Canada has a very well-developed gas turbine industry with both an original design and manufacturing capability and a large industrial user base. Research and teaching at Carlton University has focused on the needs of the Canadian industry over many years. The paper gives an overview of the propulsion content of the programs at the undergraduate and postgraduate levels, as offered to students in both Mechanical and Aerospace Engineering. A short course presented regularly to designers and users of gas turbine engines is also briefly described. Author (Herner)

A95-93668

AN EDUCATIONAL INTRODUCTION TO TRANSONIC COMPRESSOR STAGE DESIGN PRINCIPLES

PHILIP G. HILL (ISSN 0148-7191) 1993 12 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993

(SAE PAPER 931393; HTN-95-21237) Copyright

An introduction to the operational and design features of the transonic fan stage of a modern turbofan engine can give the student an example of highly developed turbomachinery whose performance and design can be readily appreciated from fundamental knowledge of compressible fluid flow and boundary layer separation. Application of continuity and momentum principles along with the constraint of a limiting tip-diameter Mach number (relative to the blade) can serve to determine the required fan size, RPM, blade angles and blade spacing for given mass flow rate and inlet stagnation pressure and temperature. Sensitivity of fan design parameters to limiting Mach number, hub-tip ratio and stall safety margin is readily determined by a simplified model which is compatible with the results of detailed design procedures. Author (Herner)

A95-93675* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

POWER SYSTEM CHARACTERISTICS FOR MORE ELECTRIC AIRCRAFT

IRVING G. HANSEN NASA Lewis Research Center, US (ISSN 0148-7191) 1993 6 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993

(SAE PAPER 931406; HTN-95-21244) Copyright

It should not be suprising that more electric aircraft must meet significantly more difficult electrical power system requirements than were considereed when today's power distribution systems were being developed. Electric power, no longer a secondary system, will become a critical element of the primary control system. Functional reliability requiirements will be extremely stringent and can only be met by controlling element redundancy within a distributed power system. Existing electrical systems were not developed to have both the power system and the control/sensing elements distributed and yet meet the requirements of lighting tolerance and high intensity radio frequency (HIRF). In addition, the operation of electric actuators involves high transient loading and reverse energy flows. Such phenomena were also not anticipated when power quality was specified for either 270 vdc or 400 Hertz ac power systems. This paper will expand upon the issues and discuss some of the technologies involved in their resolution. Author (Herner)

A95-93677

CALCULATION OF CONTROL LAWS FOR THE DIGITAL FUEL CONTROL UNIT OF A SMALL THRUST TURBOJET

G. TORELLA Italian Air Force Academy, Italy and G. LIOTTI (ISSN

0148-7191) 1993 15 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993
(SAE PAPER 931411; HTN-95-21246) Copyright

The methods and the techniques set-up for evaluating the control laws for the digital Main Fuel Control Unit (MFCU) of a small thrust turbojet engine are shown. A suitable parameter defining the surge margin is considered. The paper deals with the results of a study carried out in order to evaluate the influence of engine operating parameters on the surge margin. For this aim the steady state engine simulation programs, based on the state vector technique, have proved very effective. Finally the codes and the obtained results have been used for calculating some suitable control laws for a digital MFCU. Author (Herner)

A95-93678* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

EXPERIMENTAL PERFORMANCE OF A VENTRAL NOZZLE WITH PITCH AND YAW VECTORING CAPABILITY FOR SSTOVL AIRCRAFT

BARBARA S. ESKER NASA Lewis Research Center, Cleveland, OH, US and JACK G. MCARDLE NASA Lewis Research Center, Cleveland, OH, US (ISSN 0148-7191) 1993 10 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993
(SAE PAPER 931412; HTN-95-21247) Copyright

Aircraft with supersonic, short takeoff and vertical landing capability have been proposed to replace some of the current high-performance aircraft. Several of these configurations use a ventral nozzle in the lower fuselage, aft of the center of gravity, for lift or pitch control. Internal vanes canted at 20 deg were added to a swivel-type ventral nozzle and tested at tailpipe to ambient pressure ratios up to 5.0 on the Powered Lift Facility at NASA Lewis Research Center. The addition of sets of four or seven vanes decreased the discharge coefficient of the nozzle by at least 6 percent and did not effect the thrust coefficient. Side force produced by the nozzle with vanes was 14 percent or more of the vertical force. In addition, this side force caused only a smalll loss in vertical force in comparison to the nozzle without vanes. The net thrust force was 8 deg from the vertical for four vanes and 10.5 deg for seven. Author (Herner)

A95-93692

LIGHTWEIGHT, OPTO-ELECTRONIC ENGINE CONTROL SYSTEM FOR AEROSPACE TURBINE ENGINES

BRADLEY J. MCROBERTS AlliedSignal Controls & Accessories, South Bend, IN, US and CHARLES T. WALEJEWSKI AlliedSignal Controls & Accessories, South Bend, IN, US (ISSN 0148-7191) 1993 14 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993
(SAE PAPER 931442; HTN-95-21261) Copyright

AlliedSignal Control and Accessories (ASCA) in cooperation with Pratt & Whitney Government Engine and Space Propulsion (PW GESP) have demonstrated a lightweight opto-electronic engine conntrol system that features a lightweight fuel throttling valve, lightweight inlet guide vane servoactuator, and a opto-electronic controller with lightweight enclosure. The engine control system was built and tested in support of the first phase of the government sponsord Integrated High Performance Turbine Engine technology (IHPTET) Initiative. Both the fuel throttling valve and inlet guide vane servoactuator utilize fiber-optic position feedback sensors, low power, high force lightweight piezoelectric actuated direct drive servovalves, and advanced lightweight materials such as AA-8090 aluminum-lithium, silicon nitride ceramic, carbon fiber comoposite, and AA-8009 high temperature aluminum. Using these advanced lightweight materials, and employing innovative control techniques and advanced electromechanical interface devices, an overall weight savings of 25% was achieved over baseline YF119 components. The engine control system has completed over 100 hours of testing on the United States Air Force (USAF) JTDE XTE 65-1B engine with additional testing scheduled for the latter part of 1993. In addition, the components have amassed a total of 50 hours of component acceptance and design verification testing in the laboratory. Author (Herner)

A95-94485

EFFICIENT MAPPING TOPOLOGY FOR TURBINE COMBUSTORS WITH INCLINED SLOTS/STAGGERED HOLES

S. L. YANG Michigan Technological Univ, Houghton, MI, United States and M. C. CLINE Journal of Propulsion and Power (ISSN 0748-4658) vol. 11, no. 3 May-June 1995 p. 572-574 refs
(BTN-95-EIX0616952745805) Copyright

An efficient mapping topology for generating grid systems for gas-turbine combustors with inclined slots or staggered holes is presented. This topology can be easily extended to gas-turbine combustors with a multiple-row, staggered hole geometry. Finally, a gas-turbine combustor with inclined slots is used as an example. EI

A95-94495

EVALUATION OF THE TRANSIENT OPERATION OF ADVANCED GAS TURBINE COMBUSTORS

THOMAS J. ROSFJORD United Technologies Research Cent, East Hartford, CT, United States and JEFFREY M. COHEN Journal of Propulsion and Power (ISSN 0748-4658) vol. 11, no. 3 May-June 1995 p. 497-504 refs
(BTN-95-EIX0616952745793) Copyright

A unique test capability has been defined and used to evaluate the transient response of advanced gas turbine combustors. This facility offers the opportunity to achieve predefined time variations of the air and fuel flow rates and air temperature delivered to a combustor model. This capability can be used for model scales ranging from multinozzle combustor sectors to smaller setups focusing on one component or process. A dedicated control computer aids in establishing time profiles for the input parameters and automatically executing the transient test. Among its applications, the facility has been used to study the occurrence of in-nozzle fuel vaporization during Bodie cycles and to assess the tolerance of a fuel-staged combustor to rapid fuel redistribution. Author (EI)

A95-94503

VORTEX GENERATION AND MIXING IN THREE-DIMENSIONAL SUPERSONIC COMBUSTORS

D. W. RIGGINS Univ of Missouri-Rolla, Rolla, MO, United States and P. H. VITT Journal of Propulsion and Power (ISSN 0748-4658) vol. 11, no. 3 May-June 1995 p. 419-426 refs
(BTN-95-EIX0616952745783) Copyright

The generation and evolution of the flow vorticity established by instream injector ramps in a high Mach number/high enthalpy scramjet combustor flowfield are described in detail for a number of computational cases. Classical fluid dynamic circulation is presented for these cases in order to clarify the spatial distribution and convection of the vorticity. The ability of the simulations to accurately represent Stokes law of circulation is discussed and shown. In addition, the conservation of swirl is presented for these flows. The impact of both turbulent diffusion and the vortex/ramp nonuniformity on the downstream mixing rate is clearly illustrated. A correlation over the length of the combustor between fuel-air mixing and a parameter called the vortex stirring length is demonstrated. Finally, computational results for a representative ramp injector are compared with experimental data. Author (EI)

A95-94504

INVESTIGATION OF SCRAMJET INJECTION STRATEGIES FOR HIGH MACH NUMBER FLOWS

D. W. RIGGINS Univ of Missouri-Rolla, Rolla, MO, United States, C. R. MCCLINTON, R. C. ROGERS, and R. D. BITTNER Journal of Propulsion and Power (ISSN 0748-4658) vol. 11, no. 3 May-June 1995 p. 409-418 refs
(BTN-95-EIX0616952745782) Copyright

A method for estimating the axial distribution of thrust performance potential in a supersonic combustor is described. A complementary technique for illustrating the spatial evolution and distribution of thrust potential and loss mechanisms in reacting flows is developed. A wall jet case and swept ramp injector case for Mach 17 and Mach 13.5 flight enthalpy inflow conditions, respectively, are numerically modeled and analyzed using these techniques. Author (EI)

A95-94505

PERFORMANCE VARIATION OF SCRAMJET NOZZLE AT VARIOUS NOZZLE PRESSURE RATIOS

TETSUO HIRAIWA Kakuda Research Cent, Miyagi, Japan, SADATAKE TOMIOKA, SHUUICHI UEDA, TOHRU MITANI, MASAHIKO YAMAMOTO, and MASASHI MATSUMOTO Journal of Propulsion and Power (ISSN 0748-4658) vol. 11, no. 3 May-June 1995 p. 403-408 refs (BTN-95-EIX0616952745781) Copyright

An experimental study of scramjet nozzle was conducted to investigate how the nozzle flow is affected by ambient pressure. In order to elucidate the aerodynamic properties of nozzle flow, detailed measurements of thrust and wall pressure were carried out using cold nitrogen. Nozzle flow was also visualized using a shear sensitive liquid crystal. Wall pressure and shear stress distributions in an overexpanded nozzle showed that nozzle flow includes a crossing shock wave made at the side-fences. This flowfield can be approximated as a supersonic inlet flow compressed by sidewalls. The high-pressure region on the nozzle ramp generated by the shock waves results in a higher performance in scramjet nozzle than that estimated for a two-dimensional separation from the ramp. Author (EI)

N95-30517*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

WAVE ROTOR-ENHANCED GAS TURBINE ENGINES

GERARD E. WELCH (Army Research Lab., Cleveland, OH.), JONES M. SCOTT, and DANIEL E. PAXSON Jun. 1995 15 p Presented at the 31st Joint Propulsion Conference and Exhibit, San Diego, CA, 10-12 Jul 1995; sponsored by AIAA, ASME, SAE, and ASEE

Contract(s)/Grant(s): (RTOP 505-90-58)

(NASA-TM-106998; E-9777; NAS 1.15:106998; ARL-TR-806; AIAA PAPER 95-2799) Avail: CASI HC A03/MF A01

The benefits of wave rotor-topping in small (400 to 600 hp-class) and intermediate (3000 to 4000 hp-class) turboshaft engines, and large (80,000 to 100,000 lb(sub f)-class) high bypass ratio turbofan engines are evaluated. Wave rotor performance levels are calculated using a one-dimensional design/analysis code. Baseline and wave rotor-enhanced engine performance levels are obtained from a cycle deck in which the wave rotor is represented as a burner with pressure gain. Wave rotor-toppings is shown to significantly enhance the specific fuel consumption and specific power of small and intermediate size turboshaft engines. The specific fuel consumption of the wave rotor-enhanced large turbofan engine can be reduced while operating at significantly reduced turbine inlet temperature. The wave rotor-enhanced engine is shown to behave off-design like a conventional engine. Discussion concerning the impact of the wave rotor/gas turbine engine integration identifies tenable technical challenges. Author

N95-30589*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

EFFECTS OF INITIAL CONDITIONS ON A SINGLE JET IN CROSSFLOW

D. S. LISCINSKY (United Technologies Research Center, East Hartford, CT.), B. TRUE (United Technologies Research Center, East Hartford, CT.), and J. D. HOLDEMAN Jul. 1995 13 p Presented at the 31st Joint Propulsion Conference and Exhibit, San Diego, CA, 10-12 Jul 1995; sponsored by AIAA, ASME, SAE, and ASEE Original contains color illustrations

Contract(s)/Grant(s): (RTOP 537-02-21)

(NASA-TM-107002; E-9782; NAS 1.15:107002; AIAA PAPER 95-2998) Avail: CASI HC A03/MF A01; 4 functional color pages

An experimental investigation of the effects of jet inlet flow conditions has been conducted for the isothermal mixing of a single jet injected into a crossflow. Jet penetration and mixing was studied using planar Mie scattering to measure time-averaged jet mixture fraction distributions. The effects of 'passive' control methods such as jet 'tabs' and jet swirl are reported. Mixing effectiveness, determined using a spatial unmixedness parameter based on the variance of the mean jet concentration distributions, was compared to a baseline case of a round jet injected into a uniform crossflow. All results are compared at a jet-to-mainstream momentum-flux ratio of 8.5. In the near-field, the mixing rates are similar to, or less than, the baseline configuration using this measure of mixedness. None of the tested configurations appear to significantly augment mixing within a downstream distance of 3 diameters of an equivalent-area round orifice. Author

N95-30594*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

OBJECT-ORIENTED APPROACH FOR GAS TURBINE ENGINE SIMULATION

BRIAN P. CURLETT and JAMES L. FELDER Jul. 1995 34 p

Contract(s)/Grant(s): (RTOP 505-69-50)

(NASA-TM-106970; E-9731; NAS 1.15:106970) Avail: CASI HC A03/MF A01

An object-oriented gas turbine engine simulation program was developed. This program is a prototype for a more complete, commercial grade engine performance program now being proposed as part of the Numerical Propulsion System Simulator (NPSS). This report discusses architectural issues of this complex software system and the lessons learned from developing the prototype code. The prototype code is a fully functional, general purpose engine simulation program, however, only the component models necessary to model a transient compressor test rig have been written. The production system will be capable of steady state and transient modeling of almost any turbine engine configuration. Chief among the architectural considerations for this code was the framework in which the various software modules will interact. These modules include the equation solver, simulation code, data model, event handler, and user interface. Also documented in this report is the component based design of the simulation module and the inter-component communication paradigm. Object class hierarchies for some of the code modules are given. Author

N95-30617*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

A NUMERICAL MODEL FOR DYNAMIC WAVE ROTOR ANALYSIS

D. E. PAXSON Jul. 1995 13 p Presented at the 31st Joint Propulsion Conference and Exhibit, San Diego, CA, 10-12 Jul. 1995; sponsored by AIAA, ASME, SAE, and ASEE

Contract(s)/Grant(s): (RTOP 505-62-50)

(NASA-TM-106997; E-9776; NAS 1.15:106997; AIAA PAPER 95-2800) Avail: CASI HC A03/MF A01

A numerical model has been developed which can predict the dynamic (and steady state) performance of a wave rotor, given the geometry and time dependent boundary conditions. The one-dimensional, perfect gas, CFD based code tracks the gasdynamics in each of the wave rotor passages as they rotate past the various ducts. The model can operate both on and off-design, allowing dynamic behavior to be studied throughout the operating range of the wave rotor. The model accounts for several major loss mechanisms including finite passage opening time, fluid friction, heat transfer to and from the passage walls, and leakage to and from the passage ends. In addition, it can calculate the amount of work transferred to and from the fluid when the flow in the ducts is not aligned with the passages such as occurs in off-design operation. Since it is one-dimensional, the model runs reasonably fast on a typical workstation. This paper will describe the model and present the results of some transient calculations for a conceptual four port wave rotor designed as a topping cycle for a small gas turbine engine. Author

N95-30632*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

PRELIMINARY ASSESSMENT OF COMBUSTION MODES FOR INTERNAL COMBUSTION WAVE ROTORS

M. RAZI NALIM Jul. 1995 14 p Presented at the 31st Joint Propulsion Conference and Exhibit, San Diego, CA, 10-12 Jul. 1995; sponsored by AIAA, ASME, SAE, and ASEE

Contract(s)/Grant(s): (RTOP 505-90-58)

(NASA-TM-107000; E-9779; NAS 1.15:107000; AIAA PAPER 95-2801) Avail: CASI HC A03/MF A01

Combustion within the channels of a wave rotor is examined as a means of obtaining pressure gain during heat addition in a gas turbine engine. Several modes of combustion are considered and the factors that determine the applicability of three modes are evaluated in detail; premixed autoignition/detonation, premixed deflagration, and non-premixed compression ignition. The last two will require strong turbulence for completion of combustion in a reasonable time in the wave rotor. The compression/autoignition modes will require inlet temperatures in excess of 1500 R for reliable ignition with most hydrocarbon fuels; otherwise, a supplementary ignition method must be provided. Examples of combustion mode selection are presented for two core engine applications that had been previously designed with equivalent 4-port wave rotor topping cycles using external combustion. Author

N95-30698*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

JET MIXING AND EMISSION CHARACTERISTICS OF TRANSVERSE JETS IN ANNULAR AND CYLINDRICAL CONFINED CROSSFLOW

D. B. BAIN (CFD Research Corp., Huntsville, AL.), C. E. SMITH (CFD Research Corp., Huntsville, AL.), and J. D. HOLDEMAN Jul. 1995 32 p Presented at the 31st Joint Propulsion Conference and Exhibit, San Diego, CA, 10-12 Jul. 1995; sponsored by AIAA, ASME, SAE, and ASEE Original contains color illustrations

Contract(s)/Grant(s): (RTOP 537-02-21)

(NASA-TM-106976; E-9737; NAS 1.15:106976; AIAA PAPER 95-2995) Avail: CASI HC A03/MF A01; 11 functional color pages

Three dimensional turbulent reacting CFD analyses were performed on transverse jets injected into annular and cylindrical (can) confined crossflows. The goal was to identify and assess mixing differences between annular and can geometries. The approach taken was to optimize both annular and can configurations by systematically varying orifice spacing until lowest emissions were achieved, and then compare the results. Numerical test conditions consisted of a jet-to-mainstream massflow ratio of 3.2 and a jet-to-mainstream momentum-flux ratio (J) of 30. The computational results showed that the optimized geometries had similar emission levels at the exit of the mixing section although the annular configuration did mix-out faster. For lowest emissions, the density correlation parameter (C = (S/H) square root of J) was 2.35 for the annular geometry and 3.5 for the can geometry. For the annular geometry, the constant was about twice the value seen for jet mixing at low mass-flow ratios (i.e., MR less than 0.5). For the can geometry, the constant was about 1 1/2 times the value seen for low mass-flow ratios. Author

N95-30702*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

EFFECT OF VELOCITY AND TEMPERATURE DISTRIBUTION AT THE HOLE EXIT ON FILM COOLING OF TURBINE BLADES

VIJAY K. GARG (AYT Corp., Brook Park, OH.) and RAYMOND E. GAUGLER Jun. 1995 14 p Presented at the 40th Gas Turbine and Aeroengine Congress and Exposition, Houston, TX, 5-8 Jun. 1995; sponsored by ASME

Contract(s)/Grant(s): (RTOP 505-62-52)

(NASA-TM-106954; E-9704; NAS 1.15:106954) Avail: CASI HC A03/MF A01

An existing three-dimensional Navier-Stokes code, modified to include film cooling considerations, has been used to study the effect of coolant velocity and temperature distribution at the hole exit on the heat transfer coefficient on three-film-cooled turbine blades, namely, the C3X vane, the VKI rotor, and the ACE rotor. Results are also compared with the experimental data for all the blades. Moreover, Mayle's transition criterion, Forest's model for augmentation of leading edge heat transfer due to freestream turbulence, and Crawford's model for augmentation of eddy viscosity due to film cooling are used. Use of Mayle's and Forest's models is relevant only for the ACE rotor due to the absence of showerhead cooling on this rotor. It is found that, in some cases, the effect of distribution of coolant velocity and temperature at the hole exit can be as much as 60% on the heat transfer coefficient at the blade suction surface, and 50% at the pressure surface. Also, different effects are observed on the pressure and suction surface depending upon the blade as well as upon the hole shape, conical or cylindrical. Author

N95-30779*# United Technologies Corp., East Hartford, CT.

METHOD FOR EXTRACTING FORWARD ACOUSTIC WAVE COMPONENTS FROM ROTATING MICROPHONE MEASUREMENTS IN THE INLETS OF TURBOFAN ENGINES Final Contractor Report

D. E. CICON and T. G. SOFRIN (Sofrin, T. G., Newington, CT.) May 1995 55 p

Contract(s)/Grant(s): (NAS3-26618; RTOP 538-03-11)

(NASA-CR-195457; E-9577; NAS 1.26:195457) Avail: CASI HC A04/MF A01

This report describes a procedure for enhancing the use of the basic rotating microphone system so as to determine the forward propagating mode components of the acoustic field in the inlet duct at the microphone plane in order to predict more accurate far-field radiation patterns. In addition, a modification was developed to obtain, from the same microphone readings, the forward acoustic modes generated at the fan face, which is generally some distance downstream of the microphone plane. Both these procedures employ computer-simulated calibrations of sound propagation in the inlet duct, based upon the current radiation code. These enhancement procedures were applied to previously obtained rotating microphone data for the 17-inch ADP fan. The forward mode components at the microphone plane were obtained and were used to compute corresponding far-field directivities. The second main task of the program involved finding the forward wave modes generated at the fan face in terms of the same total radial mode structure measured at the microphone plane. To obtain satisfactory results with the ADP geometry it was necessary to limit consideration to the propagating modes. Sensitivity studies were also conducted to establish guidelines for use in other fan configurations. Author

N95-30853*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

JET MIXING IN A REACTING CYLINDRICAL CROSSFLOW

M. Y. LEONG (California Univ., Irvine, CA.), G. S. SAMUELSEN (California Univ., Irvine, CA.), and J. D. HOLDEMAN Jul. 1995 24 p Presented at the 31st Joint Propulsion Conference and Exhibit, San Diego, CA, 10-12 Jul. 1995 nsored by AIAA, ASME, SAE, and ASEE Original contains color illustrations

Contract(s)/Grant(s): (RTOP 537-02-20)

(NASA-TM-106975; E-9736; NAS 1.15:106975; AIAA PAPER 95-3109) Avail: CASI HC A03/MF A01; 10 functional color pages

This paper addresses the mixing of air jets into the hot, fuel-rich products of a gas turbine primary zone. The mixing, as a result, occurs in a reacting environment with chemical conversion and substantial heat release. The geometry is a crossflow confined in a cylindrical duct with side-wall injection of jets issuing from round orifices. A specially designed reactor, operating on propane, presents a uniform mixture without swirl to mixing modules consisting of 8, 9, 10, and 12 holes at a momentum-flux ratio of 57 and a jet-to-mainstream mass-flow ratio of 2.5. Concentrations of O_2, CO_2, CO, and HC are obtained upstream, downstream, and within the orifice plane. O_2 profiles indicate jet penetration while CO_2, CO, and

HC profiles depict the extent of reaction. Jet penetration is observed to be a function of the number of orifices and is found to affect the mixing in the reacting system. The results demonstrate that one module (the 12-hole) produces near-optimal penetration defined here as a jet penetration closest to the module half-radius, and hence the best uniform mixture at a plane one duct radius from the orifice leading edge. Author

N95-30861*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

PARAMETRICS ON 2D NAVIER-STOKES ANALYSIS OF A MACH 2.68 BIFURCATED RECTANGULAR MIXED-COMPRESSION INLET

M. MIZUKAMI and J. D. SAUNDERS Jul. 1995 16 p Presented at the 31st Joint Propulsion Conference and Exhibit, San Diego, CA, 10-12 Jul. 1995; Sponsored by AIAA, ASME, SAE and ASEE

Contract(s)/Grant(s): (RTOP 537-02-22)

(NASA-TM-107003; E-9784; NAS 1.15:107003) Avail: CASI HC A03/MF A01

The supersonic diffuser of a Mach 2.68 bifurcated, rectangular, mixed-compression inlet was analyzed using a two-dimensional (2D) Navier-Stokes flow solver. Parametric studies were performed on turbulence models, computational grids and bleed models. The computer flowfield was substantially different from the original inviscid design, due to interactions of shocks, boundary layers, and bleed. Good agreement with experimental data was obtained in many aspects. Many of the discrepancies were thought to originate primarily from 3D effects. Therefore, a balance should be struck between expending resources on a high fidelity 2D simulation, and the inherent limitations of 2D analysis. The solutions were fairly insensitive to turbulence models, grids and bleed models. Overall, the k-e turbulence model, and the bleed models based on unchoked bleed hole discharge coefficients or uniform velocity are recommended. The 2D Navier-Stokes methods appear to be a useful tool for the design and analysis of supersonic inlets, by providing a higher fidelity simulation of the inlet flowfield than inviscid methods, in a reasonable turnaround time. Author

N95-31191# BBN Systems and Technologies Corp., Cambridge, MA.

AN ACTIVE LINER SYSTEM FOR JET ENGINE EXHAUST SILENCERS, PHASE 1 Final Report, 1 Jul. 1993 - 30 Jun. 1994

ISTVAN L. VER and MICHAEL DIGNAN Jun. 1994 65 p

Contract(s)/Grant(s): (AF PROJ. 3037)

(AD-A293277; AL/OE-TR-1994-0130) Avail: CASI HC A04/MF A01

In the framework of the U.S. Air Force's Advanced Technology Active Noise Reduction Initiative - an experimental program was carried out to demonstrate the feasibility of a new concept of an Active Liner. Using a 1:4 scale model of a jet engine test cell augmenter 8 dB to 15 dB reduction of the low frequency (8 Hz to 80 Hz at full scale) was obtained by inserting one or two active liner segments into a typical lined augmenter. The topics covered in this report include: (1) problems caused by low frequency noise and their land use implications, (2) description of the active liner concept, (3) control strategies employed, (4) description of the model-scale augmenter including passive and active sections and the feedback control system, (5) experimental results, (6) full-scale ramifications and (7) risk assessment of full-scale implementation. DTIC

N95-31199 Naval Postgraduate School, Monterey, CA.

AN INVESTIGATION OF THE SIDE-DUMP DUAL IN-LINE RAMJET COMBUSTOR

M. W. DEPPE, R. F. SALYER, and D. W. NETZER *In* Johns Hopkins Univ., The 31st JANNAF Combustion Sub. Mtg., V. 1 p 59-74 Oct. 1994

Avail: CPIA, 10630 Little Patuxent Pkwy., Suite 202, Columbia, MD 21044-3200 HC

Three inlet-side-dump ramjet-combustor geometric configurations were investigated using non-intrusive water-tunnel flow visualization techniques to qualitatively determine optimum flame-stablization dome lengths and fuel-injection locations and to investigate whether new configurations may be more capable of providing high combustion efficiencies under wide operating limits. The optimum dome lengths which provided good fuel distribution and steady mixing all had lengths between 0.31 and 1.4 combustor diameters. Fuel injection in a narrow region on the upstream side of the dump inlet was the only location found capable of distributing fuel into the flame-holding region. Multiple injection locations in the inlet were required to distribute fuel uniformly into the main combustion region. Based upon the flow visualization results a dual, axially-inline, side-dump, liquid-fueled ramjet combustor was designed and tested. Particle size distributions from the fuel atomizers were measured both in ambient conditions and under hot-air, contra-flow engine conditions. Data obtained under ambient conditions were found to have little value for the engine flow environment. This geometry provided improved flammability limits and combustion efficiency at lean fuel-air ratios. Direct fuel injection into the recirculation was required for sustained combustion at lean equivalence ratios for the single side-dump configuration, but not for the dual in-line configuration. The fuel distribution in the inlet duct that is required for good flammability limits and combustion efficiency was opposite to that required to prevent pressure oscillations. A dump angle of 45 deg resulted in lower than desired combustion efficiencies, apparently due to poor mixing from the aft inlet. Author

N95-31201 Naval Air Warfare Center, China Lake, CA.

A PULSED LIQUID FUEL RAMJET

K. J. WILSON, E. J. GUTMARK, R. A. SMITH, and K. C. SCHADOW *In* Johns Hopkins Univ., The 31st JANNAF Combustion Sub. Mtg., Vol. 1 p 85-99 Oct. 1994

Avail: CPIA, 10630 Little Patuxent Pkwy., Suite 202, Columbia, MD 21044-3200 HC

A new design concept for a liquid-fueled-ramjet with increased efficiency is presented. The concept utilizes vortex combustion, a method which is based on the idea that by confining the combustion process to occur within vortices it is possible to use several advantageous features of vortical flow: combined bulk mixing of the reactants with intense fine-scale mixing leading to enhanced molecular mixing, long residence time to achieve complete combustion, localized high temperature regions, and an easily controllable environment. The concept was initially tested in laboratory scale ethylene diffusion flames. Air vortices were stabilized by acoustically forcing a turbulent air jet at its most unstable mode. Fuel was injected into the air vortices synchronously with the vortex formation sequence. The proper timing of the process was determined to be critical; when the vortex formation, the ambient air entrainment induced by the vortices and fuel injection occurred in a certain sequence the fuel burning was more complete and the energy release increased significantly. The pulsed ramjet design is based on these basic principles. The liquid fueled ramjet is a coaxial dump combustor with an axial air inlet. A pulser located in the air inlet conduit produces pressure pulses in the inlet flow using spark ignition of premixed fuel/air which generates a train of flame kernels. These growing kernels interact with the jet flow to stabilize air vortices within the combustor. Liquid fuel injectors at the dump plane inject fuel into the vortices at a controlled frequency and timing. The pulser also supplies a periodic ignition source which stabilizes the flame and extends the lean flammability limit. This design ensures that the energy release occurs close to the dump plane and that the fuel is consumed in the region of highest local temperature to obtain maximum heat release within minimal combustion chamber length. Author

N95-31425*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.

FLIGHT ASSESSMENT OF THE ONBOARD PROPULSION SYSTEM MODEL FOR THE PERFORMANCE SEEKING CONTROL ALGORITHM ON AN F-15 AIRCRAFT

JOHN S. ORME and GERARD S. SCHKOLNIK Washington Jul. 1995 20 p Presented at 31st AIAA/ASME/SAE/ASEE Joint Propulsion Conference, San Diego, CA, 10-12 Jul. 1995

Contract(s)/Grant(s): (RTOP 533-02-03)

(NASA-TM-4705; H-2060; NAS 1.15:4705; AIAA PAPER 95-2361) Avail:

CASI HC A03/MF A01

Performance Seeking Control (PSC), an onboard, adaptive, real-time optimization algorithm, relies upon an onboard propulsion system model. Flight results illustrated propulsion system performance improvements as calculated by the model. These improvements were subject to uncertainty arising from modeling error. Thus to quantify uncertainty in the PSC performance improvements, modeling accuracy must be assessed. A flight test approach to verify PSC-predicted increases in thrust (FNP) and absolute levels of fan stall margin is developed and applied to flight test data. Application of the excess thrust technique shows that increases of FNP agree to within 3 percent of full-scale measurements for most conditions. Accuracy to these levels is significant because uncertainty bands may now be applied to the performance improvements provided by PSC. Assessment of PSC fan stall margin modeling accuracy was completed with analysis of in-flight stall tests. Results indicate that the model overestimates the stall margin by between 5 to 10 percent. Because PSC achieves performance gains by using available stall margin, this overestimation may represent performance improvements to be recovered with increased modeling accuracy. Assessment of thrust and stall margin modeling accuracy provides a critical piece for a comprehensive understanding of PSC's capabilities and limitations. Author

N95-31985*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

LASER ANEMOMETER MEASUREMENTS OF THE THREE-DIMENSIONAL ROTOR FLOW FIELD IN THE NASA LOW-SPEED CENTRIFUGAL COMPRESSOR

MICHAEL D. HATHAWAY (Army Research Lab., Cleveland, OH.), RANDALL M. CHRISS, ANTHONY J. STRAZISAR, and JERRY R. WOOD Jun. 1995 297 p

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(NASA-TP-3527; E-9390; NAS 1.60:3527; ARL-TR-333) Avail: CASI HC A13/MF A03

A laser anemometer system was used to provide detailed surveys of the three-dimensional velocity field within the NASA low-speed centrifugal impeller operating with a vaneless diffuser. Both laser anemometer and aerodynamic performance data were acquired at the design flow rate and at a lower flow rate. Floor path coordinates, detailed blade geometry, and pneumatic probe survey results are presented in tabular form. The laser anemometer data are presented in the form of pitchwise distributions of axial, radial, and relative tangential velocity on blade-to-blade stream surfaces at 5-percent-of-span increments, starting at 95-percent-of-span from the hub. The laser anemometer data are also presented as contour and wire-frame plots of throughflow velocity and vector plots of secondary velocities at all measurement stations through the impeller. Author

08
AIRCRAFT STABILITY AND CONTROL

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

A95-93655

AN ADVANCED VEHICLE MANAGEMENT SYSTEM

CARLOS A. BEDOYA and JOHN L. MOHR (ISSN 0148-7191) 1993 11 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993

(SAE PAPER 931376; HTN-95-21224) Copyright

The Advanced Vehicle Management System (AVMS) Architecture Studies program defined the candidate vehicle management system (VMS) architectural concepts for advanced air vehicles and defined an integrated tool environment to support development of an advanced VMS. The AVMS program comprised four tasks. Task A determined the functional requirements of the next generation VMS. Task B defined and evaluated a baseline and six candidate architectural concepts. Task C defined a VMS development process based upon DOD Systems Engineering principles. Task D quantified benefits architectures, development processes, and tools,identified shortfalls, and recommened actions to reduce shortfalls. Author (Herner)

A95-93659

SOME ADDITIONAL STABILITY AND PERFORMANCE CHARACTERISTICS OF THE SCISSOR/PIVOT WING CONFIGURATIONS

BRUCE P. SELBERG University of Missouri-Rola, MO, US and PAUL VITT University of Missouri-Rola, MO, US (ISSN 0148-7191) 1993 9 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993

(SAE PAPER 931383; HTN-95-21228) Copyright

The scissor wing configuration is analyzed for unequal forward/rearward wing area ratios and for different wing sweep schedules of the forward and rearward wings. Moment-curve slope (C(sub l)(sub alpha)), lift-curve slope (C(sub M)(sub alpha)), static margin, and sweep schedule results are presented as a function of flight Mach number for various sweep shedules and two wing area ratios. Complete aircraft, lift to drag ratio, and power required results are presented for the configuration that was able to maintain static margin over the largest range of Mach numbers. The potential benefits of the scissor wing configuration are presented and discussed in terms of potential increased performance potential or smaller engine. Author (Herner)

A95-94045

DESIGN OF A MODERN PITCH POINTING CONTROL SYSTEM

GEORGE M. SIOURIS Air Force Inst of Technology, Wright-Patterson Air Force Base, OH, United States, JANG GYU LEE, and JAE WEON CHOI IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251) vol. 31, no. 2 April 1995 p. 730-738 refs

(BTN-95-EIX95302731226) Copyright

The development of a pitch pointing control system for an advanced high performance fighter aircraft using eigenstructure assignment and command generator tracking schemes is presented. A desired eigenstructure is first chosen to achieve a desired decoupling (i.e., pitch attitude and flight path angle), and to obtain a desired damping and rise time. The command generator tracker is next used to ensure zero steady-state error-to-step commands. The stability robustness to the parameter variations of the closed-loop system is evaluated in the sense of the conditioning of the achieved eigenstructure by using singular value analysis technique. The analysis and synthesis techniques for the pitch pointing control system are illustrated by applying the techniques to F-15 aircraft as a part of the NASA/USAF program named ACTIVE (Advanced ControLs for Integrated Vehicles). Author (EI)

A95-94208

PANEL FLUTTER LIMIT-CYCLE SUPPRESSION WITH PIEZOELECTRIC ACTUATION

ZHIHONG LAI Old Dominion Univ, Norfolk, VA, United States, DAVID Y. XUE, JEN-KUANG HUANG, and CHUH MEI Journal of Intelligent Material Systems and Structures (ISSN 1045-389X) vol. 6, no. 2 March 1995 p. 274-282 refs

(BTN-95-EIX95302731089) Copyright

An optimal control design is presented to suppress panel flutter limit-cycle motions using piezoelectric actuators. First, the nonlinear dynamic equations of motion based on the classical continuum method are derived for a simply supported isotropic panel with a pair of patched piezoelectric layers. After linearizing the dynamic modal equations, an optimal controller is developed to provide an optimal combination of inplane force and bending moments through piezoelectric actuators for flutter suppression. For the panel configuration studied, numerical simulations based on the nonlinear model show that the maximum suppressible dynamic pressure lambda(sub max) can be increased about three times of the critical dynamic pressure lambda(sub cr) by the piezoelectric actuation, and the bending moment is much more effective in flutter suppression than the inplane force. Within the maximum suppressible dynamic pressure, limit-cycle motions can be completely suppressed. For the actuator design, the two-set actuators perform better than the one-patched actuator, and the one-patched actuator may have better performance than the completely covered actuator. The results demonstrate that piezoelectric materials are effective in panel flutter suppression. Author (EI)

A95-94457

JET TRANSPORT RESPONSE TO A HORIZONTAL WIND VORTEX

DARIN R. SPILMAN Princeton Univ, Princeton, NJ, United States and ROBERT F. STENGEL Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 480-485 refs

(BTN-95-EIX0619952748163) Copyright

The dynamic response of a twin-jet transport aircraft encountering a horizontal wind vortex (or rotor) on final approach to landing is investigated. Computer simulations determine the effects of vortex strength, vortex length, lateral entry position, vertical entry position, and encounter incidence angle on the aircraft's roll response. Maximum roll rate and roll angle increase proportionally with vortex strength and length until a saturation length is reached. Roll response is highly dependent on entry location: changes in lateral entry position largely affect maximum roll angle while changes in vertical entry position affect maximum roll rate. Peak roll rate and roll angle obtain their largest values at near-zero incidence angles. The response is highly dependent on the precise initial conditions of the encounter - even small variations in initial condition cause significant changes in aircraft roll response. Author (EI)

A95-94467* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ACTUATED FOREBODY STRAKE CONTROLS FOR THE F-18 HIGH-ALPHA RESEARCH VEHICLE

DANIEL G. MURRI National Aeronautics and Space Administration Langley Research Cent, Hampton, VA, United States, GAUTAM H. SHAH, DANIEL J. DICARLO, and TODD W. TRILLING Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 555-562 refs

(BTN-95-EIX0619952748173) Copyright

A series of ground-based studies have been conducted to develop actuated forebody strake controls for flight-test evaluations using the NASA F-18 High-Alpha Research Vehicle (HARV). The actuated forebody strakes were designed to provide increased levels of yaw control at high angles of attack where conventional rudders become ineffective. Results are presented from tests conducted with the flight-test strake design, including static and dynamic wind-tunnel tests, transonic wind-tunnel tests, full-scale wind-tunnel tests, pressure surveys, and flow visualization tests. Results from these studies show that a pair of conformal actuated forebody strakes applied to the F-18 HARV can provide a powerful and precise yaw control device at high angles of attack. The preparations for flight testing are described, including the fabrication of flight hardware and the development of aircraft flight control laws. The primary objectives of the flight tests are to provide flight validation of the ground-based studies and to evaluate the use of this type of control to enhance fighter aircraft maneuverability. Author (EI)

A95-94472

DIRECTIONAL CONTROL AT HIGH ANGLES OF ATTACK USING BLOWING THROUGH A CHINED FOREBODY

A. S. ARENA, JR. Oklahoma State Univ, Stillwater, OK, United States, R. C. NELSON, and L. B. SCHIFF Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 596-602 refs

(BTN-95-EIX0619952748179) Copyright

Directional control through the use of pneumatic blowing was investigated on a generic subscale model with a chined forebody. Pneumatic control was accomplished by blowing through a chine slot in a direction normal to the forebody surface. Comparisons are made with a vertical tail on and off, and with control through conventional rudder deflection. Force and moment data were obtained for various blowing coefficients over an angle-of-attack range from 0 to 75 deg to document the techniques effectiveness. Flow visualization was also conducted in order to obtain qualitative information about the effect on the flowfield. Results indicate that pneumatic blowing through a chined forebody can be an effective technique for generating yaw moments at large angles of attack where conventional control surfaces lose their effectiveness. Yaw moments generated are typically much larger than that obtained by just the jet thrust effect alone since the forebody flowfield is significantly modified from the interaction of the jet with the chine vortices. Directional control capability was found to increase with angle of attack for a given blowing coefficient until a maximum was reached. Further increases in angle of attack result in a rather rapid loss of effectiveness. In addition, the effectiveness of the pneumatic concept was found to be dependent on tail configuration. Author (EI)

N95-30937# Carnegie-Mellon Univ., Pittsburgh, PA.

NEW ADAPTIVE METHODS FOR RECONFIGURABLE FLIGHT CONTROL SYSTEMS, APPENDIX 1 Final Report, 1 Jul. 1992 - 31 Dec. 1994

MARC BODSON 15 Feb. 1995 116 p

Contract(s)/Grant(s): (F49620-92-J-0386)

(AD-A292711; AFOSR-95-0174TR) Avail: CASI HC A06/MF A02

The report discusses methods for the design of reconfigurable flight control systems. Model reference adaptive control algorithms were developed which allow for the rapid identification of aircraft parameters after failures or damages and for automatic control redesign. These algorithms are simple enough that they can be implemented in real-time with existing computers. Simulation results were obtained using a detailed nonlinear model of a fighter aircraft. The results demonstrate the ability of the adaptive algorithms to automatically readjust trim values after failures, to restore tracking of the pilot commands despite the loss of actuator effectiveness, and to coordinate the use of the remaining surfaces in order to maintain the decoupling between the rotational axes. The report also discusses analytical results that were obtained during the course of the research regarding the stability and convergence properties of multivariable adaptive control algorithms, the use of averaging methods for the analysis of transient response and robustness, and the estimation of uncertainty in dynamic models. A modified recursive least-squares algorithm with forgetting factor is also described which gives fast adaptation under normal conditions while keeping the sensitivity to noise limited when signal to noise ratios are poor. DTIC

N95-31071# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. fuer Flugmechanik.

HANDLING QUALITIES ANALYSIS ON RATE LIMITING ELEMENTS IN FLIGHT CONTROL SYSTEMS

DIETRICH HANKE *In* Advisory Group for Aerospace Research and Development, Flight Vehicle Integration Panel Workshop on Pilot Induced Oscillations 18 p Feb. 1995

Copyright Avail: CASI HC A03/MF A02

Rate saturation conditions caused by rate limiting elements (RLE's) in flight control systems can contribute to severe pilot induced oscillation. In order to gain more theoretical insight in this problem the paper deals with the development of rate limiter describing functions in order to establish a theoretical basis for open and closed loop handling qualities analysis in the frequency domain. Although rate limitation produces nonlinear system behaviour it could be shown that rate limiter describing functions could be applied to existing methods used in handling qualities analysis of pilot/aircraft systems. A new handling quality parameter, the rate limiter onset frequency, is defined as a measure of input amplitude and frequency. Here the onset frequency in reference to the system bandwidth could be a suitable parameter in defining handling qualities boundaries for flight control systems with RLE's. The response in amplitude and phase is presented for different types of input signals such as triangle and sinusoidal oscillations. Rate limiter cascading is considered, too. Further, the suit-ability of various existing handling quality criteria are compared with the RLE results especially with respect to PIO. Finally, the improvements in system behavior by applying an alternate control scheme (ACS), as proposed by A'Harrah, will be discussed. Derived from text

N95-31400 Nielsen Engineering and Research, Inc., Mountain View, CA.
VORTICITY DYNAMICS AND CONTROL OF DYNAMIC STALL Final Report, 15 Apr. 1992 - 14 Jun. 1994
PATRICK H. REISENTHEL 18 Aug. 1994 129 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
Contract(s)/Grant(s): (DAAL03-92-C-0013)
(AD-A288658; NEAR-TR-482; ARO-29049.4-EG-S) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

The goal of the research was to understand key issues of vorticity dynamics prior to, during, and after the initiation of dynamic stall. The first portion of this work examined the indicial theory to the prediction of dynamic applicability stall. The research focused on extending the semi-analytical formalism of indicial theory to predict the vorticity fluxes and the vorticity accumulation at the leading edge during unsteady maneuver. In the second portion of this work, highly accurate two-dimensional solutions of the Navier-Stokes equation were used on a model problem to investigate the Reynolds number scaling of incipient flow separation between Re = 50,000 and Re = 800,000. This portion of the work was motivated by the suggestion that the appearance of eruptive plumes of vorticity at high Reynolds number might be critical to the formation of the dynamic stall vortex. The results of the research appear to contradict the hypothesis that a form of Reynolds number bifurcation must take place at some intermediate laminar Reynolds number. Instead, self-similar behavior was observed, at least up to the time of formation of the primary stall vortex. Author

N95-31846*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.
FLIGHT TEST VALIDATION OF A FREQUENCY-BASED SYSTEM IDENTIFICATION METHOD ON AN F-15 AIRCRAFT
GERARD S. SCHKOLNIK, JOHN S. ORME, and MARK A. HREHA (McDonnell-Douglas Aerospace, Saint Louis, MO.) Washington Jul. 1995 18 p Presented at the 31st AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, San Diego, CA, 10-12 Jul. 1995
Contract(s)/Grant(s): (RTOP 505-68-00)
(NASA-TM-4704; H-2059; NAS 1.15:4704; AIAA PAPER 95-2362) Avail: CASI HC A03/MF A01

A frequency-based performance identification approach was evaluated using flight data from the NASA F-15 Highly Integrated Digital Electronic Control aircraft. The approach used frequency separation to identify the effectiveness of multiple controls simultaneously as an alternative to independent control identification methods. Fourier transformations converted measured control and response data into frequency domain representations. Performance gradients were formed using multiterm frequency matching of control and response frequency domain models. An objective function was generated using these performance gradients. This function was formally optimized to produce a coordinated control trim set. This algorithm was applied to longitudinal acceleration and evaluated using two control effectors: nozzle throat area and inlet first ramp. Three criteria were investigated to validate the approach: simultaneous gradient identification, gradient frequency dependency, and repeatability. This report describes the flight test results. These data demonstrate that the approach can accurately identify performance gradients during simultaneous control excitation independent of excitation frequency. Author

N95-31989# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.
ACTIVE CONTROL TECHNOLOGY: APPLICATIONS AND LESSONS LEARNED [LES TECHNOLOGIES DU SYSTEME DE CONTROLE ACTIF: APPLICATIONS ET ENSEIGNEMENTS]
Jan. 1995 400 p In ENGLISH and FRENCH Presented at the Flight Mechanics Panel Symposium, Turin, France, 9-13 May 1994
(AGARD-CP-560; ISBN-92-836-0007-X) Copyright Avail: CASI HC A17/MF A04

In the last decade, Active Control Technology (ACT) has emerged from the realm of theory and modest experimental applications to full-scale use on production aircraft, while more elaborate forms of ACT are under test for the future production of aircraft. New technologies have been applied in military fighters to maximize maneuverability and agility, and in civil transports to reduce trim drag, lower pilot workload and improve riding qualities. During this symposium the status of Active Control Technology was assessed in light of the experience gained over the last decade. The symposium was organized around four sessions comprising 28 technical papers in all. These sessions focused on: Specifications for flight control design, Design and analysis methods, System integration and Implementation of experience. For individual titles, see N95-31990 through N95-32017.

N95-31990# Hoh Aeronautics, Inc., Lomita, CA.
THE ROLE OF HANDLING QUALITIES SPECIFICATIONS IN FLIGHT CONTROL SYSTEM DESIGN
ROGER H. HOH and DAVID G. MITCHELL *In* AGARD, Active Control Technology: Applications and Lessons Learned 12 p Jan. 1995
Copyright Avail: CASI HC A03/MF A04

The handling qualities specification should be an essential element of the flight control system design and testing for an active control technology (ACT) aircraft. This is a significant departure from previous conventional aircraft where handling qualities depended more on the configuration (tail size, control surface sizing, etc.). The necessity for incorporating the handling qualities specification into the flight control system design process has not been recognized by the industry, as evidenced by the fact that most of the ACT aircraft do not meet the requirements of the current handling qualities specification. This has resulted in excessive phase lag in the flight controls, and numerous cases of pilot induced oscillation. This paper reviews key handling qualities criteria for ACT aircraft as well as lessons that should be incorporated into specification upgrades and flight control design efforts. Author

N95-31991# Gibson (J. C.), Saint Annes (England).
THE PREVENTION OF PIO BY DESIGN
J. C. GIBSON *In* AGARD, Active Control Technology: Applications and Lessons Learned 12 p Jan. 1995
Copyright Avail: CASI HC A03/MF A04

Control problems caused by poor pilot-aircraft closed loop characteristics have existed for as long as aircraft have been flown. The majority of them have been the result of excessive response amplitudes and phase lags conflicting with simple stability margin requirements. Their solutions have been rather straightforward and often amount to the provision of K/S-like responses, or sufficiently similar, within the bandwidths of interest. Most high order Pilot Induced Oscillation (PIO) problems have been introduced, not by more complex fly by wire control laws, but by unnecessary lags or sometimes by excessive gain placed between the pilot and the response. The pilot is forced to operate in a region of excessive phase lag and response gain, typically with the impression that the aircraft is not actually responding to the commands. The solutions address the provision of adequate stability margins in much the same way as in earlier problems. The high order PIO problem is identified in the open loop attitude behavior in the uniquely defined PIO frequency region, in which the response lags the stick by 180 degrees or more. It is not necessary to model the pilot, who is found to operate in a synchronous manner with the attitude oscillation. The dominant feature in this is the rate zero crossing which acts to trigger the reversals of the control input. The input itself may take the form of a sinusoid, a relay switching action, or a mixture of the two. A number of simple criteria can be applied to control law design which have been found to ensure the prevention of high order PIO. The existence of a PIO problem can be identified with great certainty before flight by specific test methods, which should be applied with rigor no matter how much confidence exists in the design methods. Finally, it is crucial for all concerned to understand that if the underlying problem is there, no matter how extreme the pilot inputs may have to be to excite it, then it can be expected to happen in flight. It will be impossible to prevent it by pilot briefings. Derived from text

N95-31992# McDonnell-Douglas Aerospace, Long Beach, CA.
THE IMPORTANCE OF FLYING QUALITIES DESIGN SPECIFICATIONS FOR ACTIVE CONTROL SYSTEMS
J. HODGKINSON and K. F. ROSSITTO *In* AGARD, Active Control Technology: Applications and Lessons Learned 15 p Jan. 1995
Copyright Avail: CASI HC A03/MF A04

The first part of this paper consists of recollections of how some of the flying qualities specifications for active control fighters emerged. These recollections include some lessons learned. The second part, with these recollections and lessons as motivation, introduces new data on the much more recent developments in active control transports. Author

N95-31993# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. fuer Flugmechanik.
EXPERIENCES WITH ADS-33 HELICOPTER SPECIFICATION TESTING AND CONTRIBUTIONS TO REFINEMENT RESEARCH
C. J. OCKIER and H.-J. PAUSDER *In* AGARD, Active Control Technology: Applications and Lessons Learned 20 p Jan. 1995
Copyright Avail: CASI HC A03/MF A04

The introduction of Active Control Technology in rotorcraft created the need for new handling qualities requirements. In response to this, a new helicopter handling qualities specification was developed under the leadership of the U.S. Army and published as Aeronautical Design Standard 33 (ADS-33). Since its introduction, research has been conducted to expand the handling qualities database on which ADS-33 is based. This paper presents DLR contributions to this research. A standard BO 105 was used to evaluate the applicability and repeatability of the current ADS-33C criteria in forward flight. As a result of this study, some data gaps were recognized and the criteria that need further verification were identified. The in-flight simulator ATTHeS was used for an investigation of the effects of bandwidth and phase delay and pitch-roll coupling on helicopter handling qualities in a high gain slalom tracking task. Results are shown that indicate a need to more tightly constrain the phase delay for the roll axis than in the current ADS-33 requirements. For the pitch-roll coupling criterion it is shown that although the format of the current ADS-33 requirements is valid for control and rate coupling, it cannot be used for coupling types typical of actively controlled helicopters. A frequency domain criterion that offers more comprehensive coverage of all types of pitch-roll coupling is proposed. Author

N95-31994# Israel Aircraft Industries Ltd., Ben-Gurion Airport (Israel). Flight Operations.
LAVI FLIGHT CONTROL SYSTEM: DESIGN REQUIREMENTS, DEVELOPMENT AND FLIGHT TEST RESULTS
MENAHEM SHMUL, ELI ERENTHAL, and MOSHE ATTAR *In* AGARD, Active Control Technology: Applications and Lessons Learned 13 p Jan. 1995
Copyright Avail: CASI HC A03/MF A04

The flight control system of the Lavi Multimission fighter is described. The control laws design philosophy is given along with the control laws development, the flying qualities requirements and the final structure of the pitch axis (DFCS). The simulation phase is covered along with special control laws features. The question 'how does the Lavi fly?' is addressed. Problems uncovered during flights, and solutions found, are detailed and the flying qualities data are given. Finally, the program status is explained. Author

N95-31995# Technische Univ., Delft (Netherlands). Dept. of Aerospace Engineering.
ROBUST CONTROL: A STRUCTURED APPROACH TO SOLVE AIRCRAFT FLIGHT CONTROL PROBLEMS
S. BENNANI, J. A. MULDER, and O. H. BOSGRA *In* AGARD, Active Control Technology: Applications and Lessons Learned 24 p Jan. 1995
Sponsored by NAL
Copyright Avail: CASI HC A03/MF A04

This paper discusses an application of several robust control methodologies such as H(sub infinity) optimal control, micro-synthesis and gain scheduling via linear fractional transformations applied to a flight control system. To illustrate the approach, a design model for the short period approximation of the Cessna Citation 500 has been chosen, for which certain handling quality requirements have to be met over a large set of operating conditions. For all these methods, the design framework remains the same, only the system 'norm' changes to the object to be minimized. The paper shows how these methods work and illustrates the features of the new approach. Author

N95-31996# Honeywell, Inc., Minneapolis, MN.
DYNAMIC INVERSION: AN EVOLVING METHODOLOGY FOR FLIGHT CONTROL DESIGN
DALE ENNS, DAN BUGAJSKI, RUSS HENDRICK, and GUNTER STEIN *In* AGARD, Active Control Technology: Applications and Lessons Learned 12 p Jan. 1995
Copyright Avail: CASI HC A03/MF A04

This paper describes nonlinear dynamic inversion as an alternative design method for flight controls. The method is illustrated with super-maneuvering control laws for the F-18 High Angle-of-Attack Research Vehicle (HARV). Author

N95-31997# Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France). Dept. d'Etudes et de Recherches en automatique.
EVALUATION OF THE TECHNIQUES OF FUZZY CONTROL FOR THE PILOTING AN AIRCRAFT [EVALUATION DES TECHNIQUES DE CONTROLE FLOU POUR LE PILOTAGE D'AVION]
N. IMBERT and A. PIQUERAU *In* AGARD, Active Control Technology: Applications and Lessons Learned 10 p Jan. 1995 In FRENCH
Copyright Avail: CASI HC A02/MF A04

The characteristic of a fuzzy controller is to use a knowledge expressed in natural language in the forms of expert rules to calculate the value of the control starting from the numerical information from the sensors. The implementation of such a pilot requires the interpretation of the numerical field symbolically and reciprocally. This is carried out by the use of fuzzy assemblies. The associated theory allows starting from consideration of precise measurement, the whole of the stated expert rules, and choice of suitable operators to deduce a value from control. It results in a particular structure of the fuzzy controllers, whose main characteristics are the subject of the first part of the presentation. The implementation on the example of the longitudinal pilot control of an aircraft is then presented. Two approaches were adopted: the first uses the rules of manual piloting formulated in natural language by the 'experts' who are the pilots. The second uses the laws resulting from a conventional autopilot to build rules of piloting. The results are presented in the perspective from a comparison between the two types of controllers, conventional or fuzzy. Transl. by CASI

N95-31998# Wright Lab., Wright-Patterson AFB, OH.
THE CONTROL SYSTEM DESIGN METHODOLOGY OF THE STOL AND MANEUVER TECHNOLOGY DEMONSTRATOR
DAVID J. MOORHOUSE and KEVIN D. CITURS (McDonnell-Douglas Aerospace, Saint Louis, MO.) *In* AGARD, Active Control Technology: Applications and Lessons Learned 11 p Jan. 1995
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This paper documents the development of a full-envelope Integrated Flight/Propulsion Control system. A combination of classical and multivariable design methodologies was used, including a unique inverse procedure to produce second-order equivalent systems meeting specified flying qualities requirements. The implementation was based on a rational choice between the two methodologies. It is suggested that a parallel design approach in the beginning will produce efficient convergence on a practical optimum design. Finally, all control law revisions should be done analytically and only evaluated by simulation. Regardless of the design technique used, the process begins by specifying detailed design guidelines selected to meet the intent of MIL-F-8785C. Once the designs were complete and analyzed based on the design guidelines, manned flight simulation was used only to validate and demonstrate the flying qualities achieved prior to flight test. Problems encountered during simulation or flight testing were addressed first by reviewing the original design guidelines and evaluating the success achieved in implementing them.

Derived from text

N95-31999# Aeronautica Macchi S.p.A., Varese (Italy).

CONTROL LAW DESIGN USING H-INFINITY AND MU-SYNTHESIS SHORT-PERIOD CONTROLLER FOR A TAIL-AIRPLANE

L. MANGIACASALE *In* AGARD, Active Control Technology: Applications and Lessons Learned 11 p Jan. 1995

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The recently developed methods H-infinity and mu-Synthesis are used in the design of a control law for a tail controlled unstable airplane. The design procedure has been applied with success and seems to be very promising in order to solve control design problems in real applications. The (H-infinity) + mu controller, characterized by a very large order (namely 34th), has been successfully reduced to one having order 5th with a very low decay in the overall performance. The reduced-order controller meets all the servo technical specifications demanded to the full-order one. At present it is under test as part of a 6-DoF simulation program to verify its real robustness in face of structured and unstructured perturbations.

Author

N95-32000# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. fuer Flugmechanik.

MODEL FOLLOWING CONTROL FOR TAILORING HANDLING QUALITIES: ACT EXPERIENCE WITH ATTHES

GERD BOUWER, WOLFGANG VONGRUENHAGEN, and HEINZ-JUERGEN PAUSDER *In* AGARD, Active Control Technology: Applications and Lessons Learned 15 p Jan. 1995

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In-flight simulators will play an important and unique role in the development process of future helicopter systems and in generating credible handling qualities data which establish design guides for the integrated helicopter systems including sophisticated cockpit technologies and high authority control systems. The Institute for Flight Mechanics of DLR has developed the helicopter in-flight simulator ATTHeS (Advanced Technology Testing Helicopter System) which is based on a BO 105 helicopter. The testbed is equipped with a full authority nonredundant fly-by-wire control system for the main rotor and a fly-by-light system for the tail rotor. In the simulation mode the testbed requires a two-man crew, a simulation and a safety pilot. The onboard computer system consists of two computers to which are assigned the separated tasks, data collection and digital control system. With the implemented software structure the flexibility is achieved to change the control laws without any changes in the real time process. Before undergoing any flight test with a new or modified control system, a real-time hardware/software-in-the-loop ground-based simulation has to be successfully performed. For the purposes of in-flight simulation an explicit model following control system was developed and the model following performance was evaluated in flight. This control system is composed of a dynamic feedforward, based on an extended model of the host helicopter, and an optimized feedback control system. The capability and flexibility of ATTHeS has been demonstrated in different test programs which have been related to the use of the testbed for test pilot training, handling qualities research, helicopter simulation, and control law design and evaluation including automatic navigation and hover position hold.

Author

N95-32001*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.

X-29 FLIGHT CONTROL SYSTEM: LESSONS LEARNED

ROBERT CLARKE, JOHN J. BURKEN, JOHN T. BOSWORTH, and JEFFREY E. BAUER *In* AGARD, Active Control Technology: Applications and Lessons Learned 15 p Jan. 1995

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Two X-29A aircraft were flown at the NASA Dryden Flight Research Center over a period of eight years. The airplanes' unique features are the forward-swept wing, variable incidence close-coupled canard and highly relaxed longitudinal static stability (up to 35-percent negative static margin at subsonic conditions). This paper describes the primary flight control system and significant modifications made to this system, flight test techniques used during envelope expansion, and results for the low- and high-angle-of-attack programs. Throughout the paper, lessons learned will be discussed to illustrate the problems associated with the implementation of complex flight control systems.

Author

N95-32002# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. of Flight Mechanics.

ADVANCED GUST MANAGEMENT SYSTEMS: LESSONS LEARNED AND PERSPECTIVES

R. KOENIG, K.-U. HAHN, and J. WINTER (Dornier Luftfahrt G.m.b.H., Friedrichshafen, Germany.) *In* AGARD, Active Control Technology: Applications and Lessons Learned 17 p Jan. 1995

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Aircraft operations at low altitudes often are affected by strong gusts and turbulence producing additional aerodynamic forces and moments. This results in extra aircraft accelerations and therefore in an unpleasant impact on passenger comfort and pilot workload as well as in extra structural loads. Active Control Technology is able to suppress these effects partly. The knowledge about the potential for improvement, the parameters of influence and the performance requirements for such gust alleviation systems is still quite small. Since the mid-seventies Dornier and DLR (Institute of Flight Mechanics) have been working together on BMFT programs developing systems to improve the ride quality in gusty weather. The developed Open-Loop Gust Alleviation System OLGA was investigated through dynamic wind tunnel experiments and flight-tested onboard the experimental aircraft Do 128 TNT. This research was continued by DLR developing the Load Alleviation and Ride Smoothing System LARS using the modified VFW 614 aircraft ATTAS (Advanced Technologies Testing Aircraft System). The Deutsche Aerospace Dornier Luftfahrt GmbH has concentrated on simulation studies for their aircraft types Do 228 and Do 328. The presented paper provides a brief description of the advantages of overall gust management systems considering lift, drag and pitch control. The following topics will be presented in detail: (1) the basic flight mechanics of gust load alleviation; (2) the design of integrated gust management systems; (3) simulation and flight test results; and (4) lessons learned and general perspectives.

Author

N95-32004# Dornier Luftfahrt G.m.b.H., Friedrichshafen (Germany).

AUTOMATIC FLIGHT CONTROL SYSTEM FOR AN UNMANNED HELICOPTER SYSTEM DESIGN AND FLIGHT TEST RESULTS

M. WEIDEL and W. ALLES *In* AGARD, Active Control Technology: Applications and Lessons Learned p 10 Jan. 1995

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The use of unmanned air vehicles (UAV) in support of the Navy from small ships to fulfill tasks such as reconnaissance of large areas will succeed only if the user gains a high amount of confidence in the reliable operation of such a system, especially during the take off and landing phase. Take off from and landing on small landing pads on aviation facility ships in all-weather conditions prefer the application of VTOL-UAV's (Vertical Take Off and Landing) with a coaxial rotor system. Manual take off and landing procedures which have to be applied during operational service both at day time and at night under all-weather conditions and ship motions overtax the service personnel already at low sea states. This fact requires automatic take off and landing procedures. The German Ministry of Defence commissioned Dornier (DASA) in November 1990 with the development, test and demonstration of an automatic take off and landing system on the basis of the Gyrodyne QH-50 drone helicopter in order to prove the feasibilty of such a system in general. The essential ship and sea state dependent motions of the landing pad - roll, pitch and heave - were simulated with a ship deck simulator. The customer's requirement consisted of ten automatic take offs and landings of the UAV from a 4 by 4 meters landing pad. The test and demonstration phase was performed on the airfield of Friedrichshafen in the presence of experts from several NATO-Countries by the end of 1991. Derived from text

N95-32005# British Aerospace Defence Ltd., Preston (England). Military Aircraft Div.
THE FCS-STRUCTURAL COUPLING PROBLEM AND ITS SOLUTION
B. D. CALDWELL *In* AGARD, Active Control Technology: Applications and Lessons Learned 13 p Jan. 1995
Copyright Avail: CASI HC A03/MF A04

Implementation of ACT in aircraft is now almost routine, and often essential in realizing performance requirements. However, unless a pro-active and thorough approach is taken to ensuring that the effects of the flexibility of the airframe structure and its interaction with the FCS (Flight Control System) are analyzed and accounted for, costly development delays and control system redesigns may ensue. This paper is intended to discuss the basis of the phenomenon referred to at BAe Warton as FCS-Structural Coupling, the evolution of the methodology evolved at Warton to ensure freedom from its effects, and the development directions required to advance the state of art in this field. Author

N95-32006# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany).
STRUCTURAL ASPECTS OF ACTIVE CONTROL TECHNOLOGY
H. HOENLINGER, H. ZIMMERMANN (Deutsche Aerospace A.G., Bremen, Germany.), O. SENSBURG (Deutsche Aerospace A.G., Munich, Germany.), and J. BECKER (Deutsche Aerospace A.G., Munich, Germany.) *In* AGARD, Active Control Technology: Applications and Lessons Learned 25 p Jan. 1995
Copyright Avail: CASI HC A03/MF A04

A survey on the structural relevant applications of Active Control Technology is presented. The benefits and disadvantages of various active control systems for transport and fighter aircraft are discussed. The problem of adverse structural coupling is addressed and possible solutions are outlined. The Smart Structure Technology offers new applications for active control technology, but to exploit the full potential of this technology multidisciplinary design methods have to be improved. Author

N95-32009# Alenia Aeronautica, Turin (Italy). Flight Mechanics Group.
DIGITAL AUTOPILOT DESIGN FOR COMBAT AIRCRAFT IN ALENIA
ALDO TONON and PIER LUIGI BELLUATI *In* AGARD, Active Control Technology: Applications and Lessons Learned 13 p Jan. 1995
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ALENIA - Aeronautica has been involved in Digital Autopilot design for the AMX and EF 2000 programs. The AMX is a subsonic attack aircraft whose Flight Control System is based on Fly-by-wire technology, incorporating an Hybrid Analog and Digital Flight Control Computer for Control and Stability augmentation in pitch, roll and yaw axes, which guarantees the aircraft capability of full performance; in addition the Flight Control System has also a conventional mechanical back-up in the pitch and roll axes, which guarantees aircraft safe re-entry after failure of both hydraulic and both electrical circuits. The paper deals with the development history of the AMX autopilot through design to flight test. In particular the paper addresses the design to specification relationship, the system development and clearance process and the flight test results. The EF 2000 programme is an international development for an agile, highly unstable Fly-by-Wire Air Superiority fighter. Within the EF 2000 consortium ALENIA has the responsibility for Basic Autopilot design. This design, currently in the early stages of development, poses peculiar problems due to the interaction of Autopilot (external) feedback loops and the basic stabilization (inner) loops. The paper address these peculiar aspects in conjunction with the specific design methodologies applied. Author

N95-32010# British Aerospace Defence Ltd., Warton (England).
EXPERIMENTAL AIRCRAFT PROGRAMME (EAP): FLIGHT CONTROL SYSTEM DESIGN AND TEST
A. MCCUISH *In* AGARD, Active Control Technology: Applications and Lessons Learned 14 p Jan. 1995
Copyright Avail: CASI HC A03/MF A04

The objectives of the Experimental Aircraft Programme were to demonstrate various technologies relevant to a future combat aircraft within the rigors imposed by having to achieve flight clearance and demonstration. Prime areas for demonstration, among others, were modern cockpit displays, avionics systems integration, advanced material construction, advanced aerodynamics and active flight control. Nearly all future combat aircraft will have an unstable basic airframe due to the advantages that are accrued: smaller, lighter, aerodynamically more efficient, etc. Necessary to such an aircraft is a full time active control system. This paper outlines the philosophy and method taken to design the flight control laws and relates their development through the life of the programme. The experience gained from the three phase, 259 flight test programme is summarized. The success of the flight programme has provided a wealth of experience from the operation of the aircraft. In particular, and most impressive to the pilots, was the carefree handling capability; this was considered remarkable. A further success was the complete absence of pilot induced oscillation (PIO) tendency throughout the whole of the flight programme. Author

N95-32011# Air Force Flight Test Center, Edwards AFB, CA.
AN INVESTIGATION OF PILOT INDUCED OSCILLATION PHENOMENA IN DIGITAL-FLIGHT CONTROL SYSTEMS
WILLIAM A. FLYNN and ROBERT E. LEE *In* AGARD, Active Control Technology: Applications and Lessons Learned 6 p Jan. 1995
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This paper summarizes the results of a technical review of pilot induced oscillations (PIO) in aircraft equipped with digital flight control systems. A review of the causes of PIO, the specific interaction of digital flight control systems, and an evaluation of the flight control development process was conducted. The paper discusses the highlights of the technical review and the recommendations for future development of flight control systems to reduce the occurrences of handling qualities problems in general and PIO in particular. Author

N95-32012# British Aerospace Defence Ltd., Warton (England). Aerodynamics Dept.
FLIGHT DEMONSTRATION OF AN ADVANCED PITCH CONTROL LAW IN THE VAAC HARRIER AIRCRAFT
C. FIELDING, S. L. GALE (Defence Research Agency, Bedford, England.), and D. V. GRIFFITH (Defence Research Agency, Bedford, England.) *In* AGARD, Active Control Technology: Applications and Lessons Learned 12 p Jan. 1995 Sponsored by UK Ministry of Defence
Copyright Avail: CASI HC A03/MF A04

'Vectored thrust Aircraft Advanced flight Control' (VAAC) is a UK project, sponsored by the Ministry of Defence and managed by the Defence Research Agency (DRA). The project is investigating, through ground-based simulation and flight test on the VAAC Harrier research aircraft, the low speed flight control, handling and cockpit display concepts applicable to an aircraft replacing the Harrier. As part of the project, British Aerospace Defence Limited have designed a revolutionary two-inceptor pitch plane control law for assessment on the project aircraft. This Control Law has now been flight tested and further developed 'in-flight' by the

DRA, culminating in a series of successful flight demonstrations to guest pilots. During the latter stages of flight testing the Control Law was modified to allow single-inceptor operation. Flight testing has shown that both the two- and single-inceptor control strategies result in a large reduction in pilot workload, when compared with the VAAC Harrier's three-inceptor arrangement, during the transition from wing-borne to jet-borne flight and hover. This paper describes the Control Law's evolution from initial concept through to the results obtained from flight testing. Author

N95-32014# Boeing Defense and Space Group, Philadelphia, PA. Helicopters Div.
ADVANCED FLIGHT CONTROL TECHNOLOGY ACHIEVEMENTS AT BOEING HELICOPTERS
KENNETH H. LANDIS, CHARLES DABUNDO, JAMES M. DAVIS, and JAMES F. KELLER *In* AGARD, Active Control Technology: Applications and Lessons Learned 16 p Jan. 1995
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Over the last two decades, flight control system requirements have been in a state of transition. Rotary wing missions have become more demanding, requiring vehicle management systems capable of conducting highly aggressive missions under night / adverse-weather conditions in severe electromagnetic environments. The digital, fly-by-wire / optics control system technologies developed at Boeing Defense and Space Group, Helicopters Division to meet these air vehicle requirements are overviewed. These technologies, which integrate digital multimode control laws and sidestick controllers within redundant-reconfigurable architectures, provide the rotorcraft capabilities required for the 21st century. The advances in flight control design, as developed during various technology demonstrator programs and applied in production of the V-22 Osprey tiltrotor and the RAH-66 Comanche scout / attack helicopter, are summarized. Author

N95-32015# National Research Council of Canada, Ottawa (Ontario). Flight Research Lab.
PRACTICAL EXPERIENCES IN CONTROL SYSTEMS DESIGN USING THE NCR BELL 205 AIRBORNE SIMULATOR
STEWART W. BAILLIE, J. MURRAY MORGAN, and KEVIN R. GOHEEN *In* AGARD, Active Control Technology: Applications and Lessons Learned 12 p Jan. 1995
Copyright Avail: CASI HC A03/MF A04

The objective of this paper is to describe a variety of examples of control system design and application on the NRC Bell 205 Airborne Simulator. For background, this paper will first examine the physical characteristics of the Bell 205 and the mathematical models which have been developed to describe them. The paper then reviews the classical control design techniques which have been used to develop high bandwidth rate and attitude response type systems on the aircraft, and describes the empirically determined fixes which have become standard elements of these types of systems. To complete the paper, two sections will deal with application of modern control theories; the first describes a limited effort to develop a translational rate command system using a six degree of freedom model of the Bell 205 and a publicly available software package, MATLAB/Simulink. The second modern control theory section deals with a more detailed study performed in collaboration with Carleton University and supported by DND/CRAD to devise modern control theory controllers for the Bell 205. All discussions of the paper are substantiated with actual in-flight validation data to clearly demonstrate design successes and failures. Author

N95-32016# Aerospatiale, Toulouse (France). Handling Qualities Dept.
FLYING QUALITIES OF CIVIL TRANSPORT AIRCRAFT WITH ELECTRICAL FLIGHT CONTROL [LES QUALITIES DE VOL DE AVIONS DE TRANSPORT: CIVIL A COMMANDES DE VOL ELECTRIQUES]
D. CHATRENET *In* AGARD, Active Control Technology: Applications and Lessons Learned 5 p Jan. 1995 In FRENCH
Copyright Avail: CASI HC A01/MF A04

This conclusion to the the conference covers the flying qualities and flight control systems (FCS) of transport aircraft equipped with electrical flight control systems, as seen by Aerospatiale. A retrospective look at the related technological developments over the past 25 years precedes a comparison between the Airbus A340 and A320. The main points in the differences between the FCS in the A320 and the A340 are associated with the compensation effects of the more flexible structure of the A340, its design for long-range ('minimum drag'), and the inherent limitations in take-off performance. Derived from text

N95-32017# British Aerospace Defence Ltd., Preston (England). Military Aircraft Div.
PILOT INDUCED OSCILLATION: A REPORT ON THE AGARD WORKSHOP ON PIO
K. MCKAY *In* AGARD, Active Control Technology: Applications and Lessons Learned 10 p Jan. 1995 Workshop held on 13 May 1994
Copyright Avail: CASI HC A02/MF A04

Instability of the pilot/airframe combination has been a problem from the beginning of manned flight. The rapid advances made in aviation following the Second World War greatly increased the incidence of PIO problems and led to a large amount of research and development work aimed at understanding and mitigating these difficulties. Criteria and requirements were developed which could be used in design to obtain satisfactory PIO qualities. Nevertheless, in spite of all this work, and even with the great flexibility in modern control technologies available to the designer, PIO problems still often occur with new aircraft; in fact it is the power and responsiveness of modern control systems which makes them susceptible to various 'non-linear' effects such as time delays, rate limits, actuator saturation, etc., leading to unexpected PIO difficulties. With current experience, it is clear that a universal solution of the PIO problem still evades the engineering community. The cost of these problems in programme delay and financial terms is significant. The gathering together of specialists to discuss this problem, from their various points of view, has led to positive gains in the state of knowledge regarding PIOs; it has provided a significant step toward their elimination and contributed to the avoidance of PIO associated programme costs and penalties. This paper provides an overview of the results from the Workshop. Fuller details are to be published by AGARD in the proceedings of the Conference and Workshop in the near future and in a separate Advisory Report. Author

N95-32111 California Univ., Los Angeles, CA.
VIBRATION REDUCTION IN HELICOPTER ROTORS USING AN ACTIVELY CONTROLLED PARTIAL SPAN TRAILING EDGE FLAP LOCATED ON THE BLADE Ph.D. Thesis
THOMAS ALEXANDER MILLOTT 1993 519 p
Avail: Univ. Microfilms Order No. DA9420455

This dissertation describes the development of an aeroelastic analysis of a four-bladed hingeless helicopter rotor configuration incorporating an individually controlled aerodynamic surface located on each blade, and its application to the simulation of helicopter vibration reduction through individual blade control (IBC). The structural, inertial, and aerodynamic loads on an isolated rotor blade and control surface combination with fully coupled flap-lag-torsional dynamics are developed explicitly using a symbolic computing facility. Two blade models are used: the first is a simple offset-hinged spring restrained rigid blade model, and the second is a more realistic fully elastic blade model. The inertial loads on the blade are developed using D'Alembert's principle and quasi-steady aerodynamics, including the effects of a partial span trailing edge flap, is used to formulate the aerodynamic loads. Four blades are combined in a FORTRAN code to represent a four-bladed fixed hub hingeless rotor blade configuration. The rotor trim and blade response solutions are treated in a fully coupled manner using the harmonic balance technique. Various open-loop and closed-loop controllers based on global and local system models are implemented to reduce 4/rev vibratory hub loads using both an actively controlled aerodynamic surface on each blade as well as conventional IBC, in which the complete blade undergoes cyclic pitch change. The effectiveness of the two approaches for the simultaneous reduction of the 4/rev hub shears and hub moments is compared. It was found that both approaches are very effective in producing substantial vibration reduction. Comparisons of power requirements to implement the control were carried out and it was discovered that conventional IBC requires 5 to 25 times more power to achieve approximately the same degree of vibration reduction. The effect of blade torsional flexibility on the vibration reduction effectiveness of the actively controlled aerodynamic surface was also considered and it was found that this parameter has a very substantial influence. This study clearly demonstrates the feasibility of this novel concept for vibration reduction. Based on the results obtained, this is potentially one of the most effective means for vibration reduction. Furthermore it has the unique feature that it does not utilize the conventional swashplate of the helicopter and thus it has no effect on its airworthiness characteristics. Dissert. Abstr.

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RESEARCH AND SUPPORT FACILITIES (AIR)

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

A95-93630
THE A340 ELECTRICAL POWER GENERATION SYSTEM 1991
7 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 36 Aircraft Power Generation & Mgmt.)
(CONGRESS PAPER C428-36-193; HTN-95-21199) Copyright

The system described below has been designed by Sundstrand Aerospace in collaboration with Aerospatiale, which is responsible to Airbus Industries for the complete aircraft electrical system. Lucas is responsible for the design and development of the Generator Control Unit, Ground Power Control Unit, various Current Transformers and the Auxiliary Power Unit Generator within the system. The a. c. electrical power generation system designed for the A340 aircraft is a traditional 115V, 3phase, 400Hz supply as used on existing civil aircraft. The main novel feature is that the system is designed to allow power transfers between the various electrical power sources without any interruption in the a.c. supply. This feature assures the A340 operators that they will not need to reset their complex electronic systems (such as the auto-navigational system), as a result of power interrupts caused by transfer between ground power, Auxiliary Power Unit power and/or main engine generated power. The same system configuration is also used on the A330 aircraft, and thus common electronic control units can be used for both aircraft types and this commonality extends to the software embedded in these control units. Author (Herner)

A95-93636
THE DEVELOPMENT OF A MODEL SPECIFICATION FOR GROUND SUPPORT EQUIPMENT
N. A. HARRY 1991 15 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 38: Ground Support & Airport Equipment)
(CONGRESS PAPER C428-38-095; HTN-95-21205) Copyright

This paper outlines the development of, and the need for, a model specification for ground support equipment (GSE). Included is a brief description of some problems experienced in-service together with the results of a user/supplier questionnaire circulated to obtain views on quality standards, specifications and contracts. An initial draft form of model specification is presented. Author (Herner)

A95-93676
PROPULSION SIMULATOR FOR HIGH BYPASS TURBOFAN PERFORMANCE EVALUATION
CHELLAPPA BALAN GE Aircraft Engines, Evendale, OH, US and GREGORY E. HOFF GE Aircraft Engines, Evendale, OH, US (ISSN 0148-7191) 1993 10 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993
(SAE PAPER 931410; HTN-95-21245) Copyright

An Ultra high bypass turbofan Propulsion Simulator (UPS) was designed and built to evaluate candidate fan system configurations for current and future applications. This simulator can accommadate fans of nominally 0.06 meter tip diameter. The inlet, nacelle, exhaust system and the first stage of the booster to the core can be simulated in the UPS. The UPS can be used to evaluate fan aero performance, source noise and acoustic treatment effectiveness, high angle of attack inlet - fan operability performance and fan aeromechanics. Salient features of the design, instrumention, data aquisition and operation of this simulator are described in this paper. Author (Herner)

A95-93744
ADAPTIVE AIRFOILS
S. HANAGUD Georgia Inst. of Tech., Atlanta, GA, US and R. L. ROGLIN Georgia Inst. of Tech., Atlanta, GA, US *In* Developments in theoretical and applied mechanics; Southeastern Conference on Theoretical and Applied Mechanics, 16th, Nashville, TN, April 12-14, 1992. A95-93700 Tullahoma, TN The Univ. of Tennessee Space Inst. (SECTAM, Vol. 16) 1992 p. II.20.17-II.20.21
(ISBN 1-879921-01-4) Copyright

The application of a shape memory alloy to actuate a shape change (camber) in the chordwise direction of an airfoil is investigated. Such shape changes can be used to actively control the camber and airflow over a helicopter rotor blade or fixed wing. The following explores some of the aspects of such a mechanism with the goal of minimizing power losses through shape change of the airfoil. Author (Herner)

A95-94462
EVENT CORRELATION FOR NETWORKED SIMULATORS
AMNON KATZ Univ of Alabama, Tuscaloosa, AL, United States Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 515-519 refs
(BTN-95-EIX0619952748168) Copyright

The timing and synchronization issues of networked simulation over large distances are studied. It is shown that the absolute time-stamp is effective in removing inconsistencies between the world pictures presented by the networked simulators. The tolerance that can be maintained on correlation errors is dominated by the precision of the dead-reckoning process over a time span that is the sum of propagation delay and clock error. Dead-reckoning statistics are invoked to determine the level of correlation that can be achieved for global networking. The clock accuracy required for this purpose is assessed. Author (EI)

A95-95159
THE DEVELOPMENT OF COMPUTER-BASED INSTRUCTIONAL SIMULATIONS FOR THE AIRLINE INDUSTRY
MICHAEL KARIM Univ. of North Dakota, Grand Forks, ND, US and KEITH A. HALL Ohio State Univ., Columbus, OH, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 770-775
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Traditional training methodologies and paradigms no longer meet the needs of the pilot transitioning into the next generation digital aircraft. Significant effort is being expended on the design and development of new instructional strategies, including the area of computer-based instructional simulations (CBIS). This paper desribes a brief history of simulations, description of the elements of a type of simulation structure typically used in procedural tasks such as those associated with aircrew training activities and one method of decreasing the enormous time and labor required for developing CBIS's. This paper describes a brief history of simulations, description of the elements of a type of simulation structure typically used in procedural tasks such as those associate with aircrew training activities and one method of decreasing the enormous time and labor required for developing CBI's. Author (revised by Herner)

A95-95161
THE SIMULATOR TRAINING RESEARCH ADVANCE TESTBED FOR AVIATION (STRATA): A SIMULATION RESEARCH FACILITY FOR ARMY AVIATION
DENNIS C. WIGHTMAN Army Research Inst., Fort Rucker, AL, US and JOHN E. STEWART Army Research Inst., Fort Rucker, AL, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 787-790
Copyright

In September, 1992, the Army Research Institute Aviation Research and Development Activity (ARIARDA) initiated its research program using the Simulator Training Research Advance Testbed for Aviation (STRATA) system. STRATA was designed to specifically address the issues concerning the design and use of flight simulators and to provide a resource for the conduct of human performance research with aviation systems. This paper will describe the STRATA system and the research program to be carried out with it. Author (Herner)

A95-95193
SAFETY IN AIRPORT GROUND HANDLING
NICK MCDONALD Trinity College Dublin, Dublin, Ireland, GEORGE WHITE Trinity College Dublin, Dublin, Ireland, RAY FULLER Trinity College Dublin, Dublin, Ireland, WILLIAM WALSH Trinity College Dublin, Dublin, Ireland, and FIONA RYAN Trinity College Dublin, Dublin, Ireland *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 951-953
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Safe and effective ground handling is crucial to efficient and competitive airline operation. The airport ramp is a congested and difficult environment in which to work and there are many ergonomic and environmental hazards (including lifting in confined spaces, noise and climatic extremes, moving vehicles, jet blast). From the point of view of the safety, health and well-being of the worker the ramp is a dangerous environment with a high risk of occupational injury and mortality. The enhanced safety and well-being of the worker is thus a high priority. In other areas of aviation there has been a massive investment in the ergonomic design of new technological systems and in the human factors training of pilots. The same attention to ameliorating the human factor role in accident causation needs to be applied on the airport ramp.
Author (revised by Herner)

N95-30493 Maryland Univ., College Park, MD.
A NUMERICAL STUDY OF THE STARTING PROCESS IN A HYPERSONIC SHOCK TUNNEL Ph.D. Thesis
JANG-YEON LEE 1993 217 p
Avail: Univ. Microfilms Order No. DA9425077

This dissertation represents the first time calculations have been made of the unsteady viscous simulation of the starting process in a hypersonic shock tunnel including the bifurcation phenomenon due to the interaction of the reflected shock with the boundary layer generated by the incident shock in the shock tube. In order to simulate the unsteady viscous flow in the NASA Ames 16-inch hypersonic shock tunnel, which consists of axisymmetric shapes (shock tube and nozzle), rectangular shape (test cabin), and octagonal shape (diffuser), a time-dependent ADI (alternating direction implicit) axisymmetric full Navier-Stokes code with a second order upwind TVD (total variation diminishing) scheme and a time-dependent three-dimensional thin layer Navier-Stokes code with an explicit MacCormack TVD scheme have been developed. As shown in the code validation study, these Navier-Stokes codes with the high resolution TVD algorithms give fair agreement with available experimental data and exact solutions. Numerical simulations of the starting process for the NASA Ames 16-inch hypersonic shock tunnel show that during the reflected shock interaction process at the end of the shock tube, the bifurcation phenomenon and the strong vortices become dominant features. The vortices due to the reflected shock interactions appear in the axisymmetric simulation but are not generated in the two-dimensional flow. For the nominal testing condition, the starting process in the NASA Ames shock tunnel takes 1700 microsec. The required total testing time consists of the time for the starting process, 1.7 m sec, and the time for the flow establishment over a model in the test cabin which strongly depends on the model shape and size and model mounting location. For a 10 deg-cone model, the minimum required testing time is estimated as at least 2.7 m sec for the steady state. Dissert. Abstr.

N95-30592*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NASA LEWIS RESEARCH CENTER'S PREHEATED COMBUSTOR AND MATERIALS TEST FACILITY
STEVE A. NEMETS (NYMA, Inc., Brook Park, OH.), ROBERT C. EHLERS (NYMA, Inc., Brook Park, OH.), and EDITH PARROTT Jun. 1995 11 p
Contract(s)/Grant(s): (NAS3-27186; RTOP 505-62-84)
(NASA-TM-106676; E-9012; NAS 1.15:106676) Avail: CASI HC A03/MF A01

The Preheated Combustor and Materials Test Facility (PCMTF) in the Engine Research Building (ERB) at the NASA Lewis Research Center is one of two unique combustor facilities that provide a nonvitiated air supply to two test stands, where the air can be used for research combustor testing and high-temperature materials testing. Stand A is used as a research combustor stand, whereas stand B is used for cyclic and survivability tests of aerospace materials at high temperatures. Both stands can accommodate in-house and private industry research programs. The PCMTF is capable of providing up to 30 lb/s (pps) of nonvitiated, 450 psig combustion air at temperatures ranging from 850 to 1150 g F. A 5000 gal tank located outdoors adjacent to the test facility can provide jet fuel at a pressure of 900 psig and a flow rate of 11 gal/min (gpm). Gaseous hydrogen from a 70,000 cu ft (CF) tuber is also available as a fuel. Approximately 500 gpm of cooling water cools the research hardware and exhaust gases. Such cooling is necessary because the air stream reaches temperatures as high as 3000 deg F. The PCMTF provides industry and Government with a facility for studying the combustion process and for obtaining valuable test information on advanced materials. This report describes the facility's support systems and unique capabilities. Author

N95-31468# Federal Aviation Administration, Atlantic City, NJ.
EVALUATION OF ALTERNATIVE PAVEMENT MARKING MATERIALS Final Report
KEITH W. BAGOT Jan. 1995 50 p
(AD-A292973; DOT/FAA/CT-94/119) Avail: CASI HC A03/MF A01

This study was undertaken to evaluate potential alternative marking materials for use on airport pavement marking systems. The materials were evaluated for conspicuity, durability, rubber buildup, color retention, friction, environmental acceptability, and cost benefits. In all, five materials (two water-borne, two epoxies, and one methacrylic resin) were evaluated at three test airports around the country for a period of one year. The three test airports, chosen for their different climatic conditions, were Atlantic City, Greater Pittsburgh, and Phoenix Sky Harbor International airports. Epoxies and resins were more durable than water-borne paints in areas subject to heavy snowfall and snowplow activity, particularly when applied to Portland cement concrete surfaces. The epoxies tested, however, did show signs of yellowing after extensive ultraviolet exposure. It was also determined that the addition of silica and/or glass beads improved the conspicuity of the markings, improved friction, and minimized rubber adherence. The cost-benefit analysis showed that more durable materials and the addition of silica and/or beads does increase the initial cost of marking the airport surfaces but could reduce the number of painting cycles on many portions of the airport from several times per year to once every several years. DTIC

N95-31653*# NYMA, Inc., Brook Park, OH.
FLOW QUALITY IMPROVEMENTS IN THE NASA LEWIS RESEARCH CENTER 9- BY 15-FOOT LOW SPEED WIND TUNNEL Final Report
E. ALLEN ARRINGTON and JOSE C. GONSALEZ Cleveland, OH
NASA Jun. 1995 20 p Presented at the 31st Joint Propulsion Conference and Exhibit, San Diego, CA, 10-12 Jul. 1995; sponsored by AIAA, ASME, SAE, and ASEE
Contract(s)/Grant(s): (NAS3-27186; RTOP 505-62-82)
(NASA-CR-195439; E-9465; NAS 1.26:195439; AIAA PAPER 95-2390)
Avail: CASI HC A03/MF A01

The NASA Lewis Research Center 9- by 15-Ft Low Speed Wind Tunnel (LSWT) was recently upgraded with the addition of several flow quality improvement devices: four 10-mesh turbulence reduction screens and a flow straightening honeycomb (3/8-in. cell, length to diameter ratio, L/D = 16) in the settling chamber upstream of the test section, and a diffuser extension fairing downstream of the test section. Test section flow quality was measured prior to and following the tunnel modifications. Comparison of the pre- (baseline) to post-tunnel modification flow quality data will provide a gage of the effectiveness of the flow quality devices. An instrumented rake was used to provide both calibration and flow-field survey data at several stations in the test section. The flow-field parameters measured included total and static pressure, total temperature, pitch and yaw components of flow angle, and turbulence; boundary layer total pressure surveys were also made. The data indicated very good flow quality in the test section at all survey stations in terms of total pressure, total temperature, Mach number and flow angularity distributions, and turbulence levels. The data compared with that collected before facility flow quality additions indicate improvement in the test section Mach number distribution, flow angle distribution, and turbulence levels as well as an increase in the usable test section width. The temperature distributions can be further improved by increasing the cooling water flow into the facility heat exchanger. Author

N95-32176# Esquimalt Defence Research Detachment, Victoria (British Columbia).
FACILITIES USED FOR PLASTIC MEDIA BLASTING
TERRY FOSTER *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 4 p Apr. 1995 Copyright Avail: CASI HC A01/MF A01

The equipment used for plastic media blasting (PMB) is generally independent of the media and is similar to equipment used in traditional abrasive blasting. PMB equipment is usually modified to enable the close control of the media flow and the operation at low pressures (30 - 40 psi). Because of the delicate nature of some of the stripping procedures, the nozzles used for PMB have been redesigned to improve cleaning rates, give an even distribution of particles and reduce the variation in particle velocity across the blast stream. This results in a more equal distribution of particles and impact energies at the substrate. There are three types of blast facilities available: blast cabinets for small components; blast booths which will accommodate larger components but may be used for purposes other than blasting, and blast rooms which are designed for complete vehicles or aircraft and are generally not used for other purposes. Derived from text

N95-32217*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTER MODEL TO SIMULATE TESTING AT THE NATIONAL TRANSONIC FACILITY
RAYMOND E. MINECK, LEWIS R. OWENS, JR., RICHARD A. WAHLS, and JUDITH A. HANNON Aug. 1995 45 p Sponsored by NASA, Washington
Contract(s)/Grant(s): (RTOP 505-59-10-31)
(NASA-TM-4664; L-17459; NAS 1.15:4664) Avail: CASI HC A03/MF A01

A computer model has been developed to simulate the processes involved in the operation of the National Transonic Facility (NTF), a large cryogenic wind tunnel at the Langley Research Center. The simulation was verified by comparing the simulated results with previously acquired data from three experimental wind tunnel test programs in the NTF. The comparisons suggest that the computer model simulates reasonably well the processes that determine the liquid nitrogen (LN2) consumption, electrical consumption, fan-on time, and the test time required to complete a test plan at the NTF. From these limited comparisons, it appears that the results from the simulation model are generally within about 10 percent of the actual NTF test results. The use of actual data acquisition times in the simulation produced better estimates of the LN2 usage, as expected. Additional comparisons are needed to refine the model constants. The model will typically produce optimistic results since the times and rates included in the model are typically the optimum values. Any deviation from the optimum values will lead to longer times or increased LN2 and electrical consumption for the proposed test plan. Computer code operating instructions and listings of sample input and output files have been included. Author

10 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.

A95-93330
STATIC SHAPE CONTROL FOR ADAPTIVE WINGS
FRED AUSTIN Grumman Corporate Research Center, Bethpage, NY, US, MICHAEL J. ROSSI Grumman Corporate Research Center, Bethpage, NY, US, WILLIAM VAN NOSTRAND Grumman Corporate Research Center, Bethpage, NY, US, GARETH KNOWLES Grumman Corporate Research Center, Bethpage, NY, US, and ANTONY JAMESON Princeton Univ., Princeton, NJ, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 9 September 1994 p. 1895-1901
(HTN-95-A1767) Copyright

A theoretical method was developed and experimentally validated, to control the static shape of flexible structures by employing internal translational actuators. A finite element model of the structure, without the actuators present, is employed to obtain the multiple-input, multiple-output control-system gain matrices for actuator-load control as well as actuator-displacement control. The method is applied to the quasistatic problem of maintaining an optimum-wing cross section during various transonic-cruise flight conditions to obtain significant reductions in the shock-induced drag. Only small, potentially achievable, adaptive modifications to the profile are required. The adaptive-wing concept employs actuators as truss elements of active ribs to reshape the wing cross section by deforming the structure. Finite element analyses of an adaptive-rib model verify the controlled-structure theory. Experiments on the model were conducted, and arbitrarily selected deformed shapes were accurately achieved. Author (Herner)

A95-93671* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AIRCRAFT NOSE GEAR SHIMMY STUDIES
THOMAS J. YAGER NASA Langley Research Center, Hampton, VA, US (ISSN 0148-7191) 1993 6 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993

(SAE PAPER 931401; HTN-95-21240) Copyright

An overview of previous studies involving aircraft nose gear shimmy behavior is given together with some test results identifying the influence of different factors inducing shimmy. A NASA Langley test program conducted at the Landing Loads Track (LLT) facility to evaluate shimmy characteristics of an actual Space Shuttle nose gear is described together with some of the test results. Based on results from these various evaluations, recommendations are made concerning nose gear design features, such as corotating wheels, to minimize the occurence of shimmy. Author (Herner)

A95-93716

UNANSWERED QUESTIONS CONCERNING THE NOCILLA GAS-SURFACE INTERACTION MODEL

FRANK G. COLLINS The Univ. of Tennessee Space Inst., Tullahoma, TN, US *In* Developments in theoretical and applied mechanics; Southeastern Conference on Theoretical and Applied Mechanics, 16th, Nashville, TN, April 12-14, 1992. A95-93700 Tullahoma, TN The Univ. of Tennessee Space Inst. (SECTAM, Vol. 16) 1992 II.6.33-II.6.40
(ISBN 1-879921-01-4) Copyright

Molecular beam scattering experiments with gas/surface combinations and energies to be expected for vehicles in orbit were used to obtain accurate representations of the Nocilla model parameters and of the accommodation coefficients. Comparisons between the aerodynamic coefficient predictions from the Nocilla model and the accommodation coefficients are not good. In an attempt to examine the cause for the differences, the Nocilla model was used to predict the accommodation coefficients and they are shown to disagree with the measured accommodation coefficients. This deficiency of the Nocilla model requires further examination. Author (Herner)

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CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A95-93632

THE BASIS OF CIVIL CERTIFICATION AND CONTINUED AIRWORTHINESS FOR COMPOSITE AIRCRAFT STRUCTURES

J. W. BRISTOW Civil Aviation Authority, UK 1991 5 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 37: Airworthiness-Composites and Fly by Wire)
(CONGRESS PAPER C428-37-173; HTN-95-21201) Copyright

Already published or about to be published are three documents which set out acceptable means of compliance with civil requirements in respect of composite materials in primary aircraft structures. The fields concerned are design, manufacture and maintenance (repair). The design aspects were covered in a paper given at the IMechE conference Fibre Reinforced Composites 86 and the information given then remains valid today. The main subject of this paper is the manufacturing aspects of airworthy composite structures. Reference will also be made to facilities for maintenance of composite structures. All these activities are centered around Europe-USA cooperation to formulate common requirements that can be interpreted equally on both sides of the Atlantic. The composites referred to are organic matrix fiber reinforced materials. Author (Herner)

A95-93633

THE CERTIFICATION OF COMPOSITE STRUCTURES FOR MILITARY AIRCRAFT

A. W. CARDRICK and P. T. CURTIS 1991 5 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 37: Airworthiness-Composites and Fly by Wire)
(CONGRESS PAPER C428-37-198; HTN-95-21202) Copyright

The introduction of advanced composites has prompted a critical appraisal of the certification procedures for metal structures. This paper outlines some of the more important changes that have been made in order to ensure that in use of these materials the designer is inhibited only by those provisions which are essential to maintain acceptable standards of safety, reliability and maintenance costs. Author (Herner)

A95-93674

DISSOLVED GAS - THE HIDDEN SABOTEUR

VINCENT G. MAGORIEN (ISSN 0148-7191) 1993 6 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993
(SAE PAPER 931404; HTN-95-21243) Copyright

Almost all hydraulic power components, to properly perform their tasks, rely on one basic, physical property, i.e., the incompressibility of the working fluid. Unfortunately, a frequently overlooked fluid property which frustrates this requirement is its ability to absorb, i.e., dissolve, store and give off gas. The gas is, most often but not always, air. This property is a complex one because it is a function not only of the fluid's chemical make-up but temperature, pressure, exposed area, depth and time. In its relationshiop to aircraft landing-gear, where energy is absorbed hydraulically, this multi-faceted fluid property can be detrimental in two ways: dynamically, i.e., loss of energy absorption ability and statically, i.e., improper aircraft attitude on the ground. The pupose of this paper is to bring an awareness to this property by presenting: 1) examples of these manifestations with some empirical and practical solutions to them, 2) illustrations of this normally 'hidden saboteur' at work, 3) Henry's Dissolved Gas Law, 4) room-temperature, saturated values of dissolved gas for a number of different working fluids, 5) a description of the instrument used to obtain them, 6) some 'missng elements' of the Dissolved Gas Law pertaining to absoption, 7) how static and dynamic conditions effect gas absorption and 8) some recommended solutions to prevent becoming a victim of this 'hidden saboteur' Author (Herner)

A95-94255

CONTROLLING MECHANISMS OF IGNITION OF SOLID FUEL IN A SUDDEN-EXPANSION COMBUSTOR

JING-TANG YANG Natl Tsing Hua Univ, Hsinchu, Taiwan, Province of China and CLIFF Y. Y. WU Journal of Propulsion and Power (ISSN 0748-4658) vol. 11, no. 3 May-June 1995 p. 483-488 refs
(BTN-95-EIX0616952745791) Copyright

Ignition of solid fuel by a hot oxidizing flow in a sudden-expansion combustor was investigated experimentally. The controlled variables of the experiments were concentration of oxygen (12-25%), gas temperature (750-850 C), and flow velocity (19-46 m/s). The step height was 29 mm. The corresponding Reynolds numbers based on the flow velocity and the step heights were 12 x 10(sup 4)-31 x 10(sup 4). The controlling mechanisms of ignition in the flow with abundant oxygen were distinct from those with little oxygen. The initial flame kernels formed near the reattachment point and adjacent to the surface of solid fuel when the oxygen concentration was large. The process was controlled by diffusion and the ignition delay decreased with increased flow velocity. For the flow containing oxygen at a small concentration, the initial flame kernels formed within the recirculation zone and away from the surface of the solid fuel. The process was then controlled by the chemical kinetics and the ignition delay increased with increased flow velocity. Author (EI)

N95-30749 Department of the Navy, Washington, DC.

COMPOSITE STRUCTURE FORMING A WEAR SURFACE Patent

EDWARD I. COHEN, inventor (to Navy) 14 Feb. 1995 6 p Filed 24 Sep. 1993
(AD-D017462; US-PATENT-5,389,411; US-PATENT-APPL-SN-125715; US-PATENT-CLASS-428-34) Avail: US Patent and Trademark Office

This patent discloses a pre-stressed composite liner structure is provided for tribological systems typically associated a pump engine, compressor or systems having bearings rotating within a journal. A hollowed ceramic core is concentrically wound with cladding material in the form of a filament or braid. The ceramic core and the wound cladding form an interference fit with one another to pre-stress the ceramic core in terms of tensile strength. DTIC

N95-30750 Department of the Navy, Washington, DC.
HIGH ASPECT RATIO METAL MICROSTRUCTURES AND METHOD FOR PREPARING THE SAME Patent
JACQUE H. GEORGER, JR., inventor (to Navy), MARTIN C. PECKERAR, inventor (to Navy), MILTON L. REBBERT, inventor (to Navy), JEFFREY M. CALVERT, inventor (to Navy), and JAMES J. HICKMAN, inventor (to Navy) 30 Aug. 1994 17 p Filed 27 Apr. 1992
(AD-D017463; US-PATENT-5,342,737; US-PATENT-APPL-SN-874403; US-PATENT-CLASS-430-324) Avail: US Patent and Trademark Office

High aspect ratio metal microstructures may be prepared by a method involving: (1) forming a layer of a photoresistance on a substrate; (2) exposing the layer to actinic radiation in an image wise manner and developing the exposed layer to obtain a surface which contains regions having no remaining photoresist and regions covered with photoresist; (3) metallizing the surface to form a layer of metal on the region of the surface having no remaining photoresist and on the sides of the regions of photoresist remaining on the surface; and (4) optionally, stripping the photoresist remaining on the surface. DTIC

N95-30765# Fermi National Accelerator Lab., Batavia, IL.
REDUCING PROCESS NOISE IN SUPERCONDUCTING HELIUM LIQUID LEVEL PROBES
J. BRUBAKER Mar. 1995 7 p
Contract(s)/Grant(s): (DE-AC02-76CH-03000)
(DE95-008956; FNAL-TM-1929) Avail: CASI HC A02/MF A01

This memo presents methods to reduce the process noise accompanying the use of superconducting helium liquid level probes in a splashing environment. The development of these methods followed unsatisfactory operation of unmodified, commercially available, level probes used in each of the 24 valve box dewars of Tevatron refrigerators. The dewars function both as reservoirs of refrigeration and as phase separators at the inlet of the cold compressors used in subatmospheric magnet cooling operation. DOE

N95-30787*# General Electric Co., Cincinnati, OH. Aircraft Engines.
THE EFFECT OF INTERFACE PROPERTIES ON NICKEL BASE ALLOY COMPOSITES Final Report
M. GROVES, T. GROSSMAN, M. SENEMEIER, and K. WRIGHT Jul. 1995 89 p
Contract(s)/Grant(s): (NAS3-26501; RTOP 505-63-12)
(NASA-CR-198363; E-9769; NAS 1.26:198363) Avail: CASI HC A05/MF A01

This program was performed to assess the extent to which mechanical behavior models can predict the properties of sapphire fiber/nickel aluminide matrix composites and help guide their development by defining improved combinations of matrix and interface coating. The program consisted of four tasks: 1) selection of the matrices and interface coating constituents using a modeling-based approach; 2) fabrication of the selected materials; 3) testing and evaluation of the materials; and 4) evaluation of the behavior models to develop recommendations. Ni-50Al and Ni-20Al-30Fe (a/o) matrices were selected which gave brittle and ductile behavior, respectively, and an interface coating of PVD YSZ was selected which provided strong bonding to the sapphire fiber. Significant fiber damage and strength loss was observed in the composites which made straightforward comparison of properties with models difficult. Nevertheless, the models selected generally provided property predictions which agreed well with results when fiber degradation was incorporated. The presence of a strong interface bond was felt to be detrimental in the NiAl MMC system where low toughness and low strength were observed. Author

N95-31124# Naval Air Warfare Center, Warminster, PA.
A COMPARISON OF COATING ALTERNATIVES FOR US COAST GUARD AIRCRAFT Final Report, for Apr. 1993 - Aug. 1994
DONALD J. HIRST and STEPHEN J. SPADAFORA 12 Dec. 1994 21 p
(AD-A293270; NAWCADWAR-95014-43) Avail: CASI HC A03/MF A01

Current coatings used on U.S. Coast Guard aircraft contain high volatile organic compound (VOC) contents. Federal, state and local environmental agencies restrict the amount of VOC's from the use of these materials through legislation such as the Clean Air Act and local Air Quality Management District Rules. At the request of the Coast Guard, the Naval Air Warfare Center Aircraft Division Warminster investigated several low VOC candidate replacements to the current paint scheme. The physical performance properties of these materials (i.e. corrosion resistance, adhesion, etc.) were characterized using standard coatings tests. The results of this program show that there are several acceptable alternatives. Replacement of current coating systems would reduce the total amount of hazardous materials emitted from Coast Guard painting operations and eliminate the need for expensive control equipment which will be required by the Clean Air Act (resulting in substantial future cost savings). DTIC

N95-31203 Army Research Lab., Aberdeen Proving Ground, MD. Propulsion and Flight Div.
NUMERICAL SIMULATION OF RAM ACCELERATOR PERFORMANCE INCLUDING TRANSIENT EFFECTS DURING INITIATION OF COMBUSTION AND SENSITIVITY STUDIES
MICHAEL J. NUSCA *In* Johns Hopkins Univ., The 31st JANNAF Combustion Subcommittee Meeting, Volume 1 p 115-128 Oct. 1994
Avail: CPIA, 10630 Little Patuxent Pkwy., Suite 202, Columbia, MD 21044-3200 HC

Computational fluid dynamics solutions of the full Navier-Stokes equations have been used to numerically simulate the reacting in-bore flowfield for the ram accelerator projectile propulsion system. In this system a projectile and obturator are injected at supersonic velocity into a stationary tube filled with a pressurized mixture of hydrocarbon, oxidizer and inert gases. Flow stagnation on the obturator initiates combustion of the mixture. A system of shock waves generated on the projectile, in conjunction with viscous heating, sustains combustion. The resulting energy release, which travels with the projectile, also generates high pressures that impart thrust to the projectile. Numerical simulations utilizing finite-rate chemical kinetics have been used to investigate this flowfield. Numerical results are used to visualize the flowfield, predict effects of variation in system parameters, and predict projectile in-bore velocity. Author

N95-31208 Army Research Lab., Aberdeen Proving Ground, MD.
WORKSHOP REPORT: MEASUREMENT TECHNIQUES IN HIGHLY TRANSIENT, SPECTRALLY RICH COMBUSTION ENVIRONMENTS
TODD E. ROSENBERGER *In* Johns Hopkins Univ., The 31st JANNAF Combustion Subcommittee Meeting, Volume 1 p 345-354 Oct. 1994
Avail: CPIA, 10630 Little Patuxent Pkwy., Suite 202, Columbia, MD 21044-3200 HC

With the emergence of advanced propulsion systems such as liquid propellant (LP), electrothermal-chemical (ETC), electromagnetic (EM), conventional hypervelocity, and in-bore ramjet, the measurement of combustion phenomena has become more complex. the data associated with these systems can be rich in high-frequency components, and share similar transient behavior. Measurement techniques associated with conventional solid propellant systems are not always capable of accurately recording these phenomena. The accuracy of pressure and acceleration measurements in combustion chambers, barrels, and on-board projectiles has been compromised by the lack of a fundamental understanding of the effects of the mounting configuration and the mechanical and electrical components of the transducer on the integrity of the measurement. Consequently, the system development and technical understanding of the physical processes involved in the ignition and combustion of such advanced propulsion systems have been compromised. A workshop was needed to bring together experts from the aforementioned and related communities to disseminate knowledge of lessons learned and to discuss the techniques necessary to make high-fidelity pressure measurements in these environments. This paper states the objectives, identifies the participants who met to address them, provides a list of the technical presentations made, presents highlights from these presentations and the discussions that they prompted, and ends with conclusions and recommendations which came out of the workshop. Author

N95-31268 Combustion Inst., Pittsburgh, PA.
THE 25TH INTERNATIONAL SYMPOSIUM ON COMBUSTION 1994
1824 p Symposium held in Irvine, CA, 31 Jul. - 5 Aug. 1994; sponsored by AFOSR, DOE, NASA, National Institute of Standards & Technology, NSF, ONR, AeroChem Research Laboratories, Inc. Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(ISSN 0082-0784)
(AD-A286825) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

The following topics are discussed: (1) Gasdynamic Enhancement of Nonpremixed Combustion; (2) Navier-Stokes Numerical Simulation of Supersonic Hydrogen-Flourine Combustion in CW Chemical Lasers; (3) Numerical Modeling of Combustion Processes Induced by a Supersonic Conical Blunt Body; (4) Numerical Simulation of Supersonic Mixing and Combustion; (5) The Influence of Equivalence Ratio and Soret Effect on the Ignition of Hydrogen-Air Mixtures in Supersonic Boundary Layers; (6) Cavity-Actuated Supersonic Mixing and Combustion Control; (7) The Application of New Combustion and Turbulence Models to H2-Air Nonpremixed Supersonic Combustion; (8) Reduced Kinetic Mechanism of Ignition for Non-Premixed Hydrogen/Air in a Supersonic Mixing Layer; (9) Accumulating Sequence of Ignitions from a Propagating Pulse; (10) On Deviations from Ideal Chapman-Jouguet Detonation Velocity; (11) Theoretical and Numerical Analysis of the Photochemical Initiation of Detonations in Hydrogen-Oxygen Mixtures; and (12) H2-Air and CH4-Air Detonations and Combustions behind Oblique Shock Waves. DTIC

N95-31368# Army Tank-Automotive Command, Warren, MI.
FUEL-TYPE CLASSIFICATION AND PARAMETERS PREDICTION BY GAS LIQUID CHROMATOGRAPHY ANALYSIS Final Report
DONALD K. MINUS Mar. 1995 84 p
(AD-A293442; TARDEC-TR-13641) Avail: CASI HC A05/MF A01

There is a research effort that envisions having a vehicle mounted petroleum analysis system that could travel close to the frontlines and would provide rapid test results. This system would quicken results feedback time and increase the scope of analyses by using new technologies that could predict several fuel properties and parameters. One approach under consideration for use in this system is Gas Liquid-Phase Chromatography (GLC). To simplify the GLC chromatograph of fuel samples, the data was collected as a series of time-segmented regions. These regions were defined to simulate separations by normal alkanes carbon chain length. The GLC data was analyzed with PIROUETTE correlation software (INFOMETRIX, Seattle, WA) to assign the fuel's type and to predict a selected number of fuel's physical properties. To conduct this study, sixty-seven (67) fuel samples were used of which fifteen were JET A-1/JET As, twelve were JP-4s, nine were JP-8s seven were MOGAS, and three were DF-2s. Preliminary results have included a 100% correct classification as to fuel type and predictions of the 10%, 50%, and 90% distillation. and final boiling point temperatures; and the densities of the samples with relatively low errors of prediction. DTIC

N95-31421*# McDonnell-Douglas Aerospace, Long Beach, CA. Transport Aircraft.
DEVELOPMENT OF STITCHED/RTM PRIMARY STRUCTURES FOR TRANSPORT AIRCRAFT Report, 1 Apr. 1989 - 30 Apr. 1991
ARTHUR V. HAWLEY Jul. 1993 73 p
Contract(s)/Grant(s): (NAS1-18862; RTOP 510-02-11-08)
(NASA-CR-191441; NAS 1.26:191441; MDC-93K0265) Avail: CASI HC A04/MF A01

This report covers work accomplished in the Innovative Composite Aircraft Primary Structure (ICAPS) program. An account is given of the design criteria and philosophy that guides the development. Wing and fuselage components used as a baseline for development are described. The major thrust of the program is to achieve a major cost breakthrough through development of stitched dry preforms and resin transfer molding (RTM), and progress on these processes is reported. A full description is provided on the fabrication of the stitched RTM wing panels. Test data are presented. Author

N95-31471# Illinois Univ., Chicago, IL. Dept. of Civil Engineering Mechanics and Metallurgy.
FAILURE ANALYSIS FOR POLYCARBONATE TRANSPARENCIES Final Report, 1 May 1992 - 1 Sep. 1993
A. CHUDNOVSKY, T. J. CHEN, Z. ZHOU, C. P. BOSNYAK, and K. SEHANOBISH May 1994 45 p
Contract(s)/Grant(s): (F33615-92-C-3405)
(AD-A292992; WL-TR-94-3064) Avail: CASI HC A03/MF A01

Today polymers are increasingly used in advanced structural applications such as aircraft canopies. However, there are no well established models which could be used by design engineers for predicting time to failure for these materials. Development of adequate criteria for three basic stages of fracture (crack initiation, stable crack growth and dynamic crack propagation) is necessary for the accurate prediction of service lifetime. Part 1 of this report reflects a recent progress in understanding of various failure initiation mechanisms in transparency-grade Polycarbonate (PC). A new fatigue crack initiation map for PC is proposed. Another important stage of the fracture process which may strongly influence the total lifetime is crack propagation. Propagation of a crack surrounded by the process zone is a well-known phenomenon for the PC. The properties of the material in the process zone may strongly influence such critical fracture parameters as lifetime, fracture toughness, etc. The deformation of PC by shear banding at a notch-tip was found very similar to that obtained by cold-drawing of PC. In Part 2 of this report the tensile cold-drawing (necking) behavior of PC is further examined using simple tensile extension coupled with temperature measurements via an infrared camera. DTIC

N95-31767*# Battelle Memorial Inst., Columbus, OH.
ALTERNATIVES TO OZONE DEPLETING REFRIGERANTS IN TEST EQUIPMENT
RICHARD L. HALL and MADELEINE R. JOHNSON
(Aerospace Guidance and Metrology Center, Newark Air Force Station, OH.) *In* NASA. Marshall Space Flight Center, Aerospace Environmental Technology Conference p 225-232 Mar. 1995
Avail: CASI HC A02/MF A06

This paper describes the initial results of a refrigerant retrofit project at the Aerospace Guidance and Metrology Center (AGMC) at Newark Air Force Base, Ohio. The objective is to convert selected types of test equipment to properly operate on hydrofluorocarbon (HFC) alternative refrigerants, having no ozone depleting potential, without compromising system reliability or durability. This paper discusses the primary technical issues and summarizes the test results for 17 different types of test equipment: ten environmental chambers, two ultralow temperature freezers, two coolant recirculators, one temperature control unit, one vapor degreaser, and one refrigerant recovery system. The postconversion performance test results have been very encouraging: system capacity and input power remained virtually unchanged. In some cases, the minimum operating temperature increased by a few degrees as a result of the conversion, but never beyond AGMC's functional requirements. Author

N95-31768*# Department of the Air Force, Wright-Patterson AFB, OH.
ENVIRONMENTALLY SAFE AVIATION FUELS
PATRICIA D. LIBERIO *In* NASA. Marshall Space Flight Center, Aerospace Environmental Technology Conference p 233-237 Mar. 1995
Avail: CASI HC A01/MF A06

In response to the Air Force directive to remove Ozone Depleting Chemicals (ODC's) from military specifications and Defense Logistics Agency's Hazardous Waste Minimization Program, we are faced with how to ensure a quality aviation fuel without using such chemicals. Many of these chemicals are found throughout the fuel and fuel related military specifications and are part of test methods that help qualify the properties and quality of the fuels before they are procured. Many years ago there was a directive for military specifications to use commercially standard test methods in order to provide standard testing in private industry and government. As a result the test methods used in military specifications are governed by the American Society of Testing and Materials (ASTM). The Air Force has been very proactive in the removal or replacement of the ODC's and hazardous materials in these test methods. For example, ASTM D3703 (Standard Test Method for Peroxide Number of Aviation Turbine Fuels), requires the use of Freon 113, a known ODC. A new rapid, portable hydroperoxide test for jet fuels similar to ASTM D3703 that does not require the use of ODC's has been developed. This test has proved, in limited testing, to be a viable substitute method for ASTM D3703. The Air Force is currently conducting a round robin to allow the method to be accepted by ASTM and therefore replace the current method. This paper will describe the Air Force's initiatives to remove ODC's and hazardous materials from the fuel and fuel related military specifications that the Air Force Wright Laboratory. Author

N95-31773*# Boeing Defense and Space Group, Seattle, WA.
CADMIUM PLATING REPLACEMENTS
MARY J. NELSON and EARL C. GROSHART *In* NASA. Marshall Space Flight Center, Aerospace Environmental Technology Conference p 277-284 Mar. 1995
Avail: CASI HC A02/MF A06

The Boeing Company has been searching for replacements to cadmium plate. Two alloy plating systems seem close to meeting the needs of a cadmium replacement. The two alloys, zinc-nickel and tin-zinc are from alloy plating baths; both baths are neutral pH. The alloys meet the requirements for salt fog corrosion resistance, and both alloys excel as a paint base. Currently, tests are being performed on standard fasteners to compare zinc-nickel and tin-zinc on threaded hardware where cadmium is heavily used. The Hydrogen embrittlement propensity of the zinc-nickel bath has been tested, and just beginning for the tin-zinc bath. Another area of interest is the electrical properties on aluminum for tin-zinc and will be discussed. The zinc-nickel alloy plating bath is in production in Boeing Commercial Airplane Group for non-critical low strength steels. The outlook is promising that these two coatings will help The Boeing Company significantly reduce its dependence on cadmium plating. Author

N95-31775*# Northrop Grumman Corp., Pico Rivera, CA. Environmentally Technology Development.
ENVIRONMENTALLY REGULATED AEROSPACE COATINGS
VIRGINIA L. MORRIS *In* NASA. Marshall Space Flight Center, Aerospace Environmental Technology Conference p 295-305 Mar. 1995
Avail: CASI HC A03/MF A06

Aerospace coatings represent a complex technology which must meet stringent performance requirements in the protection of aerospace vehicles. Topcoats and primers are used, primarily, to protect the structural elements of the air vehicle from exposure to and subsequent degradation by environmental elements. There are also many coatings which perform special functions, i.e., chafing resistance, rain erosion resistance, radiation and electric effects, fuel tank coatings, maskants, wire and fastener coatings. The scheduled promulgation of federal environmental regulations for aerospace manufacture and rework materials and processes will regulate the emissions of photochemically reactive precursors to smog and air toxics. Aerospace organizations will be required to identify, qualify and implement less polluting materials. The elimination of ozone depleting chemicals (ODC's) and implementation of pollution prevention requirements are added constraints which must be addressed concurrently. The broad categories of operations affected are the manufacture, operation, maintenance, and repair of military, commercial, general aviation, and space vehicles. The federal aerospace regulations were developed around the precept that technology had to be available to support the reduction of organic and air toxic emissions, i.e., the regulations cannot be technology forcing. In many cases, the regulations which are currently in effect in the South Coast Air Quality Management District (SCAQMD), located in Southern California, were used as the baseline for the federal regulations. This paper addresses strategies used by Southern California aerospace organizations to cope with these regulatory impacts on aerospace productions programs. All of these regulatory changes are scheduled for implementation in 1993 and 1994, with varying compliance dates established. Author

N95-31778*# San Antonio Air Logistics Center, Kelly AFB, TX. Aircraft Production Div.
BICARBONATE OF SODA PAINT STRIPPING PROCESS VALIDATION AND MATERIAL CHARACTERIZATION
MICHAEL N. HAAS *In* NASA. Marshall Space Flight Center, Aerospace Environmental Technology Conference p 325-329 Mar. 1995
Avail: CASI HC A01/MF A06

The Aircraft Production Division at San Antonio Air Logistics Center has conducted extensive investigation into the replacement of hazardous chemicals in aircraft component cleaning, degreasing, and depainting. One of the most viable solutions is process substitution utilizing abrasive techniques. SA-ALC has incorporated the use of Bicarbonate of Soda Blasting as one such substitution. Previous utilization of methylene chloride based chemical strippers and carbon removal agents has been replaced by a walk-in blast booth in which we remove carbon from engine nozzles and various gas turbine engine parts, depaint cowlings, and perform various other functions on a variety of parts. Prior to implementation of this new process, validation of the process was performed, and materials and waste stream characterization studies were conducted. These characterization studies examined the effects of the blasting process on the integrity of the thin-skinned aluminum substrates, the effects of the process on both air emissions and effluent disposal, and the effects on the personnel exposed to the process. Author

N95-31798*# AC Engineering, Inc., Huntsville, AL.
STANDARDIZATION OF SURFACE CONTAMINATION ANALYSIS SYSTEMS
RICHARD E. BOOTHE *In* NASA. Marshall Space Flight Center, Aerospace Environmental Technology Conference p 517-524 Mar. 1995
Avail: CASI HC A02/MF A06

Corrosion products, oils and greases can potentially degrade material bonding properties. The Marshall Space Flight Center (MSFC) Surface Contamination Analysis Team (SCAT) utilizes a variety of analytical equipment to detect identify and quantify contamination on metallic and non-metallic substrates. Analysis techniques include FT-IR Microscopy (FT-IR), Near Infrared Optical Fiber Spectrometry (NIR), Optically Stimulated Electron Emission (OSEE), Ultraviolet Fluorescence (UVF) and Ellipsometry. To insure that consistent qualitative and quantitative information are obtained, standards are required to develop analysis techniques, to establish instrument sensitivity to potential contaminants, and to develop calibration curves. This paper describes techniques for preparing and preserving contamination standards. Calibration of surface contamination analysis systems is discussed, and methods are presented for evaluating the effects of potential contaminants on bonding properties. Author

12 ENGINEERING

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

A95-92405

NATURAL CONVECTION IN CENTRAL MICROCAVITIES OF VERTICAL, FINNED ENCLOSURES OF VERY HIGH ASPECT RATIOS

RAMON L. FREDERICK Universidad de Chile, Santiago, Chile and ALVARO VALENCIA International Journal of Heat and Fluid Flow (ISSN 0142-727X) vol. 16, no. 2 April 1995 p. 114-124 refs
(BTN-95-EIX95282711336) Copyright

Natural convection in the central microcavities of vertical, finned cavities of very high aspect ratios were numerically investigated using a spacewise periodical approach. When equally spaced fins are located on both active walls (problem b), different circulation rates are found in two consecutive microcavities. The average Nusselt number in a region comprising two consecutive microcavities is higher than the one observed when the fins are attached to only one of the active walls (problem a). The dependence of microcavity circulation rates and heat transfer on Rayleigh number, dimensionless fin length, and microcavity aspect ratio is discussed. The limits of applicability of the spacewise periodical approach are also outlined. Author (EI)

A95-92408

MEASUREMENT IN LAMINAR AND TRANSITIONAL BOUNDARY-LAYER FLOWS ON CONCAVE SURFACE

D. H. ZHANG Natl Univ of Singapore, Singapore, Singapore, S. H. WINOTO, and Y. T. CHEW International Journal of Heat and Fluid Flow (ISSN 0142-727X) vol. 16, no. 2 April 1995 88-98 refs
(BTN-95-EIX95282711333) Copyright

Measurements of streamwise mean and fluctuating velocities in laminar and transitional boundary-layer flows on a concave surface of 2.0 m radius of curvature have been performed using hot-wire anemometry technique. A new turbulent intermittency detector method was used to calculate the intermittency factor. In addition to the spanwise distributions of mean velocity, the profiles of mean, fluctuating velocities and intermittency across the boundary layer at two different spanwise positions, namely, the upwash and downwash, are also presented. The experimental results show that the normal and spanwise distributions of mean velocity, normal turbulence intensity U'(sub rms)/U(sub 0) profiles experience different streamwise evolutions in the laminar and transition regions. Significant velocity profile distortion, saturated growth of Goertler vortices, and the existence of two peaks in U'(sub rms)/U(sub 0) profiles are the main features of the boundary-layer flow at the onset of transition. The intermittency profiles in the early stages of transition at the two spanwise positions have some similar characteristics and are not consistent with each other on some other aspects. Comparisons of the gamma profiles at the two spanwise positions confirm that the transition first starts at the low-speed regions. Author (EI)

A95-92471

EFFECTS OF FREE-STREAM TURBULENCE INTENSITY ON A BOUNDARY LAYER RECOVERING FROM CONCAVE CURVATURE EFFECTS

M. D. KESTORAS Univ of Nantes, Nantes, France and T. W. SIMON Journal of Turbomachinery, Transactions of the ASME (ISSN 0889-504X) vol. 117, no. 2 April 1995 p. 240-247
(BTN-95-EIX95282710058) Copyright

In an attempt to characterize the turbulence characteristics of the high free-stream turbulence (TI approximately 8%) flow, several experiments are conducted on a flat recovery wall downstream of sustained concave curvature in the presence of such flow. A turbulent boundary layer that grows from the leading edge of a concave wall, then passes onto a downstream flat wall is considered. The results indicate that turbulence intensities increase profoundly in the outer region of the boundary layer over the recovery wall. The recovery wall is found to be lifted off by near-wall turbulent eddies while a 'stabilized' region forms near the wall. Contrary to the low-free-stream turbulence intensity flow, turbulent eddies penetrate the outer parts of the 'stabilized' region. The behavior of the Stanton numbers as well as the velocity distribution on the core of the flow are also accounted for. EI

A95-92472

EXPERIMENTAL INVESTIGATION OF THE FLOW IN DIFFUSERS BEHIND AN AXIAL FLOW COMPRESSOR

T. ZIERER ABB Power Generation Ltd, Baden, Switzerland Journal of Turbomachinery, Transactions of the ASME (ISSN 0889-504X) vol. 117, no. 2 April 1995 p. 231-239
(BTN-95-EIX95282710057) Copyright

The flow fields of four diffusers situated at the rear of a one-stage axial flow compressor were experimentally investigated. Through modification of the compressor operating point, a wide range of variations of the side wall boundary layers and the radial velocity distribution outside of the boundary layers at diffuser inlet could be achieved. The three-dimensional flow field at both diffuser inlet and outlet is analyzed. Changes of inlet blockage and radial velocity distribution and their resulting effects on pressure recovery are thoroughly presented. Compared with the results of measurements at diffusers, typically with ducted flow inlet conditions, higher values of pressure recovery are observed. Established design rules, based on investigations of diffusers with carefully developed inlet flow, are checked regarding their applicability for diffusers in turbomachine environments. Author (EI)

A95-92473

NUMERICAL CALCULATIONS OF THE TURBULENT FLOW THROUGH A CONTROLLED DIFFUSION COMPRESSOR CASCADE

SHIN-HYOUNG KANG Seoul Natl Univ, Seoul, Korea, Republic of, JOON SIK LEE, MYUNG-RYUL CHOI, and KYUNG-YUP KIM Journal of Turbomachinery, Transactions of the ASME (ISSN 0889-504X) vol. 117, no. 2 April 1995 p. 223-230
(BTN-95-EIX95282710056) Copyright

The viscous flow through a controlled diffusion (CD) compressor cascade was calculated and compared with the measured data for two different test conditions. A control volume method was used, which has been developed for a generalized nonorthogonal coordinate system. The discretized equations for the physical covariant velocity components were obtained by an algebraic manipulation of the discretized equations for the Cartesian velocity components. Low Reynolds number k-epsilon turbulence models were used to obtain the eddy viscosity. The numerical scheme using the low Reynolds number k-epsilon turbulence model reasonably predicted the general performance, i.e, mean outlet flow angle and loss coefficients. The development of the shear layer along the pressure and suction sides was well estimated, and the physical features found in the experiment were reasonably well confirmed in the simulation. However, the calculated profiles of mean velocity and turbulent kinetic energy in the near wake show considerable disagreement with the measured values. Author (EI)

A95-92474

SIMULATION OF THE UNSTEADY INTERACTION OF A CENTRIFUGAL IMPELLER WITH ITS VANED DIFFUSER: FLOW ANALYSIS

W. N. DAWES Whittle Lab, Cambridge, United Kingdom Journal of Turbomachinery, Transactions of the ASME (ISSN 0889-504X) vol. 117, no. 2 April 1995 p. 213-222

(BTN-95-EIX95282710055) Copyright

The aim of this paper is to help advance our understanding of the complex, three-dimensional, unsteady flow associated with the interaction of a splittered centrifugal impeller and its vaned diffuser. A time-resolved simulation is presented of the Krain stage performed using a time-accurate, three-dimensional, unstructured mesh, solution-adaptive Navier-Stokes solver. The predicted flowfield, compared with experiment where available, displays a complex, unsteady interaction, especially in the neighborhood of the diffuser entry zone, which experiences large periodic flow unsteadiness. Downstream of the throat, although the magnitude of this unsteadiness diminishes rapidly, the flow has a highly distorted three-dimensional character. The loss levels in the diffuser are then investigated to try and determine how time-mean loss levels compare with the levels expected from 'equivalent' steady flow analysis performed by using the circumferentially averaged exit flow from the impeller as inlet to the diffuser. It is concluded that little loss could be attributed directly to unsteady effects but rather that the principal cause of the rather high loss levels observed in the diffuser is the strong spanwise distortion in swirl angle at inlet, which initiates a strong hub/corner stall. Author (EI)

A95-92475

DESIGN AND DEVELOPMENT OF AN ADVANCED TWO-STAGE CENTRIFUGAL COMPRESSOR

D. L. PALMER Light Helicopter Turbine Engine Co, Phoenix, AZ, United States and W. F. WATERMAN Journal of Turbomachinery, Transactions of the ASME (ISSN 0889-504X) vol. 117, no. 2 April 1995 p. 205-212 refs

(BTN-95-EIX95282710054) Copyright

This paper describes the aeromechanical design and development of a 3.3 kg/s (7.3 lb/sec), 14:1 pressure ratio two-stage centrifugal compressor, which is used in the T800-LHT-800 helicopter engine. The design employs highly nonradial, splitter bladed impellers with swept leading edges and compact vaned diffusers to achieve high performance in a small and robust configuration. The development effort quantified the effects of impeller diffusion and passive inducer shroud bleed on surge margin as well as the effects of impeller loading on tip clearance sensitivity and the impact of sand erosion and shroud roughness on performance. The developed compressor exceeded its performance objectives with a minimum of 23 percent surge margin without variable geometry. The compressor provides a high-performance, rugged, low-cost configuration ideally suited for helicopter applications. Author (EI)

A95-92511

MAINTENANCE-FREE LEAD ACID BATTERY FOR INERTIAL NAVIGATION SYSTEMS AIRCRAFT

WILLIAM R. JOHNSON NSWC, Crane, IN, United States and DAVID G. VUTETAKIS IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985) vol. 10, no. 5 May 1995 p. 3-6 refs

(BTN-95-EIX95292721316) Copyright

Historically, Aircraft Inertial Navigation System (INS) Batteries have utilized vented nickel-cadmium batteries for emergency DC power. The United States Navy and Air Force developed separate systems during their respective INS developments. The Navy contracted with Litton Industries to produce the LTN-72 and Air Force contracted with Delco to produce the Carousel IV INS for the large cargo and specialty aircraft applications. Over the years, a total of eight different battery national stock numbers (NSNs) have entered the stock system along with 75 battery spare part NSNs. The Standard Hardware Acquisition and Reliability Program is working with the Aircraft Battery Group at Naval Surface Warfare Center Crane Division, Naval Air Systems Command (AIR 536), Wright Laboratory, Battelle Memorial Institute, and Concorde Battery Corporation to produce a standard INS battery. This paper discusses the approach taken to determine whether the battery should be replaced and to select the replacement chemistry. The paper also discusses the battery requirements, aircraft that the battery is compatible with, and status of Navy flight evaluation. Projected savings in avoided maintenance in Navy and Air Force INS Systems is projected to be $14.7 million per year with a manpower reduction of 153 maintenance personnel. The new INS battery is compatible with commercially sold INS systems which represents 66 percent of the systems sold. Author (EI)

A95-92751

DISCRETE CRACK GROWTH ANALYSIS METHODOLOGY FOR THROUGH CRACKS IN PRESSURIZED FUSELAGE STRUCTURES

DAVID O. POTYONDY Cornell Univ Fracture Group, Ithaca, NY, United States, PAUL A. WAWRZYNEK, and ANTHONY R. INGRAFFEA International Journal for Numerical Methods in Engineering (ISSN 0029-5981) vol. 38, no. 10 May 30 1995 p. 1611-1633 refs

(BTN-95-EIX0608952737538) Copyright

A methodology for simulating the growth of long through cracks in the skin of pressurized aircraft fuselage structures is described. Crack trajectories are allowed to be arbitrary and are computed as part of the simulation. The interaction between the mechanical loads acting on the superstructure and the local structural response near the crack tips is accounted for by employing a hierarchical modelling strategy. The structural response for each cracked configuration is obtained using a geometrically non-linear shell finite element analysis procedure. Four stress intensity factors, two for membrane behavior and two for bending using Kirchhoff plate theory, are computed using an extension of the modified crack closure integral method. Crack trajectories are determined by applying the maximum tangential stress criterion. Crack growth results in localized mesh deletion, and the deletion regions are remeshed automatically using a newly developed all-quadrilateral meshing algorithm. The effectiveness of the methodology, and its applicability to performing practical analyses of realistic structures, is demonstrated by simulating curvilinear crack growth in a fuselage panel that is representative of a typical narrow-body aircraft. The predicted crack trajectory and fatigue life compare well with measurements of these same quantities from a full-scale pressurized panel test. Author (EI)

A95-93316* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

COMPARISON OF COORDINATE-INVARIANT AND COORDINATE-ALIGNED UPWINDING FOR THE EULER EQUATIONS

PETER M. HARTWICH ViGYAN, Inc., Hampton, VA, US AIAA Journal (ISSN 0001-1452) vol. 32, no. 9 September 1994 p. 1791-1799

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(HTN-95-A1753) Copyright

A floating-shock fitting method for the Euler equations has been developed that uses one-sided spatial differences along and across streamlines. The coordinate-invariant formulation of the spatial differences permits automatic capture of shears. Results are presented for unsteady shocked flow in a duct with a ramp, for supercritical flow over a circular cylinder, and for subsonic, transonic, and supersonic (0.3 is less than or equal to M(sub infinity) is less than 1.5) flow over airfoils. In flows with strong shears, the coordinate-invariant differencing concept appears to yield some gains in accuracy over Euler methods that rely on coordinate-aligned differencing concepts. In applications to transonic airfoils, fitted shocks have a tendency to be predicted upstream of captured shocks, regardless of whether coordinate-invariant or coordinate-aligned differencing is used. The coordinate-invariant differencing method requires between 2 and 3.5 times as much computing time as its coordinate-aligned counterpart. Author (Hemer)

A95-93318

IMPLICIT MULTIBLOCK EULER AND NAVIER-STOKES CALCULATIONS

CARL B. JENSSEN Norwegian Inst. of Tech., Trondheim, Norway AIAA Journal (ISSN 0001-1452) vol. 32, no. 9 September 1994 p. 1808-1814
Research sponsored by Royal Norwegian Council for Scientific and Industrial Research
(HTN-95-A1755) Copyright

Implicit multiblock computations have been carried out for a large number of blocks using explicit coupling between the blocks. The convergence rate of this method is very sensitive to the block partitioning. For the Navier-Stokes equations the height of the blocks should be greater than the boundary-layer thickness. Also, excessively thin blocks will cause breakdown of the algorithm. For transonic calculations the best convergence rate was obtained using a red-black Gauss-Seidel approach. It is concluded that the method is well suited for massively parallel computers. Author (Herner)

A95-93337

TURBULENT FLOW MWASUREMENTS WITH A TRIPLE-SPLIT HOT-FILM PROBE

M. D. DOIRON Toronto Univ., Toronto, Canada and D. W. ZINGG Toronto Univ., Toronto, Canada AIAA Journal (ISSN 0001-1452) vol. 32, no. 9 September 1994 p. 1929-1931
(HTN-95-A1774) Copyright

Complex turbulent shear flows occur in many aerospace applications, such as aerodynamic devices and gas turbine engines. Measurements of mean and fluctuating velocity components can greatly aid our understanding of such flows. Experimental data are particularly useful in assessing and validating turbulence models used in computational fluid dynamics codes. Velocity measurements are generally made using a pitot-static tube, a constant temperature hot-wire anemometer, or a laser Doppler anemometer (LDA). For separated turbulent flows, pitot-static tubes and conventional hot-wire probes are generally inapplicable. Because of the high cost of LDA measurements, modified hot-wire techniques have been developed which are suitable for reversed flows. These include pulsed hot wires and flying hot wires. Disadvantages of these approaches are discussed by Nakayama. Triple-split hot-film probes are a potentially useful alternative for velocity measurements in separated turbulent flows. Such probes typically consist of three separate films deposited on a cylinder. The operating principle is based on the variation of the local heat transfer coefficient on a cylinder with the magnitude and direction of the oncoming flow velocity. Most studies involving split-film anemometry have been with double-split hot-film probes. These operate on the same principle but retain the directional ambiguity of conventional hot wires and, hence, are not applicable to separated turbulent flows. The results of these studies indicate that split-film probes provide comparable accuracy to hot-wire probes for mean velocities but have a more limited frequency response. Despite their potential, especially for measurements of mean velocities, triple-split hot-film probes have received little use. The only example of their use known to the authors is reported by Modera, who used a triple-split probe for low-frequency reversed flow measurements over a 0 - 8 m/s flow speed range. The purpose of this Note is to demonstrate that the triple-split hot-film probe can be very useful for measurements of mean velocities in separated turbulent flows. Further details of the present study are given. Author (Herner)

A95-93637

ELECTROMAGNETIC COMPATIBILITY - A GENERAL OVERVIEW

M. J. WOOD 1991 5 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 38: Ground Support & Airport Equipment)
(CONGRESS PAPER C428-38-084; HTN-95-21206) Copyright

The initial flight was not known to be affected by electromagnetic interference. Had it of done it would have sown the seeds for electromagnetic compatibility (EMC). however, it was not until the introduction of electric / electronic navigational aids and communications that the effects were realized. The definition of electromagnetic compatibility (EMC) is: The ability of electrical and electronic equipments, sub systems and systems to share the electomagnetic spectrum and perform their desired function without unacceptable degradation from or to the specified electomagnetic enviromnment. In other words the equipment must work without causing interference or being upset by interference from d. c. to light frequencies. Author (Herner)

A95-93640

LASER PROCESSING AIRCRAFT AND TURBINE ENGINE PARTS

TERRY L. VANDERWERT (ISSN 0148-7191) 1993 4 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993
(SAE PAPER 931356; HTN-95-21209) Copyright

Multi-axis laser machining systems are having a significant impact on the way formed aircraft and turbine engine parts are being cut, drilled and welded. For example, laser cutting has replaced milling for trimming a deep drawn gas turbine engine part and increased throughput from 18 pieces per day to 18 pieces in 30 minutes. Building on unique capabilities of laser processing, modern multiaxis laser systems incorporate a wide range of sensors, high speed computer controls and software, and automated work handling to solve industrial part manufacturing problems. The objective of this paper is to review current industrial applications of laser systems and how they are satisfying demands for higher quality, greater flexibility and faster turnaround on prototype and production aerospace parts. Author (Herner)

A95-93646

LASER VELOCIMETRY IN THE SUPERSONIC REGIME: ADVANCEMENTS, LIMITATIONS, AND OUTLOOK

MARK S. MAURICE, LINDA G. SMITH, GEORGE L. SEIBERT, CHARLES TYLER, and C. DEAN MILLER (ISSN 0148-7191) 1993 11 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993
(SAE PAPER 931365; HTN-95-21215) Copyright

Laser Velocimetry (LV) is often utilized as an off-the-shelf nonintrusive measurement technique for low speed, steady state flows. However, in complex, supersonic flows, the application of LV becomes highly specialized. Set-ups must often contend with limited optical access, poor signal-to-noise ratios, and limited tunnel run times. Furthermore, seeding particles must survive large ranges of flow temperatures and pressures, and extensive data analysis and interpretation are required to ascertain whether measured particle velocities are representative of the fluid flow. Several examples of LV studies in the supersonic regime demonstrate recent advancements and the current state-of-the-art of this measurement technique. Results are included from three wind tunnel facilities, operating at freestream Mach numbers of 1.9, 3, and 6, and track an evolution of applications from flat plate boundary layers to the complex flowfield of a supersonic inlet. Results demonstrate that further development of collection, seeding and analysis techniques will continue to extend the range of LV applications and measurement statistics, but the overall limiting factor will continue to be the ability of LV seed to model the discrete motion of fluid molecules. Author (Herner)

A95-93669

ADVANCED PASSIVE COOLING FOR HIGH POWER ELECTROMECHANICAL ACTUATORS

M. G. SCHNEIDER Sunstrand Aerospace, Rockford, IL, US and T. J. BLAND Sunstrand Aerospace, Rockford, IL, US (ISSN 0148-7191) 1993 11 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993
Contract(s)/Grant(s): (F33615-91-C-2139)
(SAE PAPER 931397; HTN-95-21238) Copyright

A passive cooling approach for the aircraft electromechanical actuators is being developed to support the Air Force More Electric Airplane (MEA) program. A two-phase coolant is used in a reflux type cooler to transport heat from the actuator electric motor to a cool aircraft structural surface. Energy storage, in the form of phase change matereial, is incorporated into the cooler to provide load leveling between peak loads and low loads. Transient thermal analysis, which was used to select the best combination of reflux working fluid and phase change material, indicates that motor temperatures can be reduced by more than 50 C when using thermal energy storage. Author (Hemer)

A95-93693

LIGHTWEIGHT HIGH-TEMPERATURE FUEL METERING VALVES

JOE BENNETT (ISSN 0148-7191) 1993 12 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993

(SAE PAPER 931444; HTN-95-21262) Copyright

AlliedSignal Fluid systems has provided fuel metering valve hardware to three aircraft engine manufacturers for evaluation. Two of the progams were Integrated High Performance Turbine Engine Technology (IHPTET) related. The third program was an IR&D effort. Bench tests and evaluation of all three valve designs have been completed, and one of the designs has actually been used for engine test. Engine testing of the other two valve designs is planned for the future. These three designs are similar, but each is intended to be ususéd in different system configurations, and each valve design offers unique features. The design approaches used for the three valve designs incorporate several new and innovative technologies, including high-temperature brushless dc motor actuators, low-pressure loss metering element design, fiber optic rotarty output position sensor, no-moving-parts oscillating jet flow meter, high-temperature RS (rapid solidification) aluminum alloy, high-temperature elastomeric seals, high-pressure shutoff capabilities, and closed loop electronic fuel flow metering. Author (Hemer)

A95-93698

DYNAMIC STIFFNESS AND DAMPING OF FOIL BEARINGS FOR GAS TURBINE ENGINES

WALTER L. MEACHAM, R. M. FRED KLAASS, RON DAYTON USAF, Wright Lab., US, and ED DURKIN USAF, Wright Lab., US (ISSN 0148-7191) 1993 9 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993

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(SAE PAPER 931449; HTN-95-21267) Copyright

Foil bearings have been used since the 1970s in low temperature (600 F) application. However, adapting this type of hydrodynamic air bearing to the high temperature (1200 F) environment of gas turbine engines has been slow, due to suspected low damping values. Foil bearings develop mechanical interactions, thought to generate coulomb damping, which affects the dynamic characteristics - dynamic stiffness and damping, the primary factors influencing dynamic stability of rotor-bearing systems - of such a bearing. This paper reports on a program of experiments to identify the design parameters affecting foil bearing dynamic. A fractional factorial technique characterized the effects of the primary independent design parameters and their interactions. Results are presented for eight test bearings, with an analysis of variance used to determine the optimum configuration and show how it can improve the stability of a typical gas turbine engine. Author (Hemer)

A95-93703

STABILITY ANALYSIS FOR ELASTICALLY TAILORED ROTOR BLADES

MARK V. FULTON Georgia Inst. of Technology, Atlanta, GA, US and DEWEY H. HODGES Georgia Inst. of Technology, Atlanta, GA, US *In* Developments in theoretical and applied mechanics; Southeastern Conference on Theoretical and Applied Mechanics, 16th, Nashville, TN, April 12-14, 1992. A95-93700 Tullahoma, TN The Univ. of Tennessee Space Inst. (SECTAM, Vol. 16) 1992 p. II.3.12-II.3.18

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A finite element based stability analysis is developed for a hingeless, composite, isolated rotor in hover. It includes a mechanism for the inclusion of a complete 6 x 6 stiffness matrix, as well as the effects of rotary inertia. No restrictions are made on the magnitudes of the displacements and rotations if the magnitudes of the strains remain small compared to unity. The equilibrium position is obtained by an iterative solution of the complete nonlinear equations. The dynamic equations are linearized about this position, yielding and eigenproblem. The lift model is a two-dimensional, quasi-steady strip theory, with inflow taken from momentum theory. Author (Hemer)

A95-93723

THE COPLANAR PROJECTILE MOTION PROBLEM INCLUDING THE EFFECTS OF LIFT AND DRAG

T. L. CAIPEN U.S. Air Force Academy, CO, US and S. E. JONES U.S. Air Force Academy, CO, US *In* Developments in theoretical and applied mechanics; Southeastern Conference on Theoretical and Applied Mechanics, 16th, Nashville, TN, April 12-14, 1992. A95-93700 Tullahoma, TN The Univ. of Tennessee Space Inst. (SECTAM, Vol. 16) 1992 p. II.8.33-II.8.40 Research sponsored by the Frank J. Seiler Research Lab.

(ISBN 1-879921-01-4) Copyright

An accurate appoximate solution to an elementary projectile motion problem is presented. The effects of velocity-squared lift and drag are included. Several examples are given which demonstrate the validity of the solution and offers a means of determining the conditions under which the approximation can be expected to succeed. Author (Hemer)

A95-93728* National Aeronautics and Space Administration, Wash., DC.

LOW GRAVITY QUENCHING OF HOT TUBES WITH CRYOGENS

BASIL N. ANTAR The Univ. of Tennessee Space Inst., Tullahoma, TN, US, FRANK G. COLLINS The Univ. of Tennessee Space Inst., Tullahoma, TN, US, and M. KAWAJI The Univ. of Toronto, Toronto, Ontario, Canada *In* Developments in theoretical and applied mechanics; Southeastern Conference on Theoretical and Applied Mechanics, 16th, Nashville, TN, April 12-14, 1992. A95-93700 Tullahoma, TN The Univ. of Tennessee Space Inst. (SECTAM, Vol. 16) 1992 p. II.9.39-II.9.45 Research sponsored by the Office of Space Commercialization, Boeing Aerospace Corp., and Canadian Space Agency

(ISBN 1-879921-01-4) Copyright

An experimental proceedure for examining flow boiling in low gravity environment is presented. The proceedure involves both ground based and KC-135 flight experiments. Two experimental apparati were employed, one for studying subcooled liquid boiling and another for examining saturated liquid boiling. For the saturated flow experiments, liquid nitrogen was used while freon 113 was used for the subcooled flow experiments. The boiling phenomenon was investigated in both cases using flow visualization techniques as well as tube wall temperature measurements. The flow field in both cases was established by injecting cold liquid in a heated tube whose temperature was set above the saturation values. The tubes were both vertically and horizontally supported with the liquid injected from the lower end of the tube. The results indicate substantial differences in the flow patterns established during boiling between the ground based, (1-g), experiments and the flight experiments, (low-g). These differences in the flow patterns will be discussed and some explanations will be offered. Author (Hemer)

A95-93735

A NOTE ON THE KUTTA-JOUKOWSKI FORMULA

JOHN CARUTHERS The Univ. of Tennessee Space Inst., Tullahoma, TN, US, HUI-YANG MA Graduate School of Chinese Academia Sinica, Beijing, China, and JIE-ZHI WU The Univ. of Tennessee Space Inst., Tullahoma, TN, US *In* Developments in theoretical and applied mechanics; Southeastern Conference on Theoretical and Applied Mechanics, 16th, Nashville, TN, April 12-14, 1992. A95-93700 Tullahoma, TN The Univ. of Tennessee Space Inst. (SECTAM, Vol. 16) 1992 II.14.43-II.14.51

(ISBN 1-879921-01-4) Copyright

In this note some clarifications are made concerning the understanding and use of the classical Kutta-Joukowski lift formula L = rho U Gamma. First, the viscous source of this lift (although it has been a very well-known fact) is re-emphasized, since its inviscid derivation in many text books still caused confusion, especially among student readers. Second, it is directly shown that, unlike some authors have conceived, such a lift does not exist if a solid rotating cylinder is replaced by a Rankine vortex. In other words, the formula is applicable to solid body with circulation only. However, it is demonstrated that a Rankine vortex enveloped by a singular vortex sheet will initially experience a side force, but only rho U Gamma/2. Author (Herner)

A95-94057

APPLICATION OF INTEGRAL METHODS TO ABLATION CHARRING EROSION, A REVIEW

ROBERT L. POTTS Science Applications Int Corp, Torrance, CA, United States Journal of Spacecraft and Rockets (ISSN 0022-4650) vol. 32, no. 2 March-April 1995 p. 200-209 refs
(BTN-95-EIX95302694460) Copyright

To predict ablation, charring, and erosion of heat-shield materials, approximate heat balance integral (HBI) methods offer speed and versatility; however, traditional HBI articles treat only simple, idealized models of material response. This paper reviews application of HBI methods to more realistic models of material response, specifically, for carbon-carbon and carbon-phenolic heat shields on reentry vehicles. The review shows that HBI successfully extends to most such simulations of ablation, charring, and erosion in hypersonic flow, but unexpected problems can crop up and trade-offs exist. Pertinent material models are also summarized, including efficient expressions that fit material thermal properties and carbon-air thermochemical ablation functions. Author (EI)

A95-94058

ENHANCEMENTS TO INTEGRAL SOLUTIONS TO ABLATION AND CHARRING

SCOTT A. LEONE Science Applications Int Corp, Fort Washington, PA, United States, ROBERT L. POTTS, and ANTHONY L. LAGANELLI Journal of Spacecraft and Rockets
(ISSN 0022-4650) vol. 32, no. 2 March-April 1995 p. 210-216 refs
(BTN-95-EIX95302694461) Copyright

Two new enhancements to the heat-balance integral (HBI) technique improve the rapid prediction of aerothermal response of heat shields of high-speed vehicles. The first enhancement uses a generalized cubic in-depth thermal profile to mitigate the well-known overreaction of classical HBI techniques to rapid changes in aerodynamic heat load. The second enhancement involves a direct method for solving in-depth charring problems in the context of an HBI solution. Together, these enhancements extend approximate HBI techniques to a broader range of aerothermal problems with improved accuracy at only a modest cost in computational speed. Author (EI)

A95-94067

LEADING-EDGE SWEEPBACK AND SHAPE EFFECTS ON FIN-INDUCED FLUCTUATING PRESSURES

K. KLEIFGES Univ of Texas at Austin, Austin, TX, United States and D. S. DOLLING Journal of Spacecraft and Rockets (ISSN 0022-4650) vol. 32, no. 2 March-April 1995 p. 286-293 refs
(BTN-95-EIX95302694471) Copyright

Measurements of the fluctuating wall pressure have been made on centerline upstream of blunt fins in a Mach 5 turbulent boundary layer. Leading-edge sweep considerably reduces the mean and rms pressure loading at the fin root, the extent of the region of unsteady separation shock motion (i.e., the intermittent region), and the separation length. The frequency of shock-induced pressure fluctuations in the intermittent region increases with leading-edge sweepback, while frequency spectra in the separated region are virtually unchanged. A strake at the root of an unswept fin has virtually no effect, whereas a swept blunted root fillet reduces the upstream influence and intermittent region lengths by 50%, and reduces the mean and rms pressure loading at the fin root by about 75% and 95%, respectively. Experiments using hemicylindrical, wedge-shaped, and flat leading edges show that separated-flow scales and root loading increase with increasing 'bluntness' (i.e., wedge to hemicylinder to flat), while the intermittent-region length increases (in terms of fin thicknesses). The changes in flowfield unsteadiness are related to changes in separated-flow structure which alter the dynamics of the primary vortex and recirculation process. Author (EI)

A95-94102

MATCHING FLUID AND STRUCTURE MESHES FOR AEROELASTIC COMPUTATIONS: A PARALLEL APPROACH

N. MAMAN University of Colorado at Boulder, Boulder, CO, United States and C. FARHAT Computers and Structures (ISSN 0045-7949) vol. 54, no. 4 February 17 1995 p. 779-785 refs
(BTN-95-EIX95302679864) Copyright

Matcher is a program that generates the data structures needed for handling arbitrary and non-conforming fluid/structure interfaces in aeroelastic computations. In this paper, we describe the key issues addressed by Matcher and overview the underlying parallel algorithm. We highlight its parallel performance on the iPSC860/32 for a complete aircraft configuration where the fluid mesh contains 439,272 tetrahedra and 77,279 vertices, and the structural model contains 7520 triangular shell elements and 3841 nodes. EI

A95-94108

DEPOLARIZING TRIHEDRAL CORNER REFLECTORS FOR RADAR NAVIGATION AND REMOTE SENSING

DAVID G. MICHELSON Univ of British Columbia, Vancouver, BC, Canada and EDWARD V. JULL IEEE Transactions on Antennas and Propagation (ISSN 0018-926X) vol. 43, no. 5 May 1995 p. 513-518 refs
(BTN-95-EIX95302727634) Copyright

A conventional trihedral corner reflector can be modified to present either a twist-polarizing or a circularly polarizing response by adding conducting fins or rectangular corrugations of prescribed dimensions and orientation to one of its interior surfaces. Since the modified reflector retains most of the mechanical ruggedness and ease of manufacture of the original, it is suitable for deployment in the field for extended periods as required in radar navigation and remote sensing applications. For most directions of incidence the response of the reflector is dominated by triple-bounce reflections from the interior and is a function of the size and shape of the reflecting panels, the dimensions of the corrugations, and the orientation of the reflector with respect to the radar. Experimental results show that prototype twist-polarizing and circularly polarizing reflectors respond as predicted. Author (EI)

A95-94130* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

3-D NAVIER-STOKES ANALYSIS OF CROSSING GLANCING SHOCKS/TURBULENT BOUNDARY LAYER INTERACTIONS

D. R. REDDY National Aeronautics and Space Administration Lewis Research Cent, Cleveland, OH, United States Computers & Fluids (ISSN 0045-7930) vol. 24, no. 4 May 1995 p. 435-445 refs
(BTN-95-EIX95302729768) Copyright

Three-dimensional viscous flow analysis is performed for a configuration where two crossing and glancing shocks interact with a turbulent boundary layer. A time marching 3-D full Navier-Stokes code, called PARC3D, is used to compute the flow field and the solution is compared to the experimental data obtained at the NASA Lewis Research Center 1 ft x 1 ft supersonic wind tunnel facility. The study is carried out as part of the continuing code assessment program in support of the Generic Hypersonic Research at NASA Lewis. Detailed comparison of static pressure fields and oil flow patterns is made with the corresponding solution on the wall containing the shock/boundary layer interaction in an effort to validate the code for hypersonic inlet applications. Author (EI)

A95-94134
SUPERSONIC, TURBULENT FLOW COMPUTATION AND DRAG OPTIMIZATION FOR AXISYMMETRIC AFTERBODIES
R. M. CUMMINGS Univ of Southern California, Los Angeles, CA, United States, H. T. YANG, and Y. H. OH Computers & Fluids (ISSN 0045-7930) vol. 24, no. 4 May 1995 p. 487-587 refs
(BTN-95-EIX95302729772) Copyright

The compressible, turbulent flow about an axisymmetric body was numerically studied using the MacCormack unsplit explicit algorithm applied to the mass-average Navier-Stokes equations solved in conjunction with the k- epsilon turbulence model of Jones and Launder. Numerical predictions of total body drag (pressure drag, skin friction drag, and base drag) were made for an axisymmetric body six diameters in length, with and without a boattail. Surface pressures and viscous layer profiles are compared with available wind tunnel data and are found to be in good agreement for both geometries. The Golden Section optimization method was used to optimize the body boattail angle for minimum drag. The solution method can serve as a tool for preliminary design analysis where the relative merits of utilizing boattails on axisymmetric afterbodies is being considered. Author (EI)

A95-94197
AIRFOIL LEADING-EDGE SUCTION AND ENERGY CONSERVATION FOR COMPRESSIBLE FLOW
R. K. AMIET Journal of Fluid Mechanics (ISSN 0022-1120) vol. 289 April 25 1995 p. 227-242
(BTN-95-EIX95302730589) Copyright

The leading-edge suction force produced when a flat-plate airfoil at zero angle of attack encounters a vertical gust was examined for compressible flow with a time-dependent gust. A simple derivation of the thrust force shows that the acoustic energy can be calculated using compact assumptions at low frequency, but that it must be calculated noncompactly at high frequency. For a general gust, the work done on the airfoil equals the energy taken from the fluid. For a sinusoidal gust the energy contained in the incident gust equals the sum of the energy remaining in the wake, the work done on the airfoil and the acoustic energy radiated away. Also, the relative proportions of the energy going to these three energy types depend on the gust frequency. EI

A95-94205
GEODESIC CONSTANT METHOD: A NOVEL APPROACH TO ANALYTICAL SURFACE-RAY TRACING ON CONVEX CONDUCTING BODIES
R. M. JHA Natl Aerospace Lab, Bangalore, India and W. WIESBECK IEEE Antennas & Propagation Magazine (ISSN 1045-9243) vol. 37, no. 2 April 1995 p. 28-38 refs
(BTN-95-EIX95302731054) Copyright

A generalized approach to analytical surface-ray tracing in three dimensions, and a review of its application to convex conducting bodies, is presented, using the Eisenhart Coordinate System. The ray-parameters so obtained, for quadric cylinders (QUACYLs) and surfaces of revolution (QUASORs), are in a one-parameter form for UTD mutual-coupling applications. The ray analysis is also extended to the hybrid QUACYLs (e.g., aircraft wings) and hybrid QUASORs (e.g., satellite-launch vehicles), by introducing Hertz's principle of particle dynamics to EM theory. This mathematical formulation is applicable even to other important non-Eisenhart surfaces, such as the ogive. A summary of the mathematical formulations is included. Author (EI)

A95-94250
STRUCTURAL INTEGRITY OF FUSELAGE PANELS WITH MULTISITE DAMAGE
JAI H. PARK Georgia Inst of Technology, Atlanta, GA, United States, RIPUDAMAN SINGH, CHANG R. PYO, and SATYA N. ATLURIS Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 656-662 refs
(BTN-95-EIX0619952748188) Copyright

Structural integrity assessment of aging flight vehicles is extremely important to ensure their economic and safe operation. A two-step analytical approach, developed to estimate the residual strength of pressurized fuselage stiffened shell panels with multi-bay fatigue cracking is presented in this article. Conventional finite element analysis of the damaged multibay panel is first carried out to obtain the load flow pattern through it. The Schwartz-Neumann alternating method is then applied to the fuselage skin with multiple site damage, to obtain stresses and the relevant crack tip parameters that govern the onset of fracture. Fracture mechanics as well as net section yield criteria are used to evaluate the static residual strength. The presence of holes with or without multisite damage ahead of a dominant crack is found to significantly degrade the capacity of the fuselage shell panels to sustain static internal pressure. An elastic-plastic alternating method is newly developed and applied to evaluate the residual strength of flat panels with multiple cracks. The computational methodologies presented herein are marked improvements to the present state-of-the-art, and are extremely efficient, both from engineering manpower as well as computational costs point of view. Once verified, they can very well complement the experimental requirements, reducing the cost of structural integrity assessment programs. Author (EI)

A95-94252
FATIGUE DESIGN OF AXIALLY LOADED SEMICIRCULAR LUGS
S. K. TSANG California Inst of Technology, Pasadena, CA, United States Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 672-676 refs
(BTN-95-EIX0619952748190) Copyright

A simplified procedure based on the results of finite element analysis is proposed for the design of semicircular lugs under repeated axial loading. Maximum lug stresses corresponding to different failure modes are obtained by multiplying nominal stresses by stress correction factors given by design curves. Analytical limitations associated with the finite element approach and factors that affect stress and strength are discussed. The effect of friction on lug stresses is also investigated. When properly implemented, the present design procedure is expected to provide a simple, efficient, and sufficiently accurate method for the preliminary estimation of lug stresses. Author (EI)

A95-94478
DAMAGE TOLERANCE CERTIFICATION OF A FIGHTER HORIZONTAL STABILIZER
JIA-YEN HUANG Aeronautical Research Lab, Taichung, Taiwan, Province of China, MING-YANG TSAI, JONG-SHENG CHEN, and CHING-LONG ONG Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 643-648 refs
(BTN-95-EIX0619952748186) Copyright

A review of the program for the damage tolerance certification test of a composite horizontal stabilizer (HS) of a fighter is presented. The object of this program is to certify that the fatigue life and damage tolerance strength of a damaged composite horizontal stabilizer meets the design requirements. According to the specification for damage tolerance certification, a test article should be subjected to two design lifetimes of flight-by-flight load spectra simulating the in-service fatigue loading condition for the aircraft. However, considering the effect of environmental change on the composite structure, one additional lifetime test was performed. In addition, to evaluate the possibilities for extending the service life of the structure, one more lifetime test was carried out with the spectrum increased by a factor of 1.4. To assess the feasibility and reliability of repair technology on a composite structure, two damaged areas were repaired after two lifetimes of damage tolerance test. On completion of four lifetimes of the damage tolerance test, the static residual strength was measured to check whether structural strength after repair met the requirements. Stiffness and static strength of the composite HS with and without damage were evaluated and compared. Author (EI)

A95-94487

EFFECTS OF THE CHEMICAL REACTION MODEL ON CALCULATIONS OF SUPERSONIC COMBUSTION FLOWS

CORIN SEGAL Univ of Virginia, Charlottesville, VA, United States, HOSSEIN HAJ-HARIRI, and JAMES C. MCDANIEL Journal of Propulsion and Power (ISSN 0748-4658) vol. 11, no. 3 May-June 1995 p. 565-568 refs

(BTN-95-EIX0616952745802) Copyright

The numerical modelling of reacting supersonic flow in a generic configuration at low enthalpy revealed a strong effect of the selection of the reaction model on the solution. This effect was verified through calculation experiments with the use of the three-dimensional version of SPARK. Additionally, a mixing, non-reacting calculation was conducted to provide a comparison with the reacting case. EI

A95-94687

INTERACTION OF A WEAK SHOCK WITH FREESTREAM DISTURBANCES

ZVI RUSAK Rensselaer Polytechnic Inst, Troy, NY, United States, THOMAS E. GIDDINGS, and JULIAN D. COLE AIAA Journal (ISSN 0001-1452) vol. 33, no. 6 June 1995 p. 977-984 refs

(BTN-95-EIX95332750473) Copyright

A new transonic small-disturbance model to analyze the interactions of freestream disturbances with a weak shock has been developed. The model equation has an extended form of the classic small-disturbance equation for unsteady transonic aerodynamics. An alternative approach shows that the pressure field may be described by an equation that has an extended form of the classic nonlinear acoustic equation that describes the propagation of sound beams with a narrow angular spectrum. The model shows that diffraction effects, nonlinear steepening effects, focusing effects, and induced vorticity fluctuations interact simultaneously to determine the development of the shock wave in space and time and the pressure field behind it. A finite difference algorithm to solve the mixed-type elliptic/hyperbolic flows around the shock wave has also been developed. Numerical calculations of shock wave interactions with various deterministic vorticity and temperature disturbances result in complicated shock wave structures and describe peaked as well as rounded pressure signatures across the shock front, as were recorded in experiments of sonic booms running through atmospheric turbulence.

Author (EI)

A95-94793

AIRBORNE IMAGING RADIOMETER SCAN SIMULATION

MARTTI KEMPPINEN Helsinki Univ of Technology, Espoo, Finland IEEE Transactions on Geoscience and Remote Sensing(ISSN 0196-2892) vol. 33, no. 3 May 1995 p. 660-669 refs

(BTN-95-EIX95332753018) Copyright

An imaging radiometer scan simulation program is developed for comparing the performance of different scan patterns and process behavior under varying circumstances. The program gives the radiometer's antenna beam the desired scan motion over an artificial target scene, computes the antenna radiometric temperature as the convolution of the antenna pattern with the scene brightness temperature deviation, computes a moving average of the antenna output, and records the data values as well as the corresponding coordinates at the sampling moments. The simulation indicated that a helicopter-borne imager needs at least passive attitude stabilization. In addition, the state-of-the-art sampling rate was found to be too slow, if the sampling period is set equal to the integration time. A detailed study revealed the achievable spatial resolution (line pairs/length unit-definition) to be 1.0-1.2 x footprint dimensions, but the integration and sampling periods should be as short as 0.2-0.4 x footprint dimensions. Author (EI)

A95-95357* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

COMPUTATIONAL FLUID DYNAMICS '92; PROCEEDINGS OF THE EUROPEAN COMPUTATIONAL FLUID DYNAMICS CONFERENCE, 1ST, BRUSSELS, BELGIUM, SEP. 7-11, 1992. VOLS. 1 & 2

CHARLES HIRSCH, editor Vrije Universiteit Brussel, Brussels, Belgium, J. PERIAUX, editor Dassault Aviation, Saint-Cloud, France, and W. KORDULLA, editor Institute of Theoretical Fluid Dynamics, Goettingen, Germany Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 1164 p.

(ISBN 0-444-89793-3; HTN-95-A1843) Copyright

A conference was held on Computational Fluid Dynamics (CFD) and produced related papers. Topics included CFD algorithms, transition and turbulent flow, hypersonic reacting flow, incompressible flow, two phase flow and combustion, internal flow, compressible flow, grid generation and adaption, boundary layers, environmental and industrial applications, and non-Newtonian flow. For individual titles, see A95-95358 through A95-95507. Hemer

A95-95362

DISCRETIZATION OF THE PARABOLISED NAVIER-STOKES EQUATIONS

L. R. C. ECA Maritime Research Inst., Wageningen, Netherlands and M. HOEKSTRA Maritime Research Inst., Wageningen, Netherlands *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 29-36 Research sponsored by Junta Nacional de Investigacao Cientifica and Commision of the European Communities

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Many of the engineering applications of Computational Fluid Dynamics involve the calculation of flows with a predominant flow direction, as for example, ship stem flows and tip vortex flows. The Parabolized Navier-Stokes (PNS) equations can be used to describe the physical characteristics of this type of flows. The main advantage of the PNS equations is that the solution can be obtained much more efficiently than for the general Navier-Stokes equations. This paper presents and compares two different techniques of discretization of the Reynolds-averaged incompressible PNS equations written in contravariant form. The contravariant velocity variables, multiplied by metric factors, are used as the velocity dependent variables. The finite difference approximations, grid characteristics and the solution procedure used are equal to the ones used in the computer code PARNASSOS, that has been developed at MARIN since 1980. The flow solution is obtained by solving the continuity and momentum equations with the appropriate boundary conditions.

Author (revised by Hemer)

A95-95366

NUMERICAL SOLUTION OF EULER AND NAVIER-STOKES EQUATIONS FOR 2D TRANSONIC PROBLEMS

T. HULEK Czech Technical Univ., Prague, Czech Republic, M. HUNEK Czech Technical Univ., Prague, Czech Republic, and K. KOZEL Czech Technical Univ., Prague, Czech Republic *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 61-68 Research sponsored by IBM

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The present contribution is a numerical solution of Euler and Navier-Stokes equations for 2D transonic flow problems using several different numerical methods. The time marching cell centered and cell vertex finite volume methods were used for both flow models. Various explicit multistage Runge-Kutta methods (RK methods) were applied for inviscid flows and these methods were also used for numerical solution of incompressible and compressinble Navier-Stokes equations. *Author (Hemer)*

A95-95383
LAMINAR AND TURBULENT FLOW OVER OPTIMAL RIBLETS
C. H. CRAWFORD Princeton Univ., Princeton, NJ, US, D. C. CHU Princeton Univ., Princeton, NJ, US, and G. E. KARNIADAKIS Princeton Univ., Princeton, NJ, US *In* Computational fluid dynamics '92; Proceedings of the *European Computational Fluid Dynamics Conference, 1st,* Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 191-198
Research sponsord by AFOSR
Contract(s)/Grant(s): (NSF CTS-89-14422; F49620-91-C-0059)
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In the search for viscous drag reduction, many different techniques have been developed and investigated. One of the more interesting techniques is the drag reduction method involving the use of 'riblets'. Riblets are micro-grooves on the bounding surface that are aligned with the mean flow direction; this method is particularly attractive due to its completely passive nature. Riblets have been thoroughly investigated in recent years. A considerable amount of experimental data has been collected regarding the flow over various shapes, sizes, and spacings of riblets in the turbulent regime. It has been found that drag reduction on the order of 8% can be achieved for flow over a flat plate mounted with riblets, if the proper spacings and heights are used. The purpose of the present work is twofold: First, to investigate optimal shapes of riblets, and second to compare our detailed numerical results for triangular riblets with recenly obtained experimental results. Author (revised by Hemer)

A95-95394
HEAT TRANSFER ON BENT-NOISE BICONIC IN HYPERSONIC FLOW
NORIO ARAI Tokyo Noko Univ., Tokyo, Japan and TAKAO FURUYA Tokyo Noko Univ., Tokyo, Japan *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 279-283
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The present article investigates numerically the characteristics of the heat flux distribution due to the separated flow around the bent-nose biconic. With emphasis on capturing the correlation between the separated flow and the heat flux dustribution, thin layer Navier-Stokes equations are solved by the second-order Total Variation Dimminishing (TVD) scheme at Mach number 7.0. The strong correlation between the heat flux distribution and the separation pattem is shown clearly. Author (Hemer)

A95-95397
OPTIMAL SHAPE DESIGN IN HYPERSONIC AERODYNAMICS AND ELECTROMAGNETICS
F. CARRERE Commissariat a l'Energie Atomique, Le Barp, France and P. LE TALLEC Universite Paris-Dauphine, Paris, France *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 299-304
Copyright

In the present study, we are trying to optimize the shape of an axisymmetric supersonic body. The shape of the body is defined by a finite set of design variables. Our problem is to find a shape minimizing the cost function under the constraints that the flowfield satisfies the Euler equations and that the radar cross section of the body stays below a certain limit. The design variables are chosen in order to get a well conditioned problem, while retaining a high degree of smoothness while computing the electromagnetic field. These critreia are fulfilled by B-splines curves. In order to apply a descent method, we have to compute for any given design, the reference flowfield, the cost function and its gradient with respect to the shape. This is done by using the framework of optimal control theory. Due to the discretization of the Euler equations by an explicit space marching technique, the adjoint state equation can be solved by an explicit upstream space marching technique. In addition to the above flowfield and gradients calculation, the radar cross section corresponding to the shape is obtained by integrating an asymptotic formulation of the Maxwell equations based on geometrical optics. The algorithm is demonstrated on several simple examples. Author (Hemer)

A95-95401
A NUMERICAL INVESTIGATION OF FLOW AROUND A SQUARE-SECTION CYLINDER MOUNTED WITH A SPLITTER PLATE
NORIO ARAI Tokyo Noko Univ., Tokyo, Japan and SATOSHI SAITOH Tokyo Noko Univ., Tokyo, Japan *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 331-336
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The present article investigates the structure of the wake behind a square-section cylinder mounted with a splitter plate. With emphasis on both the small gap width between the bodies and the splitter plate with the 'pressure permeability', two dimensional incompressible Navier-Stokes equations are solved numerically. The existence of the propagation of pressure through a small gap width has very considerable influence on the hydraulic forces. It is confirmed that the pressure propagation in the vicinity of a body has controlled almost the flowfield, namely that whether the 'pressure-tight condition' is complete or not is very important to form the pressure distribution on the body surface. Author (Hemer)

A95-95404
EFFECTS OF SPLITTER PLATE ON WAKE FORMATION FROM A CIRCULAR CYLINDER: A DISCRETE VORTEX SIMULATION
A. R. CETE Istanbul Technical Univ., Istanbul, Turkey and M. F. UNAL Istanbul Technical Univ., Istanbul, Turkey *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 349-356
Contract(s)/Grant(s): (NATO-CRG-890427)
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By means of the Lagrangian inviscid discrete vortex method, the two-dimensional flow around a circular cylinder with a splitter plate attched to its end is simulated. Effects of the splitter plate on the wake characteristics and the forces acting on the cylinder are investigated. Various experimentally-observed flow features are successfully reproduced. Author (Hemer)

A95-95407
AN EFFICIENT DISCRETE VORTEX METHOD FOR LOW REYNOLDS NUMBER INCOMPRESSIBLE FLOWS
D. R. EMERSON Science and Engineering Research Council, Warrington, UK, A. P. BURROWS Manchester Univ., Manchester, UK, and P. G. BETTAMY-KNIGHTS Manchester Univ., Manchester, UK *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 369-374
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An efficient discrete vortex method, suitable for low Reynolds number flows, is presented. The numerical method is described and the technique used to simulate diffusion is explained. Results are presented for a rotating and non-rotating cylinder over a Reynolds number range from 5 to 500. The lift coefficient was found to vary linearly with cylinder rotation rate at all Reynolds numbers considered. Author (Hemer)

A95-95421
VISCOUS FLOW SIMULATION USING THE DISCRETE VORTEX DIFFUSION VELOCITY METHOD
J. H. WALTHER Technical Univ. of Denmark, Lyngby, Denmark *In* Com-

putational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 489-494
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A Discrete Vortex Method has been developed to simulate the 2D viscous flow around bodies of arbitrary shape. The effect of diffusion is introduced by the diffusion velocity as proposed by Ogami & Akamatsu. Three test cases are considered: the flow around a circular cylinder at Reynolds number 200, the early stage of the unsteady flow around a circular cylinder at Reynolds number 9500, and flow around a NACA0012 airfoil at an angle of incidence of 15 deg at Reynolds number 50000. Author (Herner)

A95-95423
NUMERICAL SIMULATION OF THE 3D TURBULENT FLOW AROUND THE COMBUSTOR DOME OF AN AIRCRAFT ENGINE
G. BRUN Societe Metraflu, Ecully, France, M. BUFFAT Ecole Centrale de Lyon, Lyon, France, S. AUBERT SNECMA, Moissy-Cramayel, France, and J. L. SCHULTZ SNECMA, Moissy-Cramayel, France *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 511-516
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A precise knowledge of the aerodynamic field around the combustor of an aircraft engine is required to improve its performances. In particular, a low pressure loss and a stable flow around the liner must be obtained. A numerical approach by use of classical stairstep discretization techniques is out of order to describe such a complex domain. To circumvent this drawback, a Finite Method has been developed. In the past years, 2D approximations of these problems have been studied, but now, the rapid increase in the power of the computers allows the designer to perform complete 3D calculation. The code is based on the resolution of a closed system of equations governing the mean momentum, the mean density, a generalized pressure, the mean temperature and two scalar scales of the turbulence. These equations are presented in a first part. The numerical method is based on the use of a semi-implicit time scheme, a finite element discretization of the domain by tetrahedrons. the continuity constraint, coupled with the momentum equation, is solved by an iterative scheme based on an Uzawa's algorithm and a conjugate gradient method. The linear systems are solved by use of an iterative method based on a conjugate gradient square algorithm. All these numerical methods are described in the second part of this paper. The validation of the code and its application to the calculation of an industrial combustor dome, developed by SNECA is detailed in the last part. Comparisons of the numerical results with the available experimental data are performed. Author (Herner)

A95-95431
A ROBUST INVERSE INVISCID METHOD FOR AIRFOIL DESIGN
P. CHAVIAROPOULOS National Technical Univ. of Athens, Athens, Greece, V. DEDOUSSIS National Technical Univ. of Athens, Athens, Greece, and K. D. PAPAILIOU National Technical Univ. of Athens, Athens, Greece *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 581-588
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An irrotational inviscid compressible inverse design method for two-dimensional airfoil profiles is described. The method is based on the potential streamfunction formulation, where the physical space on which the boundaries of the airfoil are sought, is mapped onto the (phi, psi) space via a body-fitted coordinate transformation. A novel procedure based on differential geometry arguments is employed to derive the governing equations for the inverse problem, by requiring the curvature of the flat 2-D Euclidean space to be zero. An auxiliary coordinate transformation permits the definition of C-type computational grids on the (phi, psi) plane resulting to a more accurate description of the leading edge region. Geometry is determined by integrating Frenet equations along the grid lines. To validate the method inverse calculation results are compared to direct, 'reproduction', calculation results. The design procedure of a new airfoil shape is also presented. Author (Herner)

A95-95439
AN IMPROVED FINITE ELEMENT METHOD FOR THE SOLUTION OF THE COMPRESSIBLE EULER AND NAVIER-STOKES EQUATIONS
G. S. BARUZZI Concordia Univ., Montreal, Canada, W. G. HABASHI Concordia Univ., Montreal, Canada, and M. M. HAFEZ California Univ., Davis, CA, US *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 643-650
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Finite element solutions of the compressible Euler and Navier-Stokes equations have been previously obtained by the authors using an artificial viscosity in the form of Laplacians of the pressure and the velocity components, for the continuity and momentum equations, respectively. The present report outlines finite element scheme for the solution of the compressible Navier-Stokes equations, based on a higher order nonlinear artificial viscosity. The Laplacian terms of the artificial viscosity are balanced by nonlinear terms obtained from the governing equations. The added balancing terms are evaluated using a standard Galerkin method and are lagged; hence the Jacobian matrix of the original method is unaltered by these modifications. The residual, however, is of higher order accuracy and the solution is not contaminated with the effects of the often excessive viscosity needed in the previous work for numerical stability. Results are presented for compressible laminar flow over airfoils and are in good agreement with available data. Author (Herner)

A95-95443
IMPLICIT MULTIDOMAIN CALCULATION OF VISCOUS TRANSONIC FLOWS WITHOUT ARTIFICIAL VISCOSITY OR UPWINDING
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When solving the compressible Navier-Stokes equations, any method requires some numerical dissipation. This dissipation, internal in upwind and Lax-Wendroff-type centered schemes, and artificial in Runge-Kutta centered scheme, is necessary to avoid instability and spurious oscillations. However, this numerical dissipation should be significantly smaller than the physical one, otherwise the accuracy would be disastrous. For steady problems, a good compromise can be achieved by using the implicit centered Lax-Wendroff method developed for inviscid flows and extended to viscous flows. In calculations of inviscid transonic flows, this method with no artificial viscosity or any other correction, gives accurate results and sharp numerical shocks. This means that its internal dissipation is very low and just sufficient to ensure inviscid and viscous flows, some robustness improvements were studied. The present paper is devoted to steady viscous transonic flow calculations using this implicit numerical method and a multidomain treatment. After a presentation of the method, an original multidomain matching condition suitable for implicit schemes is discussed. Then an a-priori mesh adaptation in the boundary layer is suggested, and finally efficiency and accuracy are studied in details through numerical tests. Author (Herner)

A95-95444

HIGH-LIFT CALCULATIONS USING NAVIER-STOKES METHODS

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Wing sections on an aircraft are designed for optimal cruise performance, whereas during the take-off and landing phase totally different lift-to-drag characteristics are needed. High lift and low drag is essential while taking off, on the other hand high lift and high drag is favorable when landing. The design and shaping of the high-lift system can have a major influence on the overall economy and safety of the aircraft. In a historical perspective experimental investigations have been the only way to gain any deeper knowledge of the performance of a given wing-flap configuration. Today, computational methods for high-lift systems based on the viscid-inviscid interaction approach with integral methods for boundary layers and wakes are quite common. Although fast solutions can be obtained with these methods it is highly desirable to have a numerical method that captures the flow physics in a more detailed and adequate way. The present wotk demonstrates that Navier-Stokes methods can be used with good results for simulating high-lift flow fields, but also points to the area where further research is needed. Author (revised by Herner)

A95-95445

PERMEABLE WALL BOUNDARY CONDITIONS FOR TRANSONIC AIRFOIL DESIGN

O. LEONARD Polytechnique de Mons Service de Mecanique des Fluides, Mons, Belgium and R. VAN DEN BRAEMBUSSCHE Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese, Belgium *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 689-695

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This paper describes a method for the design of airfoils with prescribed Mach number or static pressure distribution along both the suction and pressure sides. The method consists of an iterative procedure, in which the final geometry is obtained through successive modifications of an existing shape. Each modification is computed by solving the Euler equations using permeable wall boundary conditions, in which the required Mach number distribution can be imposed on the airfoil wall. Since the classical slip condition is no longer imposed, the resulting flow is not tangent to the wall. A new geometry is created using this normal velocity component and a transpiration method. Author (Herner)

A95-95446

A MODULAR SYSTEM FOR COMPUTATIONAL FLUID DYNAMICS

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This paper describes the Modular System for Compuational Fluid Dynamics (MOSYS), a software facility for the construction and execution of arbitrary solution procedures on multizone, structured body-fitted grids. It focuses on the structure and capabilities of MOSYS and the philosophy underlying its design. The system offers different levels of capability depending on the objectives of the user. It enables the applications engineer to quickly apply a variety of methods to geometrically complex problems. The methods developer can implement new algorithms in a simple form, and immediately apply them to problems of both theoretical and practical interest. And for the code builder it consitutes a toolkit for fast construction of CFD codes tailored to various purposes. These capabilities are illustrated through applications to a particularly complex problem encountered in aircraft propulsion systems, namely, the analysis of a landing aircraft in reverse thrust. Author (Herner)

A95-95448

ON THE PREDICTION OF TRANSONIC UNSTEADY FLOWS USING SECOND ORDER TIME ACCURACY

M. P. THOMADAKIS National Technical Univ. of Athens, Athens, Greece and S. TSANGARIS National Technical Univ. of Athens, Athens, Greece *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 711-718

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An implicit central scheme in a formulaton which ensures the second order time accuracy of the computations is used for the simulation of unsteady inviscid and viscous transonic flows. Computations are performed using the second order time accuracy's capabilities of the scheme and the comparison to first order computations reveals that it is much cheaper to use second order accuracy. Comparison between the inviscid and the viscous solutions shows that only quantitative differences exist between these two, while qualitatively the results are similar and in good comparison to experimental data. Author (Herner)

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IMPLICIT UPWIND-EULER SOLUTION ALGORITHMS FOR UNSTRUCTURED-GRID APPLICATIONS

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The development of implicit upwind algorithms for the solution of the three-dimensional, time-dependent Euler equations on unstructured tetrahdral meshes is described. The implicit temporal discretization involves either a two-sweep Gauss-Seidel relaxation procedure, a two-sweep Point-Jacobi relaxation procedure, or a single-sweep Point-Implicit procedure; the upwind spatial discretization is based on the flux-difference splitting of Roe. Detailed descriptions of the three implicit solution algorithms are given, and calculations for the Boeing 747 transport configuration are presented to demonstrate the algorithms. Advantages and disadvantages of the implicit algorithms are discussed. A steady-state solution for the 747 configuration, obtained at transonic flow conditions using s mesh of over 100,000 cells, required less than one hour of CPU time on a Cray-2 computer, thus demonstrating the speed and robustness of the general capability. Author (Herner)

A95-95457

2-D AND 3-D NUMERICAL SIMULATION OF A SUPERSONIC INLET FLOWFIELD

SHUNJI ENOMOTO Tokyo Univ., Tokyo, Japan and CHUICHI ARAKAWA Tokyo Univ., Tokyo, Japan *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 781-788

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The 2-D and 3-D steady, Reynolds-averaged Navier-Stokes equations were numerically solved for the flowfields in an experimentally tested inlet model with bleed through a cavity. In the 2-D analysis, a normal shock was located at diffuser inlet instead of the position below the cavity. The normal shock in the middle of the diffuser caused a massive separation of the boundary layer and a large total pressure loss. In the 3-D analysis, the shock wave was distorted by the side wall boundary layer separation, and the complex flow structure was established. The result of the 3-D analysis agreed well with the experiment. Author (Hemer)

A95-95459

MULTIGRID SOLUTION FOR THE COMPRESSIBLE EULER EQUATIONS BY AN IMPLICIT CHARACTERISTIC-FLUX-AVERAGING

A. KANARACHOS National Technical Univ. of Athens, Athens, Greece and I. VOURNAS National Technical Univ. of Athens, Athens, Greece *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 795-802 Research sponsored by Commission of the European Communities

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A formulation of an implicit characteristic-flux-averaging method for the compressible Euler equations combined with the multigrid method is presented. The method is based on correction scheme and implicit Gudunov type finite volume scheme and is applied to two dimensional cases. Its principal feature is an averaging procedure based on the eigenvalue analysis of the Euler equations by means of which the fluxes are evaluated at the finite volume faces. The performance of the method is demonstrated for different flow problems around RAE-2922 and NACA-0012 airfoils and an internal flow over a circular arc. Author (Hemer)

A95-95462

TRANSONIC VORTICAL FLOW PREDICTED WITH A STRUCTURED MILTIBLOCK EULER SOLVER

S. SANTILLAN Alenia Aeronautica, Turin, Italy and V. SELMIN Alenia Aeronautica, Turin, Italy *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 815-822 Research sponsored by Italian Ministry of Defence

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A methodology for solving the Euler equations in geometrically complex domains has been developed at Alenia (DVD). The general features of the Alenia multiblock system, which provides a grid generation and Euler solution capability for complex configuration, are discussed. A systematic multiblock grid generator has been used to make the grids. Numerical results compared with available experimental data in transonic vortical flow around delta wing, wing-body and wing-body-canard configurations with sharp leading edge are presented and explained in a physical context. Author (Hemer)

A95-95463

AN UNSTRUCTURED NODE CENTERED SCHEME FOR THE SIMULATION OF 3-D INVISCID FLOWS

V. SELMIN Alenia Aeronautica, Turin, Italy, E. HETTENA Alenia Aeronautica, Turin, Italy, and L. FORMAGGIA Alenia Aeronautica, Turin, Italy *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 823-828

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The paper describes an efficient way to generalize central difference schemes for the solution of Euler equations in an unstructured context. Applications to very complex geometries illustrates the flexibility and reliability of the numerical procedure. Author (Hemer)

A95-95467

AN INNOVATIVE ALGORITHM TO ACCURATELY SOLVE THE EULER EQUATIONS FOR ROTARY WING FLOW

S. WAGNER Universitaet Stuttgart, Stuttgart, Germany and E. KRAEMER Universitaet Stuttgart, Stuttgart, Germany *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 851-858

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Due to the ability of Euler methods to treat rotational, nonisentropic flows and also to correctly transport on the rotation embedded in the flow field it is possible to correctly represent the inflow conditions on the blade in the stationary hovering flight of a helicopter, which are significantly influenced by the tip vortices (blade-vortex interaction) of all blades. It is shown that also the very complex starting procedure of a helicopter rotor can be very well described by a simple Euler method that is to say without a wake model. The algorithm based on the procedure is part of category upwind schemes, in which the difference formation orientates to the actual, local flow state that is to say to the typical distrubance expansion direction. Hence, the artificial dissipation required for the numerical stability is included in a natural way adapted to the real flow state over the break-up error of the difference equation and has not to be included from outside. This makes the procedure robust. An implicit solution algorithm is used, where the invertation of the coefficient matrix is carried out by means of a Point-Gauss-Seidel relaxation. Author (revised by Hemer)

A95-95470

SAUNA: A SYSTEM FOR GRID GENERATION AND FLOW SIMULATION USING HYBRID STRUCTURED/UNSTRUCTURED GRIDS

P. N. CHILDS Aircraft Research Association Ltd., Bedford, UK, J. A. SHAW Aircraft Research Association Ltd., Bedford, UK, A. J. PEACE Aircraft Research Association Ltd., Bedford, UK, and J. M. GEORGALA Aircraft Research Association Ltd., Bedford, UK *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 875-882 Research sponsored by Ministry of Defence

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We describe the development of a flow simulation facility for predicting the aerodynamics of complex configurations wherein the grid is composed of both structured and unstructured regions. This paper considers issues relating to the generation and analysis of such grids and to the accurate and efficient computation of both inviscid and viscous flows thereon. Further, the development of a comprehensive post-processing and visualization facility is explored. Techniques are illustrated throughout by application to realistic aircraft geometries. Author (Hemer)

A95-95471

A CARTESIAN GRID FINITE ELEMENT METHOD FOR AERODYNAMICS OF MOVING RIGID BODIES

Q. V. DINH Dassault Avaiation, Saint-Cloud, France, B. MANTEL Dassault Avaiation, Saint-Cloud, France, and J. W. HE Dassault Avaiation, Saint-Cloud, France *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 883-890

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A finite element solver based on non body-fitted meshes has been developed for steady transonic potential flows. Its extension to unsteady flows around arbitraily moving rigid bodies is presented. Its two main ingredients are: a robust potential flow solver and an effective mesh management strategy. They are illustrated by numerical experiments which simulate a two-dimensional store release problem. Author (Hemer)

A95-95472

GRID ADAPTATION FOR PROBLEMS IN COMPUTATIONAL FLUID DYNAMICS

R. HAGMEIJER National Aerospace Lab., Amsterdam, Netherlands and K. M. J. DE COCK National Aerospace Lab., Amsterdam, Netherlands *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 891-898

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A recently developed algorithm to adapt computational grids is briefly described and the main features are discussed. Application to a turbulent-flow Computational Fluid Dynamics (CFD) problem around a NACA-0012 airfoil shows that the algorithm is robust and that high-gradient spots are well-captured. Author (Herner)

A95-95473

MULTI-BLOCK FINITE VOLUME CALCULATION OF COMPRESSIBLE FLOW PAST AERODYNAMIC CONFIGURATIONS

K. M. LEE Singapore Aerospace Ltd., Singapore, M. DAMODARAN Nanyang Technological Univ., Singapore, J. L. TAN Singapore Aerospace Ltd., Singapore, and ALEX K. H. LEE Nanyang Technological Univ., Singapore *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 899-906 Research sponsored by National Science and Technology Board

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The primary objective of this paper is to describe an on-going local endeavor in developing and applying computational fluid dynamics technology focusing on the implementation of a proven finite volume numerical solution technique for integrating the Euler/Navier-Stokes equations in a muitl-block framework consisting of structural grids, while preserving its accuracy and convergence properties. The implementation is carried out on a NEC-SX1A supercomputer by using its extended memory unit to facilitate block flow data transfer and storage during each cycle of computation. Some preliminary computed inviscid results are presented for high Reynold's number aerodynamic flows over a wing and wing-body combinations. Comparison of the results with the corresponding experimental data is also provided. Author (Herner)

A95-95475

A 2D PARALLEL MULTIBLOCK NAVIER-STOKES SOLVER WITH APPLICATIONS ON SHARED- AND DISTURBED MEMORY MACHINES

C. MENSINK Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese, Belgium and H. DECONINCK Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese, Belgium *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 913-920

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Based on a finite volume discretization of the compressible Navier-Stokes equations, a multiblock method has been developed in which non-overlapping grid blocks are connected in a conservative way. The code has benn parallelized and implemented on both shared- and distributed memory multiprocessor machines. The 2D parallel multiblock method is illustrated by an airfoil and a cascade flow computation. Author (Herner)

A95-95477

GRID GENERATION: ALGEBRAIC AND PARTIAL DIFFERENTIAL EQUATIONS TECHNIQUES REVISITED

BHARAT K. SONI Mississippi State Univ., Mississippi State, MS, US *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 929-936

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A systematic procedure for grid generation which can provide compuational grids for a wide range of geometries related to internal/external flow configuration is developed by combining the best features of algebraic and elliptic grid generation systems. The algebraic and elliptic grid generation system are well developed in the literature. A revisit to these techniques is given in this paper in view of economy and efficiency of the grid generation process. A technique to automatically calculate slopes and twist vectors required in hermite transfinite interpolation is developed. The weighted transfinite interpolation is combined with automatically created Bezier, B-spline curves, and Non-Uniform Rational B-spline (NURB) curves to generate well-distributed, smooth and near orthogonal grid patches (sub-blocks). A novel approach to evaluate control functions for elliptic generation systems is developed. This approach allows a quick refinement utilizing elliptic system. Computational examples are presented to demonstrate the success of these methodologies. Author (Herner)

A95-95478

SURFACE GRID GENERATION FOR MULTI-BLOCK STRUCTURED GRIDS

S. P. SPEKREIJSE National Aerospace Lab., Amsterdam, Netherlands, J. W. BOERSTOEL National Aerospace Lab., Amsterdam, Netherlands, J. L. KUYVENHOVEN Fokker Aircraft B.V., Schiphol-Oost, Netherlands, and M. J. VAN DER MAREL Delft Hydraulics W.L., Delft, Netherlands *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 937-944 Research sponsored by Netherlands Agency for Aerospace Programs

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A new grid generation technique for the computation of a structured grid on a generally curved surface in 3D is discussed. The starting assumption is that the parameterization of the surface exists, i.e. a smooth geometrical shape function exists which maps the parametric space (the unit square) one-to-one on the surface. The grid generation system computes a grid on the surface with as boundary conditions the following data specified along the four edges of the surface: (1) the position of the boundary grid points, (2) the grid line slopes at the boundary grid points, (3) the first grid cell lengths at the boundary grid points. The fourth-order elliptic biharmonic equations are used to compute the two families of grid lines in the parametric space. After that, each grid point in the parametric space is found as the intersection point between two individual grid lines, one from each family. The grid points on the surface are finally found by mapping the grid points in the parametric space on the surface via the geometrical shape function. Results are shown for an O-type 2D Euler grid, a C-type 2D Navier-Stokes grid and on some curved surfaces in 3D space. Author (revised by Herner)

A95-95485

ARBITRARY LAGRANGIAN-EULERIAN FINITE ELEMENT ANALYSIS FOR FLOW-INDUCED VIBRATION OF RIGID BODY

K. EDAMOTO Kawada Industries, Inc., Tokyo, Japan and M. KAWAHARA Chuo Univ., Tokyo, Japan *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 993-1000

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The purpose of this paper is to present a numerical method which is effective in solving the flow-induced vibration of structures. In order to take proper measures aganist the problem, the arbitrary Lagrangian-Eulerian description is applied to the basic equation. The relationship between a displacement of the moving body and a distortion form of the finite element mesh is connected with linear function for simplification of mesh reconstruction. Two applications, the Reynolds number 100 and 400 flows around a perfect square cylinder with vortex-induced vertical oscillations, are presented. Author (Herner)

A95-95495

HIGH PERFORMANCE PARALLELIZED IMPLICIT EULER SOLVER FOR THE ANALYSIS OF UNSTEADY AERODYNAMIC FLOWS

C. BOREL Matra Defense, Villacoublay, France and M. BREDIF Matra Defense, Villacoublay, France *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 1069-1076

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Simulation of transient flows is more and more useful for industrial applications in aeronautics. For instance, the unsteady aerodynamic coefficients can be of great importance in order to predict the behavior of flying bodies: this is in particular the case for missiles which are spun around their longitudinal axis. It is also well known that the experimental tools used to evaluate the unsteady aerodynamic characteristics present a certain number of limitations: complexity of the experiments, limited degree of accuracy, high costs and delays. In this context, the Computational Aerodynamics Department of Matra Defense has been developing a software library called AEROLOG for the prediction of the steady and unsteady aerodynamics of tactical missiles using Computational Fluid Dynamics (CFD) techniques. The aim of this paper is as follows: (1) Detailed presentation of the numerical method, with particular emphasis on the high performances in terms of computational time achieved thanks to the use of an implicit scheme combined with a domain decomposition of structured mesh well suited for vector and parallel implementation, and (2) Analysis of 2-D and 3-D unsteady numerical simulations corresponding to academic and industrial cases, showing the accuracy of the method together with its range of applications. Author (Herner)

A95-95497

HYPERSONIC NAVIER-STOKES COMPUTATIONS ABOUT COMPLEX CONFIGURATIONS

C. LACOR Vrije Universiteit Brussel, Brussels, Belgium, P. ALAVILLI Vrije Universiteit Brussel, Brussels, Belgium, CHARLES HIRSCH Vrije Universiteit Brussel, Brussels, Belgium, P. ELIASSON Aeronautical Research Inst. of Sweden, Bromma, Sweden, I. LINDBLAD Aeronautical Research Inst. of Sweden, Bromma, Sweden, and A. RIZZI Aeronautical Research Inst. of Sweden, Bromma, Sweden *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 1089-1096

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A 3D code, called EURANUS, for solving the Reynolds Averaged Navier-Stokes equations is presented. The code is based on a multiblock/multigrid approach and incorporates both central and upwind schemes within a global formulation. Runge-Kutta time stepping and implicit solvers, using relaxation methods, are available. EURANUS is illustrated with perfect gas calculations around the Hermes configuration at M = 10 and 30 deg angle of attack. Author (Herner)

A95-95507

NAVIER-STOKES SIMULATION OF TURBULENT VORTEX HIGH-RE-NUMBER FLOWS OVER A DELTA WING

ARTHUR RIZZI Aeronautical Research Inst. of Sweden, Bromma, Sweden, CUNEYT ELDEM EPFL, Lausanne, Switzerland, and JAN VOS EPFL, Lausanne, Switzerland *In* Computational fluid dynamics '92; Proceedings of the European Computational Fluid Dynamics Conference, 1st, Brussels, Belgium, Sep. 7-11, 1992. Vols. 1 & 2. A95-95357 Amsterdam, Netherlands Elsevier Science Publishers B.V. 1992 p. 1151-1158

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An investigation of a Reynolds-averaged Navier-Stokes method for simulating the high Reynolds number flow over a delta wing is presented. The flow equations are solved by the finite volume method using a space centered explicit time marching scheme stabilized by scalar adaptive dissipation. Implicit residual smoothing accelerates convergence to steady state, and the Baldwin-Lomax turbulence model closes the system. Results are presented for flow over a delta wing with M(sub unfinity) = 0.85 and alpha = 12 degrees, at two Reynolds numbers, 9 and 72 million, in both laminar and turbulent flow. Author (Herner)

N95-30502# Norwegian Defence Research Establishment, Kjeller (Norway).

RESULTS FROM TESTS OF THE KEARFOTT T16-B INERTIAL MEASUREMENT UNIT

B. JALVING 6 Jan. 1995 87 p

(PB95-212031) Avail: CASI HC A05/MF A01

The Norwegian Defense Research Establishment (NDRE) has tested Kearfott Guidance & Navigation Corporation's T16-B Inertial Measurement Unit (IMU) as part of a program for investigating alternative technologies and vendors for the new antiship missile for the Royal Norwegian Navy. Two different IMU's were tested. Among the tests carried out were static navigation, gyro compassing, dynamic navigation, performance during vibrations and determination of gyro random walk coefficients, accelerometer biases and gyro biases. Additionally the applicability of the IMU navigation data for seeker stabilization has been investigated. Significant difference in performance between the two tested units and dependence on the flight profile were observed. The results obtained indicate that the Kearfott T16-B IMU is well suited for the new antiship missile. NTIS

N95-30507# Lawrence Livermore National Lab., Livermore, CA.

INTEGRATED X-RAY TESTING OF THE ELECTRO-OPTICAL BREADBOARD MODEL FOR THE XMM REFLECTION GRATING SPECTROMETER

J. V. BIXLER, W. CRAIG, T. DECKER, H. AARTS (Space Research Organization Netherlands, Utrecht, Netherlands.), T. DENBOGGENDE (Space Research Organization Netherlands, Utrecht, Netherlands.), A. C. BRINKMAN (Space Research Organization Netherlands, Utrecht, Netherlands.), W. BURKERT (Max-Planck-Inst. fuer Extraterrestrische Physik, Munich, Germany.), and H. BRAUNINGER (Max-Planck-Inst. fuer Extraterrestrische Physik, Munich, Germany.) 12 Jul. 1994 12 p Presented at the Annual Meeting of the Society of Photo-Optical Instrumentation Engineers, San Diego, CA, 24-29 Jul. 1994

Contract(s)/Grant(s): (W-7405-ENG-48)

(DE95-008829; UCRL-JC-118213; CONF-940723-36) Avail: CASI HC A03/MF A01

X-ray calibration of the Electro-Optical Breadboard Model (EOBB) of the XXM Reflection Grating Spectrometer has been carried out at the Panter test facility in Germany. The EOBB prototype optics consisted of a four-shell grazing incidence mirror module followed by an array of eight reflection gratings. The dispersed x-rays were detected by an array of three CCD's. Line profile and efficiency measurements where made at several energies, orders, and geometric configurations for individual gratings and for the grating array as a whole. The x-ray measurements verified that the grating mounting method would meet the stringent tolerances necessary for the flight instrument. Post EOBB metrology of the individual gratings and their mountings confirmed the precision of the grating boxes fabrication. Examination of the individual grating surface's at micron resolution revealed the cause of anomalously wide line profiles to be scattering due to the crazing of the replica's surface. DOE

N95-30521 Selskapet for Industriell og Teknisk Forskning, Trondheim (Norway). Div. of Safety and Reliability.
METASCIENTIFIC PROBLEMS IN SAFETY SCIENCE
R. ROSNESS 31 Dec. 1993 18 p
(PB95-196408; STF75-S93041) Avail: Issuing Activity (National Technical Information Service (NTIS))

This paper is an introduction to a workshop on safety science and the theory of science. The paper examines a study of helicopter safety in order to identify some of the metascientific problems in safety science. It then considers the nature of safety science in more general terms. Finally, it argues that a considerable part of safety science cannot be expected to conform to orthodox falsified criteria of science. This leads to the conclusion that safety scientists should take the responsibility of proposing and justifying norms for empirical and theoretical work in the area. NTIS

N95-30524*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE EFFECT OF ADDING ROUGHNESS AND THICKNESS TO A TRANSONIC AXIAL COMPRESSOR ROTOR
KENNETH L. SUDER, RODRICK V. CHIMA, ANTHONY J. STRAZISAR, and WILLIAM B. ROBERTS (Flow Application Research, Fremont, CA.) Jun. 1995 22 p Presented at the 39th International Gas Turbine and Aeroengine Congress and Exposition, The Hague, Neatherlands, 13-16 Jun. 1994; sponsored by ASME
Contract(s)/Grant(s): (RTOP 505-62-52)
(NASA-TM-106958; E-9709; NAS 1.15:106958) Avail: CASI HC A03/MF A01

The performance deterioration of a high speed axial compressor rotor due to surface roughness and airfoil thickness variations is reported. A 0.025 mm (0.001 in.) thick rough coating with a surface finish of 2.54-3.18 RMS microns (100-125 RMS microinches) is applied to the pressure and suction surface of the rotor blades. Coating both surfaces increases the leading edge thickness by 10% at the hub and 20% at the tip. Application of this coating results in a loss in efficiency of 6 points and a 9% reduction in the pressure ratio across the rotor at an operating condition near the design point. To separate the effect of thickness and roughness, a smooth coating of equal thickness is also applied to the blade. The smooth coating surface finish is 0.254-0.508 RMS microns (10-20 RMS microinches), compared to the bare metal blade surface finish of 0.508 RMS microns (20 RMS microinches). The smooth coating results in approximately half of the performance deterioration found from the rough coating. Both coatings are then applied to different portions of the blade surface to determine which portions of the airfoil are most sensitive to thickness/roughness variations. Aerodynamic performance measurements are presented for a number of coating configurations at 60%, 80%, and 100% of design speed. The results indicate that thickness/roughness over the first 10% of blade chord accounts for virtually all of the observed performance degradation for the smooth coating, compared to about 70% of the observed performance degradation for the rough coating. The performance deterioration is investigated in more detail at design speed using laser anemometer measurements as well as predictions generated by a quasi-3D Navier-Stokes flow solver which includes a surface roughness model. Measurements and analysis are performed on the baseline blade and the full-coverage smooth and rough coatings. The results indicate that coating the blade causes a thickening of the blade boundary layers. The interaction between the rotor passage shock and the thickened suction surface boundary layer then results in an increase in blockage which reduces the diffusion level in the rear half of the blade passage, thus reducing the aerodynamic performance of the rotor.
Author

N95-30587*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FABRY-PEROT INTERFEROMETER MEASUREMENT OF STATIC TEMPERATURE AND VELOCITY FOR ASTOVL MODEL TESTS
HELEN E. KOUROUS and RICHARD G. SEACHOLTZ Jul. 1995 8 p Presented at the Symposium on Laser Anemometry: Advances and Applications, Lake Tahoe, NV, 19-23 Jun. 1994; sponsored by ASME
Contract(s)/Grant(s): (RTOP 505-62-50)
(NASA-TM-107014; E-9799; NAS 1.15:107014) Avail: CASI HC A02/MF A01

A spectrally resolved Rayleigh/Mie scattering diagnostic was developed to measure temperature and wing-spanwise velocity in the vicinity of an ASTOVL aircraft model in the Lewis 9 x 15 Low Speed Wind Tunnel. The spectrum of argon-ion laser light scattered by the air molecules and particles in the flow was resolved with a Fabry-Perot interferometer. Temperature was extracted from the spectral width of the Rayleigh scattering component, and spanwise gas velocity from the gross spectral shift. Nozzle temperature approached 800 K, and the velocity component approached 30 m/s. The measurement uncertainty was about 5 percent for the gas temperature, and about 10 m/s for the velocity. The large difference in the spectral width of the Mie scattering from particles and the Rayleigh scattering from gas molecules allowed the gas temperature to be measured in flow containing both naturally occurring dust and LDV seed (both were present). Author

N95-30669 Michigan Univ., Ann Arbor, MI.
SCATTERING AND RADIATION FROM CYLINDRICALLY CONFORMAL ANTENNAS Ph.D. Thesis
LEO CHARLES KEMPEL 1994 180 p
Avail: Univ. Microfilms Order No. DA9423227

Microstrip patch antennas offer considerable advantages in terms of weight, aerodynamic drag, cost, flexibility, and observability over more conventional protruding antennas. Two hybrid finite element methods are presented and are used to examine the scattering and radiation behavior of cylindrically conformal patches. In conjunction with a new divergence-free cylindrical shell element, the finite element-boundary integral method is shown to have low computational and memory requirements when compared with competing approaches. This method uses an efficient creeping wave series for the computation of the dyadic Green's function and a uniform surface mesh so that a fast Fourier transform may be used to reduce the computational and memory burden of the method. An alternative finite element-absorbing boundary condition approach incorporates a new conformal vector condition which minimizes the computational domain. The latter method is more flexible than the former because it can incorporate surface coatings and protruding antennas. Guidelines are established for minimal ABC displacement from the aperture. These two hybrid finite element methods are used to study the scattering, radiation, and input impedance of typical conformal antenna arrays. In particular, the effect of curvature and cavity size is examined for both discrete and wrap-around antenna arrays. Dissert. Abstr.

N95-30682*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STRUCTURAL DESIGN USING EQUILIBRIUM PROGRAMMING FORMULATIONS
STEPHEN J. SCOTTI Jun. 1995 116 p
Contract(s)/Grant(s): (RTOP 537-06-21-09)
(NASA-TM-110175; NAS 1.15:110175) Avail: CASI HC A06/MF A02

Solutions to increasingly larger structural optimization problems are desired. However, computational resources are strained to meet this need. New methods will be required to solve increasingly larger problems. The present approaches to solving large-scale problems involve approximations for the constraints of structural optimization problems and/or decomposition of the problem into multiple subproblems that can be solved in parallel. An area of game theory, equilibrium programming (also known as noncooperative game theory), can be used to unify these existing approaches from a theoretical point of view (considering the existence and optimality of solutions), and be used as a framework for the development of new methods for solving large-scale optimization problems. Equilibrium programming theory is described, and existing design techniques such as fully stressed design and constraint approximations are shown to fit within its framework. Two new structural design formulations are also derived. The first new formulation is another approximation technique which is a general updating scheme for the sensitivity derivatives of design constraints. The second new formulation uses a substructure-based decomposition of the structure for analysis and sensitivity calculations. Significant computational benefits of the new formulations compared with a conventional method are demonstrated. Author

N95-30727 Department of the Navy, Washington, DC.
APPARATUS AND METHOD FOR PRODUCING THREE-DIMENSIONAL IMAGES Patent
KENNETH K. KNAELL, inventor (to Navy) and GLEN R. HEIDBREDER, inventor (to Navy) 28 Feb. 1995 13 p Filed 30 Sep. 1993
(AD-D017455; US-PATENT-5,394,151; US-PATENT-APPL-SN-129499; US-PATENT-CLASS-342-25) Avail: US Patent and Trademark Office

An apparatus and method is capable of acquiring useful three-dimensional radar images from an aircraft which travels in a curvilinear path to generate only a sparsely filled synthetic array. A motion measurement unit outputs position measurements as the aircraft travels in the curvilinear path. The system includes a motion compensation and timing unit and a wave transmitter which outputs chirped radar signals. An antenna coupled to the wave generator sends the chirped radar signals to a region to be imaged and receives scattered chirped radar return signals from scatterers in the region. DTIC

N95-30783*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ORBITER RAREFIED-FLOW REENTRY MEASUREMENTS FROM THE OARE ON STS-62
R. C. BLANCHARD and J. Y. NICHOLSON (Vigyan Research Associates, Inc., Hampton, VA.) Jun. 1995 36 p
Contract(s)/Grant(s): (RTOP 242-80-01-01)
(NASA-TM-110182; NAS 1.15:110182) Avail: CASI HC A03/MF A01

Acceleration data taken from the Orbital Acceleration Research Experiment (OARE) during reentry on STS-62 has been analyzed using calibration factors taken on-orbit. The data includes the flight regime from orbital altitudes down to about 100 km which covers the free-molecule-flow regime and some of the flow-transition into the hypersonic continuum. Ancillary data on orbiter position, orientation, velocity, and rotation rates have been used in models to transform the measured accelerations to the orbiter center-of-gravity, from which aerodynamic accelerations along the orbiter body axes have been calculated. Additional steps are discussed which remove residual offsets introduced in the measurements by unmodeled orbiter forces. The resulting aerodynamic accelerations and their ratios, A(sub z)/A(sub x), are discussed and compared with free-molecule-flow predictions of the aerodynamic coefficient ratios C(sub N)/C(sub A). Author

N95-30851*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A LASER-BASED ICE SHAPE PROFILOMETER FOR USE IN ICING WIND TUNNELS
EDWARD A. HOVENAC (NYMA, Inc., Brook Park, OH.) and MARIO VARGAS Jun. 1995 25 p Original contains color illustrations
Contract(s)/Grant(s): (NAS3-27186)
(NASA-TM-106936; E-9664; NAS 1.15:106936) Avail: CASI HC A03/MF A01; 1 functional color page

A laser-based profilometer was developed to measure the thickness and shape of ice accretions on the leading edge of airfoils and other models in icing wind tunnels. The instrument is a hand held device that is connected to a desk top computer with a 10 meter cable. It projects a laser line onto an ice shape and used solid state cameras to detect the light scattered by the ice. The instrument corrects the image for camera angle distortions, displays an outline of the ice shape on the computer screen, saves the data on a disk, and can print a full scale drawing of the ice shape. The profilometer has undergone extensive testing in the laboratory and in the NASA Lewis Icing Research Tunnel. Results of the tests show very good agreement between profilometer measurements and known simulated ice shapes and fair agreement between profilometer measurements and hand tracing techniques. Author

N95-30902# Federal Aviation Administration, Atlantic City, NJ.
OFFSHORE NEXT GENERATION WEATHER RADAR(NEXRAD) OT&E INTEGRATION AND OT&E OPERATIONAL TEST Final Report
RADAME MARTINEZ, BAXTER STRETCHER, JOHN PORCELLO, PETER GUTHLEIN, and WILLIAM DIVINEY Mar. 1995 83 p
(AD-A293223; DOT/FAA/CT-TN95/10) Avail: CASI HC A05/MF A01

This document is the Final Report for Phase 1 limited Operational Test and Evaluation (OT&E) Integration and OT&E Operational testing of the first Federal Aviation Administration (FAA) redundant configuration Next Generation Weather Radar (NEXRAD) installed in Kauai, Hawaii, and provides an account of the results of OT&E testing, including recommendations for future considerations. This report provides background information on the Offshore NEXRAD system. In addition, the report contains a description of testing and evaluation including information about the test schedule and location test participants, specialized test equipment used during testing, test objectives/criteria, test descriptions, test results, and methods used for data collection and analysis. The report continues with a comprehensive discussion of overall test results, including Critical Operational Issues (C 01) and their resolution. Finally, the report ends with test conclusions and recommendations to improve system performance. DTIC

N95-30906# Arnold Engineering Development Center, Arnold AFS, TN.
ANALYSIS OF PLANAR LASER-INDUCED FLUORESCENCE IMAGES OBTAINED DURING SHAKEDOWN TESTING OF THE AEDC IMPULSE FACILITY Final Report, Oct. 1993 - Sep. 1994
W. M. RUYTEN, W. D. WILLIAMS, and F. L. HELTSLEY Mar. 1995 62 p
(AD-A293237; AEDC-TR-94-14) Avail: CASI HC A04/MF A01

Following a proof-of-principle demonstration of Planar Laser-Induced Fluorescence (PLIF) in the AEDC Impulse Facility in FY93, a set of four PLIF images was obtained during FY94 runs of the facility. The images were obtained away from the nose region of a spherically blunt cone, using excitation of nitric oxide in the flow. Two laser sheet geometries were employed and two excitation wavelengths were used. A procedure was developed whereby calibration images allow the remapping of the PLIF images to test article coordinates. Using this technique, it was shown that the bow shock positions determined by PLIF agree well with the shock positions measured using schlieren photography. More importantly, the set of PLIF images constitutes an initial database against which Computational Fluid Dynamics calculations of high enthalpy flows can be compared. Initial results of such a comparison, obtained through Computational Flow Imaging, are reported. Recommendations are given for future PLIF applications at the Impulse Facility. DTIC

N95-30922# Federal Aviation Administration, Atlantic City, NJ.
ELECTRICAL SHORT CIRCUIT AND CURRENT OVERLOAD TESTS ON AIRCRAFT WIRING
PATRICIA CAHILL Mar. 1995 13 p
(AD-A293308; DOT/FAA/CT-TN94/55) Avail: CASI HC A03/MF A01

This document describes the electrical short circuit and current overload tests that were conducted on wires used in commercial transport category aircraft. This testing was conducted to evaluate the fire potential that may result from electrical faults. Results of this testing showed that circuit breakers provide reliable overcurrent protection and that circuit breakers may not protect wire from ticking faults but can protect wire from direct shorts. It also showed that circuit breakers may not safeguard against the ignition of flammable materials by ticking faults. Preliminary testing also indicated that direct short circuits are not likely to start a fire and that direct short circuits do not erode insulation and conductors to the same degree that ticking faults do. Current overload testing that resulted in complete thermal degradation of the wire was also conducted to compare it with a fire-exposed wire. No differences were seen; however, the conductor of the wire subjected to the fire was more brittle than the current overloaded wire. Further testing along with metallurgical evaluation would be necessary to substantiate this finding fully. DTIC

N95-30956 Technische Univ., Delft (Netherlands).
DYNAMICAL SYSTEMS AS MODELS FOR FLOW-INDUCED VIBRATIONS
A. H. P. VANDERBURGH 1994 34 p Limited Reproducibility: More than 20% of this document may be affected by microfiche quality
(PB95-206991) Copyright Avail: Issuing Activity (National Technical Information Service (NTIS))

In this paper a number of oscillators with two degrees of freedom is considered. Attention is paid to the case in which only one degree of freedom interacts with a flowing medium. For the modeling of the flow-induced vibrations use is made of a quasi-steady theory. Model equations systems of non-linearly coupled harmonic oscillators are obtained. The *analysis of these equations is restricted to special periodic and quasi-periodic solutions.* The physical interpretation may be of relevance for the understanding of a number of technical problems. NTIS

N95-30957# Technische Univ., Delft (Netherlands).
ACCELERATION POTENTIAL MODELS PREDICHAT/PREDICDYN APPLIED FOR CALCULATION OF AXISYMMETRIC DYNAMIC INFLOW CASES
G. J. W. VANBUSSEL Dec. 1993 32 p
(PB95-207015; IW-93071R) Avail: CASI HC A03/MF A01

Under the assumption of incompressible, inviscid and irrotational flow, it can be shown that the pressure perturbation in the complete flow field is given by a Laplace equation and acts as an acceleration potential function. The rotor blades are represented in the model as discrete surfaces on which a pressure discontinuity is present. The model implies the presence of spanwise and chordwise pressure distributions, which are composed of analytical asymptotic solutions for the Laplace equation. This model is implemented in the PREDICHAT and PREDICDYN computer code series, for steady and axisymmetric dynamic inflow cases respectively. Dynamic inflow concerns with large scale unsteady rotor aerodynamics, such as coherent wind gusts, collective blade pitch and rotor speed variations. The basic equations implemented in the codes are presented, as well as some results from uniform flow, blade pitching and a safety stop. Comparisons with other calculations and with measurements are presented and show a good agreement. NTIS

N95-30992 Pacific-Sierra Research Corp., Santa Monica, CA.
HOT JET/WAKE TURBULENT STRUCTURE AND LASER PROPAGATION. PART 3: LASER PROPAGATION MEASUREMENTS AND MODELING
ALAN R. SHAPIRO and J. H. CHURNSIDE (National Oceanic and Atmospheric Administration, Boulder, CO.) *In* JHU, The 21st JANNAF Exhaust Plume Technology Meeting, Volume 1 p 79-95 Oct. 1994
Contract(s)/Grant(s): (F33615-92-C-1028)
Avail: CPIA, 10630 Little Patuxent Pkwy., Suite 202, Columbia, MD 21044-3200 HC

The use of lasers aboard aircraft is affected by the perturbed airflow in its vicinity. Therefore, an ability to predict the structure of aircraft-induced turbulence would be useful in system and performance analysis. Pacific-Sierra Research Corp. performed temperature and velocity fluctuation measurements in the wakes of an NRA-3B and a B-1B at trail distances of 50 to 5500 m, at two Mach numbers (0.5 and 0.75) and at two altitudes (0.9 and 6 km). Analysis of the data suggested significant differences with the predictions of the computational fluid dynamics code (CFD) WAKE developed for this application by ARAP for the U.S. Air Force. The magnitude and scales of the temperature fluctuations suggest that first order laser propagation models would not apply. The principal difference between the data and the CFD predictions is that the temperature *fluctuations which determine C(n)-2 are not isotropic-and exhibit spectra* and correlation scales which differ greatly from those of velocity. This paper reports wind tunnel measurements to determine the source of this temperature structure in aircraft wakes and laser propagation measurements in this regime. Modifications to CFD and to propagation models are suggested. Author

N95-31098 Ecole Polytechnique, Montreal (Quebec).
THERMAL-MECHANICAL FATIGUE CRACK GROWTH IN AIRCRAFT ENGINE MATERIALS Ph.D. Thesis
YI DAI 1993 353 p
(ISBN-0-315-86543-1) Avail: Univ. Microfilms Order No. DANN86543

This thesis summarizes the major technical achievements obtained as a part of a collaborative research and development project between Ecole Polytechnique and Pratt & Whitney Canada. These achievements include: (1) a thermal-mechanical fatigue (TMF) testing rig which is capable of studying the fatigue behaviors of gas turbine materials under simultaneous changes of temperatures and strains or stress; (2) an advanced *alternative current potential drop* (ACPD) *measurement system which is* capable of performing on-line monitoring of fatigue crack initiation and growth in specimen testing under isothermal and TMF conditions; (3) fatigue crack initiation and short crack growth data for the titanium specimens designed with notch features associated with bolt holes of compressor discs; (4) thermal-mechanical fatigue crack growth data for two titanium alloys being used in PWC engine components, which explained the material fatigue behavior encountered in full-scale component testing; (5) a complete fractographic analysis for the tested specimens which enhanced the understanding of the fatigue crack growth mechanisms and helped to establish an analytical crack growth model; and (6) application of the ACPD fatigue crack monitoring technique to single tooth firtree specimen (STFT) LCF testing of PWA 1480 single crystal alloy. Finally, a comprehensive discussion concerning the results pertaining to this research project is presented. Dissert. Abstr.

N95-31355# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Cologne (Germany). Inst. fuer Antriebstechnik.
EXPERIMENTAL INVESTIGATION OF TURBULENT PARTICLE DISPERSION IN SWIRLING FLOWS Ph.D. Thesis - Ruhr Univ. Bochum [EXPERIMENTELLE UNTERSUCHUNG DER TURBULENTEN PARTIKELDISPERSION IN DRALLSTROEMUNGEN]
CHRISTOPH HASSA 1994 155 p In GERMAN
(ISSN 0939-2963)
(DLR-FB-94-20) Avail: CASI HC A08/MF A02

The turbulent particle dispersion is investigated with regard to the two-phase flow of fuel spray and combustion air in gas turbine combustion chambers. For that purpose, an atmospheric isothermal experiment is presented, that allows the verification of mathematical models for the calculation of turbulent two-phase flows by virtue of the application of nonintrusive measuring techniques and the similarity of its flow configuration to the practical flow. The basic configuration of the gas flow is an axisymmetric, expanding swirl flow with a practical swirl strength and expansion ratio. By using a monodisperse droplet generator, the investigation of turbulent dispersion was separated from atomization. For the gaseous phase, mean and fluctuating velocities as well as Eulerian integral time scales have been measured. The droplet-phase is documented by the measurement of droplet-flux density, velocity, and ensemble rms velocity. Author

N95-31374# Analytic Power Corp., Boston, MA.
LINEAR MOTOR FREE PISTON COMPRESSOR Final Report
DAVID P. BLOOMFIELD 17 Feb. 1995 30 p
Contract(s)/Grant(s): (DAAL03-92-C-0016)
(AD-A293452; ARO-30443.1-CH-5) Avail: CASI HC A03/MF A01

A Linear Motor Free Piston Compressor (LMFPC), a free piston pressure recovery system for fuel cell powerplants was developed. The LMFPC consists of a reciprocating compressor and a reciprocating *expander which are separated by a piston. In the past energy efficient* turbochargers have been used for pressure large (over 50 kW) fuel cell powerplants by recovering pressure energy from the powerplant exhaust. A free piston compressor allows pressurizing 3 - 5 kW sized fuel cell powerplants. The motivation for pressurizing PEM fuel cell powerplants is to improve fuel cell performance. Pressurization of direct methanol fuel cells will be required if PEM membranes are to be used Direct methanol oxidation anode catalysts require high temperatures to operate at reasonable power densities. The elevated temperatures above 80 C will cause high water loss from conventional PEM membranes unless pressurization is employed. Because pressurization is an energy intensive process, recovery of the pressure energy is required to permit high efficiency in fuel cell powerplants. A complete LMFPC which can pressurize a 3 kW fuel cell stack was built. This unit is one of several that were constructed during the course of the program. DTIC

N95-31423*# Allison Engine Co., Indianapolis, IN.
ADVANCED K-EPSILON MODELING OF HEAT TRANSFER Final Report
OKEY KWON and FORREST E. AMES Jul. 1995 153 p
Contract(s)/Grant(s): (NAS3-25950; RTOP 505-62-10)
(NASA-CR-4679; E-9748; NAS 1.26:4679) Avail: CASI HC A08/MF A02

This report describes two approaches to low Reynolds-number k-epsilon turbulence modeling which formulate the eddy viscosity on the wall-normal component of turbulence and a length scale. The wall-normal component of turbulence is computed via integration of the energy spectrum based on the local dissipation rate and is bounded by the isotropic condition. The models account for the anisotropy of the dissipation and the reduced mixing length due to the high strain rates present in the near-wall region. The turbulent kinetic energy and its dissipation rate were computed from the k and epsilon transport equations of Durbin. The models were tested for a wide range of turbulent flows and proved to be superior to other k-epsilon models, especially for nonequilibrium anisotropic flows. For the prediction of airfoil heat transfer, the models included a set of empirical correlations for predicting laminar-turbulent transition and laminar heat transfer augmentation due to the presence of freestream turbulence. The predictions of surface heat transfer were generally satisfactory. Author

N95-31432# Christian Brothers Coll., Memphis, TN.
IMPROVED MODELING OF UNSTEADY HEAT TRANSFER (THE FIRST STEP) Final Report, 1 Jun. - 31 Jul. 1994
MARK A. DRIVER 28 Feb. 1995 69 p
Contract(s)/Grant(s): (F49620-94-1-0292)
(AD-A292777; AFOSR-95-0192TR) Avail: CASI HC A04/MF A01

Application of Total Variation Diminishing (TVD) schemes to turbulent flows is considered. The mathematical and physical basis of TVD schemes is discussed. TVD methodology is extended to the solution of turbulent flow problems. A first-order time accurate, second-order space accurate algorithm is used to compute solutions to the problems of shock-boundary-layer interaction, turbine rotor cascade flow, and unsteady, shock-induced heat transfer using the TVD algorithm. This algorithm provides the capability to accurately predict separation, reattachment and pressure and skin friction profiles for shock-boundary-layer inter action. Improved accuracy is demonstrated in computing surface pressures for a turbine rotor cascade. Heat transfer for the cascade is predicted with fair accuracy, showing all the significant features of the experimental Stanton number profile. Fairly accurate comparison with theory and experiment is evident in the unsteady solutions. DTIC

N95-31443# Mississippi Univ., University, MS.
INVESTIGATING THE USE OF SMART ACOUSTICALLY ACTIVE SURFACES FOR FLOW SEPARATION CONTROL IN TURBOMACHINERY Final Report, 1 Sep. 1991 - 31 Aug. 1994
SUMON K. SINHA 21 Feb. 1995 60 p
Contract(s)/Grant(s): (AF-AFOSR-0410-91)
(AD-A292819; SKS/95/1; AFOSR-95-0191TR) Avail: CASI HC A04/MF A01

In order to develop a mechanically simple and robust actuator for active flow separation control on axial compressor blades, three different types of acoustic transducers were tested in a wind tunnel. Flow separation on a cylinder in cross flow was used. The first transducer had an internally mounted acoustic speaker blowing through a slot. It could control flow separation only for low Reynolds number laminar flows. A flush mounted high-frequency circular piezo-electric transducer was tried next. It was marginally effective only around the laminar-turbulent transition regime. Since it could not focus the perturbations over a small area, the Acoustosurf was developed next. It consisted of an array of flush mounted narrow strip shaped acoustic transducers capable of detecting surface pressure fluctuations prior to separation. When the appropriate strips were excited at the predominant fluctuation frequency, separation was delayed for transitional and tripped flows. It is believed that the Acoustosurf produces a synergistic interaction between roughness, surface compliance and acoustic radiation to redirect the kinetic energy of the flow by exploiting flow instabilities. Negligible power is therefore needed to operate the Acoustosurf. This has attracted the attention of several aircraft manufacturers. DTIC

N95-31475# Hampton Univ., VA.
APPLICATION OF MULTIGRID COMPUTATIONAL FLUID DYNAMICS (CFD) METHODS TO ROTOR ANALYSIS Final Report, 1 Sep. 1993 - 31 Aug. 1994
HONG HU Mar. 1995 158 p
Contract(s)/Grant(s): (DAAJ02-93-C-0021)
(AD-A293012; USAATCOM-TR-94-D-22) Avail: CASI HC A08/MF A02

The TLNS3DR code is applied to various advanced rotor blades to study tip vortex and to investigate the general capabilities of the code. For nonrotating flows, the solutions in terms of the tip vortex and surface pressure coefficients are obtained for realistic helicopter rotor-tip configurations to study effects of blade planforms on the tip vortex under incompressible flow condition. Calculated results are compared with experimentally obtained data at NASA-Langley's Basic Aerodynamic Research Wind Tunnel (BART). A Berp-type tip, a swept-type tip and its equivalent taper-type tip configurations are investigated. For both nonrotating and rotating flows, the Berp-type blade, the swept-type blade, and its equivalent taper-type and rectangle-type blades with zero twist are considered under compressible flow condition. Solutions are presented. DTIC

N95-31614# Sandia National Labs., Albuquerque, NM.
HIGH STRAIN-RATE TESTING OF PARACHUTE MATERIALS
KENNETH W. GWINN, JOHN J. TOTTEN, and DONALD E. WAYE 1994 8 p Presented at the 13th Aerodynamics Decelerator Systems Technology Conference, Clearwater, FL, 15-19 May 1995
Contract(s)/Grant(s): (DE-AC04-94AL-85000)
(DE95-009577; SAND-94-2302C; CONF-950550-2) Avail: CASI HC A02/MF A01

Research at Sandia National Laboratories has shown a strain rate dependence of many materials used in the production of parachutes. Differences in strength of 30% have been found between strain rates of 12/s and slow rates normally used to define material properties for lightweight nylon cloth. These structures are sometimes deployed in a rapid fashion and the loading is experienced in milliseconds; the production of material data in the same loading regime is required for full understanding of material response. Also, material behavior suitable for structural analysis of these structures is required for successful analysis. This is especially important when different materials are used in the same fabric structure. Determining the distribution of load to various portions of a nylon and Kevlar parachute requires the correct moduli and material behavior in the analytical model. The effect of strain rate on the material properties of nylon and Kevlar components commonly used in parachute construction are reported in this paper. These properties are suitable for use in analytical models of these fabric structures. DOE

N95-31728# Foreign Broadcasting Information Service, Washington, DC.
FBIS REPORT: SCIENCE AND TECHNOLOGY. CENTRAL EURASIA
18 Jul. 1995 81 p Transl. into ENGLISH from various Central Eurasian articles
(FBIS-UST-95-029) Avail: CASI HC A05/MF A01

Translated articles cover the following topics: Use of Radar Set With Synthesized Antenna for Estimating Effectiveness of Active Masking and Simulating Interference Signals; Simulation of Echo Signals Picked From Sea Surface by Grazing Radar Beam at Low Grazing Angle; Methods and Algorithms of Sea Surface Radar Image Processing and Identification; Aircraft Optimum Control Synthesis Based on Group Analysis of Motion Equations; On Issue of Maximizing Aircraft Glide Range Planning; Effect of Amplitude and Phase Noise on Quality of Radar Image Formation; Narrow-Band Infrared (1.0-1.2 micron) Photodiodes on Stressed Selective Epitaxial GaAs/InGaAs Structures; Selection of Transverse Modes in InGaAsP Lasers with Dielectric Coating on Mirrors; Single-Mode Strip-Geometry lambda = 1.55 micron Stripe-Geometry InGaAsP/InP Lasers; and Effect of Hydrogen on Cracking of Metals and Testing Them for Indication of Cracking Processes by Acoustic Emission. CASI

N95-31738*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EXPERIMENTAL AND COMPUTATIONAL INVESTIGATION OF THE TIP CLEARANCE FLOW IN A TRANSONIC AXIAL COMPRESSOR ROTOR
KENNETH L. SUDER and MARK L. CELESTINA (Sverdrup Technology, Inc., Brook Park, OH.) Jun. 1995 17 p Presented at the 39th International Gas Turbine and Aeroengine Congress and Exposition, The Hague, Netherlands, 13-16 Jun. 1994, sponsored by ASME
Contract(s)/Grant(s): (NAS3-25266; RTOP 505-62-52)
(NASA-TM-106711; E-9076; NAS 1.15:106711) Avail: CASI HC A03/MF A01

Experimental and computational techniques are used to investigate tip clearance flows in a transonic axial compressor rotor at design and part speed conditions. Laser anemometer data acquired in the endwall region are presented for operating conditions near peak efficiency and near stall at 100% design speed and at near peak efficiency at 60% design speed. The role of the passage shock/leakage vortex interaction in generating endwall blockage is discussed. As a result of the shock/vortex interaction at design speed, the radial influence of the tip clearance flow extends to 20 times the physical tip clearance height. At part speed, in the absence of the shock, the radial extent is only 5 times the tip clearance height. Both measurements and analysis indicate that under part-speed operating conditions a second vortex, which does not originate from the tip leakage flow, forms in the endwall region within the blade passage and exits the passage near midpitch. Mixing of the leakage vortex with primary flow downstream of the rotor at both design and part speed conditions is also discussed. Author

N95-31837 Old Dominion Univ., Norfolk, VA.
UNSTEADY FLOW SIMULATIONS ABOUT MOVING BOUNDARY CONFIGURATIONS USING DYNAMIC DOMAIN DECOMPOSITION TECHNIQUES Ph.D. Thesis
GUAN-WEI YEN 1994 155 p
Avail: Univ. Microfilms Order No. DA9423440

A computational method is developed to solve the coupled governing equations of an unsteady flowfield and those of rigid-body dynamics in six degrees-of-freedom (6-DOF). This method is capable of simulating the unsteady flowfields around multiple component configurations with at least one of the components in relative motion with respect to the others. Two of the important phenomena that such analyses can help us to understand are the unsteady aerodynamic interference and the boundary-induced component of such a flowfield. By hybridizing two dynamic domain decomposition techniques, the grid generation task is simplified, the computer memory requirement is reduced, and the governing equations of the rigid-body dynamics are simplified with certain assumptions. Three dimensional, unsteady Navier-Stokes equations are solved on each of the subdomains by a fully-vectorized, finite-volume, upwind-biased, and approximately-factored method. These equations are solved on the composite meshes of hybrid subdomain grids that can move with respect to each other. Hence, the present method combines the advantages of an efficient, geometrically conservative, minimally and automatically dissipative algorithm with the advantages and flexibility of the domain decomposition techniques. Several measures that reduce the numerical error are studied and compared with the exact solution of a moving normal shock in a tube. This solution compares very well with the analytic solution of the isentropic equations. It is concluded, that as a minimum measure, the connectivity of nonconservative overlapped scheme needs to be second-order accurate for spatial and temporal discretizations, as well as for the moving subdomain interpolations. Furthermore, the CFL numbers should be restricted to below unity, if affordable, for flows with high flow gradients. The method is further scrutinized by simulating the flow past a sinusoidally pitching airfoil, and the flow past a sinusoidally pitching and plunging airfoil. The results of the former case are successfully compared with the experimental data. The final two-dimensional case is the separation of a store from an airfoil along a prescribed path. As the first three dimensional case, the flowfield past an oscillating cylinder near a vertical wall is simulated. Prior to coupling it with the flowfield equations, the 6-DOF trajectory method is validated by successfully comparing the path it predicts with the one used in a captive trajectory testing. Finally, a rigid-body dynamics method is used to predict the aerodynamically determined trajectory of a store dropped from its initial position under a wing. The results of the present investigation contribute to the understanding of the unsteady aerodynamic interference and the boundary-induced component of such a flowfield. However, its main contribution is the newly proposed computational method for flows involving relative boundary motions. Dissert. Abstr.

N95-31948 Clarkson Univ., Potsdam, NY.
A TIME STEPPING COUPLED FINITE ELEMENT-STATE SPACE MODELING ENVIRONMENT FOR SYNCHRONOUS MACHINE PERFORMANCE AND DESIGN ANALYSIS IN THE ABC FRAME OF REFERENCE Ph.D. Thesis
FANG DENG 1994 290 p
Avail: Univ. Microfilms Order No. DA9422824

This dissertation centers on the development of a modeling environment to predict the performance and operating characteristics of salient-pole synchronous generators. The model basically consists of an algorithm consisting of two sections, a time stepping two-dimensional (2D) magnetostatic field finite element (FE) computation algorithm coupled to a state-space (SS) time-domain model of the winding circuits. Hence the term time stepping Coupled Finite Element-State Space (CFE-SS) modeling environment is adopted for this approach. In the FE section, magnetic vector potential (MVP) based finite element (FE) formulations and computation of two-dimensional (2D) magnetostatic fields are used to get the magnetic field solutions throughout a machine's cross-section at a sequence (samplings) of rotor positions covering a complete (360 deg e) ac cycle. These field solutions yield the winding inductances by means of an energy and current perturbation method. The output of the FE section is the magnetic field solutions and the entire set of phase, field, damper, and sleeve winding inductance profiles versus rotor position, including all space harmonics due to rotor saliency, damper bar slotting, sleeve segmentation, stator slotting, and magnetic saturation. These inductance profiles are decomposed into their harmonic components by Fourier analysis. The magnetic field solutions and resulting winding inductances represent the key input data to the SS portion of the CFE-SS modeling environment. Laminated machine iron core loss calculations, which include the losses in the stator and rotor as well as pole face are

subsequently performed using the magnetic field solution data. Conversely, the output of the SS portion is the entire set of phase, field, damper winding (circuit), and sleeve segment currents, which also include all the resulting time harmonics. These winding current results form in turn the key input data to the FE portion of the modeling environment which is iteratively used in obtaining inductance parameters prior to another round of SS computation of the steady-state current profiles. Again, the model is iterative in nature, in which the user continues cycling through the two sections, namely the FE and SS sections of the CFE-SS modeling environment, until the desired degree of convergence is achieved. The CFE-SS approach uses only design data such as physical dimensions, magnetic circuit geometry, magnetic material characteristics, winding particulars and layouts, and hence does not depend on the existence of actual hardware. The modeling environment is totally within the ABC frame of reference, therefore no approximating assumptions such as sinusoidally distributed mmf's or current sheets were made.
Dissert. Abstr.

N95-32109 Virginia Univ., Charlottesville, VA.
SPATIALLY-RESOLVED VELOCITY MEASUREMENTS IN STEADY, HIGH-SPEED, REACTING FLOWS USING LASER-INDUCED OH FLUORESCENCE Ph.D. Thesis
KURT G. KLAVUHN 1994 180 p
Avail: Univ. Microfilms Order No. DA9424479

The theoretical development and calibration of a nonintrusive, high-resolution, optical flowfield-diagnostic technique utilizing OH laser-induced fluorescence (OH LIF) for the measurement of velocity in steady, high-speed, reacting flows is reported. The particular high-speed, reacting flows of interest are those occurring in supersonic combustors for proposed hypersonic flight vehicles. The theory of the OH LIF strategy employed is described, with emphasis on the optimization of the strategy for quantitative velocity measurements. A simplified model is derived for the calculation of expected signal levels from pulsed, narrow-linewidth, (1,0) band excitation of OH in flames when collecting filtered (1,1) and (0,0) band fluorescence with a gated detector. Several illumination techniques are presented for measuring the Doppler shift of the OH LIF while eliminating systematic errors. A unique reacting underexpanded jet was constructed for the calibration of the OH LIF velocity measurement technique over a wide range of flow conditions. A complete analysis of the distribution of flow properties in the jet flowfield is presented, including results from a full Navier-Stokes calculation with finite-rate chemistry. Comparisons of results from pointwise OH LIF velocity measurements along the centerline and planar OH LIF velocity measurements along the central plane of the reacting underexpanded jet with the numerical solution demonstrate the resolution, range, and accuracy of the technique. Measured and calculated velocities in the supersonic jet core agree on average to within +/- 1.3 percent for the pointwise measurements and +/- 2.2 percent for the planar measurements. The uncertainty (2 sigma) in the pointwise velocity measurements in the jet core was on average +/- 6.0 percent for a single measurement and +/- 3.5 percent for the average value of three scans. For the planar velocity measurements in the jet core, the uncertainty (2 sigma) was on average +/- 4.9 percent for a single measurement and +/- 2.2 percent for the average value of five scans.
Dissert. Abstr.

N95-32163# Allison Engine Co., Indianapolis, IN.
ADVANCED TURBINE SYSTEMS PROGRAM CONCEPTUAL DESIGN AND PRODUCT DEVELOPMENT Quarterly Report, Nov. 1993 - Jan. 1994
Jan. 1995 16 p
Contract(s)/Grant(s): (DE-AC21-93MC-29257)
(DE95-000088; DOE/MC-29257/4018) Avail: CASI HC A03/MF A01

This report describes progress made in the advanced turbine systems program conceptual design and product development. The topics of the report include selection of the Allison GFATS, castcool technology development for industrial engines test plan and schedule, code development and background gathering phase for the ultra low NOx combustion technology task, active turbine clearance task, and water vapor/air mixture cooling of turbine vanes task.
DOE

N95-32165# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
ENVIRONMENTALLY SAFE AND EFFECTIVE PROCESSES FOR PAINT REMOVAL [PROCEDES EFFICACES ET ECOLOGIQUES POUR L'ENLEVEMENT DES PEINTURES]
Apr. 1995 91 p Lecture series held in Lisbon, Portugal 27-28 Apr. 1995, in Eskisehir, Turkey 1-2 May 1995 and in Ottobrunn, Germany 4-5 May 1995
(AGARD-LS-201; ISBN-92-836-1017-2) Copyright Avail: CASI HC A05/MF A01

Paint stripping and repainting of aircraft surfaces are required periodically during the operating lifetime of an aircraft. Historically, paint removal has been achieved using chemical strippers, involving materials which contain toxic components and which create hazardous working conditions. The process generates large amounts of hazardous waste from the chemicals used. Alternative methods for aircraft paint removal are now being investigated within the NATO nations with regard to their environmental safety and effective application. These processes include: Plastic Media Blasting, Wheat Starch Dry Media Blasting, Carbon Dioxide Pellet Blasting, Sodium Bicarbonate Blasting and Thermal Decomposition Methods (Laser, Flash Lamps/Carbon Dioxide). The Lecture Series will review these current state-of-the-art alternative methods with environmental effects and related health hazards, costs, process controls, and more. For individual titles, see N95-32166 through N95-32181.

N95-32170# Esquimalt Defence Research Detachment, Victoria (British Columbia).
WATER BLASTING PAINT REMOVAL METHODS
TERRY FOSTER *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 3 p Apr. 1995
Copyright Avail: CASI HC A01/MF A01

Water blasting is a paint removal technique that has been used for cleaning and paint removal for many years. The major disadvantages until recently were the slow rate of paint removal and the possibility of damage to the substrate from the high pressures used. With the improvement in nozzle design that allows for higher operating pressures and the use of environmentally compliant paint softeners or strippers, water blasting is becoming a recognized technique for paint removal in the aircraft industry.
Author

N95-32175# Aerospatiale, Toulouse (France). Direction des Estudes.
SELECTIVE CHEMICAL STRIPPING
OLIVIER MALAVALLON *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 3 p Apr. 1995
Copyright Avail: CASI HC A01/MF A01

At the end of the 80's, some of the large European airlines expressed a wish for paint systems with improved strippability on their aircraft, allowing the possibility to strip down to the primer without altering it, using 'mild' chemical strippers based on methylene chloride. These improvements were initially intended to reduce costs and stripping cycle times while facilitating rapid repainting, and this without the need to change the conventionally used industrial facilities. The level of in-service performance of these paint systems was to be the same as the previous ones. Requirements related to hygiene safety and the environment were added to these initial requirements. To meet customers' expectations, Aerospatiale, within the Airbus Industry GIE, formed a work group. This group was given the task of specifying, following up the elaboration and qualifying the paint systems allowing requirements to be met, in relation with the paint suppliers and the airlines. The analysis made in this report showed the interest of transferring as far upstream as possible (to paint conception level) most of the technical constraints related to stripping. Thus, the concept retained for the paint system, allowing selective chemical stripping, is a 3-coat system with characteristics as near as possible to the previously used paints. Derived from text

N95-32179# Esquimalt Defence Research Detachment, Victoria (British Columbia).

OPERATIONAL PARAMETERS AND MATERIAL EFFECTS

TERRY FOSTER *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 6 p Apr. 1995

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Although there are six types of plastic media, the focus on operational parameters and materials effects of PMB (plastic media blasting) will be on the Type 5 acrylic media with some reference and comparisons to Type 2 media. The other four plastic media are not used extensively in general aircraft stripping and will not be discussed in this paper. There are several military and commercial documents available with detailed procedures for plastic media stripping of aircraft. The actual choice of blasting parameters will, to a great extent, depend on the media chosen and the substrate to be stripped. The effects of various blasting conditions on materials can be evaluated using visual, optical microscopy, scanning electron microscopy (SEM) and mechanical and corrosion test methods. In some test methods up to twelve specimens are required to give meaningful results, therefore statistical analysis tools are also required to interpret the results due to the scatter in some of the data. Derived from text

N95-32180# Aerospatiale, Toulouse (France). Direction des Etudes.

PROCESS EVALUATION

OLIVIER MALAVALLON *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 3 p Apr. 1995

Copyright Avail: CASI HC A01/MF A01

It is not always easy to conduct a study and implement a systematic policy in the aeronautical paint stripping field. The situations to be studied are complicated by extensive technical data, material conditions and financial unknowns. To these are added demands both in the civil and military fields to increase the performance obtained, optimize cycles, reduce recurrent costs, quickly amortize investments and now increasing respect for the environment. To reply correctly, the various possibilities must be assessed using, if possible, identical criteria and reference systems. The only criterion which applies to all the processes and methods is the overall stripping cost. It is not sufficient for a process to meet the related technical requirements (for example 'IATA guidelines'), it must also be economically justifiable. The overall costs take into account therefore the costs and materials, labor and also the downtime of the aircraft, amortization and maintenance of the installations and processing of waste, etc. For many years now, AEROSPATIALE has undertaken research and development programs to find and evaluate alternatives to the conventional chemical stripping process. This work has led it to carry out comparative analyses from technical elements enhanced as the work progressed. Derived from text

N95-32181# Aerospatiale, Toulouse (France). Direction des Etudes.

STANDARDIZATION WORK

OLIVIER MALAVALLON *In* AGARD, Environmentally Safe and Effective Processes for Paint Removal 1 p Apr. 1995

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For several years now, the main civil aircraft manufacturers (Airbus and its partners, Boeing, Fokker, McDonnell Douglas) have been working jointly on the writing of technical recommendations and the drawing up of an international standard. This work concerns the evaluation of the processes and products used to strip aeronautical paint systems. This procedure was initiated on request from the main airlines. In effect, the airlines are faced with situations in which the financial and operational objectives are becoming increasingly important. The need was felt to rationalize and, if possible, harmonize the criteria and technical requirements of the various civil aircraft manufacturers in order to facilitate in-service maintenance of the fleets of airlines operating Airbus, Boeing, Douglas aircraft, etc. Derived from text

N95-32205*# Toledo Univ., OH.

FPCAS3D USER'S GUIDE: A THREE DIMENSIONAL FULL POTENTIAL AEROELASTIC PROGRAM, VERSION 1 Final Contractor Report

MILIND A. BAKHLE Jul. 1995 46 p

Contract(s)/Grant(s): (NAG3-1234; RTOP 538-06-14)

(NASA-CR-198367; E-9796; NAS 1.26:198367) Avail: CASI HC A03/MF A01

The FPCAS3D computer code has been developed for aeroelastic stability analysis of bladed disks such as those in fans, compressors, turbines, propellers, or propfans. The aerodynamic analysis used in this code is based on the unsteady three-dimensional full potential equation which is solved for a blade row. The structural analysis is based on a finite-element model for each blade. Detailed explanations of the aerodynamic analysis, the numerical algorithms, and the aeroelastic analysis are not given in this report. This guide can be used to assist in the preparation of the input data required by the FPCAS3D code. A complete description of the input data is provided in this report. In addition, six examples, including inputs and outputs, are provided. Author

N95-32206*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

A PROBABILISTIC DESIGN METHOD APPLIED TO SMART COMPOSITE STRUCTURES

MICHAEL C. SHIAO and CHRISTOS C. CHAMIS (NYMA, Inc., Brook Park, OH.) Aug. 1995 18 p Presented ath the 39th International Symposium and Exhibition, Anaheim, CA, 11-14 Apr. 1994; sponsored by the Society for the Advancement of Materials, and Process Engineering

Contract(s)/Grant(s): (NAS3-27186; RTOP 505-62-10)

(NASA-TM-106715; E-9081; NAS 1.15:106715) Avail: CASI HC A03/MF A01

A probabilistic design method is described and demonstrated using a smart composite wing. Probabilistic structural design incorporates naturally occurring uncertainties including those in constituent (fiber/matrix) material properties, fabrication variables, structure geometry and control-related parameters. Probabilistic sensitivity factors are computed to identify those parameters that have a great influence on a specific structural reliability. Two performance criteria are used to demonstrate this design methodology. The first criterion requires that the actuated angle at the wing tip be bounded by upper and lower limits at a specified reliability. The second criterion requires that the probability of ply damage due to random impact load be smaller than an assigned value. When the relationship between reliability improvement and the sensitivity factors is assessed, the results show that a reduction in the scatter of the random variable with the largest sensitivity factor (absolute value) provides the lowest failure probability. An increase in the mean of the random variable with a negative sensitivity factor will reduce the failure probability. Therefore, the design can be improved by controlling or selecting distribution parameters associated with random variables. This can be implemented during the manufacturing process to obtain maximum benefit with minimum alterations. Author

13
GEOSCIENCES

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

A95-93441

INTERNATIONAL CONFERENCE ON AVIATION WEATHER SYSTEMS

5TH, VIENNA, VA, AUG, 2-6, 1993. PREPRINT VOLUME Boston, MA American Meteorological Society 1993 472 p.

(HTN-95-92940) Copyright

Papers presented at the conference included overviews of aviation weather systems, range and aerospace meteorology, detecting weather systems that can impact on aviation, training and education in aviation meteorology, aviation impact weather variables, aviation weather forecasting, dissemination of aviation weather information, and the economic effects of weather on aviation. Papers dealing with forecasting aviation weather were also presented in a joint session with the 13th Conference on Weather Analysis and Forecasting. Poster sessions at the conference dealt with requirements for aviation weather products, aviation weather forecasting, detecting weather systems that can impact on aviation, dissemination of aviation weather information, range and aerospace meteorology, and aviation impact variables. For individual titles, see A95-93442 through A95-93561. Hemer

A95-93442

AN OVERVIEW OF FAA-SPONSORED AVIATION WEATHER RESEARCH AND DEVELOPMENT

DAVID A. SANKEY Federal Aviation Administration, Washington, DC, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 1-4

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The Federal Aviation Administration sponsors research and development work aimed at improving the weather information provided to the air traffic control system, pilots and other users of aviation weather information, e.g. dispatchers and airport operators. There are four major thrusts currently underway: The Aviation Gridded Forecast System (AGFS), the Aviation Weather Products Generator (AWPG), the Integrated Terminal Weather System (ITWS) and applied research and development. Author (Hemer)

A95-93443

THE FORECAST SYSTEMS LABORATORY'S ROLE IN THE FAA'S AVIATION WEATHER DEVELOPMENT PROGRAM

MICHAEL J. KRAUS NOAA, Boulder, CO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 5-7

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The Federal Aviation Administration (FAA) has embarked on an ambitious program to upgrade weather support for a large cross section of the aviation community. With National Weather Service (NWS) participation, this program will affect the products coming out of the National Meteorological Center (NMC), the operations of the National Aviation Weather Advisory Unit (NAWAU) in Kansas City, Missouri and the operations of each Center Weather Service Unit (CWSU) in the country. (There is a CWSU at every Air Route Traffic Control Center and at the Air Traffic Control Systems Command Center (ATCSCC) in Washington, D.C.) The new NWS products, based on forecast models and analyses called the Aviation Gridded Forecast System (AGFS), will be produced more frequently and have a higher spatial resolution than current products. Products will be transmitted in a gridded format, enabling meteorologists and users in the aviation community to create graphics along any desired spatial plane. For example, aviation users will be able to create displays along route-specific vertical cross sections. The jargon in the FAA Aviation Weather Development Program (AWDP) for this type of product creation is to 'slice and dice' the data. This paper provides an overview of the responsibilities of the Forecast Systems Laboratory (FSL) in helping the FAA and NWS accomplish the goals of the AWDP.

Author (revised by Hemer)

A95-93445

NATIONAL AVIATION WEATHER PROGRAM PLAN

RICHARD HEUWINKEL Federal Aviation Administration, Washington, DC, US, KELLY CONNOLLY The MITRE Corporation, McLean, VA, US, and GRAHAM GLOVER The MITRE Corporation, McLean, VA, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 13-17

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The aviation weather system exists to serve the operational needs of the many users of the national airspace. Users can be broadly categorized as follows: Non-federal users, such as general aviation, air taxi/commuters, air carriers, helicopters, fixed base operators, state aviation entities, and commercial vendors. Department of Defense (DOD) users, including Air Force, Navy, Army, and Marines. Other federal users, such as the Federal Aviation Administration (FAA), the National Weather Service (NWS), the National Aeronautics and Space Administration (NASA), the Department of Agriculture (USDA), the Department of Interior (DOI), and the U.S. Coast Guard. The operational usage of weather information can be viewed in terms of both information categories and phases of flight. The former includes current observations, and forecasts from very near-term to time horizons of 24 hours and beyond; the latter includes flight planning, terminal departure, en route/oceanic, and approach/landing. Clearly when the range of information and the diversity of users is considered, the provision of adequate aviation weather products/services represents a multi-faceted challenge. Author (Hemer)

A95-93446

OPERATIONAL AVIATION WEATHER REGULATIONS

GRAHAM K. GLOVER The MITRE Corporation, McLean, VA, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 18-22

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The Federal Aviation Administration (FAA) is responsible for aviation within the United States (US), and within US controlled airspace. This responsibility includes providing support to aviation operations, one aspect of which is aviation weather. In accordance with various agreements, aviation weather information is jointly provided by the National Weather Service, the FAA, and non-Federal organizations including private industry. The weather needs of the aviation users can be provided by the Government and/or the private sector. However, the Government must ensure that the operational aviation weather requirements in the Federal Aviation Regulations (FAR) are met. The FAR identify situations and circumstances where the use of specific weather information is required. These regulations are recognized as having the full force of federal law behind them, and have identified procedures to be followed in their enforcement. As such, the weather related FAR are considered to be legally valid without need for further justification. The purpose of this paper is to identify the weather related aviation regulations in general, and to show their application in a scenario using a hypothetical flight profile from the preflight phase through landing. Author (Hemer)

A95-93447

A STATUS REPORT ON THE DEVELOPMENT OF THE FEDERAL AVIATION ADMINISTRATION/NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION MEMORANDUM OF AGREEMENT

RICHARD J. HEUWINKEL Federal Aviation Administration, Washington, DC, US and CHRISTINE A. MALACANE The MITRE Corporation, McLean, VA, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 23-26
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The Federal Aviation Act of 1958 directs the Secretary of Transportation 'to make recommendations to the Secretary of Commerce for providing meteorological service necessary for the safe and efficient movement of aircraft in air commerce'. As a result of Office of Management and Budget (OMB) directive and budget guidance, the National Weather Service (NWS) must have the Federal Aviation Administration's (FAA's) requirements before it can enhance existing aviation-specific products and services or add new products and services for the FAA. The current Memorandum of Agreement (MOA) between the FAA and the National Oceanic and Atmospheric Administration (NOAA) for the provision of aviation weather services has been in effect since 1977. A working group composed of FAA and NOAA/NWS participants is updating the existing MOA. The updated MOA will address the FAA's weather-related requirements. The Memorandum of Agreement defines working arrangements between the FAA and NOAA with regard to aviation weather services. It is intended to provide broad guidance to regional offices of the FAA and NOAA for the development of regional and local agreements and working arrangements for day-to-day operations. The MOA addresses the high-level roles and responsibilities of the agencies in providing aviation weather services and defines working arrangements related to the following areas: Administration, Finance, Facilities and Equipment, Operations, Communications, Training, and Research and Development. Author (revised by Herner)

A95-93448

AN APPROACH TO WEATHER REQUIREMENTS MANAGEMENT

VINCENT P. SCHULTZ Federal Aviation Administration, Washington, DC, US and ROBERT K. CALZETTA Technology Planning Incorporated, Rockville, MD, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 27-30
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The Federal Aviation Administration (FAA) is faced with the challenge of implementing increasingly complex, interrelated technological solutions to satisfy the weather needs of multiple users and diverse operations within the aviation community. Operational system planning is a new way of looking at making the best use of technology and arriving at appropriate functional capabilities for advanced aviation weather systems. Operational system planning is based on thorough examination of the operational processes pertinent to the National Airspace System (NAS) goals of safety, capacity, and efficiency. Requirements management for weather requirements is an activity which promotes oversight of operational system planning throughout the Major Systems Acquisition (MSA) process. It begins with articulation of the user's need and rationale for weather information for the daily operations performed by the user. Operational requirements are derived from these needs by analyzing the user's environment, decision levels, and overall job responsibilities. Operational requirements become the NAS top level weather requirements which flow down into system specifications and designs, and operational test and evaluation criteria. This paper presents a requirements management methodology which can be used to identify Air Traffic (AT) needs for weather information in the NAS and apply them to operational system planning. This methodology includes the identification of operational weather needs, a process for the translation of operational weather needs into engineering requirements, and an approach for requirements management which expedites both programmatic decision-making and the proper choice of technological solutions to meet the needs. Author (Herner)

A95-93449

ON DESIGNING AND ENGINEERING THE INTEGRATED TERMINAL WEATHER SYSTEM

ELIZABETH R. DUCOT MIT, Lexington, MA, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 31 Research sponsored by the Federal Aviation Administration
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The Integrated Terminal Weather System (ITWS) is one of three major development projects sponsored by the Federal Aviation Administration's (FAA's) Aviation Weather Development Program (Sankey, 1993). Focused on the environment within the terminal area, ITWS integrates data and products from relevant FAA and National Weather Service (NWS) sensors and systems to create a suite of weather products that will provide for improvements in terminal planning, capacity, and safety. The ITWS products, which will require no special meteorological interpretation, will be tailored to the needs of individual users (e.g., pilots, controllers, terminal area traffic managers and terminal automation systems). Although ITWS has no dedicated sensors of its own, the system architecture is extremely complex. A functional prototype of the ITWS is being developed by M.I.T. Lincoln Laboratory to provide a mechanism for exploring the operational concept for the system, for identifying the issues surrounding real-time access to the diverse data sources, for exercising the algorithms that produce the products in an operational setting, and for facilitating transfer of the ITWS technology to a production contractor. There are a number of challenges inherent in designing and engineering the ITWS – the most significant of which are derived from the high priority placed on an early system deployment. The conference speech will present the overall system concept followed by a review of the design and engineering challenges; indicating first how these challenges affect the strategies applied to phased development and validation of the weather algorithms, second how they affect the strategies for the development and use of prototype systems in the field, and finally how they affect various mechanisms for achieving an early initial operational capability for the system. Progress to date in addressing these challenges will be presented. Author (Herner)

A95-93450

STATUS OF THE TERMINAL DOPPLER WEATHER RADAR WITH DEPLOYMENT UNDERWAY

DONALD TURNBULL Federal Avaition Administration, Washington, DC, US, DAVID M. BERNELLA MIT, Lexington, MA, US, and JAMES E. EVANS MIT, Lexington, MA, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 32-34 Research sponsored by the Federal Aviation Administration
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The Federal Aviation Administration (FAA) initiated the Terminal Doppler Weather Radar (TDWR) program in the mid-1980's in response to the need for improved real-time hazardous weather (especially low-altitude wind shear) surveillance in the terminal area. The initial focus of the TDWR was to provide reliable, fully automated Doppler radar detection of microbursts and gust fronts and 20-minute warning of wind shifts which could effect runway usage. Subsequent operational demonstrations have shown that the overall terminal situational awareness provided by the TDWR color Geographical Situation Display (GSD) depiction of wind shear locations, weather reflectivity and storm motion also yields substantial improvements in terminal operations efficiency for air traffic managers and for airlines. In this paper, we will describe the current status and deployment strategy for the operational systems and recent results from the extensive testing of the radar system concept and of the weather information dissemination approach. Author (Herner)

A95-93452

THE INTEGRATED TERMINAL WEATHER SYSTEM(ITWS) STORM CELL INFORMATION AND WEATHER IMPACTED AIRSPACE DETECTION ALGORITHM

DIANA KLINGLE-WILSON MIT, Lexington, MA, US, EVELYN MANN MIT, Lexington, MA, US, and ANDREW DENNENO MIT, Lexington, MA, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 40-44 Research sponsored by the Federal Aviation Administration

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The Integrated Terminal Weather System (ITWS) is an FAA-sponsored program (Sankey, 1993; Ducot, 1993) whose objective is to acquire data and products from a variety of weather sensors, integrate the data and create aviation weather products for users, such as Air Traffic Control (AT) controllers and traffic managers, pilots, and airline and airport operations managers. The goal of ITWS is to increase capacity at airports, reduce controller workload, and enhance safety. The objective of the ITWS Storm Cell Information (StoCel) and Weather Impacted Airspace (WIA) Detection products is to identify storm cell characteristics (echo top, echo bottom, presence of heavy rain, hail, etc.) and airspace that pilots are likely to avoid because it contains hazardous weather. The StoCel/WIA products rely on the integration of pencil-beam data and products and Air Surveillance Radar (ASR-9) Weather Channel data. ASR-9 radars are useful because they cover the entire airspace of interest, perform a volume update at roughly 30-second intervals, and will be the weather representation most widely available to the Air Traffic Control (ATC) community. Nearby WSR-88D radars also cover the entire airspace of interest and provide indications of storm vertical structure. However, the volume update rate is typically on the order of 5 to 10 minutes, depending on the scanning strategy. Terminal Doppler Weather Radar (TDWR) radars perform volume updates about every 2.5 to 3 minutes, but perform sector scans that do not cover the entire airspace. Integration of the data from these various sensors produces a product that is superior to a product based on any single sensor. Field tests of components of this algorithm were conducted at Dallas-Ft. Worth (DFW) and Orlando (MCO) International Airports during the summer of 1993. The objectives of these tests are to evaluate the technical performance of the algorithm and the validate the operational concept. This paper will describe the algorithm, and discuss the operational concept and functional requirements for the product. Author (revised by Herner)

A95-93453

IMPROVING AIRCRAFT IMPACT ASSESSMENT WITH THE INTEGRATED TERMINAL WEATHER SYSTEM MICROBURST DETECTION ALGORITHM

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In recent years a number of aircraft accidents have resulted from a small scale, low altitude wind shear phenomena known as a microburst. Microbursts are produced within thunderstorms and are characterized by intense downdrafts which spread out after impacting the earth's surface, displaying strong divergent outflows of wind. The Terminal Doppler Weather Radar (TDWR) program is the first system developed to detect microbursts from a ground-based radar in the airport terminal area. Improving safety is its primary goal, and test operations in Denver, Kansas City, and Orlando have shown it to be highly successful in identifying microbursts. In general, this identification has been performed with a more than 90% Probability of Detection (POD) and a less than 10% Probability of False Alarm (PFA). The Integrated Terminal Weather System (ITWS) will introduce several new low-level wind shear products. These products include the Microburst Prediction product, the Microburst Trend product, and an improved Microburst Detection Product. The Microburst Prediction product will provide estimates of the future location, onset time, and peak intensity of microbursts before their surface effects are evident. The Improved Microburst Detection Algorithm being developed under the ITWS program attempts to build on the performance of the TDWR Microburst algorithm by improving POD and PFA and providing finer localization capabilities. Most importantly, enhancements to the TDWR algorithm are necessary in order to: (1) provide a consistent input to the microburst trend algorithm; (2) closely relate the microburst alert to the energy loss that the aircraft will actually experience and to alerts from an on-board forward-looking Doppler radar. The TDWR algorithm does a good job detecting the microburst impacted airspace, but makes no attempt to deduce the number and centers of the events. The focus of this paper is on the second motivating factor listed above: relating the microburst alert more closely with actual aircraft performance.

Author (revised by Herner)

A95-93454

ITWS CEILING AND VISIBILITY PRODUCTS

F. WESLEY WILSON, JR. MIT, Lexington, MA, US, JOHN KELLER MIT, Lexington, MA, US, R. GARY RASMUSSEN MIT, Lexington, MA, US, and PETER ZWACK University of Quebec and Montreal, Canada *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 51-55 Research sponsored by the Federal Aviation Administration

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A major function of the Integrated Terminal Weather System (ITWS) is to provide weather products that can be used in traffic planning and management to increase the actual capacity of an airport. The ITWS ceiling and visibility products are directed towards the management of the arrival traffic. The planned rate of arriving traffic at an airport is based on the Airprot Acceptance Rate (AAR), the number of arriving airplanes per hour that is believed can be safely handled by Air Traffic Control. Ceiling and visibility conditions near the airport are a major consideration in setting the AAR. Low ceilings and obscured visibility restrict the ability of pilots to see the runway and other aircraft. Necessary increased caution and separations in these conditions impede traffic flow near the airport. Unexpected, rapidly degrading low ceiling or visibility conditions can reduce the airport arrival capacity below the AAR with the result of holding large numbers of airplanes in terminal airspace before they can be safely landed. In extreme circumstances, pilots may be required to divert to their alternate destination. Conversely, unexpected rapidly improving low ceiling or visibility conditions can increase the airport arrival capacity at a time when there is insufficient approaching traffic to take advantage of the situation. Accurate short-term forecasts of these changing situations will provide the information needed by traffic managers for planning realistic acceptance rates and by pilots for diversion decisions. We present an overview of the product development strategy and discuss some of the technical considerations. It will be necessary to overcome significant scientific challenges in order to be successful. Our optimism comes from the improved operational meteorological data in the terminal area, from the ability to access and to process these data rapidly, and from ongoing advances in data assimilation for mesoscale models. Our role is to coordinate the fusion of these technical and scientific advances into operational aviation weather products and to evaluate the effectiveness of these products. Author (Herner)

A95-93455

ITWS GRIDDED ANALYSIS

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The Integrated Terminal Weather System (ITWS) brings together data from a number of FAA and non-FAA weather sensors to provide knowledge of the weather in an extended region surrounding an airport. ITWS supports a variety of new products designed to increase airport capacity and improve safety. The ITWS gridded analysis system provides an analysis of several state-of-the-atmosphere variables: wind, temperature, pressure, and humidity. The Local Analysis and Prediction System (LAPS), developed by NOAA/ERL/FSL provides the basic concepts and the initial prototype. The LAPS analysis combines data from the Mesoscale Analysis and Prediction System (MAPS) with observations from a variety sensors, such as wind profilers, ground stations, and aircraft. Several enhancements are being added to LAPS, creating an analysis system that is appropriate for terminal-area sensors and the temporal and spatial scales required for terminal operations. In 1992, a prototype terminal gridded winds analysis was tested at Orlando International Airport. Successful field operations from August 17 until September 25 featured the first real-time analysis using Terminal Doppler Weather Radar (TDWR) and the National Weather Service WSR-88D (NEXRAD) data. An improved system will operate at the Orlando airport this summer. We describe the prototype winds analysis, with particular attention to our implementation of Multiple Single Doppler Analysis (MSDA) and the cascade of scales, and give some examples from our 1992 demonstration.

Author (revised by Herner)

A95-93456

THE ITWS MICROBURST PREDICTION ALGORITHM

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Lincoln Laboratory is developing a prototype of the Federal Aviation Administration (FAA) International Terminal Weather System (ITWS) to provide improved aviation weather information in the terminal area by integrating data and products from various FAA and National Weather Service (NWS) sensors and weather information systems. The ITWS Microburst Prediction products is intended to provide an additional margin of safety for pilots in avoiding microburst wind shear hazards. The product is evisioned for use by traffic managers, supervisors, controllers, and pilots (directly via datalink). Our objective is to accurately predict the onset of microburst wind shear five or more minutes in advance. The approach we have chosen in developing the ITWS Microburst Prediction algorithm emphasizes fundamental physical principles of thunderstorm evolution and downdraft development, incorporating heuristic and/or statistical methods as needed for refinement. Image processing and data fusion techniques are used to produce an 'interest' image (Delanoy et al., 1991, 1992) that reveals developing downdrafts. We use Doppler radar data to identify regions of growing thunderstorms and probable regions of downdraft, and combine these with measures of the ambient temperature structure (height of the freezing level, lapse rate in the lower atmosphere; Wolfson 1990), total lightning flash rate, and storm motion to predict the microburst location, timing, and outflow strength. Author (Herner)

A95-93457

THE REAL-TIME ANALYSIS AND PREDICTION OF STORMS PROGRAM

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The Research Applications Program (RAP) at the National Center for Atmospheric Research (NCAR) has been conducting a variety of basic and applied research on meteorological technologies that may improve the safety and efficiency of our nation's air traffic system. To this end, RAP has had a rich history in the organization and participation of field observation programs. RAP has found that field programs enhance the understanding of the physical and dynamical processes of the atmosphere, allow rapid testing and evaluation of systems to detect and forecast meteorological phenomena, and facilitate the simultaneous scientific and engineering development that is necessary to rapidly transfer the technology to the operational community. RAP has participated in a multitude of field programs (e.g. JAWS, CLAWS, CINDE, TDWR, CaPE and WISP) to study phenomena ranging from microbursts to in-flight icing. The Real-time Analysis and Prediction of Storms (RAPS) field program represents an extension of RAP's ongoing efforts to observe and study phenomena in the convective weather environment. These studies have included short-term thunderstorm forecasting (using humans and artificial intelligence), advanced remote sensing, real-time numerical modeling, hail detection, and tornado forecasting. The purpose of this paper is to describe the programs general research, goals and operations.

Author (Herner)

A95-93458

PRELIMINARY COMPARISONS BETWEEN MM5 NCAR/PENN STATE MODEL GENERATED ICING FORECASTS AND OBSERVATIONS

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The Winter Icing and Storms Project (WISP) is a research study primarily directed toward improving the forecasting of icing conditions for the aviation community. A large part of this study is to develop and upgrade microphysical parameterizations for use in numerical models which predict areas of icing potential on a national scale. Presently, within the National Weather Service, the National Aviation Weather Advisory Unit in Kansas City is the only provider of aircraft-icing forecasts for the continental Untied States. Because none of the present numerical forecasts models explicitly predict areas of supercooled liquid water (hereinafter referred to as SCLW), the icing forecasts are primarily based on humidity and temperature thresholds to determine potential icing conditions. Schultz and Politovich, (1992) developed an algorithm that uses the temperature and humidity data from the National Meteorological Center, Nested-Grid Model (NGM) to diagnose areas of potential icing. Due to the coarse horizontal resolution of the larger scale forecast models (about 80 km) mesoscale features like frontal rain or snowbands are not accurately resolved. In addition to under predicting the severity of aircraft icing, lack of horizontal resolution can also result in over predicting the spatial and temporal evolution of the icing event. In this paper, additions made to the microphysical package of the MM5 NCAR/Penn State mesoscale model to explicitly predict SCLW will be described. An example of how the new parameterizations improve the prediction of SCLW and therefore icing events will also be given. Author (Herner)

A95-93459

KNOWING OUR USERS – A CHALLENGE FOR METEOROLOGISTS AT THE NATIONAL AVIATION WEATHER ADVISORY UNIT

RICHARD J. WILLIAMS National Aviation Weather Advisory Unit, Kansas City, MO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 70-71

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The National Aviation Weather Advisory Unit (NAWAU) in Kansas City, with a staff of 20 meteorologists, plays a major role in the National Weather Service's aviation weather program. NAWAU forecast products include: Sigmets, Convective Sigmets, Airmets and Area Forecasts for the 48 contiguous states. The unit recently began issuing International Sigmets for large portions of the north Atlantic and north Pacific. Products of the unit serve both general and commercial aviation. Two categories of NAWAU inflight advisories are important to both groups, the Convective Sigmets which advise of significant convective activity and non-convective Sigmets which describe severe turbulence and icing conditions of importance to all aircraft. Certain other phenomena rate Sigmet attention such as volcanic ash and areas of blowing sand or dust. The Airmet advisories describe areas of Instrument Flight Rules (IFR) conditions (generally ceilings less than 1000 feet above ground level and/or visibility less than 3 miles or 4800 meters). Other Airmet criteria include: mountain obscuration, moderate intensity turbulence and icing, and strong sustained surface winds. Another in the NAWAU lineup of products is the Area Forecast, commonly termed the FA. The FA provides a state by state description of general cloud and weather conditions for a 12 hour period with an outlook for an additional 6 hours. Who uses NAWAU products? And how do they receive those products? Virtually all who fly come in contact with NAWAU issuances. But no one receives the product directly from the Kansas City unit. Distributors of NAWAU products include: Center Weather Service Unit meteorologists, Central Flow Control Facility meteorologists in Washington DC, FAA Flight Service Station specialists, Weather Service pilot briefing offices, Airline dispatch, meteorological and operation personnel, DUAT - The Direct User Access Terminal, computer based briefing service, Private vendors or weather data and firms providing briefing services, and Military users. Among those groups, the chief disseminators for general aviation products are the briefing specialists at the FAA's Automated Flight Service Stations (AFSS) and Flight Service Stations. Author (revised by Herner)

A95-93460

AN INTEGRATED SYSTEM TO IMPROVE AVIATION WEATHER FORECASTS FOR THE ALASKA RANGE

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A large amount of tight air traffic flies over the Alaska Range. The complex terrain comprising the Alaska range and surrounding mountain ranges in conjunction with their proximity to the gulf of Alaska, a region of major cyclone activity, creates a flying environment that is extremely hazardous to general aviation. There is, therefore, a need to improve aviation weather forecasts for the Alaska Range. A proposed integrated system for forecasting weather conditions in the area is discussed. The system would include profilometers for measuring wind, temperature, and other meteorological parameters and a remote lower powered sensor system uplinked to small relay satellites that would downlink the data to a computer in the weather forecast office. These data would form the basis for advisories to aircraft flying the Alaska Range. A system incorporating these features will be evaluated by a two stage process. The first stage will involve case study modeling, model development, evaluation, and improvement, and simulation experiments. The second stage will involve an extended field demonstration of a prototype system. Herner

A95-93461

TRANSITIONING TO THE AVIATION ROUTINE WEATHER REPORT (METAR) AND THE INTERNATIONAL AERODOME FORECAST (TAF) WITHIN THE FEDERAL AVIATION ADIMINSTRATION

STEVEN R. ALBERSHEIM Federal Aviation Administration, Washington, DC, US, RICHARD J. HEUWINKEL Federal Aviation Administration, Washington, DC, US, and ANN MARIE SCALEA MITRE Corporation, McLean, VA, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 77-81

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With more airlines operating in an international environment there is a need to move towards a single surface aviation weather code. The adoption of a single code has been under review for more than 10 years and is fully supported by the international aviation community, specifically International Air Transport Association (IATA). At the present time, two aviation weather codes are in use, the Surface Aviation Weather Observation (SAO) used in North America and the Aviation Routine Weather Report (METAR) used by the rest of the world. Similarly, there are two forecast codes, the Terminal Aerodrome Forecast (TAF) and the Terminal Forecast (FT). The adoption of a single surface aviation weather and forecast code benefits users by simplifying the training requirements and, of greater importance, reducing the possible miscommunication of information, therefore increasing safety. The purpose of this paper is to describe the process the United States undertook in committing to implement METAR/TAF, the code format and the most significant differences/exceptions filed with the International Civil Aviation Organization (ICAO) and the World Meteorological Organization (WMO) and provide a description of the coordination process within the United States. Author (Herner)

A95-93462

AVIATION WEATHER EDUCATION AND THE UNIVERSITY OF NORTH DAKOTA AVIATION WEATHER SURVEY

NATHAN P. ALM University of North Dakota, Grand Forks, ND, US, LEON F. OSBORNE University of North Dakota, Grand Forks, ND, US, and MICHAEL R. POELLOT University of North Dakota, Grand Forks, ND, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 82-84

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The state of pilot aviation weather knowledge has recently become the focus of academic investigations. Studies conducted by the Aviation Weather Forecasting Task Force of the National Center for Atmospheric Research and the US Air Force have generated an increasing amount of interest in the subject. These studies indicated that today's pilots are not very knowledgeable about aviation meteorology. Much of the blame for this problem has been directed towards the FAA for its apparent lack of concern for the problem. This has led to many pilots being certificated without a necessary, comprehensive knowledge of meteorology. Some of these pilots become flight instructors. These young and inexperienced flight instructors, who were poorly trained and tested as students in the aviation meteorology field to start with, are now responsible for teaching meteorology to new pilots. As a part of an effort to meet this problem, the Center for Aerospace Sciences of the University of North Dakota conducted a survey of active flight students and instructors to evaluate their knowledge of aviation weather and their preflight aviation meteorology gathering skills and techniques in the spring of 1992. One part of the survey involved having the flight instructors and students self rate their knowledge of aviation meteorology. The results indicated that both the instructors and students were deficient in general meteorology, special aircraft systems aviation weather theory, and graphic weather information, although the flight instructors were more knowledgeable in these areas than the students. Hemer

A95-93463
PILOT TRAINING INITIATIVES FOR THE '90S
RICHARD HEUWINKEL Federal Aviation Administration, Washington, DC, US and ANN MARIE SCALEA The MITRE Corporation, McLean, VA, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 85-88
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The Federal Aviation Administration (FAA) and the National Weather Service (NWA) have spent the last decade defining and developing aviation weather and air traffic systems which will meet the anticipated needs and requirements of the users. As part of these modernization plans, the National Aviation Weather Program Plan (NAWPP) was developed. After extensive survey of the user communities: pilot, industry and government personnel, a list of needs was developed. Unanimously, the groups pinpointed the training of pilots in weather as the most critical area to be addressed. In response to this consensus the FAA, as lead organization for the government in this issue, is developing an action plan to respond to this need. The purpose of this paper is to present a baseline of the current state of the training function, describe the specific weakness from the perspectives of the pilots, the government and private industry involved in training tasks, and suggest solutions. There are also training initiatives being developed by the government and private industry which may help in eliminating the weakness discovered. These initiatives will also be discussed. Author (Hemer)

A95-93464
AVIATION AND THE ENVIRONMENT
CHARLES H. SPRINKLE World Meteorological Organization, Geneva, Switzerland and KENNETH J. MACLEOD World Meteorological Organization, Geneva, Switzerland *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 89-91
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Environmental issues associated with aviation are discussed. Concerns about the potential impact of aviation on the environment have increased since the United States Conference on Environment and Development held at Rio de Janeiro in 1992. Since the conference, attention has been focused on concerns that aviation may contribute to a depletion of the ozone layer, global warming, and acidification, especially since the number of air passangers in the year 2000 is predicted to be around 800 million. Until recently, the most important environmental concern associated with civil aviation was aircraft noise. Although technological improvements to reduce aircraft noise have been made, noise is still high on the agenda of problems. Atmospheric pollution from aircraft engine emissions, however, has become the major environmental concern of the 1990s. The world's aviation industry consumed an estimated 138 million tons of fuel in 1990. This is expected to increase to 220 million tons by the year 2010. This well lead to increases in emissions of carbon dioxide and nitrogen oxides. Currently world aviation has been estimated to produce just 3% of the carbon dioxide resulting from the burning of fossile fuels and less than 3% of the nitrogen oxides produced by man-made sources. Limited financial resources make it essential that the aviation community use all of the information available to understand and lessen its impact on the environment. Greater use of in-flight weather reports could become an important part of a fuel efficient flight planning program. Greater fuel efficiency means less fuel burned and fewer emissions into the atmosphere. Hemer

A95-93465
STRATUS' TEPHIGRAM AS A TRAINING/FORECASTING TOOL
FRANCES DE VERTEUIL Environment Canada, Montreal, Quebec, Canada, CAMERON HAYNE Environment Canada, Montreal, Quebec, Canada, SIMON INWOOD Environment Canada, Montreal, Quebec, Canada, DENIS JACOB Environment Canada, Montreal, Quebec, Canada, and PETER ZWACK Universite de Quebec a Montreal, Montreal, Quebec, Canada *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 92-94
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The goal of the Stratus project is to design and develop a prototype expert advisory system to assist meteorologists in the production of the low cloud portion of airport terminal weather forecasts. One of the X window based tools developed in the project is the tephigram. This tool is a computerized version of the graph of potential temperature versus temperature commonly used by aviation meteorologists to display a vertical profile of the atmosphere. It can be used to visualize data from a variety of sources including numerical model output and upper-air soundings. The tephigram tool enables interactive editing of the temperature and humidity data, with automatic recalculation and display of the wet bulb and frost point curves. The editing is available on both the original and zoomed views of the graph. The mouse is used to drag a data point to the desired temperature point along the isobar. This editing is usually constrained to satisfy the following physical criteria: the dew point temperature cannot exceed the temperature; the unsaturated lapse rate cannot exceed the dry adiabatic lapse rate; and the saturated lapse rate cannot exceed the wet adiabatic lapse rate. The user can disable any of the above constraints, edit freely, and then request that the data points be adjusted so that the constraints apply. Alternatively, the user has the option of having the other data points adjusted continuously as the one data point is moved. Full numeric and graphical feedback is provided so that the meteorologists is firmly in control. Author (revised by Hemer)

A95-93466
AVIATION METEOROLOGY EDUCATION IN AN AB INITIO SETTING
MICHAEL R. POELLOT University of North Dakota, Grand Forks, ND, US, FRED M. REMER University of North Dakota, Grand Forks, ND, US, and LEON F. OSBORNE University of North Dakota, Grand Forks, ND, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 95-97
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Ab initio flight and ground training embraces the crew concept. It is designed to take paired pilots applicants with no prior flight deck experience through an intensive flight and ground school program. Candidates leave the program as crew-qualified aviators with the skill and knowledge required to assimilate quickly into an air carrier's flight line as first officers. Many flight training facilities have recognized this need and offer ab initio pilot training; approximately sixteen programs have been developed by various institutes worldwide. Few, however, offer meteorology as a separate part of the curriculum. The University of North Dakota Aerospace Foundation, located in Grand Forks, ND, has developed a curriculum entitled 'Spectrum' which offers a significant amount of meteorological training to the pilot candidates. This paper will discuss pilot education in the Spectrum ab initio pilot training program. Author (Hemer)

A95-93467
SENSING THUNDERSTORM MICROPHYSICS WITH MULTIPARAMETER RADAR: APPLICATION FOR AVIATION
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Polarimeteric radar signatures depend on the mean values and distributions of size, shape, and spatial orientation as well as the composition (dielectric constant) of particles filling the radar resolution volume. Hail, graupel, snow, and rain have distinctive electromagnetic scattering characteristics. Multi-wavelength radar systems exploit geometric relationships between hydrometeor size and radar wavelength and have shown potential for detecting hail. Multiparameter radars, i.e., radars capable of making both polarimetric and multi-wavelength measurements, can be used to identify mixed-phase precipitation and homogeneous precipitation types. During the summer of 1992 radar measurements were obtained with the National Center for Atmospheric Research (NCAR) CP-2 radar and with the Colorado State University-University of Chicago and Illinois State WaterSurvey (CSU-CHILL) radar. The combined dataset gives a full suite of mulitparameter radar measurements and is being used to refine multiparameter techniques for the remote retrieval of precipitation microphysical properties. This paper illustrates how the radar measurements can be used to specify regions of snow, graupel, hail, and rain within thunderstorms. In an operational setting, such techniques can be used to automatically determine areas of potential aviation hazard and to optimize airport capacity. Author (Herner)

A95-93468

A COMPARATIVE PERFORMANCE STUDY OF TDWR/LLWAS 3 INTEGRATION ALGORITHMS FOR WIND SHEAR DETECTION

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In 1993 the FAA will begin to deploy two new wind shear detection systems, the Terminal Doppler Weather Radar (TDWR) and the third generation Low Level Windshear Alert System (LLWAS 3). Eventually, up to 45 airports may receive both a TDWR and an LLWAS 3. Co-located systems will be integrated to provide a single set of wind shear alerts, and to provide increased performance relative to each subsystem. To meet TDWR production schedules one of three integration algorithms had to be chosen for specification by Fall 1991. To assess the relative performance of the three algorithms we performed a comparative study of the integration algorithms, and the TDWR and LLWAS 3 algorithms at Orlando International Airport (MCO) in the Summer of 1991. This paper gives an overview of this study. The algorithms are described briefly, followed by a section on data collection at the Orlando test bed. Next, a methodology for estimating various algorithm performance statistics based on a comparison with a dual Doppler algorithm is detailed. Lastly, some results of applying this methodology to the various algorithms are presented and discussed. Author (Herner)

A95-93469

USE OF WSR-88D DATA IN THE FAA'S WEATHER IMPACTED AEROSPACE PRODUCT

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A network of Doppler weather radars (WSR-88D) is being deployed at the present time. By 1996, most of the continental U.S. will have radar coverage. This data source will provide the aviation community a new 4-dimensional data set with weather information that has never been available on such a large scale. This information will be valuable for both enroute and terminal area users. As part of the Federal Aviation Administration's (FAA) improvement of weather information for aviation, three systems are being developed to improve aviation weather products: the Aviation Gridded Forecast System (AGFS), the Integrated Terminal Weather System (ITWS) and the Aviation Weather Products Generator (AWPG). In the scheme of the ITWS and AWPG, products are being developed to identify airspace that is potentially hazardous due to weather conditions. This product, deemed Weather Impacted Airspace (WIA) will be utilized in both the ITWS and AWPG for both terminal area and enroute airspace activities. The initial WIA Product will define a volume of airspace, in which, the weather is deemed hazardous to all aircraft. Future developments for the WIA Product may include aircraft dependent or index defined regions of airspace. For the Terminal WIA product, ASR-9, TDWR and WSR-88D data will be utilized along with numerous other weather sensors. The processing of the WSR-88D data will include the running of four convective weather algorithms: Storm Cell Identification and Tracking, Hail Detection, Mesocyclone Detection and Tornado Detection. The focus of this paper is to describe the plans to use the WSR-88D data and algorithms to define the WIA. Author (revised by Herner)

A95-93470

NEXRAD/ARSR OPERATIONAL COMPARISON

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The National Weather Service (NWS), Federal Aviation Administration (FAA), and Department of Defense are in the process of fielding the Next Generation Weather Radars (NEXRAD). These doppler weather radars, also known as Weather Surveillance Radar (WSR)-88D, will be replacing the WSR-57 and WSR-74 weather radars in use today. The NEXRAD data will be used by the FAA's Advanced Automation System (AAS) in place of the Air Route Surveillance Radar (ARSR) weather data currently being used by air traffic controllers. Because the NEXRAD's scanning strategy is more time consuming than the ARSR's, there have been some concerns expressed within the FAA about using 'untimely' NEXRAD data in an Air Traffic Control (ATC) environment. In response to these concerns, the FAA's Center for Advanced Aviation System Development (CAASD) at MITRE conducted a study (Dunbar, 1993) under the sponsorship of the FAA's National Airspace System (NAS) System Engineering Service (ASE), to assess the relative ability of NEXRADs and ARSRs to detect and present significant weather in order to determine if there is any operational impact in using NEXRAD data in lieu of ARSR data. There are four types of weather radar data used in the study: NEXRAD, ARSR, Terminal Doppler Weather Radar (TDWR), and Airport Surveillance Radar (ASR)-9. Each is described as well as a description of the reflectivity mapping scheme. Author (Herner)

A95-93471

FINAL RESULTS OF THE WEATHER TESTING COMPONENT OF THE TERMINAL DOPPLER WEATHER RADAR OPERATIONAL TEST AND EVALUATION

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The final results of the operational testing and evaluation of the weather observation component of the Terminal Doppler Weather Radar (TDWR) system are presented. The TDWR is a C-band weather radar consisting of a 25 foot diameter center-fed parabolic reflector antenna, with the feed mounted on a tripod. The antenna beamwidth is 0.55 degrees. The transmitter tube is a 250 kilowatt peak power pulsed klystron that transmits a 1.1 microsecond pulse (-6 decibe width) at pulse repetition frequencies of 250 to 2000 hertz. The large dynamic range, more than 128 decibels, provides good clutter suppression and accurate reflectivity measurements. The TDWR was tested at the Federal Aviation Administration Aeronautical Center in Oklahoma City from 24 August to 30 October 1992 and 26 April to 24 May 1993. The Fall test results were inconclusive mainly because there was not a significant number of weather cases for evaluation. The most significant results obtained during Spring testing was the observation of a large number of large scale thunderstorm complexes most often associated with fast moving squall lines with strong gust fronts. Isolated storms with strong microbursts, which are more likely to occur during the summer months in Oklahoma, were rarely observed. The microburst detection algorithms, however, seemed to perform well with few false alarms. The gust front detection algorithm also performed well. However, it periodically identified false wind shifts due to range folded echoes for failures in the velocity dealiasing algorithm.

Herner

A95-93472

FLYING WITH AUTOMATED SURFACE OBSERVATIONS

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Two automated observing systems are now being deployed in the national airspace: the automated weather observation system (AWOS) and the automated surface observation system (ASOS). When the network is completed, more than 1,200 automated systems will provide minute by minute observations 24 hours a day. Voice transmission of the current weather conditions will also be instantaneous to pilots via phone and aircraft radios. Both the AWOS and ASOS evaluate visibility, sky conditions, precipitation, and other meteorological parameters than can obstruct vision, using multiple sensors that are linked to a computer. The data were then converted into transmitted surface observations utilizing complicated algorithms. Data obtained from a network of human observers are also used in the transmissions. After 2 years of using AWOS and ASOS in Nebraska, pilots have praised the ability of the systems to provide continuous observations at many airports where before only limited or no observations existed. The pilots, however, have raised concerns over the limited areas of coverage of AWOS and ASOS. The pilots have also continued to rely on human observations. Despite this, automated observations are a reality. They will provide a vast observation network with continuous reports. Although AWOS and ASOS are not an exact replacement for human observations, they are a valuable source of information.

Herner

A95-93476

INVESTIGATION OF OUTFLOW STRENGTH VARIABILITY IN FLORIDA DOWNBURST-PRODUCING STORMS

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The term 'downburst' was coined by Fujita and Byers (1977) to describe unusually intense, small-scale convective downdrafts having vertical velocities greater than 12 ft/s (approximately m/s) at an altitude of 300 ft (approximately 100 m) AGL. As the descending column of negatively-buoyant air nears the ground, vertical momentum is converted to horizontal momentum and accelerated radially by pressure gradient forces, resulting in horizontally-divergent, shallow outflow patterns that can exhibit wind speeds in excess of 40 m/s. In this study we make no distinction between the mechanisms of a typical thunderstorm downdraft and those of a downburst. However, we define downbursts as surface outflow events with a divergent Doppler radar differential radial velocity (delta V) of 10 m/s or greater. During June, July, and August of 1990, the FAA held an Operational Test and Evaluation (OT and E) of a prototype TDWR system in Orlando, Florida as part of the radar's on-going development. This project utilized two 5-cm Doppler radars, operated by Lincoln Laboratory (FL-2C) and the University of North Dakota (UND). Upper-air soundings were taken by the National Severe Storms Laboratory's (NSSL) mobile sounding system, and a surface mesonet was also in place. Inspection of Doppler radar data from the 1990 TDWR OT and E revealed that storms of similar reflectivity structure, occurring in similar environments, often produced downbursts of very different strength, with low-altitude Doppler radar measured velocity difference across the downburst (delta V) varying anywhere from 10 to 40 m/s. As part of the important task of understanding downbursts, this study utilized Doppler radar data, soundings, mesonet data and a 3D numerical cloud model to investigate eight downburst-producing storms in an effort to gain insight into the cause of this variability. It is proposed that information from this study may benefit further development of a microburst prediction (MBF) product as well as our general understanding of convective outflows.

Author (revised by Herner)

A95-93477

TRANSPORT CANADA PROPOSED R&D PROGRAM FOR THE DEVELOPMENT OF A MULTI-PARAMETER DUAL X-KA BAND DOPPLER RADAR FOR AVIATION METEOROLOGY APPLICATIONS

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Transport Canada Aviation Research and Development (R and D) approach to the weather observation systems deficiencies regarding the collection of data with resolutions suitable to aviation has been to conduct preliminary studies on potential sensing technologies before prototyping. R and D plans for the design and development of a Multi-parameter Dual X-Ka Band Cloud Research Doppler Radar System result from such a preliminary study. The knowledge acquired in the development and use of such a system could be used in the development of a core sensor of an intelligent atmospheric information processing system for the detection and classification of weather phenomena impacting aviation. A cloud sensing system is required to detect the cloud bulk parameters relevant to air operations which are: cloud amount, cloud opacity, and heights of bases and tops of each layer, as well as to analyze the spatio-temporal variability of each layer. The initial system should be able to detect all types of clouds to a distance of not less than 20 km in all directions and to discriminate between light and moderate precipitation and cloud layers. The range resolution should not exceed 30 m. As a remote sensing instrument, the system would support research and development in aviation meteorology. Transport Canada Aviation contracted the McMaster University's Communications Research Laboratory for a feasibility study to determine possible upgrades to their IPIX radar to permit millimeter wave operation. The objectives of the study were to define the functional and performance requirements of a Multi-parameter Dual X-Ka Band Cloud Research Doppler Radar System, derive design specifications, and estimate the cost of the proposed implementation. The use of X and Ka bands is considered to be the most appropriate choice for dual-wavelength operation given constraints of matched beamwidths and transportability.

Author (Herner)

A95-93479

ESTIMATION OF ATMOSPHERIC TURBULENCE SEVERITY FROM IN-SITU AIRCRAFT MEASUREMENTS

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Throughout the latter half of this century, a great deal of research has been performed to better understand atmospheric turbulence. These wide ranging efforts dealt with turbulence phenomenology, in-situ and remote detection, numerical modeling, forecasting and the response of aircraft flying through turbulent air. However, direct application of the resultant knowledge to operational meteorology and aviation has been somewhat limited. This is due, in large part, to an all too common problem: inadequate real-time measurements. Apart from the poor spatial and temporal resolution of the basic meteorological data that could be used to diagnose it, the only direct measurement of turbulence intensity currently available is from pilot reports (PIREPS). The purpose of this paper is to describe new, operationally useful techniques intended to provide adequate real-time, comprehensive, and direct atmospheric turbulence measurements. In brief, these methods would augment the qualitative, intermittent and subjective turbulence PIREPS with quantitative, 'state-of-the-atmosphere' measurements. These real-time and fully automated algorithms have been designed to run on commercial transport aircraft utilizing currently available data sources and computational capabilities. Computationally efficient methods have been developed to estimate eddy dissipation rates from aircraft vertical acceleration data. Computed turbulence measurements would then be appended to the winds and temperature reports currently broadcast via the Aircraft Communications Addressing and Reporting System (ACARS). Author (Herner)

A95-93480

TOWARDS IMPROVING THE NMC AIRCRAFT DATA BASE

BRADLEY A. BALLISH National Meteorological Center, Washington, DC, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 157-160
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The National Meteorological Center (NMC) receives a variety of aircraft reports from a number of different sources. We now have automated aircraft reports, such as ACARS, AMDAR, and ASDAR types, which are usually of very good quality, but the majority of these reports are over land areas with few in data sparse oceanic regions. In addition, we receive conventional non-automated reports from the GTS. ARINC (Aeronautical Radio Inc), and Carswell Airforce Base. Many of these reports are over oceanic or data-sparse areas and give us important data. This paper focuses on our efforts to both increase the quantity and quality of these reports. Towards this important goal, we show a number of areas that require better understanding and cooperation between airlines, data processing centers, government agencies, and NMC. Author (Herner)

A95-93481

AN IN-SITU SYSTEM FOR WARNING OF ICING CONDITIONS

THOMAS HAUF DLR, Oberpfaffenhofen, Germany *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 161-162
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From measurements, the critical ranges for temperature, cloud liquid water content, and cloud drop size can be identified under which aircraft icing is likely to occur. These data can, therefore, be used to either forecast or monitor atmospheric icing conditions. In this paper, a system is described for in-situ monitoring of icing conditions. The system is based on a hot film sensor and is intended to be installed aboard aircraft. It combines measurements of three parameters, temperature and cloud liquid water content and drop size, and generates a warning if the values fall within critical ranges. With such a system, warning of icing is possible before the first observable icing occurs. A laboratory version of the hot film system was developed. The set-up consists of a small wind tunnel with flow speeds up to 150 m/s and various drop generators. Drops can be sprayed into the flow and subsequently hit the hot film sensor. The size of the active part of the sensor is approximately 1 mm. The output voltage of the anemometer system is digitized. A sampling frequency of 0.5 to 1 MHz is used. Digitized data are analyzed on-line with a signal detection algorithm. A typical signal is characterized by three time scales: an initial increase lasting for about 10 to 50 microsec, followed by a nearly exponential decrease of 100 microsec, which is followed by a smaller than exponential decrease lasting several msec. Studies are currently underway to identify which signal characteristic is related to drop size and to evaluate the performance of various drop generators. Herner

A95-93482

REPRESENTATIVENESS AND RESPONSIVENESS OF AUTOMATED WEATHER SYSTEMS

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It has been asked how we can determine visibility by peering out through a little hole in the side of a dark room or the sky condition by shining a single laser beam through a hole in the ceiling. We are going to explain how this can be done and then ask the converse: How can you take a representative observation by going outside just once an hour and observing whatever happens to be there at that time? We claim that there is a natural persistance to the atmosphere which the human observer takes advantage of in one way and automation in a different way; and that both observations are useful and valid and provide the information needed for safe aircraft operations. Each of these methods has its own unique 'area of validity' or 'area of representativeness'. In this paper we will describe the research that has led us to determine these areas of validity. We will discuss the concept of an observation, the area an observation represents, the sensors that are used to make these measurements, and then the algorithms we developed to transform those sensor measurements into the current operational ASOS (Automated Surface Observing System) observation. To do this, we will use visibility as the prototype weather element and thus describe the concept of visibility, the sensor used, how we determined the responsiveness and area of validity - and then extend these thoughts to the other weather elements.
Author (revised by Herner)

A95-93483

THE INFERENCE OF AVIATION WEATHER HAZARDS BASED ON THE INTEGRATION OF RADAR AND LIGHTNING DATA

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During the past 3 years, the National Weather Service (NWS) Eastern Region has conducted a national risk-reduction exercise at the Washington D.C. Weather Service Forecast Office in Sterling, VA. The focus of this exercise is to devise and test ways in which information from complementary atmospheric remote sensor technologies, such as the weather radar system, a lightning detection network, and the Automated Surface Observing System (ASOS; Short and McNitt 1991), can be integrated to detect aviation weather hazards. The development of ASOS impacts both weather forecasting procedures and airport operations. The new, automated observational system provides for the continuous monitoring of many important weather phenomena. However, the identification, location, and movement of thunderstorms, which are of considerable significance to aviation activities, will not be reported by ASOS. Supplemental, thunderstorm-related information is readily available from radar and lightning detection system data. Hence, a technique has been developed, evaluated, and refined to infer the presence of convective activity based on the analysis of data from conventional radar reports and lightning detection information. The preliminary version of the lightning/radar product (Phase One Product) was tested, and the evaluation indicated this product correctly identified a variety of aviation hazards. However, the initial format of the product required considerable meteorological interpretation by the users and was technically restrictive. Subsequently, several changes were introduced, and an Enhanced Phase One Product was evaluated last summer. For the enhanced product, the radar reflectivity data were post-processed in combination with short-range dynamical model forecasts to allow for the identification of storm segments, components, and associated centroids. Summary information was included about the location and movement of convective storms. In addition, lightning and radar data were analyzed to determine the presence of a thunderstorm at an evaluation site. Author (revised by Herner)

A95-93484

PRELIMINARY RESULTS OF HIGH RESOLUTION MEASUREMENTS OF SNOWFALL AT STAPLETON INTERNATIONAL AIRPORT DURING THE WINTER OF 1992-93

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Efficient runaway management and plane de-icing or anti-icing efforts depend on accurate measurement and prediction of snowfall rate and water content. Snowfall rates at the ground often show significant variations on the one minute time scale. Hold-over-times (HOT's) for ground deicing purposes are also given in terms of minutes, suggesting that short time period fluctuations in snowfall rate may be important in determining HOT's. The hourly snow observation made at local National Weather Service (NWS) stations are clearly inadequate for these purposes. These requirements include high resolution measurements of snowfall, both spatially and temporally. The National Center for Atmospheric Research (NCAR) has developed a snowfall rate display based on radar data that was demonstrated at Stapleton Internatinal Airport (SIA) during the winters of 1990 and 1991. A problem with this type of snowfall rate estimation is the conversion between radar return and the actual snowfall rate. Often there is significant ambiguity on the amount of snowfall estimated by this conversion. This ambiguity occurs primarily due to the variations in ice crystal type and temperature that are typically present in the snowfall. In order to overcome this problem, NCAR conducted a snowgauge/radar experiment during the winter of 1992-93 at SIA in order to investigate the possible use of real-time snowgauge data to calibrate the radar snowfall estimate. We present preliminary results from this study. Author (Herner)

A95-93485

AUTOMATION OF OBSERVATIONS IN THE NETHERLANDS

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In the Netherlands, the Royal Netherlands Meteorological Institute (KNMI) has replaced its regular forecasting stations and many of its observing sites with a network of automatic observation stations. This has been done, in part, to meet the increasing demand for weather information on the North Sea required for helicopter flight operations. Although in the entire network the standards as developed by KNMI are used, there is an exception made for civil airports. A different system has been developed for the civil airports because of the need to incorporate additional or modified data generated by human observers and to link this with the air traffic control system. A suggested system for civil airports, as exemplified by the system currently in use at Schipol Airport, outside Amsterdam, consists of sensors interfaced to a microcomputer system, known as the Sensor Intelligent Adaptation Module (SIAM). SIAM generates a weather forecast or message every 12 seconds and is linked to the Aeronautical Meteorological Information Systems (AMIS). AMIS provides data via various graphical and numerical databases to aviation users such as observers, meteorologists, and air traffic controllers. Herner

A95-93486

USE OF HIGH RESOLUTION LIGHTNING DETECTION AND LOCALIZATION SENSORS FOR HAZARDOUS AVIATION WEATHER NOWCASTING

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The presence of lightning is taken by most pilots to indicate the likelihood of turbulence, strong updrafts and downdrafts, and heavy precipitation. We note, for example, that the 'Stormscope' used widely by General Aviation pilots is viewed as an operationally useful substitute for onboard weather radar. Additionally, lightning poses a direct hazard through the possibility of strike to an aircraft in flight (often triggered by the conducting plane) or to ground personnel engaged in baggage handling or refueling operations. The U.S. Government has recently awarded a contract to provision of real-time information on the location of cloud-to-ground (CG) lightning strikes throughout the contiguous 48 states. These data, while operationally valuable, do not reliably detect intracloud (IC) flashes -- by far the dominant type of lightning. In this paper, we discuss measurements and an airport operational evaluation that used lightning mapping systems capable of 'imaging' both CG and IC lightning with resolution comparable to weather radar. Case studies are presented documenting the close coupling between lightning activity and the updraft/downdraft cycle that governs the evolution of deep convection. Algorithms that exploit these relationships, for example in forecasting of storm growth or dissipation, are presented and an ongoing evaluation program is described. We conclude with discussion of an initial operational evaluation of the high-resolution lightning data at an airlines ground operation center at Orlando, Florida's International Airport (MCO).

Author (revised by Herner)

A95-93488

THE USE OF RADAR WIND PROFILES TO REMOVE TDWR GUST FRONT ALGORITHM FALSE ALARMS CAUSED BY VERTICAL WIND SHEAR

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In response to increasing awareness of wind shear hazards to aviation, the Federal Aviation Administration (FAA) developed the Terminal Doppler Weather Radar (TDWR) program. A network of 5-cm Doppler radars will be deployed throughout the country at 47 major airports to assist in warning aircraft of wind shear hazards. Computer algorithms have been developed to detect the radar signatures associated with various wind shear phenomena, including gust fronts. A gust front is the leading edge of the cold air outflow originating from rain-cooled thunderstorm downdrafts. Changes in wind speed and direction along these boundaries can produce wind shears and turbulence severe enough to be hazardous to aircraft during takeoff and landing. These wind shifts also impact runway management. Throughout the course of the algorithm development over the past few years, the TDWR system has been tested operationally at several locations across the country, including Denver (1987 and 1988), Kansas City (1989), and Orlando (1990-1993). Upon testing of the TDWR Gust Front Algorithm (GFA) in Kansas City during the spring and summer of 1989, an unexpected high number of false alarms was detected. Upon closer inspection, we found that these false detections occurred during times when there was a strong low-level jet (LLJ) occurring, causing regions of strong vertical wind shear within 2 km of the ground. In this manuscript, we will describe the low-level jet phenomenon and explain how its associated vertical wind shear causes false detections within the TDWR GFA. Then, we will describe a method we have developed to remove the false alarms generated by vertical wind shear. In essence, we employ a Velocity Azimuth Display (VAD) algorithm to determine the vertical wind profile, use this information to determine the regions in the radar domain where the vertical wind shear is strong enough to cause false detections, and then remove all or part of the detections in these regions. Author (Herner)

A95-93489

THE PERFORMANCE OF FORWARD SCATTER VISIBILITY SENSORS FOR APPLICATION IN AUTOSTATIONS AND RUNWAY VISUAL RANGE IN SNOW AND FREEZING PRECIPITATION EVENTS

R. VAN CAUWENBERGHE Atmospheric Environment Service, Toronto, Canada *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 196-200

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Forward scatter visibility sensors have come into general service in the past few years for automatic weather stations and are about to come into service in Runway Visual Range (RVR) applications. Forward scatter visibility sensors are cheaper to buy, install, and operate than transmissometers, which have been previously used for RVR applications. Although transmissometers provide strong signals at the receiver when visibilty is high, they are limited in the range of visibility that they report. If something happens to the beam (such as blockage with ice or a burned out emitter), the default signal is a low visibility. Hence, the interest in forward scatter visibility sensors. This paper reports the results of tests of seven forward scatter visibility sensors conducted at the Atmospheric Environment Service Test Site in St. Johns, Newfoundland during the winters from 1988 through 1993. The sensors evaluated consisted of the Belfort visibility sensor, the Qualimetrics sensor, horizontal plane two head and four head sensors, the Handar commercial sensor, the HSS visibility sensor, and the Vaisala sensor. The performance of the sensors was compared with that of a transmissometer. Herner

A95-93490

TERMINAL DOPPLER WEATHER RADAR POINT TARGET FILTER THRESHOLD SELECTION

J. G. WIELER Raytheon Company, Sudbury, MA, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 201-203

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The Terminal Doppler Weather Radar (TDWR) system developed by Raytheon Company for the Federal Aviation Administration (FAA), provides automatic detection of microbursts and low-level wind shear. Another major function of TDWR is to improve air traffic management through forecasts of wind shifts, precipitation and other weather hazards. The TDWR system generates high quality meteorological base data and windshear products and, through the timely detection and reporting of hazardous windshear, automatically prepares warning messages for air traffic controllers to relay to pilots. These data are displayed to air traffic controllers in easy to interpret graphic and alphanumeric products. The radar collects low altitude meteorological data and performs reliably in the terminal area environment characterized by natural and man-made ground clutter. The TDWR through the use of special data conditioning techniques provides for the extraction of weather information in the presence of contaminated radar returns. Radar returns in the airport environment are subjected to contamination from severe ground clutter, moving non-weather targets, and range and velocity ambiguities. One of the function utilized to produce high quality data is a technique referred to as the Point Target Fitter (PTF). This filter has been independently implemented and tested on the MIT/LL FL-2 radar. This paper describes the filter and the process utilized to establish the thresholds for the filter.

Author (Herner)

A95-93491

LLWAS 2 AND LLWAS 3 PERFORMANCE EVALUATION

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Low level wind shear has been identified as a cause or contributing factor in a significant number of aviation accidents. Research has shown that the most dangerous type of wind shear is the microburst. During the past 17 years, the mainstay of the effort by the Federal Aviation Administration (FAA) to provide wind shear warnings to pilots has been the Low Level Wind Shear Alert System (LLWAS). The LLWAS system is being developed in four phases, I, II, III, and IV. The original LLWAS, now called LLWAS I, was designed for the detection of frontal shears under the assumption that hazardous wind shear is associated with large-scale meteorological features. LLWAS II was developed to reduce the false alert rate of LLWAS I and to provide a modest microburst detection capability. It is a direct response to recommendations by the National Research Council (NRS-NAS, 1983), following the 1982 microburst crash in New Orleans. This upgrade, deployed by modifying the software in LLWAS I, provided an improvement that would not suffer the delays and the costs of the major construction that is required for off-airport LLWAS III sensors. These upgrades to LLWAS I were installed between 1988 and 1991. LLWAS II will be the operational wind shear detection system at many airports until the late '90s. LLWAS III was developed in response to the requirement that LLWAS have a microburst detection capability. LLWAS III combines a dense sensor network and a sophisticated Wind Shear/Microburst (WSMB) detection algorithm to provide substantial microburst detection capability. The prototype LLWAS III has continued to operate at Stapleton International Airport, Denver since 1987 and has been credited with the 'save' of a commercial airliner on July 8, 1989. Nine LLWAS III's are being installed this year. LLWAS IV will be deployed at 83 airports in the late '90s. The LLWAS IV wind shear and microburst detection algorithms will be identical to LLWAS III. Major improvements include an ice-free sensor and hardware that is more reliable and maintainable. This report provides an evaluation of the effectiveness of LLWAS II and LLWAS III. The TDWR operational test bed at Orlando International Airport, Orlando (MCO) provides a unique data set for this evaluation. This test-bed features data from a 14-sensor LLWAS, the prototype TDWR, FL-2C operated by MIT/LL, and the University of North Dakota meteorological radar (UND). Data from this test bed in the summers of 1991 and 1992 are used to provide an evaluation of LLWAS II and LLWAS III. Author (revised by Herner)

A95-93492

TEST RESULTS OF A LOW COST AIRPORT WEATHER RADAR

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Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 209-212

Paramax Systems Corporation embarked on a study and design effort 3 years ago to develop a 'mini-TDWR' with an installed cost of $500K that would have the added capability of predicting a microburst 2-4 minutes before it becomes a hazard to aviation. Specific performance goals were: (1) surface microburst windshear detection and track within 10 km of the airport (2) gust front detection and track within 20 km of the airport; (3) thunderstorm detection and track within 30 km of the airport; (4) 2 to 4 minute microburst prediction. It was recognized that microburst prediction would be the most difficult task and the research and development effort initially focussed on achieving this capability. Field tests at Denver and Orlando in 1991 and 1992 have demonstrated greater than 90% correct prediction and less than 10% incorrect prediction. As a result the radar is now referred to as the Microburst Prediction Radar (MPR). The following design decisions were made at the outset: (1) on-airport radar location to decrease rf power and improve windshear aspect measurement geometry; (2) X-band operation for increased weather reflectivity and smaller antenna size; (3) multiple antenna beams for reduced surveillance time. The MPR measures the reflectivity, velocity and spectral width of return from rain droplets (which act as faithful tracers of the wind) between 1-3 km AGL to detect microburst downdrafts which are the most reliable precursor signatures of surface microburst windshear. The MPR utilizes a unique paired beam antenna pattern to resolve measured radial raindrop velocity into vertical and horizontal components. Vertical velocity is computed from the sum and difference of radial velocities measured in an antenna beam pair that are slightly offset from each other in elevation. The radial sum and difference velocity are compensated for vertical and horizontal windshear, when present. A joint estimate of vertical and horizontal velocities and vertical and horizontal shears are made using a Kalman filter which introduces weighted previous estimates of these quantities. Measurement variances are estimated from SNR and turbulence inputs derived from the reflectivity and spectral width measurements for each range cell. The 2D wind-field aloft permits detection of microburst generating downdrafts (including so-called 'dry microbursts' whose downdraft moisture evaporates before reaching the earth's surface). No other single airport sensor has the ability to directly measure microburst downdraft velocity aloft. Author (revised by Herner)

A95-93493

CRITERIA OF FORECASTING LOW LEVEL WIND SHEAR OVER QATAR

ABDELAATI MUSTAFA ALTOM Civil Aviation College, Doha, Qatar *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 213-217

Based on theoretical knowledge in meteorology, local accumulated data and practical experience gained in four years of operational work at Doha central forecasting office, this attempt has been made to make forecasting of a low level wind shear possible through forecasting meteorological phenomena producing this shear in this region. The main phenomena include thunderstorms, low level nocturnal jet, strong (Shamal) surface wind. The scope of the paper is to develop operational criteria to enable aeronautical forecasters to predict the low level wind shear accompanying such phenomena and to issue the required warning with relatively high probability of occurence. The observations showed that, most of vertical low level wind shears were of light (less than 4 knots/100 Feet) magnitude and were extending in the layer between 250 and 1500 Feet above the surface with a max core centered in a layer between 600-800 Feet. They occured mainly in early morning and evening hours. These lasted normally for 3-5 hours before diminishing. The occurence of wind shear in the early morning is found to be related to the low level temperature inversion and low level nocturnal jet at the boundary layer. The criteria for the expectation of boundary layer inversion are developed. Author (Herner)

A95-93494

ROLE OF THE AVIATION WEATHER SYSTEM IN PROVIDING A REAL-TIME ATC VOLCANIC ASH ADVISORY SYSTEM

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Inadvertent engine ingestion of volcanic ash has caused expensive damage to a number of aircraft recently and could have caused accidents in at least two cases. Consequently, there is a great interest in a real-time air traffic control (ATC) volcanic ash advisory system which could provide timely warnings of operationally significant ash concentrations to planes in flight as well as information for flight planning. The current system is characterized by non-automatic determination of ash eruption characteristics (especially altitudes) with trajectory analysis based on the National Meteorological Center (NMC) forecast winds being used to provide warnings of future locations. SIGMETS and Airport Weather Advisories are the principal means of providing information of the ash locations to pilots and controllers. After one to three days, volcanic ash from Alaska can be transported over major portions of the US aviation system. The operational use of the ash trajectory predictions which do not provide information on hazard associated with the ash density has resulted in more frequent disruption of air traffic. The most recent example was an incident on 19 September 1992 where a 17 September eruption from Mt. Spurr in Alaska resulted in a significant disruption of air traffic in the Upper Midwest. This paper discusses how the weather sensors and an aviation-oriented weather information dissemination system currently under development by the Federal Aviation Administration (FAA) and National Weather Service (NWS) could play a key role in generating and disseminating volcanic ash advisory information to the aviation system.
Author (revised by Herner)

A95-93495

ALASKA'S VOLCANIC ASH WARNING SYSTEM

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At least 42 active volcanoes exist in the Alaska Range west of Anchorage and southwestward along the Alaska Peninsula and the Aleutian Islands. Volcanic eruptions in this area are especially dangerous to aircraft opertions because of the proximity of the great circle routes between North America and Asia, the impact on the major air terminal at Anchorage, and the general impact on aviation dependent Alaska. Since 1986, three volcanoes west and southwest of Anchorage have erupted. St. Augustine volcano erupted in 1986 causing a major disruption to air traffic and damage to jet aircraft in flight. The ash plume from Redoubt's December 15, 1989 eruption damaged several commercial aircraft in flight. Most recently, Spurr volcano erupted in June, August, and September of 1992. The August eruption closed Anchorage International Airport for more than a day, blanketed the city of Anchorage with ash, and disrupted air traffic throughout much of Southcentral and Southeast Alaska. The 1989-90 eruptions of Redoubt with the accompanying disruption to air travel and potential for disaster, created a strong need for an effective volcanic ash warning system that could quickly and accurately warn of eruptions and ash plumes and their trajectories. The warning system is now in place and has been operating effectively for over a year. While the U.S. Geological Survey (USGS), the Federal Aviation Administration (FAA) and the National Weather Service (NWS) all play critical roles in the volcanic ash warning process, this paper focuses on the technology and activity of the NWS's volcanic eruption response in Alaska.

Author (Herner)

A95-93497

DEVELOPMENT OF A CLIMATOLOGY FOR POSSIBLE MICROBURST OCCURRENCE IN CANADA

T. B. LOW KelResearch Corporation, Downsview, Ontario, Canada *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 231-235 Research sponsored by the Transportation Development Centre of Transport Canada

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Low level wind shear, specifically the hazardous form of wind shear known as microbursts, has been recognized as a danger to aviation that has caused a number of accidental disasters over the past two decades. Their existence, frequency of occurrence, and potential threat in Canada has always been suspected, but never scientifically confirmed. This study, performed for Transport Canada's Transportation Development Centre, was an effort to establish a climatology of days with possible microburst events on a country-wide basis. Transport Canada will use the results of this study to assist in determining the requirements and potential placement of detection systems for the country's airports. Author (Herner)

A95-93498

THE AVIATION GRIDDED FORECAST SYSTEM VERIFICATION PROGRAM - A DESCRIPTION OF AVIATION-IMPACT-VARIABLE EVALUATION PLANS

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The Federal Aviation Administration (FAA) has developed a program to improve aviation weather services. Participants in the program include the Forecast Systems Laboratory (FSL), the National Center for Atmospheric Research's (NCAR) Research Applications Program (RAP), and the Massachusetts Institute of Technology's (MIT) Lincoln Laboratory (LL). FSL's role is to develop the Aviation Gridded Forecast System (AGFS). The AGFS will generate analyses and gridded forecasts of state-of-the-atmosphere variables (SAVs) (i.e., mass, momentum, and moisture) and aviation-impact variable (AIVs) (e.g., visibility, ceiling, turbulence, and icing). The FSL Aviation Division's Verification Program was created to assist in the derivation of AIVs from the output of meteorological forecast and analysis systems. The objective of this program is to provide atmospheric modelers with statistical measures of the accuracy of forecasts and analyses to develop and improve aviation forecasts. This program will continue through the development of the AGFS and its planned implementation in 1996. Periodic evaluations will be performed on the forecast and analysis systems. To date, a first evaluation has been conducted and completed. A second evaluation is in progress. The first evaluation, Exercise 1 (E1), which was conducted in 1992, provided a baseline evaluation of four forecast and analysis systems. Analyses and forecasts were made for select points across the continental United States for 1-10 April 1991. These 10 days included snow storms, wind storms, and convective events. The second evaluation, Exercise 2 (E2), includes those forecast and analyses systems evaluated in E1 and one other system. For the second evaluation, a more complete independent verification data set was obtained from NCAR's Storm-scale Operational and Research Meteorology (STORM) Project Office. Data collected during the STORM-Fronts Experiment Systems Test (STORM-FEST) program conducted from 1 February to 15 March, 1992, includes automated surface observations, experimental aircraft, and a higher resolution (both in time and space) of upper air sounding data (STORM 1992). This paper describes the first two evaluations. Author (revised by Herner)

A95-93500

COMPREHENSIVE VERIFICATION OF TERMINAL FORECAST CEILING AND VISIBILITY

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Since 1983, the National Weather Service (NWS) has implemented a national forecast verification system utilizing Automation of Field Operations and Services (AFOS), known as AFOS Era Verification (AEV). The aviation portion of AEV verifies NWS terminal forecast (FT) ceiling, visibility, and wind against corresponding surface observation (SAO) data sampled at three or six hour intervals. Aside from quality control measures regarding FT product format, this sampling procedure constitutes the entirety of AEV for aviation forecast products. However, this does not mean that AEV is simple -- far from it. One cause of difficulty lies in decoding the nearly limitless possibilities available to both FTs and SAOs. AEV output statistics are available to local AFOS sites via AEV local verification. Despite these efforts, however, AEV falls far short of full evaluation of FT ceiling and visibility forecasts. Not only are conditional FT terms not even considered, but the sampling process also discards most observational SAO data. Those SAOs that are sampled, often do not represent the overall situation. These can have a catastrophic effect on verification results. To counter this, some forecasters have tended to forecast mainly for the sampling times. Others have tended to use conditional terms carelessly; since these are not verified at all. Finally AEV makes no acknowledgements regarding forecast difficulty either at a given site or between sites. In this article a verification system is presented which addresses and attempts to remedy these shortcomings.

Author (Herner)

A95-93501

OBJECTIVE VERIFICATION OF AN ENHANCED TERMINAL FORECAST EXPERIMENT AT DENVER, COLORADO

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In 1991, the National Weather Service (NWS) conducted an experiment at the forecast office in Denver, CO, to assess short-fused aviation weather prediction. An enhanced terminal forecast (EFT) concept (National Weather Service, 1990) was developed to increase spatial and temporal resolution, replace the outlook phrases with specific element forecasts, and improve product readability. The primary adjustments to standard terminal forecasts (FT's) as defined in NWS Operations Manual Chapter D-21 (National Weather Service, 1988), included: tightening amendment criteria, adding restrictions to the use of remarks during the initial 3 hr, increasing forecast frequency, and replacing categorical forecasts in the last 6 hr with conventional FT terminology. In addition, the visual format was changed from continuous to one phrase per line. The experiment began in mid-January and concluded by the end of November. Scheduled forecasts were issued every 6 hr, and scheduled updates were issued, if necessary, at 3-hr midpoints. Hence, the maximum number of daily non-amended forecasts was eight. Amendments were issued if aircraft operations were affected by changing conditions. Meteorologists provided EFT's to three local airports: Denver/Stapleton (DEN), Arapahoe/Centennial (APA), and Broomfield/Jefferson County (BJC). Due to time constraints, the final verification data set was limited to forecasts and observations from DEN for March and April, 1991. Author (Herner)

A95-93502
VERIFICATION OF TERMINAL FORECASTS
NEIL GORDON Meteorological Service of New Zealand Limited, Wellington, New Zealand *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 254-257
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There is increasing interest in assessing the accuracy and skill of all kinds of forecasts. The uses to which this information can be put include: Providing information on quality to customers, Providing feedback to forecasters and managers on the quality of the service to assist in an ongoing improvement program, and assessing longer term trends of the quality of the service. Because of the particular weather dependence of aviation operations, the accuracy of airport forecasts is of special interest. The information on these forecasts, and the way in which it is expressed, is defined by international standards of the International Civil Aviation Organization (ICAO) and the World Meteorological Organization (WMO). The forecasts are referred to as TAFs, or terminal airport forecasts. The forecast weather elements in a TAF include wind speed and direction, weather type, visibility and cloud amounts and heights. These are expressed in quantitative terms, which should allow a direct comparison between forecast values and observed values of these elements for any particular time. Unfortunately, things are not that simple. One cannot directly compare observed conditions at a single time with what the forecast from the TAF was. A more complex approach is required. In view of these difficulties with the probabilistic approach, a new approach has been tried. It relies on checking, for blocks of time (such as three hours), the worst (minimum) forecast conditions against the worst observed conditions. Author (revised by Herner)

A95-93503
ANALYSIS OF EN ROUTE CONTROLLER HAZARDOUS WEATHER-RELATED TASKS
CATHERINE M. BATTLE The MITRE Corporation, McLean, VA, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 258-262
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The Federal Aviation Administration (FAA) is modernizing the National Airspace System (NAS) through the implementation of the Aviation System Capital Investment Plan (CIP) (FAA, 1991). As part of this modernization, improvements will be made in the detection and forecasting of weather and in the processing and dissemination of weather information within the NAS. As a result of these improvements, new hazardous weather products will be available for use by en route controllers. Before requirements are specified for these new hazardous weather products, the operational context within which the products will be used, both current and future, must be analyzed to ensure that the products will effectively meet the operational needs of en route controllers. This paper presents the results of an analysis of en route controllers' hazardous weather-related tasks. The purpose of this analysis was to determine how controllers currently use hazardous weather information to make decisions and perform their air traffic control duties and to determine the types and characteristics of the hazardous weather information controllers currently need. The analysis focused on en route controllers in Air Route Traffic Control Centers (ARTCCs). Specifically, the analysis focused on the radar controller position of the Washington, Atlanta, and Denver ARTCCs. Author (Herner)

A95-93504
THE DATA LINK FLIGHT INFORMATION SERVICE APPLICATION
CHRISTINA R. BAUHOF The MITRE Corporation, McLean, VA, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 263-267
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The initial flight information services, provided by the Data Link Processor (DLP), help to fulfill the need for pilots to receive weather information in-flight and help to satisfy a long-standing Federal Aviation Administration (FAA) need to reduce the controller's role in weather dissemination. The services are basically request/reply, initiated by the aircraft, and were chosen to be easily implemented with low risk in order to get a data link system into the field quickly. Initially, they were intended for general aviation users; the Automatic Terminal Information System (ATIS) and windshear services were added to appeal to commercial users. While the initial services will be useful, users have requested graphical weather products. Data represented graphically has the potential to convey more information in a shorter period of time then would a conventional alphanumeric display. This becomes especially important in the cockpit where heads down time is at a premium. Display technology is advancing to the point where it will be practical for more and more aircraft, including general aviation aircraft, to have graphical displays in the cockpit. Future services will meet the need of these aviation users. The DLP will provide a platform for the collection of aviation related weather and aeronautical information and for the dissemination of information to pilots of data linked equipped aircraft in-flight. Initially, the DLP will collect alphanumeric products from the Weather Message Switching Center Replacement (WMSCR), from the Automated Weather Observing System (AWOS) Data Acquisition System (ADAS), and from the Tower Data Link System (TDLS) and store them in its own database for later retrieval by pilot request via data link. The DLP is a phased implementation in which functionality will be added over a series of builds. Services provided by these builds can be categorized as either initial or future, with initial services being fielded in the 1995 timeframe and future services being fielded after the turn of the century. Author (Herner)

A95-93505
A NEW LOOK AT AVIATION METEOROLOGY: INTEGRATING AIRCRAFT SITUATION DISPLAY (ASD) WITH CONVENTIONAL WEATHER DISPLAYS
P. O. G. HEPPNER RMS Technologies, Inc., Marlton, NJ, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 268-271
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Integrating aircraft situation displays (ADSs) with conventional weather displays was discussed. Stand-alone data offer some insight into weather forecasting and aircraft dispatch; however, a composite view of their individual elements requires integrating them onto a single screen or display. Observing the proximity of aircraft to strong convection cells, for example, can be achieved by integrating ASD with conventional weather displays such as those obtained by radar and satellite observations. ASD consists of different display elements that provide a latitude/longitude fix on the aircraft, flight ID, aircraft type, speed, time to arrival, origin and destination, flight path test, waypoints, and flight events. ASD is currently being combined with conventional weather displays at Southwest Airlines. ASD is part of an overall integrated workstation that is also used to monitor dispatch operations. Future applications could include incorporated ASD with features such as the icing potential at multiple flight levels. Herner

A95-93506
JET STREAM WINDS: COMPARISONS OF OPERATIONAL ANALYSES WITH INDEPENDENT AIRCRAFT DATA AT MULTIPLE LONGITUDES
J. TENEBAUM State University of New York, Purchase, NY, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 272-274
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This paper expands a 1989 comparison of jet stream wind analyses with independent aircraft data to a wider range of longitudes and forecast centers. Initial results obtained in 1992 indicate that recent model improvements at the United Kingdom Meteorological Center Office (UKMO, Bracknell) and other centers have reduced the discrepancy between the peak wind speeds present in the analyses and observed by aircraft from -17 to -9% (analysis minus aircraft) and that the problem is present in both data poor regions such as Southwest Asia and in data rich regions (Japan). Since forecasts derived from such analyses show similar errors, the implication is that some fundamental property of global numerical prediction models is still preventing accurate depiction of strong jets. Results are consistent with UKMO, Bracknell practice which is to multiply winds sent out to aviation customers by 1.06. An ensemble average of about 2/3 of our 1992 data when compared with the UKMO analyses also shows that there is no obvious correlation of the discrepancies between the UKMO analysis and aircraft data over East and Southwest Asia with height. These errors can have substantial impacts on air carrier operations. These range from consistently carrying excess fuel on eastbound flights to incorrect balances of payload versus fuel and unscheduled fuel diversions on westbound flights. Suggested remedies include varying the correction factor by quadrant of jet streak, using aircraft data acquired in real time to correct flight plan forecasts, and running higher resolution analyses and forecasts limited to the regions of the long haul tracks. Herner

A95-93508

USE OF PILOT REPORTS FOR VERIFICATION OF AIRCRAFT ICING DIAGNOSES AND FORECASTS

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In recent years, efforts have been made to develop algorithms to diagnose and predict in-flight icing conditions using numerical weather prediction models. For example, Schultz and Politovich (1992) developed an algorithm that uses gridded relative humidity and temperature data from the National Weather Service (NWS) National Meteorological Center (NMC) Nested Grid Model (NGM) to detect and forecast icing conditions. Availability of such algorithms would be very useful for pilots and air traffic controllers, if the algorithms can be shown to be accurate and reliable. Unfortunately, determining the accuracy of in-flight icing (and, similarly, turbulence) forecasts is not straightforward, primarily due to limitations in the availability and quality of data to verify such products. Currently the best available data for verification of icing are pilot reports (pireps), which have a number of serious problems. In this paper, priep data recorded for 3 years over the continental United States are analyzed. These reports, which were obtained from the NWS National Aviation Weather Advisory Unit (NAWAU), consist entirely of positive icing reports for the months of February and March for the years 1990, 1991, and 1992. A total of 12,707 pireps are included in the dataset. Basic characteristics of the pireps, such as spatial and temporal distributions, are described. An alternative approach for the use of pireps in verification studies is suggested. This approach actually takes advantage of the fact that the pireps are not randomly distributed spatially. Specific applications of this approach for algorithm development and verification are described.
Author (revised by Herner)

A95-93509

EXAMINATION OF CONDITIONS IN THE PROXIMITY OF PILOT REPORTS OF AIRCRAFT ICING DURING STORM-FEST

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Motivation for this study was based partly on earlier work by Schultz and Politovich (1992), which showed that icing could be forecast with state-of-the-science accuracy by using a scheme involving only temperature and humidity. In that scheme, two categories of icing are forecast: Class 1, temperature from 0 to -20 C and relative humidity greater than 50%; Class 2, temperature from -2 to -15 C and relative humidity greater than 65%. Since supercooled liquid drops cannot physically develop in such sub-saturated conditions, questions arise concerning why the Schultz-Politovich scheme should work with relative humidities so low. One hypothetical answer is that much of the icing is occurring within convective elements protruding upward from saturated layers below. Conditions would be saturated within the convective elements, whereas the large-scale environment through which they were protruding might be quite dry. The new study summarized below was conducted to determine to what extent the low humidity thresholds of the Schultz-Politovich scheme were required in order to account for icing in convective elements protruding into otherwise dry layers. A three-stage approach was planned and executed, with the study proceeding to the next stage only when convective icing continued to appear important. First, surface and upper-air charts were examined to coarsely identify the synoptic-scale weather regimes in which aircraft icing occurred. In the second stage, icing proximity soundings were examined for the presence of conditional instability and other factors of potential relevance to the icing forecast. In the third stage, the most promising factors were selected and tested with the NMC Eta model analysis and forecast data to see how well a static stability-based scheme could assess icing threat. Special rawinsonde releases were made during the 20 intensive observing periods (IOPs) of STORM-FEST, conducted in February and March 1992. Most of these were at mesoscale spacings over the Midwest; many at three-hour intervals. These observations provided the opportunity for a detailed examination of the general conditions under which aircraft icing is reported by pilots of nearby aircraft. Reports of no-icing conditions were also examined. Author (revised by Herner)

A95-93510

A SHORT-TERM, HIGH-RESOLUTION AUTOMATED SNOWFALL FORECASTING SYSTEM

PETER P. NEILLEY National Center for Atmospheric Research, Boulder, CO, US and LAURIE PASCHAL CARSON National Center for Atmospheric Research, Boulder, CO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 287-289
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A spatially and temporally accurate short-term (0-1 hr) snowfall prediction system would be of considerable benefit to ground and terminal area aviation operations during snowstorms. Currently, many operational decisions that depend on short-term snowfall forecasts (e.g. deicing, capacity) are often made using either persistance or the relatively coarse terminal-area forecasts. Particularly during marginal and variable weather conditions, these forecasts can be subject to considerable error and therefore may be inhibiting the safe and efficient operations of the airport. To this end, we have been developing an automated system aimed at proving high resolution (approximately 1 km spacial, 5 min. temporal) snowfall rate and accumulation guidance to airport operations personnel. Our approach has been first to make a prediction of the radar reflectivity image in the terminal area andthen to calibrate the radar image into asnowfall rate using a continuously updated calibration on recent snowgauge measurements. Author (Herner)

A95-93512
AUTOMATED AIRCRAFT ROUTING THROUGH WEATHER-IMPACTED AIRSPACE
MICHAEL DIXON National Center for Atmospheric Research, Boulder, CO, US and GERRY WIENER National Center for Atmospheric Research, Boulder, CO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 295-298 Research sponsored by the FAA
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The FAA has embarked on a project to develop a 3-dimensional data grid containing current and forecast weather information (FAA, 1992). Typical data fields envisioned are radar reflectivity, wind speed and direction, turbulence, icing severity and temperature. One of the purposes of the grid is to provide data to an automated system tasked with routing aircraft through the nation's airspace while avoiding those regions which contain weather more severe than the pilot wishes to encounter. In this paper we describe a simple approach to automating the computation of aircraft tracks through a grid of weather-impacted airspace. For simplicity we use radar reflectivity to determine the degree of impact. We apply the method to simulate traffic along several typical routes into and out of Denver's Stapleton airport for most of the heavy weather periods during June 1992, and examine the statistics produced by this simulation. Author (Herner)

A95-93513
AN ECHO MOTION ALGORITHM FOR AIR TRAFFIC MANAGEMENT USING A NATIONAL RADAR MOSAIC
MARK E. JACKSON NOAA, Boulder, CO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 299-303
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The Advanced Traffic Management System (ATMS) is a rapid prototype system used to provide automation support for air traffic management at the Federal Aviation Administration's (FAA) Central Flow Control Facility and 20 Air Route Traffic Control Centers (ARTCC). The primary purpose of air traffic management is to minimize delays and congested airspace while maximizing the overall flow of the National Airspace System. Accordingly, timely and accurate weather information is essential for the strategic planning of air traffic. At the heart of ATMS is the Aircraft Situation Display (ADS), an interactive workstation that integrates real-time air traffic and weather information. In addition to knowing cloud ceilings and visibilities, air traffic managers are interested in knowing where areas of strong thunderstorms will severly impact the flow of air traffic within the enroute structure, and particularly near critical pace-setting terminal areas. Today's air traffic managers function mostly in a reactive sense, or after thunderstorms have already moved near a terminal area. By having some sort of objective guidance as to where significant echoes are expected to be in a window of 15 to 30 minutes, the traffic manager can be 'proactive' in determining when these areas will adversely affect a terminal area or jet route. This paper describes a product soon to be available on the ASD that applies a cross-correlation tracker (CCT) to a national radar mosaic, providing traffic managers with short-term position forecasts of significant echoes. A description of the product derivation will be given, followed by case examples that show the utility of such a product. One particular case is a graphic example of how this product can aid in the strategic planning of air traffic near a major airport. Author (revised by Herner)

A95-93514
DEVELOPING THUNDERSTORM FORECAST RULES UTILIZING FIRST DETECTABLE CLOUD RADAR-ECHOES
SANDRA G. HENRY National Center for Atmospheric Research, Boulder, CO, US and JAMES W. WILSON National Center for Atmospheric Research, Boulder, CO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 304-307
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In an attempt to improve the safe and efficient operation of aircraft, the National Center for Atmospheric Research (NCAR) is developing, for the FAA, techniques for accurate and precise forecasts to thunderstorms and related phenomena. It has been shown that monitoring the location of boundary layer convergence lines with Doppler radars, together with monitoring cumulus cloud development in the vicinity of these boundaries, provides the capability to make spatially detailed short-term (0-30 minute) forecasts of thunderstorm initiation. This study noted that the initiation of thunderstorms by moving and/or colliding convergence lines is often dependent upon whether cumulus clouds are already present in the region into which the convergence lines are moving. Present satellite cloud imagery usually does not provide sufficient temporal and spatial resolution for the cloud monitoring function. However, a recent study by Knight and Miller (1993) emphasizes that sensitive Doppler radars can be used to detect cumulus clouds, even in their earliest development stages, before precipitation develops. For very short period forecasting purposes it is necessary to know how fast a 40 dBZ(sub e) storm can be initiated. Knight et al. (1983) have shown from visual and model simulations that a cloud can grow, by the ice process, from first cloud to a 30 dBZ(sub e) echo in roughly 15 minutes. If clouds are already present this time could be as little as 5 minutes. However, this study did not examine cases relative to boundary locations. Wilson and Schreiber (1986) showed that the median time was 19 minutes for echoes to reach 30 dBZ(sub e) after a convergence line passed a location but their study did not consider whether clouds were present before the convergence line arrival. In this study we examine the time required for radar echoes to reach 40 dBZ(sub e) in the vicinity of convergence lines using a radar capable of detecting early cumulus clouds. Author (Herner)

A95-93515
TESTING OF TKE PARAMETERIZATIONS IN NUMERICAL MODELS FOR CLEAR-AIR TURBULENCE FORECASTING
ADRIAN MARROQUIN NOAA, Boulder, CO, US and EVERETT NICKERSON NOAA, Boulder, CO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 308-312
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In the past, the approach to forecasting clear air turbulence (CAT) has been based on diagnostic formulations or risk-indices that fall into two main categories: (1) empirical relations based upon correlations between atmospheric deformation regions and CAT, and (2) formulations using the Richardson number (Ri) and/or its tendency. The use of the Richardson number has been motivated by theoretical results from linear stability analysis of stable sheared flows. In the bases of this analysis, a critical value of Ri = 0.25 has been used indiscriminately to infer turbulence generation in linear and nonlinear flows everywhere in the atmosphere. Several studies point to the fact that Ri = 0.25 is a necessary but not a sufficient condition for instability (turbulence). Furthermore, observational and theoretical investigations reveal that turbulence can exist for Ri's greater than 2.0. This is why it is difficult to define a critical Ri to characterize the onset of turbulence. CAT forecasting algorithms based on turbulent kinetic energy (TKE) parameterizations will obviate such difficulty. The phenomenology of turbulence in the upper troposphere has received relatively little attention. Richard et al. (1989) used a 1.5-order-closure TKE parameterization to study the effects of surface friction on downslope windstorms. They found a more realistic description of the winds and TKE aloft when surface friction was included for the wind storm over Boulder, Colorado, on 11 January 1972 (Lilly 1978). Shapiro (1976, 1980), Kennedy and Shapiro (1980), and Shapiro and Hastings (1973) conducted field experiments using aircraft to study CAT in upper-jet-stream/frontal-zone systems. They concluded that regions of turbulence may be observed above and below the jet maximum. The purpose of our paper is to investigate the applicability of the 1.5-order-closure TKE parameterization of Bechtold et al. (1992) which is a modified version of the one used by Richard et al. (1989) and the Mellor and Yamada (1974) boundary layer TKE parameterization to describe turbulence in the upper troposphere using numerical weather prediction models. These parameterizations are aimed at solving a prognostic turbulent kinetic energy equation that includes contributions to TKE from advection, diffusion, vertical and horizontal shear, buoyancy, and dissipation. A realistic transition into the regimes conducive to turbulence is provided by the dynamics of the numerical model. In this paper we address two main problems associated with these TKE formulations: (1) vertical and horizontal resolution of the numerical model, and (2) mixing-length computation. We make use of turbulence studies from gravity wave breaking and upper-level jet-front systems published in the literature to address these problems.

Author (revised by Herner)

A95-93516

MEMFOG - THE MEMPHIS FOG ALGORITHM

D. A. DOCKUS Federal Express Corporation, Memphis, TN, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 313-316

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In 1986, Federal Express Corporation realized the possible consequences of fog and other delay-related weather phenomena on its operations. This led to creation of a meteorology department at its hub in Memphis, where more than 100 of its jet aircraft arrive between 11 PM and 2 AM local time. Its meteorologists track not only Memphis weather, but also predict cloud ceilings, visibility, and other critical meteorological parameters for over 150 airports across North America. Along with standard forecast tools such as satellite, national radar, and computer model guidance, the meteorologists have access to in-house algorithms of such mesoscale parameters as lake effect snow. Recently a new algorithm has been developed as an aid in predicting Memphis fog episodes. The algorithm known as MEMFOG is based on recognizing typical synoptic conditions present when radiation fog forms. MEMFOG uses six parameters: mean relative humidity, 700 mb level vertical velocity, mean boundary layer wind speed, surface wind speed, 3,000 foot wind speed, and visibility. The algorithm is run at the Federal Express Weather Services office on its primary weather service support system (currently McIDAS from the University of Wisconsin). Upon input of data from the National Meteorological Center at 0345Z and 1545Z daily, MEMFOG predicts the possibility of fog occurring at 6 hour intervals. The McIDAS workstation screens will prompt a fog alert when conditions indicate that fog can form. The results of using MEMFOG to predict fog over the past two winter seasons have been encouraging. During the winter of 1991-1992, six of eight actual fog events characterized by surface visibility remaining below 0.5 mile for at least 2 hours were predicted by the algorithm. Herner

A95-93517

MDCRS: AIRCRAFT OBSERVATIONS COLLECTION AND USES

RONALD C. MARTIN, MARILYN M. WOLFSON MIT, Lexington, MA, US, and ROBERT G. HALLOWELL MIT, Lexington, MA, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 317-321

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The Meteorological Data Collection and reporting System (MDCRS) is a system designed for the Federal Aviation Administration and National Weather Service to collect, store, and disseminate aircraft meteorological observations. It is designed primarily to improve upper air wind forecasts. The major features of MDCRS include receiving aircraft weather observations in multiple formats and forwarding them to users in a standard format, obtaining observations along airline flight routes, having the capability of adding new airline formats without creating a new decoder for each one, and having a query capability that allows scheduled transmissions of predefined geographic areas, routes, and altitudes. MDCRS currently provides approximately 8,000 observations a day. Delta, Northwest, and United Airlines are currently participating in MDCRS. Future goals of MDCRS include adding new airlines, adding SATCOM reports, and increasing reporting frequency. Herner

A95-93518

THE IMPROVEMENT OF METEOROLOGICAL DATA FOR AIR TRAFFIC MANAGEMENT PURPOSES

DAVID A. FORRESTER Meteorological Office, Berkshire, UK *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 322-326

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Over the next decade, the potential axis for an enhanced capability to be introduced into the air traffic management (ATM) system by the use of increased automation and computer assistance both on the ground within air traffic control (ATC) and on the flight deck within the flight management system (FMS). This project examines the meteorological forecast requirements in terms of accuracy and timeliness, and the role of an air-ground and ground-air data link, to meet the future needs for short-term forecasts required for accurate trajectory prediction and for the avoidance of unsuitable flying conditions in the climb, cruise and descent phases of flight. The timescales involved are typically 20 minutes ahead in the case of ATC (the time taken to fly across a sector of airspace), but this may be extended to 1 or even 2 hours ahead for FMS planning (within Europe). This involves consideration of the effects of errors in the forecasts of wind, temperature, icing, turbulence and, possibly, vertical air movement. Weather in the terminal area (eg cloud, visibility, windshear, wake vortices) is not considered in this study. Author (Herner)

A95-93519

FTGEN - AN AUTOMATED FT PRODUCTION SYSTEM

BRUCE WHIFFEN Newfoundland Weather Centre, Newfoundland, Canada *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 327-330

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A software program, called FTGEN, is being developed at the Newfoundland Weather Center (NWC) to automatically generate airport forecasts (FT's). The process incorporates graphical manipulation of numerical model output, a climatological database, and assimilation of present conditions. Preliminary testing has already produced FT's via this procedure; the results have been very encouraging. Author (Herner)

A95-93520

AVIATION TERMINAL FORECASTS BASED ON AUTOMATED OBSERVATIONS (FTAUTO)

JAY ANDERSON Atmospheric Environment Service, Winnipeg, Manitoba, Canada and BRAD SHANNON Atmospheric Environment Service, Winnipeg, Manitoba, Canada *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 331-334

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For the first time in Canada, on October 9, 1992, aviation terminal forecasts were issued operationally using airport observations from a completely automated system. The automated observing system is known as the Remote Environmental Automatic Data Acquisition Concept (READAC). This paper describes the READAC system and our

experiences in implementing and writing the FTAUTO forecasts to date.
Author (Herner)

A95-93521

NORTAF: COMPUTER GENERATED AERODOME FORECASTS

STEFAN GOLLVIK Swedish Meteorological and Hydrological Inst., Norrkoping, Sweden and ESBJORN OLSSON Swedish Meteorological and Hydrological Inst., Norrkoping, Sweden *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 335-338

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The national meteorological institutes in Finland, Sweden, Norway and Denmark has agreed to start a joint project called Nortaf. The objective of the project is to create an automatic/semiautomatic system for production of Terminal Area Forecasts (TAFs) at each institute. The system that is built should be able to produce both short and long TAFs according to new regulations. TAFs are at the moment produced to a great extent subjectively by forecasters. This production is highly manual and therefore ineffective. An automatic system must rely on output from numerical models. Partly direct model output and partly statistical interpretation. A forecast matrix will be filled with observations and data from different models. Data from this matrix, which contains all necessary meteorological parameters, will be translated to a TAF. The forecaster should be able to change the final forecast, either by editing the forecast matrix or the TAF-coded forecast. The local projects in each institute will decide in what way the forecaster should interact with the system. The Swedish contribution to the project will mainly be a development of a one-dimensional version of the HIRLAM-model. HIRLAM is now the operational model for numerical weather prediction in Finland, Sweden and Denmark. This article will describe how the one-dimensional model is constructed and in what way it will be used in the system.
Author (Herner)

A95-93522

THE COMBINATION OF FORECASTS IN AN AUTOMATED AVIATION WEATHER FORECASTING SYSTEM

JUHA KILPINEN Finnish Meteorological Institute, Helsinki, Finland *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 339-340

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Terminal airport forecasts (TAF) are produced manually at the moment in Nordic countries (Denmark, Finland, Norway and Sweden). During spring 1992 a research and development project was started. The aim of the project was develop tools for operative automatic production or terminal airports forecasts (TAF). The project was called NORTAF. The purpose of the effort was to make the production and verification of TAF's more effective. Each participating country was in responsible for building their own operative systems. The software tools to be developed are related to following branches: quality control of observations, application of a 1-dimensional high resolution numerical model, interpretation of numerical model output and radar information in terms of local weather phenomena, encoding of a forecasts matrix to TAF code and real time verification. Extensive verification of the existing manual TAF's was also an important element of the project. The different sub projects are divided between the meteorological institutes of the four Nordic countries. The individual institutes are, however, in charge of the implementation of final operative systems. The backbone of the system is a numerical high resolution model. The vertical resolution of the model is, anyhow, too coarse in planetary boundary layer to estimate cloud base. Because there is not enough computer power available at the moment for a mesoscale model the very same large scale model is then used with additional observations and higher vertical resolution in 1 dimension. The output of this additional model run is then used to estimate wind, visibility, significant weather and cloud base as well as cloud amount.
Author (Herner)

A95-93523

AVIATION WEATHER FORECASTING AUTOMATED METHODS IN THE RAFC MOSCOW AND THE AIRPORT VNUKOVO

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During the past 2 to 4 years, the weather forecasting techniques of the RAFC Moscow and the Vnukovo Airport Aviation Weather Forecasting Center (AWC) which provides the Moscow Air Traffic area with weather forecasts has undergone automation. Traditional synoptic based forecasting techniques have been replaced or supplemented by automated methods based on numerical model output data and local network measurements. The automated developments were developed in the Aeronautical Meteorology Department of the Hydrometeorological Center of Russia (HCR). The AWC creates charts depicting maximum winds, jet streams, tropopause height, and clear air turbulence, which are then used to create forecasts for the Moscow Air Traffic area. Since 1991, the HCR has conducted research on detecting and forecasting cold and warm fronts and forecasting cloud heights, visibility, fog, and icing conditions in clouds and on the ground.
Herner

A95-93524

A POOR MAN'S EXPERT SYSTEM FOR AVIATION VSRF IN COMPLEX TERRAIN

HERBERT PUMPEL Civil Aviation Authority of Austria, Austria *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 343-347

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Commercial and General Aviation operations in a steep valley where instrument Landing Systems cannot be fully installed will for the foreseeable future remain highly weather-sensitive. Weather minima will be considerably more stringent than in flat, open terrain, and severe weather bears as even greater risk for aircraft operations where approach and escape routes are strictly determined by the orography surrounding the airport. The increased need for accurate and dependable forecasting of the above mentioned phenomena, however, conflicts with a number of forecasting handicaps related to the topography: Human observers and radar installations have a limited view or range of detection; Mesoscale systems (fronts, convective systems) are modified, decelerated or accelerated by the orography; local wind-systems and convective systems may be forced by the orography; and kinematic extrapolation of moving systems, direct model output and statistical guidance material is affected by all or most of the above. The proposed 'Poorman's expert system' is a guideline to forecasters in their decision-making process. The first, or entry-level consists of determining the seasonal type prevailing at the time. Next, the current weather type ('Grosswetterlage') needs to be found. The concept of weather types has been used before to a varying degree of success. The concept of directly linking such weather types to observed weather is tempting, but prone to failure. The weather types used in the following are few, flow-dependent and differ according to seasons. The basic forecasting tools used in this study are fairly standard and available in most forecasting offices: Direct model output at the nearest gridpoint (GP); Upper air soundings (UA): with derived parameters such as cu-base, PWC, showalter index, etc; Conventional Weather Maps: Analyses (Surface, UA) Model forecast maps; Vertical Cross Sections (CS) of potential and equiv. pot. temp., wind; Information on Local Conditions (LC); Soil moisture, Snow cover, Vegetation type, Radar Network data (RN); Calibrated rainfall rates from a weather radar network, Satellite imagery (SAT): IR, VIS and WV-channels, the use of manually produced UA-analyses, cross-sections and surface charts may appear anachronistic at first sight: nevertheless they provide a rapid means of verifying the latest available model run, which may be 12-18 hrs old in some circumstances. Such a real-time check on timing, intensity and phase of synoptic-scale and mesoscale systems is a valuable aid in avoiding unnecessary 'misses'. Author (revised by Herner)

A95-93525

DISSEMINATION OF TERMINAL WEATHER PRODUCTS TO THE FLIGHT DECK VIA DATA LINK

STEVEN D. CAMPBELL MIT, Lexington, MA, US and RONALD C. MARTIN *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 348-352

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A new concept for providing up-to-the-minute terminal weather information based on ground radar and other information was presented. The proposed Terminal Weather Data Link Service would provide near real-time information about (1) runway wind shear, and precipitation impact, (2) microburst, gust front and storm cell location and motion near the airport and (3) forecasted wind shear, precipitation and wind shift impact at the airport. The proposed service makes use of the existing aircraft communications, addressing and reporting system (ACARS) data link capability found in many air carrier aircraft and the new ground-based weather sensing systems, such as Terminal Doppler Weather Radar (TDWR), which are currently being deployed. A demonstration of the proposed service is planned during the summer of 1993 at Orlando, FL involving up to five air lines. Additional demonstrations are planned for 1994 involving the use of advanced Integrated Terminal Weather System weather products and the transmission of graphical weather products via ACARS. Author (Herner)

A95-93526

DISSEMINATION OF WEATHER PRODUCTS

FRANK DALTON Meteorological Office, UK *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 353-356

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It is vital for the safety of flight that meteorological information reaches the pilot without delay and that the data is easy to read and understand. Text data can be difficult to assimilate quickly and if sent over long distances can be distorted by some communication systems making the information difficult to read. It is essential that the end product received by the customer is equally as good as the original, and if pssible the data should be presented in a graphics format such as a chart or map display to assist mental assimilation. The increasing use of facsimile and personal computer (PC) systems is enabling these problems to be overcome, and with satellite communication links will ensure that products can be sent over long distances with little distortion of the data during the transmission. A facsimile system known as 'Automatic Routine Transmission of Information via Facsimile' (ARTIFAX) has been developed within the United Kingdom Meteorological Office (UK Met O) for the dissemination of products in T4 facsimile code direct to customers using a group 3 facsimile receiver, which are universally available in offices and homes. This system developed within the UK Met O enables products generated on the main frame computer to be fed directly into the ARTIFAX facility and sent directly to individual customers, equally data which is prepared in the Central Forecasting Office (CFO) by the forecasters can be scanned into the ARTIFAX and then routed to those customers requiring the information. Finally other data either generated within CFO or collected in the telecommunications center and routed through the telecommunications systems can be fed into ARTIFAX and directed to the customers as necessary. Products from each of these three different sources are identified within the ARTIFAX and stored, each product has a defined customer list and each is assigned a priority category to enable it to be disseminated efficiently to each customer. Author (revised by Herner)

A95-93527

WEATHER PRODUCTS FOR AVIATION FROM WAFC BRACKNELL

GIL H. ROSS Meteorological Office, Bracknell, UK *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 357-361

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As a World Area Forecast Center (WAFC), Bracknell has a commitment to develop and expand weather forecast products for the aviation community, and a program of research directed at improving the quality of the forecasts from our numerical weather prediction models. In the Fourth Conference on Aviation Meteorology, Lyne (1991) reported on the progress of the implementation of the new Unified Model, which, in fact, went operational just before the Conference in June 1991. The Unified Model is actually the design of a series of linked models, ranging from the global forecast model, the climate and long range variants, through regional, mesoscale, stratospheric, ocean and ice models. Mawson (1991) reported the on the motivation and implementation and gave an overview of the model itself, but full details of the formulation are available from Bracknell. This paper gives a short description of the Unified Model in section 2, and reports work in progress to incorporate new aircraft observations into the model assimilation cycle in section 3. In section 4 the rationale for of a new 'Thinned Grid' digital range of products for flight planning purposes is explained, and section 5 reports on the implementation of a system on semi-automated significant weather charts for aviation. Author (Herner)

A95-93528

WINDSHEAR DETECTION: TDWR AND LLWAS OPERATIONAL EXPERIENCE IN DENVER 1988-1992

WILLIAM P. MAHONEY, III National Center for Atmospheric Research, Boulder, CO, US and CLEON BITER National Center for Atmospheric Research, Boulder, CO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 362-366

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The Terminal Doppler Weather Radar (TDWR), which has been under development since the mid-1980s, becomes operational in 1993 (Turnbull et al., 1989; Evans and Turnbull, 1989). Between 1993 and 1996, 45 airports will be equipped with integrated TDWR and Low-Level Windshear Alert Systems (LLWAS). The TDWR system coupled with LLWAS comprises the FAA's ground-based arsenal for the detection and warning of hazardous low-level windshear in major airport terminal areas. During development, the TDWR was tested at several locations in the United States. This paper discusses the operational experiences gained during testing at Denver's Stapleton International Airport between 1987 and 1992. Author (Herner)

A95-93529* National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, FL.

DEVELOPMENT OF A CLIMATOLOGICAL DATA BASE TO HELP FORECAST CLOUD COVER CONDITIONS FOR SHUTTLE LANDINGS AT THE KENNEDY SPACE CENTER

M. KEVIN ATCHISON ENSCO Inc., Melbourne, FL, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 367-371

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The Space Shuttle is an extremely weather sensitive vehicle with very restrictive constraints for both launches and landings. The most important difference between Shuttle and normal aircraft landings is that the Shuttle has no go-around capability once it begins its decent into the earth's atmosphere. The de-orbit burn decision is generally made approximately 90 minutes before landing requiring a forecast with little room for error. Because of the Shuttle's rapid re-entry to earth, the pilot must be able to see all runway and visual navigation aids from high altitude to land the Shuttle. In addition, the heat resistant tiles which are used to protect the Shuttle during its re-entry into the earth's atmosphere are extremely sensitive to any type of precipitation. Extensive damage to these tiles could occur if the Shuttle passes through any cloud that contains precipitation size particles. To help guard against changing weather conditions or any type of weather problems that might occur prior to landing, flight rules have been developed as guidelines for all landings. Although the rules vary depending on the location of the landing (Kennedy Space Center or Edwards AFB), length of mission, and weight of vehicle, most of the rules can be condensed into 4 major groupings. These are: (1) Cloud ceilings should not be less than 3048 m (10,000 feet), (2) Visibility should not be less than 13 km (7 nm), (3) Cross-wind no greater than 5-8 m/s (10-15 knots); and (4) No showers or thunderstorms at or within 56 km (30 nm) of the Shuttle Landing Facility. This study consisted of developing a climatological database of the Shuttle Landing Facility (SLF) surface observations and performing an analysis of observed conditions one and two hours subsequent to given conditions at the SLF to help analyze the 0.2 cloud cover rule. Particular emphasis was placed on Shuttle landing weather violations and the amounts of cloud cover below 3048 m (10,000 ft.). This analysis has helped to determine the best and worst times to land the Shuttle at KSC. In addition, nomograms have been developed to help forecasters make cloud cover forecasts for End of Mission (EOM) and Return to Launch Site (RTLS) at KSC. Results of categorizing this data by month, season, time of day, and surface and upper-air wind direction are presented. Author (revised by Herner)

A95-93531* National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, FL.

ANALYSIS OF RAPIDLY DEVELOPING FOG AT THE KENNEDY SPACE CENTER

MARK M. WHEELER ENSCO Inc., Melbourne, FL, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 376-380

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Space Shuttle landings at Kennedy Space Center (KSC) are of special concern to NASA's landing community because of Florida's rapidly changing weather conditions. Since a large number of Shuttle landing attempts occur in the morning hours (just after sunrise) fog and stratus development are a problem. The deorbit burn decision for a landing at KSC is typically made 90 minutes before Shuttle touchdown. In that 90 minutes weather conditions can change very rapidly. Fog to the west of KSC an advect in and reduce visibility to less than 7 miles. The most important difference between Shuttle and normal aircraft landings is that the Shuttle has no go-around capability requiring a forecast with little room for error. To help guard against rapidly changing weather conditions, flight rules have been developed as guidelines for all landings. This paper concerns fog development that would affect less than 7-statue mile visibility rule which is in effect for End-Of-Mission (EOM) Shuttle landings at KSC (Rule 4-64(A)). Data used for this analysis included hourly surface observations at the X68 Shuttle Landing Facility (SLF) and upper-air observations form the CCAFS (Cape Canaveral Air Force Station-72794) rawinsonde site for the five year period, 1986 to 1990. This investigation focused on rapidly developing fog or stratus that developed between decision time and landing. Author (Herner)

A95-93532

DEVELOPING THE AVIATION GRIDDED FORECAST SYSTEM

LYNN SHERRETZ NOAA, Boulder, CO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 381-383

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Increasing air traffic and higher performance aircraft demand that the Federal Aviation Administration (FAA) find ways to increase the capacity of the nation's airspace, decrease weather-related delays, and provide pilots maximum flexibility in using airspace. A promising way to do this is to increase the accuracy, timeliness and spatial resolution of the weather products used by pilots, air traffic controllers, and airspace managers. This paper describes the Aviation Gridded Forecast System (AGFS) and the approach and tasks that NOAA's Forecast Systems Laboratory (FSL) is undertaking to develop it. The AGFS is part of a major effort by the FAA and the National Weather Service (NWS) to improve weather-related decision-making products for aviation users. That effort includes the following: implementing advanced weather sensors that make many more observations than today's sensors make; conducting field experiments to understand better atmospheric processes that impact aviation (e.g., processes that cause icing); developing the high-resolution forecast tools capable of generating the accurate, timely, and site-specific meteorological information required to tailor products to aviation decision making; and developing advanced processing (i.e., massively-parallel processing) required to run those high-resolution forecast tools quickly. Author (Herner)

A95-93533

DEVELOPING AND TESTING DECISION-MAKING PRODUCTS FOR CENTER WEATHER SERVICE UNIT METEOROLOGISTS

DENICE WALKER NOAA, Boulder, CO, US, LYNN SHERRETZ NOAA, Boulder, CO, US, MARY CAIRNS NOAA, Boulder, CO, US, and RON MILLER NOAA, Boulder, CO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 384-387

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This paper describes initial results of the work to evaluate Center Weather Service Unit (CWSU) forecasters' assessments of the utility of the meteorological products on the Aviation Gridded Forecast System (AGFS) functional prototype (FP) workstation. This interactive, information-processing, display, and communications system is intended to serve as a vehicle for testing concepts, interfaces, and experimental products. It is part of the larger AGFS effort being undertaken by NOAA's Forecast Systems Laboratory (FSL) in conjunction with the Federal Aviation Administration and the National Weather Service. Author (Herner)

A95-93534

THE PROTOTYPE AVIATION WEATHER PRODUCTS GENERATOR A VEHICLE TO ASSESS USER NEEDS

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The FAA is developing three new major initiatives: the Integrated Terminal Weather System (ITWS), the Aviation Gridded Forecast System (AGFS), and the Aviation Weather Product Generator (AWPG). These initiatives were developed to take advantage of the weather sensor modernization program developed by the FAA and the National Weather Service (NWS) that is projected to dramatically increase the quality and quantity of aviation weather information during this decade. These new instrumentation platforms coupled with the development of the ITWS, AGFS, and AWPG processing systems are part of the FAA Aviation Weather Development Program (AWDP). The AWPG, which is being developed by the National Center for Atmospheric Research (NCAR), will collect, integrate, and process data from both the AGFS and ITWS. It will provide user-specific, aviation weather products to regional and national FAA facilities including: Air Route Traffic Control Centers (ARTCC), Automated Flight Service Stations (AFSS) and the Air Traffic Control System Command Center (ATCSCC). The AWPG products will also be available to non-FAA facilities such as the airlines and weather vendors. The major goals of the AWPG are to: (1) provide weather information to aviation users that require no meteorological interpretation, (2) improve safety of flight by providing accurate and timely warnings of weather impacted airspace, (3) improve the capacity of the NAS by providing timely and accurate weather forecasts to assist air traffic management, flight planning, and air traffic control, (4) improve the efficiency of FAA operations by improving the human factors of depicting weather information and, (5) improve the efficiency of operations by providing much-improved analyses and forecasts of winds, temperatures, and weather impacted airspace. Author (Hemer)

A95-93535

AVIATION VALUE-ADDED PRODUCTS AND SERVICES FROM THE NEXRAD INFORMATION DISSEMINATION SERVICE (NIDS)

TODD S. GLICKMAN WSI Corporation, Billerica, MA, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 392-394

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Over the next five years, the National Weather Service (NWS) will deploy under its Next Generation Weather Radar (NEXRAD) program, the Weather Surveillance Radar 88D (WSR-88D). The NWS has chosen four private firms to distribute NEXRAD data from 137 sites through the NEXRAD Information Dissemination Service (NIDS). WSI Corporation, an official NIDS provider, has developed a number of value-added products and services. These include derived products (alteration of basic data); mosaicked products (data of the same type but from mulitple sources); and fused products (combinations of multiple data types). The goal of this development was to provide WSR-88D products that are easier to understand, provide more information, and provide the user more flexibility than the basic, unaltered products. Author (Hemer)

A95-93536

USING ATMS WEATHER PRODUCTS FOR AIR TRAFFIC STRATEGIC PLANNING

RICHARD T. JESUROGA NOAA, Boulder, CO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 395-398

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The primary purpose of air traffic management is to minimize delays and congested airspace while maximizing the overall throughput of the National Airspace System (NAS). The Advanced Traffic Management System (ATMS), a prototype workstation and associated database used to validate automation support for air traffic management. The database consists of NAS elements such as airports, jet routes, navigational fixes, real-time flight data and weather information. ATMS weather products are rapidly prototyped in NOAA's Forecast System Laboratory (FSL) as well as NCAR's Research Applications Program (RAP). FSL generates and distributes these products in real time to the Volpe National Transportation Systems Center (VNTSC), where they are integrated into the ATMS environment. Some of these products include jet stream forecasts, national-scale radar images, lightning strike data and other observations. By overlaying these products upon aircraft flight data, traffic managers can track air traffic and monitor weather events to plan for efficient use of high altitude jet routes and changes in airport acceptance rates.

Author (Hemer)

A95-93537

USER INVOLVEMENT IN THE DEVELOPMENT OF AN ADVANCED ICING PRODUCT FOR USE IN AVIATION

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The in-flight icing forecast product presently available to aviation users has limited utility. A typical example of the product available on the Direct User Access Terminal (DUAT) home computer briefing indicates that the product valid time spans eight hours and the pilot must decode the area delimiters and visualize or plot the area boundaries on a map to ascertain the impacted region. In 1990, the Federal Aviation Administration (FAA) initiated the Aircraft Icing Forecasting Program. This six-year program is a cooperative, basic and applied research effort involving a number of organizations and individuals. One of the major goals of the program is to improve in-flight icing forecasts on a national scale. Efforts toward improving the forecasts are occurring simultaneously in a number of areas, including: (1) Basic research designed to better understand the production and depletion of supercooled liquid water in the atmosphere; (2) The development and use of numerical analysis systems and models to diagnose and predict icing regions and to provide the basis for future automated, high-resolution temporal and spatial icing products; (3) Development of a meteorologically-based Icing Severity Index (ISI) that has meaning to pilots; and (4) End-user participation to help define the desired attributes of the new icing product and to participate in the iterative development and testing of prototype icing product display formats and concepts to enhance and help ensure the utility of the final product. This paper discusses end-user involvement thus far in the development and testing of the prototype advanced in-flight icing product. This participation will be discussed under the two broad complementary areas under which the work was conducted: user experiences with prototype in-flight icing products and icing briefing task analysis and interview. Author (Hemer)

A95-93538

A STUDY OF THE SAVINGS IN TIME AND FUEL TO AVIATION THROUGH THE USE OF UPPER-AIR WIND FORECASTS

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Given an upper-air wind forecast, aircraft can save time by choosing a route which avoids excessive headwinds and exploits possible tailwinds. This time saving immediately gives rise to a fuel saving because the aircraft is airborne for less time. In addition, because fuel must be burned to carry excessive reserves of fuel, savings will accrue through carrying only the exact required amount of fuel for each trip. In general, the savings through the first mechanism derive from the spatial variability of wind while the savings through the second mechanism derive from the temporal variability of wind. An algorithm is used to convert these fuel savings into equivalent time savings (ETSs) so that they can be compared with the actual savings. The material presented in this study quantified both savings in the North Atlantic area during the winter 1992-3 period. By reference to earlier work, qualitative inferences are made as to the savings to be made elsewhere in the world. Author (Hemer)

A95-93539

NORTHWEST AIRLINES ATMOSPHERIC HAZARDS ADVISORY & AVOIDANCE SYSTEM

THOMAS H. FAHEY, III Northwest Airlines, St. Paul, MN, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 409-413

A weather hazards advisory system for aviation was developing at Northwest Airlines (NWA) in the 1950's with the introduction of clear air turbulence forecasting techniques. Also joint work was done by United Airlines and NWA in the early 1960's on the forecasting and avoidance of mountain wave activity. On 10 October 1968 the copyrighted Turbulence Plot (TP) System became operational at NWA. There were 3 major types of hazards for which reports and or forecasts were issued, in 1968: (1) CAT and mountain wave activity; (2) thunderstorms and (3) low altitude frontal wind shear. All three categories of TP messages would be hand written, passed to another employee to be typed and sent as a teletype message to NWA company radio operators, stations and dispatchers. The Minneapolis-St. Paul International Airport (MSP) dispatch and meteorology office used the large board for displaying the active TP's. Station agents would post TP messages for preflight review by flight crews. Radio operators would broadcast the message to flight crews en route. Crews plotted the information on a map similar to a Jeppesen airway chart during both preflight preparation and en route. The TP system was incorporated into the NWA training of all involved: dispatcher, meteorologist and pilot. Avoidance of CAT and Mountain Wave TP hazards were included as part of the daily and meteorology flight planning procedures. Pilot training addressed all three hazards. Pilot avoidance was emphasized, and operating procedures to minimize effects when en encounter occurred were also included. The TP system has been expanded to include advisories for ozone, volcanic ash and icing, in addition to the three original hazards. Also, hazards are now differentiated between low altitude: surface to approximately 5.5 km (18,000 feet), and high altitude: 5.5 km (18,000 feet) to 13.7 km (45,000 feet).

Author (revised by Herner)

A95-93540

ASSESSMENT OF THE BENEFITS FOR IMPROVED TERMINAL WEATHER INFORMATION

JAMES E. EVANS MIT, Lexington, MA, US and DAVID A. CLARK MIT, Lexington, MA, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 414-416 Research sponsored by the FAA

An important part of the FAA Aviation Weather Development Program is a system, the Integrated Terminal Weather System (ITWS), that will acquire data from the various FAA and National Weather Service (NWS) sensors and combine these with products from other systems (e.g., NWS Weather Forecast Offices and the FAA Aviation Weather Products Generator. This wide variety of input and products will enable the ITWS to provide a unified set of weather products for safety and planning/capacity improvement for use in the terminal area by pilots, controllers, terminal area traffic managers, airlines, airports, and terminal automation systems (e.g., Terminal Air Traffic Control Automation (TATCA) Center Tracon Advisory System (CTAS) and wake vortex advisory systems. The assessment of benefits from the ITWS, particularly in the area of reducing delay and other aviation system operations costs, has been an important element of the ITWS initial development phase. At the last Aviation Weather Conference, initial results were reported on delays associated with various types of weather based on use of climatology and FAA National Airspace Performance Reporting System (NAPRS) statistics for O'Hare airport. This paper extends the earlier results to consider a broader range of terminal weather impacts on aviation and discuss how the ability of the ITWS to reduce the impact will be quantified. Author (Herner)

A95-93541

CREATING A GLOBAL CLIMATOLOGY OF FREEZING RAIN USING NUMERICAL MODEL OUTPUT

M. AHMED UK Meteorological Office, Bracknell, UK, R. J. GRAHAM UK Meteorological Office, Bracknell, UK, and R. W. LUNNON UK Meteorological Office, Bracknell, UK *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 417-421

The accretion of sheet ice on aircraft surfaces which may occur on encounter with freezing rain represents a considerable aviation hazard. Records exist with which the frequency of freezing rain observed at ground level may be assessed. However, because freezing rain often occurs in layers above the surface, little is known about the overall frequency of freezing rain events. In the current design environments for civil aircraft (FAR25 and JAR25) the problem of freezing rain is not explicitly addressed, although this is a recognized shortcoming. This work aims to help quantify the aviation hazard through the creation of a global climatology of freezing rain based on analyses from the UK Met Office Unified Model (Cullen, 1993). The work was prompted by an earlier study of Mills-Hicks and Mansfield (1990) which suggested that the frequency of both surface and elevated freezing rain events over the British Isles was about 1%. This incidence is, perhaps, higher than might be expected and suggests that in regions more susceptible to freezing rain the aviation hazard might have been under estimated. In section 2 the algorithm used to diagnose freezing rain from the model analyses is briefly described. Initial results from 6 months of analyses - November 1992 through April 1993 - are presented in section 3. Author (Herner)

A95-93542

THE PRODUCTION OF SUPERCOOLED LIQUID WATER BY A SECONDARY COLD FRONT

BEN C. BERNSTEIN National Center for Atmospheric Research, Boulder, CO, US and MARCIA K. POLITOVICH National Center for Atmospheric Research, Boulder, CO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 422-426 Research sponsored by the FAA

Aircraft icing, the accretion of supercooled liquid water on an airframe, has been shown to cause a degradation of performance characteristics as well as contribute to accidents. A comprehension of the processes which both produce and deplete cloud liquid is vital to understanding when and where icing conditions will occur. On 27 February 1990, during the Winter Icing and Storms Project (WISP), a cold front passed through the Colorado Front Range area, followed twenty-four hours later by a strong secondary cold surge which produced a widespread upslope, primarily liquid water cloud. Scattered altostratus and altocumulus cloud embedded in southwesterly flow above the frontal surface produced ice crystals which fell into the lower cloud, reducing the liquid water content through riming. This paper will present measurements obtained during the event to document the processes involved in supercooled liquid water (SLW) production and depletion, provide preliminary explanations of the observations, and suggest ways that these findings may be incorporated into detection and forecasting schemes.

Author (Herner)

A95-93543

AN APPLICATION OF SOME CLOUD MODELING TECHNIQUES TO A REGIONAL MODEL SIMULATION OF AN ICING EVENT

GEORGE D. MODICA Phillips Laboratory, Hanscom AFB, MA, US and SCOT T. HECKMAN Phillips Laboratory, Hanscom AFB, MA, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 427-431

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Aircraft icing continues to be one of the primary causes of accidents among civilian aviation aircraft and is a concern for the military which has requirements for high-performance aircraft operations in potential icing environments. Therefore, both the military and civilian aviation communities stand to benefit from the accurate prediction of aircraft icing conditions. The methods and techniques currently used by the Air Force to predict aircraft icing were developed mainly in the 1950's, with some later refinements (Air Weather Service 1980). However, enormous advances in theory and computer power have made possible the use of sophisticated numerical weather prediction (NWP) models to predict objectively the timing, location, and intensity of icing events. In the last two decades alone, cloud microphysics research has made substantial progress. It is also true that considerable research on limited-area, or regional numerical models has yielded impressive gains in the forecast skill of mesoscale motions. This has occurred despite the wide use within these models of highly parameterized moist physics. Only recently have efforts been directed toward merging these two areas of model formulation. In this report, we describe a microphysics parameterization that incorporates some formulations developed for use within cloud-scale prediction models. The parameterization was included with a regional hydrostatic prediction model which was then used to simulate the events surrounding an icing event that occurred on 13-15 February during the 1990 Winter Icing and Storms Project (WISP-90). The main goals of WISP are to (1) study and improve our understanding of the dynamical and microphysical processes leading to the formation, depletion, and deposition of supercooled liquid water in winter storms, and (2) improve forecasts of aircraft icing. It is hoped that parameterizations like the one described here will eventually contribute toward the attainment of these goals. Author (Hemer)

A95-93544

AIRPLANE ICING RESEARCH AT THE BOEING COMPANY: PARTICIPATION IN THE SECOND CANADIAN ATLANTIC STORMS PROGRAM

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From 15 January to 15 March 1992, the Boeing Company took part in the second Canadian Atlantic Storms Program (CASP II), based out of St. John's, Newfoundland, Canada. CASP II was under the direction of the Canadian Atmospheric Environment Service (AES); its objective was to study winter storms in the north Atlantic in the vicinity of the Maritime provinces of Canada. It was preceded by the First Canadian Atlantic Storms Program (CASP I), based out of Nova Scotia, Canada in 1986. Boeing's primary motivation for participating in CASP II was to collect data pertinent to airplane icing concerns specific to Extended Range Operation with Two-Engine Airplanes (ETOPS) diversion flights along oceanic routes. The Boeing approach to defining the ETOPS diversion icing threat is through determination of the probability of supercooled water catch along possible ETOPS diversion routes. The key elements in the threat analysis are thus to determine statistically the supercooled cloud water content (SLWC), and the fraction of the diversion path through SLWC. Author (Hemer)

A95-93545

AIRCRAFT ICING: METEOROLOGICAL EFFECTS ON AIRCRAFT PERFORMANCE

MARCIA K. POLITOVICH National Center for Atmospheric Research, Boulder, CO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 435-439 Research sponsored by the FAA

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Aircraft icing is a complex interaction between environmental and aircraft characteristics. What we refer to as 'icing intensity' is related to the rate of accretion as well as to the effect on flight. Although progress is being made in understanding the factors involved in ice accretion through wind tunnel, numerical simulation, and flight test experiments, there is little dialogue between those conducting such studies and the meteorological community. Forecasters generally lack guidance to assist them in prediction of icing occurrence or intensity. Likewise, those conducting research into forecast model development have little direction for definition, calculation, and required accuracy of parameters critical to the icing environment. The purpose of this paper is to discuss meteorological variables related to icing, describe their effect on ice accretion and flight, and suggest areas to concentrate further efforts on. Numerical simulations, flight tests and wind tunnel experiments are reviewed, and some examples of recently-collected data are provided. Author (Hemer)

A95-93546

PRELIMINARY STUDIES OF ICE FORMATION IN UPSLOPE CLOUDS

ROY M. RASMUSSEN National Center for Atmospheric Research, Boulder, CO, US and IAN BAKER National Center for Atmospheric Research, Boulder, CO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 440-443 Research sponsored by the FAA

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Winter storms in the Colorado Front range are strongly influenced by the presence of the Rocky mountains and associated local east-west ridges such as the Palmer Divide and the Cheyenne Ridge. Regions of enhanced vertical motions develop in association with these topographic features, resulting in high condensate supply rates in preferred locations. These locations provide optimal growth conditions for ice crystals, resulting in high snowfall close to these regions. If sufficient numbers of ice crystals are not present, these same regions can produce sustained regions of supercooled liquid water hazardous to aircraft. Our current understanding of ice initiation in the atmosphere, however, is relatively poor, making it difficult to accurately model the depletion of supercooled liquid water by ice crystals. Crystal concentrations often vary by one to two orders of magnitude from predictions based on known primary and secondary ice formation processes. In this paper we will investigate the formation of ice crystals in shallow upslope storms along the Colorado Front Range using data from the 1990 and 1991 field seasons of the Winter Icing and Storms Project (WISP). In particular, the initiation of ice near the tops of these clouds will be investigated using data collected by the University of Wyoming King Air aircraft and University of North Dakota Citation II jet aircraft. Author (Hemer)

A95-93547

A NORTHERN HEMISPHERE CLEAR AIR TURBULENCE CLIMATOLOGY

GARY P. ELLROD NOAA/NESDIS, Washington, DC, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 444-448

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With the increase in high altitude, international air traffic expected to continue indefinitely, there is a need for knowledge of clear-air turbulence (CAT) frequency and coverage worldwide. CAT is a sub-synoptic to mesoscale aviation hazard that may result in: (1) passenger injury or discomfort, (2) structural damage to aircraft, (3) increased fuel consumption, and (4) late arrivals due to reduced airspeeds. A climatological data base that shows the global distribution of CAT risk and its variation with the seasons should assist in the planning of air routes and daily forecast operations. Collections of aircraft pilot reports (PIREPs) have been relied upon in the past to determine where CAT can be found. With this approach, however, only heavily traveled air routes can be considered to be sampled often enough to obtain a clear picture of CAT frequency. The merging of PIREPs with computer techniques provided more uniform information, but because this approach relied on radiosonde data, it was limited to continental regions. The rapid improvement of numerical forecast models within the last ten years and their assimilation of wind data from various sensors (aircraft, satellite, radiosonde and profiler) has made numerical model data the most logical approach in producing CAT climatologies. This paper describes a preliminary climatology of CAT for the northern hemisphere based on long period averages of a numerical index. Regions of relatively high CAT risk are described, as are typical variations with season and flight level. Author (Herner)

A95-93548

AN EVALUATION OF CLEAR-AIR TURBULENCE INDICES

DONALD W. MCCANN National Severe Storm Forecast Center, Kansas City, MO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 449-453

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The diagnosis of clear air turbulence (CAT) has been a baffling problem for aviation meteorologists in spite of the advances in understanding CAT during the last quarter century. Since the capability of forecasting CAT begins with diagnosis, a study was initiated to determine how some of the better known CAT indices detect the reports of CAT from aircraft in flight. The study ran from December 1992 through February 1993, a period when significant CAT is very likely to occur in the United States each day. A total of 567 turbulence reports obtained from computer analyses of rawinsonde data were analyzed according to six turbulence indices (TIs) to determine if any would be useful in forecasting CAT. The indices included the Richardson number (Ri), the rate of LnRi to Ri (CATX), the Ellrod index (EI), a parameter based on deformation of a front and vertical wind shear (LROD), an improved EI which included contributions from the convergence (LDR1), and an index based on horizontal flow deceleratioin which was modeled as a Lagrangian parcel acceleration (ACCL). The ability of the TIs to diagnose CAT, as exemplified by their correlation coefficients, varied from -0.346 to 0.219. The Ri and EI showed the best correlation with the rawinsonde data; however, neither cloud indicate how severe the turbulence would be. It was concluded that although the study data suggest that the Ri, and to a lesser extent the EI, can diagnose CAT, neither of these indices can determine its serverity. New indices that can diagnose CAT severity must be found. The ideal index should take into account the importance of vertical eind shear in CAT production and how the stability can delay the development of turbulence until the wind shear is large. Herner

A95-93549

THE DEVELOPMENT OF AN AIRCRAFT ICING FORECAST TECHNIQUE USING DATA FROM MAPS

JOHN R. SMART NOAA, Boulder, CO, US, JOHN A. MCGINLEY NOAA, Boulder, CO, US, and PAULA T. MCCASLIN NOAA, Boulder, CO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 454-457

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This paper describes ongoing research at the Forecast Systems Laboratory (FSL) in developing an objective technique to forecast inflight aircraft icing. This work began during the Winter Icing and Storms Projects (WISP90 and WISP91) when meteorologists from FSL and the National Center for Atmospheric Research (NCAR) conducted experiments in forecasting supercooled liquid water content (SLWC). A primary objective of the experiments was to develop conceptual models suitable for diagnosing and forecasting SLWC production and depletion over eastern Colorado. While the technique that resulted from the WISP experiment is designed for eastern Colorado, and does have skill, our present work is to examine the performance nationally. This paper describes the icing algorithm and the implementation design and discusses the performance using the Mesoscale Analysis and Prediction System, MAPS for one period during an icing event over eastern Colorado 30 on March 1993. In addition, the investigation sets the framework for more thorough analyses of MAPS gridded data for aircraft icing diagnoses.

Author (Herner)

A95-93551

PRELIMINARY RESULTS OF TURBULENCE PREDICTIONS FOR USE IN AVIATION WEATHER FORECASTING

THOMAS L. BLACK NOAA/NWS, Camp Springs, MD, US and ADRIAN MARROQUIN NOAA, Boulder, CO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 461-462

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Because atmospheric turbulence can become a significant hazard to aviation, the prediction of its location and intensity before it is physically encountered would contribute significantly to flight safety. The National Weather Service's Mesoscale Eta Model is scheduled to begin producing operational forecast guidance in 1994. One component of that guidance that is being studied is its turbulence prediction capability. Turbulent kinetic energy (TKE) is a prognostic variable in the model's Mellor-Yamada Level 2.5 second-order turbulence closure scheme. It is assumed that some of the processes that are parameterized in this formulation of TKE generation correspond to those responsible for the creation of atmospheric turbulence that occurs in nature and thus the model's description of TKE evolution might be useful in aviation weather guidance. The computation of TKE in the model generally follows that specified by Level 2.5 in the hierarchy described by Mellor and Yamada (1974, 1982). The so-called boundary layer approximation is used in which only the vertical derivatives of wind and potential temperature are retained in the calculations for production/dissipation of TKE due to shear and buoyancy; all horizontal derivatives are ignored. In the Eta Model, the prognostic equation for the production/dissipation term is expanded in terms of the TKE itself. The value of TKE at the new time step is then found by analytic integration of the prognostic equation while considering physical realizability constraints. Many reports of turbulence were made by pilots over the Denver area on 9 December 1992. Among other things, these reports include the latitude, longitude, and altitude of the turbulence as well as a subjective relative intensity. The intensity scale runs from 0 (none) to 7 (extreme). Between 0600 UTC and 2100 UTC, pilots reported experiencing turbulence in the vicinity of Denver with intensities of 4 (moderate) or 5 (moderate to severe) and once with an intensity of 6 (severe to extreme). Most of these incidents were at altitudes ranging from 31,000 to 39,000 feet (9.4 to 11.9 km). Several different configurations of the Eta Model were used in order to determine if it was possible to see any evidence of the reported turbulence in the forecast.

Author (revised by Herner)

A95-93552

AMPLIFICATION AND BREAKING OF ATMOSPHERIC GRAVITY WAVES

TEDDIE L. KELLER National Center for Atmospheric Research, Boulder, CO, US and PIOTR K. SMOLARKIEWICZ National Center for Atmospheric Research, Boulder, CO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 463-464

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Here we investigate the amplification and breaking of atmospheric gravity waves generated by airflow over mountains. Understanding the conditions conductive to wave breaking, and determining the location of breaking, is of fundamental importance in determining the potential for wave-induced turbulence. In the upper troposphere and lower stratosphere overturning gravity waves are associated with Clear Air Turbulence (CAT), presenting a substantial in-flight hazard. Large amplitude mountain waves can also produce windstorms and localized regions of severe turbulence near the lee side of mountain ranges. In this study we address the amplification of nonhydrostatic gravity waves and the location of the breaking region as a function of the depth of the tropopause and tropospheric Richardson number. The upstream atmospheric profile includes the important dynamical effects of wind increasing with height in the troposphere and a stability jump at the tropopause. The troposphere is characterized by constant stability and linearly increasing wind, and hence constant Richardson number. For this atmospheric profile, the linear solution consists of partially trapped, nonhydrostatic gravity waves which are preferred atmospheric modes, and may dominate the solution throughout the troposphere and far into the stratosphere. Preliminary results from a nonlinear, anelastic numerical model based on second-order-accurate semi-Lagrangian approximations suggest that wave breaking in the troposphere depends on the Froude number (based on the ground wind), the depth of the tropopause, and the Richardson number. When the gravity wave does not break in the troposphere, the nonlinear solution closely resembles the linear solution in the troposphere, and the partially trapped, nonhydrostatic waves leak into the stratosphere. Once in the stratosphere these waves amplify and break due to non-Boussinesq effects. Author (Herner)

A95-93553* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

TURBULENCE NEAR THUNDERSTORM TOPS

PETER F. LESTER San Jose State University, San Jose, CA, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 465-468

Contract(s)/Grant(s): (NCC2-315)

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For several years, scientists at San Jose State University, NASA-Ames, and the University of Arizona have carried out cooperative research programs to understand the causes and effects of severe turbulence. The primary sources of data for this work are Digital Flight Data Recorder (DFDR) tapes from airliners that have been involved in turbulence incidents. A significant result of the analysis of these data has been the identification and quantification of the turbulence causes. Turbulence signatures include breaking Kelvin-Helmholtz waves, large amplitude mountain lee waves, turbulence in and around thunderstorms, and maneuvering. The requirements that must be met for a turbulence incident to be included in the NASA study are rather straightforward: (1) severe or greater turbulence must have been reported (usually with passenger injuries) and (2) the flight data tapes must be available. Despite these rather general criteria, and the fact that our cases are drawn from a wide geographical area over the U.S. and the Atlantic Ocean, we have found an interesting bias in our sample. Of 12 cases at cruise altitude, four were definitely associated with thunderstorms and two are suspected thunderstorm cases. The others were due to mountain waves, CAT, high level windshear/maneuvering, or to causes not yet determined. Although our sample is small, these numbers have raised several questions, not the least of which are: How pervasive is the problem of aircraft encounters with severe turbulence in or near thunderstorm tops (TNTT)? Given the available visible and radar evidence of thunderstorms, Why do such incidents occur? Can anything be done to allevaite the problem? This paper outlines some very preliminary efforts to answer these questions. In the following sections, physical and statistical characteristics of TNTT are discussed (Section 2), TNTT causes are summarized (Section 3), current recommendations for TNTT avoidance are reviewed (Section 4), and some suggestions to ameliorate the problem are given (Section 5). Author (Herner)

A95-93555

A PROTOTYPE FOR DISPLAYING AVIATION FORECAST VARIABLES USING ETA NUMERICAL MODEL OUTPUT

BRIAN D. JAMISON NOAA, Boulder, CO, US, ADRIAN MARROQUIN NOAA, Fort Collins, CO, US, and PHILIP A. MCDONALD NOAA, Colorado Springs, CO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. 470-472

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In response to the need for more timely and accurate aviation weather information, NOAA's Forecast System Laboratory (FSL) in collaboration with the Federal Aviation Administration (FAA) is developing the Aviation Gridded Forecast System (AGFS). The goal of the AGFS is to improve aviation weather forecasting by developing high-resolution gridded analyses and forecasts of weather affecting the aviation community using numerical weather prediction models. The Eta model, the National Meteorological Center's next generation forecast model, is one of the national domain models that will be used as a forecast component of the AGFS. Weather variables that pertain to the aviation community, known as aviation impact variables or AIVs, include visibility and obstruction to visibility; heights of cloud tops, bases and ceilings; relative humidity; altimeter setting; precipitation phase and type; and most importantly, icing and clear air turbulence. AIVs are diagnostically computed from state-of-the-atmosphere variables (SAVs) such as temperature and dew-point temperature, wind magnitude and direction, precipitation occurrence and amount, and turbulent kinetic energy (TKE), all of which are obtained directly from Eta numerical model output. This paper describes a prototype display system (PDS) to display SAVs and AIVs using Eta model output. We also discuss the basic software support for the PDS, the commercially available Application Visualization System (AVS). Author (Herner)

A95-93556

OPERATIONAL MULTI-SCALE ENVIRONMENT MODEL WITH GRID ADAPTIVITY (OMEGA) APPLICATION TO AVIATION WEATHER

D. P. BACON Science Applications International Corporation, McLean, VA, US, T. J. DUNN Science Applications International Corporation, McLean, VA, US, Y.-L. HO Science Applications International Corporation, McLean, VA, US, I. LOTTATI Science Applications International Corporation, McLean, VA, US, M. D. MCCORCLE Science Applications International Corporation, McLean, VA, US, S. E. PECKHAM Science Applications International Corporation, McLean, VA, US, R. A. SARMA Science Applications International Corporation, McLean, VA, US, S. YOUNG Science Applications International Corporation, McLean, VA, US, and J. ZACK Science Applications International Corporation, McLean, VA, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. J1-J4

Contract(s)/Grant(s): (DNA001-92-C-0076)

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The Operational Mesoscale Environment model with Grid Adaptivity (OMEGA) represents a new approach to atmospheric simulation which merges state-of-the-art computational fluid dynamics techniques with a comprehensive non-hydrostatic equation set. Based upon an unstructured triangular prism grid, OMEGA can operate with horizontal grid resolution ranging from 100 km down to 1 km and a vertical resolution from a few meters in the boundary layer to 1 km in the free troposphere. More importantly, OMEGA can allocate this resolution in a natural fashion anywhere in the computational domain. OMEGA represents a significant advance in the field of weather prediction in general, and opens up numerous possibilities for new aviation weather forecasts. For example, the OMEGA grid can be made to adapt to fixed surface features of particular importance to aviation such as terminal airspace or air traffic corridors. The OMEGA grid could also be made to dynamically adapt to weather features which might not drive the weather, but might be significant for aviation operations such as freezing level, fog, or frontal passage.

The basic formulation of the OMEGA model is contained in a companion paper by the authors in the 13th Conference on Weather Analysis and Forecasting. In this paper, we will focus on the OMEGA grid structure and upon the grid generation techniques which have application to aviation weather. Author (Hemer)

A95-93560
AN OVERVIEW OF ISSUES ENCOUNTERED IN PARALLELIZING HIGH-RESOLUTION WEATHER PREDICTION MODELS
FRANCIS G. TOWER Forecast Systems Laboratory, Boulder, CO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. J20-J23
Copyright

The Forecast Systems Laboratory (FSL) in Boulder, Colorado, transfers technological developments in atmospheric and oceanic research to the Nation's operational services. FSL is working with the Federal Aviation Administration (FAA) Aviation Weather Development Program (AWDP) to develop high-resolution analysis and prediction models to provide both en route and terminal weather support. The modeling portion of the project will continue over the next seven years and will provide both state-of-the-atmosphere variables and aviation-impact variables. To provide both en route and terminal weather support, the models will cover two specific domains. The national domain covers the lower 48 states. The first two models scheduled to be parallelized for the nation domain are FSL's Mesoscale analysis and Prediction system (MAPS) model and the National Meteorological Center's (NMC) Eta model. The second domain is centered on the Weather Forecast Office (WFO) and covers an area 400 by 400-km. WFO domain models will analyze every 5 minutes at 2-km resolution and forecast every hour at 10-km resolution using the locally available, higher density data (i.e., Doppler radar, mesonet, profiler). Many risks are associated with a modeling effort of this scope and duration. Risks associated with computing hardware, the complexity of parallel processing, and the distributed nature of the software development must be minimized to assure program success and amortize the enormous cost to parallelize models. FSL has therefore taken a very conservative approach to the issues that have arisen on software, software management, and hardware. Parallel software is being developed with source code portability and maintainability as the primary consideration. Existing standards are used when possible and propriety solutions are avoided. This paper briefly discusses issues that arose during the startup of the project. Author (Hemer)

A95-93561
THE 1992-3 OPERATIONAL WINTER FORECASTING EXPERIMENT FOR STAPLETON AIRPORT
DOUGLAS A. WESLEY National Center for Atmospheric Research, Boulder, CO, US, ROY RASMUSSEN National Center for Atmospheric Research, Boulder, CO, US, GREG STOSSMEISTER National Center for Atmospheric Research, Boulder, CO, US, and ED SZOKE National Center for Atmospheric Research, Boulder, CO, US *In* International Conference on Aviation Weather Systems, 5th, Vienna, VA, Aug. 2-6, 1993. Preprint Volume. A95-93441 Boston, MA American Meteorological Society 1993 p. J24-J28
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During the 15 November 1992 - 2 April 1993 time period, a winter forecasting experiment was conducted for Denver's Stapleton airport (DEN), as part of RAP's ongoing program on aircraft ground de-icing. Snowfall forecasts, especially in the 0-5 hour time frame, are critically important to airline operations such as de-icing scheduling and procedures. Highly varying snowfall rates on both small temporal and spatial scales complicate the de-icing problem for the airlines and necessitate the measurement and prediction of precipitation on a sub-1-hour basis. The goals of the NCAR operational forecast experiment last winter were as follows: (1) Detect and nowcast snowfall at DEN in the 0-1 hour time period. (2) Provide additional snowfall outlooks in the 1-24 hour time period. (3) Gain insight into the dynamical and microphysical aspects of snow production in the Colorado Front Range region. In this project, 24-hour outlooks were prepared daily. During snowfall, 1 and 5-hour forecasts of accumulation, liquid equivalent, temperature and winds were disseminated. The tools used in developing these forecasts were primarily Mile High Doppler radar data, a special high-resolution snowgauge network, surface meteorological measurements from the PROFS mesonetwork and two PAM stations, and standard NWS surface, sounding, satellite and model data. Author (Hemer)

N95-31157# Technische Univ., Delft (Netherlands).
DIGITAL SIMULATION OF WIND VELOCITIES FOR WIND TURBINE ROTORS: GENERAL CONSIDERATIONS
J. B. DRAGT Dec. 1993 18 p
(PB95-206447; IW-93070R) Avail: CASI HC A03/MF A01

One of the methods to reliably predict the dynamic loads of a wind turbine rotor due to the turbulence of the atmosphere is to simulate the stochastic wind field over the rotor area in a digital way, in order to generate the wind input for a rotor dynamical code. As many points in the rotor area are involved and many time steps, a rather time consuming computation is required. A number of different approaches can be followed, some of which have been realized in practical computer programs, others still have to be explored. This report gives a general overview of simulation methods based on the inverse fast Fourier transform. NTIS

N95-31465# Massachusetts Inst. of Tech., Lexington, MA.
INITIAL EVALUATION OF THE OREGON STATE UNIVERSITY PLANETARY BOUNDARY LAYER COLUMN MODEL FOR ITWS APPLICATIONS
J. L. KELLER, F. W. WILSON, and C. B. SMITH 13 Apr. 1995 28 p
Contract(s)/Grant(s): (DTFA01-91-Z-02036; F19628-95-C-0002)
(AD-A293775; ATC-233) Avail: CASI HC A03/MF A01

The Federal Aviation Administration (FAA) Integrated Terminal Weather System (ITWS) is supporting the development of products important for air traffic control in the terminal area. Some ITWS products will allow air traffic managers to anticipate operationally significant short-term (0-30 min) changes in ceiling and visibility (C&V) and aircraft separations necessary to avoid encounters with wake vortices. Development of such products exploits data that will by available from new FAA terminal area sensor systems. These sensor systems include Terminal Doppler Weather Radar (TDWR), Next Generation Weather Radar (NEXRAD), the Meteorological Data Collection and Reporting System (MDCRS), and the Automated Surface Observing System (ASOS). A Dynamic Atmospheric Vertical Structure Nowcast System (DAVS-NS) is being developed that will add value to ITWS by providing current analyses and short-term forecasts of the vertical atmospheric structure focused at specific sites within the terminal domain. This report summarizes the initial evaluation of the Oregon State University one-dimensional boundary layer model for its potential role within a DAVS-NS. DTIC

N95-31587# Federal Aviation Administration, Atlantic City, NJ.
THE ATC OPERATIONAL EVALUATION OF THE PROTOTYPE INTEGRATED TERMINAL WEATHER SYSTEM(ITWS) AT DALLAS/FORT WORTH AND ORLANDO AIRPORTS (MAY-SEPTEMBER 1993) Final Technical Note
THOMAS M. WEISS Mar. 1995 119 p
(AD-A293808; DOT/FAA/CT-TN95/1) Avail: CASI HC A06/MF A02

The Integrated Terminal Weather System (ITWS) was developed by Massachusetts Institute of Technology/Lincoln Laboratory (MIT/LL). The ITWS processor acquires data from Federal Aviation Administration (FAA) and National Weather Service (NWS) weather sensors in the terminal area and provides an integrated set of safety and planning weather products to air traffic personnel. An operational evaluation of the ITWS functional prototype was performed from May through September, 1993 at Dallas/Fort Worth (DFW) and Orlando (MCO) airports. ITWS geographical situation displays (6 SD) were located both at DFW and MCO as well as the Fort Worth Air Route Control Center (ARTCCXZFW) and Jacksonville ARTCC (ZJX). The purpose of testing ITWS at these sites was to evaluate various technical and operational issues of IIWS weather products and their display and usability on the GSD. DTIC

15
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.

A95-92597
MULTIVARIABLE ADAPTIVE CONTROL USING ONLY INPUT AND OUTPUT MEASUREMENTS FOR TURBOJET ENGINES
JIN-QUAN HUANG Nanjing Univ of Aeronautics and Astronautics, Nanjing, China and JIAN-GUO SUN Journal of Engineering for Gas Turbines and Power, Transactions of the ASME (ISSN 0742-4795) vol. 117, no. 2 April 1995 p. 314-319 refs
(BTN-95-EIX95292721165) Copyright

Current and future aircraft engines are increasingly relying upon the use of multivariable control approach for meeting advanced performance requirements. A multivariable model reference adaptive control (MRAC) scheme is proposed in this paper. The adaptation law is derived using only input and output (I/O) measurements. Simulation studies are performed for a two-spool turbojet engine. The satisfactory transient responses are obtained at different operating points from idle to maximum dry power within the flight envelope. These show insensitivity of the design to engine power level and flight condition. Simulation results also show high effectiveness of reducing interaction in multivariable systems with significant coupling. Using the multivariable MRAC controller, the engine acceleration time is reduced by about 19% in comparison with the conventional engine controller. Author (EI)

A95-92708
NEW FILTERING METHOD FOR LINEAR WEAKLY COUPLED STOCHASTIC SYSTEMS
Z. GAJIC Rutgers Univ, Piscataway, NJ, United States and Z. AGANOVIC Journal of Guidance, Control, and Dynamics (ISSN 0731-5090) vol. 18, no. 3 May-June 1995 p. 630-633 refs
(BTN-95-EIX0608952736485) Copyright

Weakly coupled structures are often found in models of many real dynamical control systems. These weakly coupled systems also represent the linearized models of dynamical systems. A new method for optimal filtering of linear weakly coupled stochastic system is presented. This method simplifies both off-line and on-line calculations. The method is demonstrated by solving the filtering problem for a helicopter in low-speed flight control condition. EI

A95-93595
EVOLVING STANDARDS FOR SAFETY CRITICAL SOFTWARE
P. A. BENNETT 1991 7 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 24: Software in Safety Critical Applications
(CONGRESS PAPER C428-24-142; HTN-95-21164) Copyright

In this paper the author seeks to give an insight to the development of the imminent International Standard on Safety Related Software from the International Electrotechnical Commision (IEC). In June 1989 the IEC published a Draft for Comment which prompted considerable support and has led to the development of the most recent work. The material for this paper has been taken directly from the imminent standard and so reflects the contents. Author (Herner)

A95-93596
DEPENDABLE SOFTWARE - THE STATE OF THE ART
J. A. MCDERMID The University of York, UK 1991 5 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 24: Software in Safety Critical Applications
(CONGRESS PAPER C428-24-212; HTN-95-21165) Copyright

This paper is intended to set out the author's views of the 'state of the art' in the development of dependable (especially safety critical avionics) software from both an industrial and an academic (research) perspective. Inevitably such an exercise is judemental as there is no uniform 'state of the art' in either academia or industry and I am reflecting my perceptions of those industrial and academic organizations with which I have significant interactions. The purpose of making such a comparison is to try to enlighten academics to engineering perspectives and problems, and to inform industrialist about pertinent research. Author (Herner)

A95-93597
DEVELOPMENT OF SOFTWARE FOR SAFETY CRITICAL APPLICATIONS FOR THE EH101 HELICOPTER
M. J. HARRIS 1991 8 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 24: Software in Safety Critical Applications
(CONGRESS PAPER C428-24-160; HTN-95-21166) Copyright

This paper describes the management of software developed for use in flight critical applications on the EH101 Helicopter. It discusses the integrity rationale, design assurance and verification techniques employed. The interpretation of the certification requirements and interface with the regulatory authorities. It examines the approach adopted in three specific applications; flight control, cockpit displays and aircraft sensors. Author (Herner)

A95-93757
A STUDY OF MESH ADAPTION TECHNIQUES IN STRUCTURED AND UNSTRUCTURED MESHES
SYED M. REHMAN *In* Developments in theoretical and applied mechanics; Southeastern Conference on Theoretical and Applied Mechanics, 16th, Nashville, TN, April 12-14, 1992. A95-93700 Tullahoma, TN The Univ. of Tennessee Space Inst. (SECTAM, Vol. 16) 1992 p. IV.S1.1-IV.S.7
(ISBN 1-879921-01-4) Copyright

Two distinctively different approaches to grid adaption were studied. The first method is for structured meshes which were adapted by moving points on the mesh. The unstructured meshes were adapted using a point enrichment algorithm. The object of the research was to study the advantages and shortcomings of each method. The mesh generation and mesh adaption techniques were applied to two different geometries. The first is a ramp at an angle of 5 degrees and a frees stream Mach number of 2. The second geometry is a missile with open bays travelling at a free stream Mach number of 1.87. Finally, the last case is a NACA-0012 airfoil at a free stream Mach number of 2.1. Author (Herner)

N95-30406# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
SELECTING OPTIMAL EXPERIMENTS FOR FEEDFORWARD MULTILAYER PERCEPTRONS Ph.D. Thesis
LISA M. BELUE Mar. 1995 187 p
(AD-A290856; AFIT/DS/ENS/95-01) Avail: CASI HC A09/MF A02

Where should a researcher conduct experiments to provide training data for a multilayer perceptron? This question is investigated and a statistically-based method for optimally selecting experimental design points for multilayer perceptrons is introduced. Specifically, a criterion is developed based on the size of an estimated confidence ellipsoid for the weights in the multilayer perceptron. This criterion is minimized over a set of exemplars to find optimal design points. Initially, single output networks are examined. An example is used to demonstrate the superiority of optimally selected design points over randomly chosen points and points chosen in a grid pattern. Also, two measures are successfully used to rank the design points in terms of their importance. Two methods are presented to significantly reduce complexity-a distributed linear feedthrough network structure and a weight subset method. Next, multiple output networks are examined. The criterion in this framework becomes more complex and a simplifying technique is employed to judiciously choose desired outputs of the network to produce uncorrelated actual outputs. Finally, the methods described above are integrated and tested on two applications dealing with aircraft survivability. In both cases, simulating the indicated experiments produced a superior multilayer perceptron. DTIC

N95-30892# Stanford Univ., CA. Dept. of Electrical Engineering.
FOUNDATIONS OF TECHNOLOGY FOR CONSTRUCTING HIGHLY RELIABLE DISTRIBUTED REALTIME SYSTEMS Final Report, 1 Aug. 1991 - 30 Sep. 1994
DAVID C. LUCKHAM 30 Sep. 1994 12 p
Contract(s)/Grant(s): (AF-AFOSR-0354-91)
(AD-A293254; AFOSR-95-0235TR) Avail: CASI HC A03/MF A01

We have investigated event-based specification and constraint language extensions of our Rapide prototyping language. We have also investigated testing methods and tools for detecting constraint violations in simulations of distributed time-sensitive avionics systems and control systems. Rapide models the behavior of a distributed system by generating causal event simulations. A causal event simulation is a timed poset (partially ordered set of events with timing). Dependencies between events as well as their timing are captured in the poset execution model, thus providing a more detailed and precise picture of the behavior of a realtime, distributed system than current simulation technology based upon sequential traces of events. Posets allow more powerful constraint specifications than traces, e.g., asynchronous behavior. This work has developed (1) basic algorithms for implementing poset computations, (2) a constraint language for specifying behavior in terms of posets, and (3) automatable algorithms and tool-set for detecting constraint violations in posets. To establish the feasibility of scaling this simulation technology to practical avionics examples, we have applied the technology to developing high level systems architectures of avionics systems. We have also applied constraint monitoring of the avionics simulations to detect design errors. The avionics systems studied include the IBM ADAGE helicopter avionics system architecture, and a high level architecture of the Boeing DARTS system for building flight simulators. DTIC

N95-30961 Michigan Univ., Ann Arbor, MI.
ROBUST FIXED-STRUCTURE CONTROL Final Report, 1 Feb. 1992 - 30 Sep. 1994
DENNIS S. BERNSTEIN 30 Oct. 1994 28 p Limited Reproducibility: More than 20% of this document may be affected by poor print
Contract(s)/Grant(s): (F49620-92-J-0127)
(AD-A292883; AFOSR-95-0202TR) Avail: Issuing Activity (Defense Technical Information Center (DTIC))

This final report for AFOSR Grant F49620-92-J-0127 summarizes results obtained in five areas, namely, robust control, linear control, sampled-data control, tracking and disturbance rejection, and nonlinear control. Principal results include new bounds for the structured singular value, implementation of structured singular value synthesis using fixed-structure optimization techniques, a more rigorous foundation for the Maximum Entropy control technique, extensions of linear-quadratic control to stable stabilizing controllers, determination of the achievable performance of sampled-data controllers in the presence of sample-rate constraints, control of noise in an acoustic duct, stability theory for second-order systems, a rigorous treatment of Guyan reduction, a deterministic foundation for energy flow theory, a unified treatment of quadratic optimality and servocompensation, nonlinear control of the spinning top and rotating bodies with known and unknown mass imbalance, global stabilization of the oscillating eccentric rotor using integrator backstepping, and Lyapunov theory for finite-time convergence. DTIC

N95-31455# Massachusetts Univ., Amherst, MA. Dept. of Mechanical Engineering.
INTELLIGENT FINITE ELEMENT SUBMODELING OF MULTICHIP MODULES FOR RELIABILITY ANALYSIS Final Technical Report, Jan. 1993 - Jan. 1994
IAN R. GROSSE, MICHAEL SHEEHY, PRASANNA KATRAGADDA, and SHANKAR RAMAN Dec. 1994 122 p
Contract(s)/Grant(s): (F30602-93-C-0040)
(AD-A292911; RL-TR-94-218) Avail: CASI HC A06/MF A02

Modeling methodologies were developed, implemented, and tested for both rapid thermal finite element analysis of small-scale integrated circuit features in MCM's, and for thermal stress finite element analysis of chip-to-substrate interconnects. A three-step sequential analysis methodology was developed that is initiated with a macroscope thermal analysis of the entire MCM package. The macroscope finite element thermal analysis is then followed by two successive finite element thermal submodels of the hottest die first and then of the hottest die microfeature. In this manner, the thermal analysis process mathematically zooms into the hottest IC microfeature without resorting to supercomputer-size finite element models of the MCM. A two-step sequential thermal-stress finite element submodeling analysis procedure was also developed for thermally induced stress analysis of the most highly stressed wirebond or TAB interconnect in an MCM package. For automation purposes, both the IC thermal submodeling and the interconnect elastostatic submodeling methodologies were implemented into an existing blackboard-based, object-oriented MCM software design tool called the Intelligent MCM Analysis (IMCMA). DTIC

N95-31684# Dayton Univ., OH. Research Inst.
IMAGE REPRESENTATION USING FAST ALGORITHMS BASED ON THE ZAK TRANSFORM Final Technical Report, Oct. 1990–Mar. 1994
GEORGE A. GERI and IZIDOR C. GERTNER Dec. 1994 124 p Prepared in cooperation with City College of the City Univ. of New York, NY
Contract(s)/Grant(s): (F33615-90-C-0006)
(AD-A293416; AL/HR-TR-1994-0106) Avail: CASI HC A06/MF A01

Flight simulator imagery is often made up of natural scenes whose characteristics are not constant across the image. This property suggests that such imagery can be most efficiently represented by spectral techniques that use spatially localized basis functions. This report describes techniques for decomposing full gray-scale images into a joint position/spatial-frequency domain using bases derived from various window functions. The first set of window functions consists of the hermite functions which are related to gaussian derivatives. The second set is based on a new window function that is obtained from a weighted ZAK transform and that provides good localization properties and stable computation. The third set is based on a localized cosine function and allows images to be decomposed using real numbers only. All of the techniques described provide a framework for filtering images in a position-varying manner. For all the basis functions described here, image generation from combined position and spatial-frequency information involves a computationally intensive four-dimensional summation. By an application of the Zak Transform, we are able to replace this summation with a fast Fourier transform, significantly reducing the complexity of the computation. DTIC

N95-31982*# Old Dominion Univ., Norfolk, VA. Dept. of Computer Science.
GEOMETRIC MODELING FOR COMPUTER AIDED DESIGN Final Report, period ended 30 Jun. 1995
JAMES L. SCHWING and STEPHEN OLARIU Jul. 1995 28 p
Contract(s)/Grant(s): (NCC1-99)
(NASA-CR-198828; NAS 1.26:198828) Avail: CASI HC A03/MF A01

The primary goal of this grant has been the design and implementation of software to be used in the conceptual design of aerospace vehicles particularly focused on the elements of geometric design, graphical user interfaces, and the interaction of the multitude of software typically used in this engineering environment. This has resulted in the development of several analysis packages and design studies. These include two major software systems currently used in the conceptual level design of aerospace vehicles. These tools are SMART, the Solid Modeling Aerospace Research Tool, and EASIE, the Environment for Software Integration and Execution. Additional software tools were designed and implemented to address the needs of the engineer working in the conceptual design environment. SMART provides conceptual designers with a rapid prototyping capability and several engineering analysis capabilities. In addition, SMART has a carefully engineered user interface that makes it easy to learn and use. Finally, a number of specialty characteristics have been built into SMART which allow it to be used efficiently as a front end geometry processor for other analysis packages. EASIE provides a set of interactive utilities that simplify the task of building and executing computer aided design systems consisting of diverse, stand-alone, analysis codes. Resulting in a streamlining of the exchange of data between programs reducing errors and improving the efficiency. EASIE provides both a methodology and a collection of software tools to ease the task of coordinating engineering design and analysis codes. Derived from text

N95-31987# General Accounting Office, Washington, DC. National Security and International Affairs Div.

REPORT TO THE CHAIRMAN, LEGISLATION AND NATIONAL SECURITY SUBCOMMITTEE, COMMITTEE ON GOVERNMENT OPERATIONS, HOUSE OF REPRESENTATIVES. TACTICAL AIRCRAFT: F-15 REPLACEMENT IS PREMATURE AS CURRENTLY PLANNED

25 Mar. 1994 10 p

(GAO/NSIAD-94-118; B-253662) Avail: CASI HC A02/MF A01; GAO, PO Box 6015, Gaithersburg, MD 20877 HC

The F-22 program was initiated in 1981 to meet the evolving threat in the mid-1990's. This threat revolved around a fighter threat that had a significant quantitative advantage and was becoming more capable with the introduction of two new high performance fighters. Since the F-22 program entered full-scale development in 1991, the severity of the projected military threat in terms of quantities and capabilities has declined. Instead of confronting thousands of modern Soviet fighters, U.S. air forces are expected to confront potential adversary air forces that include few fighters that have the capability to challenge the F-15 - the U.S. front line fighter. The F-15 exceeds the most advanced threat system expected to exist. And no improvements will be made to the F-15 but the capability of the 'most advanced threat' assumes certain modifications. Further, analysis shows that the current inventory of F-15's can be economically maintained in a structurally sound condition until 2015 or later. Thus, the F-22's initial operational capability can be delayed 7 years and its planned production start date of 1996 can be postponed to a future date deemed appropriate by DOD to meet the new initial operational capability date. Derived from text

16 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.

A95-93691

FIBER OPTIC HARDWARE FOR TRANSPORT AIRCRAFT

JOHN A. WHITE (ISSN 0148-7191) 1993 27 p. SAE, Aerospace Atlantic Conference & Exposition, Dayton, OH, April 20-23, 1993

(SAE PAPER 931439; HTN-95-21260) Copyright

Fiber Optic Technology is being developed for aircraft and offers benefits in system performance and manufacturing cost reduction. Thr fiber optic systems have high bandwidths that exceeds all of the new aircraft design requirements and exceptional electromagnetic interference (EMI) immunity. Additionally, fiber optic systems have been installed in production aircraft proving design feasiblity. Author (Herner)

A95-93965

EFFECTS OF ACTIVATED REACTIVE EVAPORATION PROCESS PARAMETERS ON THE MICROHARDNESS OF POLYCRYSTALLINE SILICON CARBIDE THIN FILMS

YONGHWA CHRIS CHA Department of Materials Science and Engineering, School of Engineering and Applied Science, University of California, Los Angeles, CA 90024, US, GUHO KIM Department of Materials Science and Engineering, School of Engineering and Applied Science, University of California, Los Angeles, CA 90024, US, HANS J. DOERR Department of Materials Science and Engineering, School of Engineering and Applied Science, University of California, Los Angeles, CA 90024, US, and ROINTAN F. BUNSHAH Department of Materials Science and Engineering, School of Engineering and Applied Science, University of California, Los Angeles, CA 90024, US Thin Solid Films (ISSN 0040-6090) vol. 253, no. 1-2 December 15, 1994 p. 212-217 Copyright (c) 1995 Elsevier Science B.V., Amsterdam. All rights reserved.

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Polycrystalline beta-SiC is expected to be an excellent material for thin film temperature sensors for the measurement of the surface temperature of gas turbine engine components operated at high temperatures (up to 1500 C). In this paper, Vickers and Knoop indentation microhardness tests were carried out on the silicon carbide films grown on Si(100) substrates by the activated reactive evaporation (ARE) process to measure one of the important mechanical properties, i.e. hardness of the films. The results of these tests are presented as a function of the ARE process parameters, such as C2H2 pressure P(sub C2H2, substrate temperature T(sub sub), ARE electrode voltage V(sub ARE) for the generation of d.c. glow discharge and substrate bias V(sub sub). It was found that the hardness of the films is very much dependent on these process parameters. A Vickers hardness value of 3680 kgf/sq mm (36.1 GPa) at 25 gf load (0.25 N) and a Knoop hardness value of 2060 kgf/sq mm (20.2 GPa) at 100 gf load (0.98 N) are obtained for polycrystalline beta-SiC films (C-to-Si ratio, 1.17) prepared under the following deposition conditions: C2H2 pressure, 3 mTorr (0.4 Pa); substrate temperature, 700 C; ARE electrode voltage, +150 V; substrate bias, -50 V. Microhardness variation of the beta-SiC films with applied load on the indenter was also studied. It was found that the hardness of the films decreases with increasing load, which is believed to be due to indentation size and substrate hardness effects. Author (Elsevier)

A95-94248

SIGNAL PROCESSING OF NOISE DATA FROM HIGH-SPEED FLYOVERS

JEFFREY J. KELLY Lockheed Engineering and Sciences Co, Inc, Hampton, VA, United States and MARK R. WILSON Journal of Aircraft (ISSN 0021-8669) vol. 32, no. 3 May-June 1995 p. 590-595 refs

(BTN-95-EIX0619952748178) Copyright

Narrow-band spectra characterizing jet noise are constructed from flyover acoustic measurements. Radar and c-band tracking systems provided the aircraft position histories from which directivity and smear angles from the aircraft to each microphone are computed. These angles are based on source emission time. This allowed spectra to be correlated to aircraft position at the time of sound emission. Simulated spectra are included in this article to demonstrate spectral broadening due to smear angle. A detailed description of the signal processing procedures is provided. The spectra demonstrated the forward radiation of broadband shock noise of supersonic jets, confirming what has been observed in static tests. Author (EI)

N95-32187*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA). PHASE A: SYSTEM CONCEPT DESCRIPTION

1995 439 p
Contract(s)/Grant(s): (PROJ. SOFIA)
(NASA-TM-110669; NAS 1.15:110669) Avail: CASI HC A19/MF A04

Infrared astronomers have made significant discoveries using the NASA/Ames Research Center C-141 Kuiper airborne Observatory (KAO) with its 0.91-meter telescope. The need for a 3-meter class airborne observatory has been established to improve astronomy data gathering capability. The new system envisioned by NASA and the international community of astronomers will be known as the Stratospheric Observatory for Infrared Astronomy (SOFIA). The platform of choice for SOFIA is a modified Boeing 747SP. SOFIA is viewed as a logical progression from the KAO. Potentially, a 3-meter telescope operating at the altitude achievable by the 747SP aircraft can be 11 times more sensitive than the KAO, can have 3.3 times better angular resolution, and will allow observations of compact sources in a volume of space up to 36 times that of the KAO. The KAO has enabled detection of about 15 percent of the far infrared IRAS survey point-sources; SOFIA should be able to detect them all. This document presents the results of in-house ARC and contracted concept definition studies for SOFIA. Using the ARC-based Kuiper Airborne Observatory as a basis for both SOFIA design and operations concepts, the SOFIA system concept has been developed with a view toward demonstrating mission and technical feasibility, and preparing preliminary cost estimates. The reference concept developed is not intended to represent final design, and should be treated accordingly. The most important products of this study, other than demonstration of system feasibility, are the understanding of system trade-offs and the development of confidence in the technology base that exists to move forward with a program leading to implementation of the Stratospheric Observatory for Infrared Astronomy (SOFIA). Derived from text

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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.

A95-93602
THE MINI-BUSINESS APPROACH AT CHADDERTON
P. L. PARRY and D. WILSON British Aerospace (CA) Ltd, UK 1991 4 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 26: Design of Competitive Manufacturing Systems 2)
(CONGRESS PAPER C428-26-037; HTN-95-21171) Copyright

To accomodate a 60 per cent share increase in variety and a five-fold increase in volume over five years, British Aerospace's Chadderton factory is implementing cell manufacture for Airbus wing componenets. This required the introductin of demand-driven manufacture, supported by logistics and control systems which balance production through the four mini-business cells and permit on-time delivery to the assembly plant. Author (Herner)

A95-93603
CHANGING MRP SYSTEMS WITHIN THE AEROSPACE INDUSTRY
I. R. MCFIGGANS 1991 3 p. AeroTech 92; The Aerospace & Airport Technology Exhibition & Congress, UK, 1992, (Seminar 26: Design of Competitive Manufacturing Systems 2)
(CONGRESS PAPER C428-26-051; HTN-95-21172) Copyright

A large number of organizations within the aerospace industry were amongst the first in the use of automated resource planning systems. Given the advances made in technology and the demands being placed on companies to become more efficient and competitive, many of these original planning systems are no longer able to support the objetives of the aerospace industry. The purpose of this paper is to describe some of the business pressures that are forcing organizations to re-imlement Material Resource Planning (MRP) and to define a strategy to assist with the implementation. Author (Herner)

A95-95066
COOPERATIVE PROBLEM SOLVING BETWEEN AIRLINE OPERATIONS CONTROL AND ATC TRAFFIC FLOW MANAGEMENT
ROGER BEATTY Airline Dispatchers Federation, US *In* International Symposium on Aviation Pyschology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 204-208
Copyright

The author discusses his observations on cooperative decision making as he has viewed it as an airline operations controller. The comments are personal observations of the interaction between Air Traffic Control Traffic Flow Management (ATC TFM) and Airline Operations Control (AOC). The paper addresses the increase in cooperative planning between ATC TFM and AOC. Author (revised by Herner)

A95-95204* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
INITIAL EXPLORATION OF THE ASRS DATABASE
RICHARD KRAFT NASA. Ames Research Center, Moffett Field, CA, US and BUNTINE WRAY NASA. Ames Research Center, Moffett Field, CA, US *In* International Symposium on Aviation Psychology, 7th, Columbus, OH, April 26-29, 1993. Vols. 1 & 2. A95-95037 Columbus, OH Ohio State University April 1993 p. 1020-1024
Copyright

We applied a standard classification algorithm to a subset of NASA/FAA Aviation Safety Reporting System (ASRS) database. The subset concerned incidents of aircraft altitude deviations. We are exploring the database to address questions such as: Are there 'natural' classes into which the data will fall? How would these classes correspond to recognizable events or situations? Beyond addressing these we want the data to determine directions for further study. We conducted experiments on different data subsections and analyzed diagnostics such as 'message length reduction'; these characterize the classification in terms of its significance and information content. The classification effort was successful in revealing relationships in the data that were in consonance with other studies of the data and expert opinion. Author (Herner)

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SPACE SCIENCES

Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.

N95-31979*# National Aeronautics and Space Administration, Washington, DC.
AERONAUTICS AND SPACE REPORT OF THE PRESIDENT Activities Report, Fiscal Year 1994
1995 147 p Original contains color illustrations
(NASA-TM-110743; NAS 1.15:110743) Avail: CASI HC A07/MF A02; 1 functional color page

This report describes the activities and accomplishments of all agencies of the United States in the fields of aeronautics and space science during FY 1994. Activity summaries are presented for the following areas: space launch activities, space science, space flight and space technology, space communications, aeronuatics, and studies of the planet Earth. Several appendices providing data on U.S. launch activities, the Federal budget for space and aeronautics, remote sensing capabilities, and space policy are included. CASI

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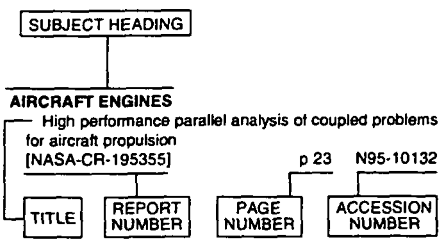

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SUBJECT

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P

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Z

PERSONAL AUTHOR INDEX

Typical Personal Author Index Listing

PERSONAL AUTHOR

GLASSMAN, ARTHUR J.
Modeling improvements and users manual for axial-flow turbine off-design computer code AXOD
[NASA-CR-195370] p 8 N95-10853

TITLE | REPORT NUMBER | PAGE NUMBER | ACCESSION NUMBER

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CORPORATE SOURCE INDEX

Typical Corporate Source Index Listing

CORPORATE SOURCE

Colorado Univ., Boulder, CO.
High performance parallel analysis of coupled problems for aircraft propulsion
[NASA-CR-195355] p 23 N95-10132

TITLE | REPORT NUMBER | PAGE NUMBER | ACCESSION NUMBER

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Typical Foreign Technology Index Listing

COUNTRY OF INTELLECTUAL ORIGIN

FRANCE
Numerical study of Gortler instability: Application to the design of a quiet supersonic wind tunnel
[PB94-184801] p 21 N95-10844

TITLE | REPORT NUMBER | PAGE NUMBER | ACCESSION NUMBER

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Typical Contract Number Index Listing

N00014-82-K-0185 .... p 22 N95-10231

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NASA-CR-186030 .... p 13 N95-11410 * #

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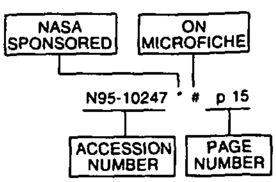

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Chapel Hill, NC 27514-8890
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