

NASA SP-7037 (324)
December 1995

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY



National Aeronautics and Space Administration
Scientific and Technical Information Office
Washington, DC

1995

The NASA STI Office ... in Profile

Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA Scientific and Technical Information (STI) Office plays a key part in helping NASA maintain this important role.

The NASA STI Office provides access to the NASA STI Database, the largest collection of aeronautical and space science STI in the world. The Office is also NASA's institutional mechanism for disseminating the results of its research and development activities.

Specialized services that help round out the Office's diverse offerings include creating custom thesauri, building customized databases, organizing and publishing research results ... even providing videos.

For more information about the NASA STI Office, you can:

- **Phone** the NASA Access Help Desk at (301) 621-0390
- **Fax** your question to the NASA Access Help Desk at (301) 621-0134
- **E-mail** your question via the **Internet** to help@sti.nasa.gov
- **Write** to:

NASA Access Help Desk
NASA Center for AeroSpace Information
800 Elkridge Landing Road
Linthicum Heights, MD 21090-2934



SCAN Goes Electronic!

If you have electronic mail or if you can access the Internet, you can view biweekly issues of *SCAN* from your desktop absolutely free!

Electronic SCAN takes advantage of computer technology to inform you of the latest worldwide, aerospace-related, scientific and technical information that has been published.

No more waiting while the paper copy is printed and mailed to you. You can view *Electronic SCAN* the same day it is released—up to 191 topics to browse at your leisure. When you locate a publication of interest, you can print the announcement. You can also go back to the *Electronic SCAN* home page and follow the ordering instructions to quickly receive the full document.

Start your free access to *Electronic SCAN* today. Over 1,000 announcements of new reports, books, conference proceedings, journal articles . . . and more—available on your computer every two weeks.

For Internet access to *E-SCAN*, use any of the following addresses:

<http://www.sti.nasa.gov>

<ftp.sti.nasa.gov>

<gopher.sti.nasa.gov>



National Aeronautics and
Space Administration

Scientific and Technical
Information Office

Electronic SCAN
Timely
Flexible
Complete
FREE!

To receive a free subscription, send e-mail for complete information about the service first. Enter **scan@sti.nasa.gov** on the address line. Leave the subject and message areas blank and send. You will receive a reply in minutes.

Then simply determine the *SCAN* topics you wish to receive and send a second e-mail to **listserv@sti.nasa.gov**. Leave the subject line blank and enter a subscribe command in the message area formatted as follows:

Subscribe <desired list> <Your name>

For additional information, e-mail a message to **help@sti.nasa.gov**.

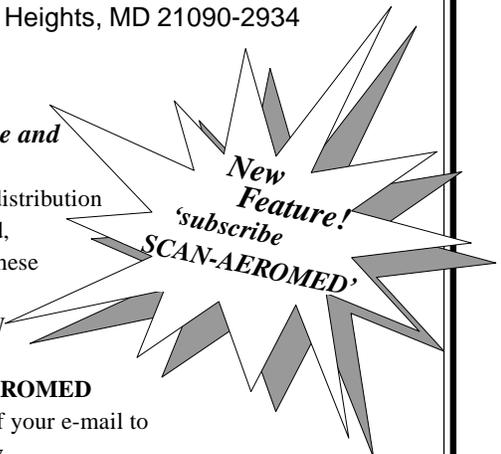
Phone: (301) 621-0390

Fax: (301) 621-0134

Write: NASA Access Help Desk
NASA Center for AeroSpace Information
800 Elkridge Landing Road
Linthicum Heights, MD 21090-2934

**Looking just for
Aerospace Medicine and
Biology reports?**

Although hard copy distribution has been discontinued, you can still receive these vital announcements through your *E-SCAN* subscription. Just **subscribe SCAN-AEROMED** in the message area of your e-mail to **listserv@sti.nasa.gov**.



INTRODUCTION

This issue of *Aeronautical Engineering — A Continuing Bibliography* (NASA SP-7037) lists 149 reports, journal articles, and other documents recently announced in the NASA STI Database.

Accession numbers cited in this issue include:

<i>Scientific and Technical Aerospace Reports (STAR)</i> (N-10000 Series)	N95-32373 — N95-34822
Open Literature (A-60000 Series)	A95-95939 — A95-96758

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.

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

TABLE OF CONTENTS

Category 01	Aeronautics	683
Category 02	Aerodynamics Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.	683
Category 03	Air Transportation and Safety  Includes passenger and cargo air transport operations; and aircraft accidents.	686
Category 04	Aircraft Communications and Navigation Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.	688
Category 05	Aircraft Design, Testing and Performance Includes aircraft simulation technology.	N.A.
Category 06	Aircraft Instrumentation Includes cockpit and cabin display devices; and flight instruments.	693
Category 07	Aircraft Propulsion and Power Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and onboard auxiliary power plants for aircraft.	694
Category 08	Aircraft Stability and Control Includes aircraft handling qualities; piloting; flight controls; and autopilots.	N.A.
Category 09	Research and Support Facilities (Air) Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tubes; and aircraft engine test stands.	699
Category 10	Astronautics Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; space communications, spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.	701
Category 11	Chemistry and Materials Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; propellants and fuels; and materials processing.	701
Category 12	Engineering Includes engineering (general); communications and radar; electronics and electri- cal engineering; fluid mechanics and heat transfer; instrumentation and photogra- phy; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.	702

Category 13	Geosciences	N.A.
	Includes geosciences (general); earth resources and remote sensing; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.	
Category 14	Life Sciences	N.A.
	Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and space biology.	
Category 15	Mathematical and Computer Sciences	709
	Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.	
Category 16	Physics	710
	Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.	
Category 17	Social Sciences	711
	Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law, political science, and space policy; and urban technology and transportation.	
Category 18	Space Sciences	N.A.
	Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.	
Category 19	General	N.A.
Appendix	APP-1

TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

↓
ON MICROFICHE
↓

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

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. 324)

December 1995

01

AERONAUTICS (GENERAL)

N95-32783# General Accounting Office, Washington, DC. National Security and International Affairs Div.

ARMY AVIATION: MODERNIZATION STRATEGY NEEDS TO BE REASSESSED. REPORT TO CONGRESSIONAL REQUESTORS

21 Nov. 1994 54 p
(GAO/NSIAD-95-9; B-257915) Avail: CASI HC A04/MF A01; GAO, PO Box 6015, Gaithersburg, MD 20877 HC

The validity of the Army's plan for modernizing its aviation fleet is discussed and alternatives to the strategy's proposed armed reconnaissance and light attack helicopter are described. Funding issues surrounding the Army's decisions to acquire its aviation fleet are identified. Because the Bottom-Up Review used different total force structure and unit composition data than the Army to determine the size of the Army's attack and reconnaissance fleet, the validity of the Army's aviation modernization strategy is now questionable. In addition, the Army overstated the expected benefits and understated technical risks associated with the major systems that comprise its modernization strategy. Some field commanders and pilots are concerned that implementation of the current procurement plan could result in an inappropriate mix and quantity of helicopters and, therefore, adversely impact their operational effectiveness. Additionally, DOD and Army studies have not fully considered alternative helicopters and weapon systems that could accomplish many of the planned roles and missions of the strategy's centerpiece - the Comanche. For its aviation modernization strategy, the Army has chosen to use most of its available resources to procure Comanche helicopters and upgrade Apache helicopters while deferring or canceling funding of other Army helicopter modernization programs, such as medical evacuation and cargo helicopters, that the Army believes are important to the performance of its aviation missions. CASI

02

AERODYNAMICS

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

N95-32548# National Renewable Energy Lab., Golden, CO.
WIND TURBINE TRAILING EDGE AERODYNAMIC BRAKES
P. G. MIGLIORE, L. SCOTT MILLER (Wichita State Univ., Wichita, KS.), and GENE A. QUANDT (Quandt, Gene A., Pocatello, ID.) Apr. 1995 10 p Presented at the 25th Annual Conference and Exhibition on Wind Power, Washington, DC, 26-30 Mar. 1995
(Contract(s)/Grant(s): DE-AC36-83CH-10093)
(DE95-004061; NREL/TP-441-7805; CONF-950309-2) Avail: CASI HC A02/MF A01

Five trailing-edge devices were investigated to determine their potential as wind-turbine aerodynamic brakes, and for power modulation and load alleviation. Several promising configurations were

identified. A new device, called the spoiler-flap, appears to be the best alternative. It is a simple device that is effective at all angles of attack. It is not structurally intrusive, and it has the potential for small actuating loads. It is shown that simultaneous achievement of a low lift/drag ratio and high drag is the determinant of device effectiveness, and that these attributes must persist up to an angle of attack of 45 deg. It is also argued that aerodynamic brakes must be designed for a wind speed of at least 45 m/s (100 mph). DOE

N95-32682*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

SOFIA: AFT CAVITIES WIND TUNNEL TEST Final Report

31 Dec. 1994 70 p Prepared in cooperation with Rose Engineering and Research, Inc., Incline Village, NV.
(Contract(s)/Grant(s): PROJ. SOFIA)
(NASA-TM-110673; NAS 1.15:110673) Avail: CASI HC A04/MF A01

This appendix to the final report of SOFIA 2 is a collection of configuration photos of the wind tunnel test and a brief description of each for the Stratospheric Observatory for Infrared Astronomy (SOFIA). CASI

N95-32764*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

SOFIA 2 MODEL TELESCOPE WIND TUNNEL TEST REPORT

PAUL KEAS 12 Jan. 1995 190 p
(Contract(s)/Grant(s): PROJ. SOFIA)
(NASA-TM-110668; SER-PK-001; NAS 1.15:110668) Avail: CASI HC A09/MF A02

This document outlines the tests performed to make aerodynamic force and torque measurements on the SOFIA wind tunnel model telescope. These tests were performed during the SOFIA 2 wind tunnel test in the 14 ft wind tunnel during the months of June through August 1994. The test was designed to measure the dynamic cross elevation moment acting on the SOFIA model telescope due to aerodynamic loading. The measurements were taken with the telescope mounted in an open cavity in the tail section of the SOFIA model 747. The purpose of the test was to obtain an estimate of the full scale aerodynamic disturbance spectrum, by scaling up the wind tunnel results (taking into account differences in sail area, air density, cavity dimension, etc.). An estimate of the full scale cross elevation moment spectrum was needed to help determine the impact this disturbance would have on the telescope positioning system requirements. A model of the telescope structure, made of a light weight composite material, was mounted in the open cavity of the SOFIA wind tunnel model. This model was mounted via a force balance to the cavity bulkhead. Despite efforts to use a 'stiff' balance, and a lightweight model, the balance/telescope system had a very low resonant frequency (37 Hz) compared to the desired measurement bandwidth (1000 Hz). Due to this mechanical resonance of the balance/telescope system, the balance alone could not provide an accurate measure of applied aerodynamic force at the high frequencies desired. A method of measurement was developed that incorporated accelerometers in addition to the balance signal, to calculate the aerodynamic force. Author

A
B
S
T
R
A
C
T
S

02 AERODYNAMICS

N95-32769*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

INVESTIGATION OF WATER DROPLET TRAJECTORIES WITHIN THE NASA ICING RESEARCH TUNNEL

ANDREW REEHORST and MOUNIR IBRAHIM (Cleveland State Univ., OH.) Aug. 1995 11 p Presented at the International Icing Symposium 1995, Montreal, Canada, 18-21 Sep. 1995; sponsored by the American Helicopter Society and SAE (Contract(s)/Grant(s): RTOP 508-68-10) (NASA-TM-107023; E-9828; NAS 1.15:107023) Avail: CASI HC A03/MF A01

Water droplet trajectories within the NASA Lewis Research Center's Icing Research Tunnel (IRT) were studied through computer analysis. Of interest was the influence of the wind tunnel contraction and wind tunnel model blockage on the water droplet trajectories. The computer analysis was carried out with a program package consisting of a three-dimensional potential panel code and a three-dimensional droplet trajectory code. The wind tunnel contraction was found to influence the droplet size distribution and liquid water content distribution across the test section from that at the inlet. The wind tunnel walls were found to have negligible influence upon the impingement of water droplets upon a wing model.

Author

N95-32821*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

DRAG MEASUREMENTS OF AN AXISYMMETRIC NACELLE MOUNTED ON A FLAT PLATE AT SUPERSONIC SPEEDS

JEFFREY D. FLAMM and FLOYD J. WILCOX, JR. Jun. 1995 35 p (Contract(s)/Grant(s): RTOP 505-59-20-01) (NASA-TM-4660; L-17416; NAS 1.15:4660) Avail: CASI HC A03/MF A01

An experimental investigation was conducted to determine the effect of diverter wedge half-angle and nacelle lip height on the drag characteristics of an assembly consisting of a nacelle fore cowl from a typical high-speed civil transport (HSCT) and a diverter mounted on a flat plate. Data were obtained for diverter wedge half-angles of 4.0 deg, 6.0 deg, and 8.0 deg and ratios of the nacelle lip height above a flat plate to the boundary-layer thickness ($h_{\text{sub } n}/\delta$) of approximately 0.87 to 2.45. Limited drag data were also obtained on a complete nacelle/diverter configuration that included fore and aft cowls. Although the nacelle/diverter drag data were not corrected for base pressures or internal flow drag, the data are useful for comparing the relative drag of the configuration tested. The tests were conducted in the Langley Unitary Plan Wind Tunnel at Mach numbers of 1.50, 1.80, 2.10, and 2.40 and Reynolds numbers ranging from 2.00×10^6 to 5.00×10^6 per foot. The results of this investigation showed that the nacelle/diverter drag essentially increased linearly with increasing $h_{\text{sub } n}/\delta$ except near 1.0 where the data showed a nonlinear behavior. This nonlinear behavior was probably caused by the interaction of the shock waves from the nacelle/diverter configuration with the flat-plate boundary layer. At the lowest $h_{\text{sub } n}/\delta$ tested, the diverter wedge half-angle had virtually no effect on the nacelle/diverter drag. However, as $h_{\text{sub } n}/\delta$ increased, the nacelle/diverter drag increased as diverter wedge half-angle increased.

Author

N95-34505# National Aerospace Lab., Tokyo (Japan). **SPECIAL PUBLICATION OF NATIONAL AEROSPACE LABORATORY**

16 Jun. 1994 380 p IN ENGLISH and JAPANESE Presented at the 12th NAL Symposium on Aircraft Computational Aerodynamics, Tokyo, Japan, 14-16 Jun. 1994 (ISSN 0289-260X) (NAL-SP-27) Avail: CASI HC A17/MF A03

The proceedings of the 12th NAL (National Aerospace Laboratory) Symposium on Aircraft Computational Aerodynamics are presented. Technological areas discussed include: computational aerodynamics as a tool for aircraft design, euler code, numerical study on stabilization flame over a flat plate, a variation of the Riemann problem solution and its application to implicit Godunov's

scheme, multigris incompressible NS solver, a flux splitting scheme, hypersonic CFD analysis for aerothermodynamic design of HOPE, numerical solution of inviscid and viscous flows about airfoils by TVD method, solitary wave solution for mixing-layer turbulence, and direct numerical simulation of compressible isotropic turbulence. For individual titles, see N95-34506 through N95-34560.

N95-34520# National Aerospace Lab., Tokyo (Japan).

HYPERSONIC CFD ANALYSIS FOR THE AEROTHERMODYNAMIC DESIGN OF HOPE

YUKIMITSU YAMAMOTO, YASUHIRO WADA, and MINAKO YOSHIOKA (Fujitsu Ltd., Tokyo, Japan.) *In its* Special Publication of National Aerospace Laboratory p 129-134 16 Jun. 1994 Avail: CASI HC A02/MF A03

Numerical study of hypersonic flow around HOPE (H - II Orbiting Plane) is performed, using upwind TVD Navier-Stokes CFD code. Parametric computations are made to investigate the aerodynamic and aerothermodynamic characteristics of HOPE. In our calculations, NWT (Numerical Wind Tunnel) at NAL (National Aerospace Laboratory) is used. NWT is the parallel vector super computer system, which enlarges the applicability and data productivity of CFD in practical aerodynamic design. Numerical results are compared with the experimental data obtained at Calspan's shock tunnel. These works have been done as the joint research of NAL and NASDA.

Author

N95-34521# Tokai Univ., Tokyo (Japan). Dept. of Aerospace.

NUMERICAL SOLUTIONS OF INVISCID AND VISCOUS FLOWS ABOUT AIRFOILS BY TVD METHOD

HAMID REZA KHEIRANDISH, GORO BEPPU, and JIRO NAKAMICHI (National Aerospace Lab., Tokyo, Japan.) *In* National Aerospace Lab., Special Publication of National Aerospace Laboratory p 135-140 16 Jun. 1994 Avail: CASI HC A02/MF A03

The need to properly compute steady and unsteady viscous flows surrounding airfoils at transonic speeds remains an outstanding problem in fluid dynamics. In transonic flow where viscous effects such as shock-boundary interactions and separation are dominant, methods based on the Navier-Stokes equations are needed. Calculations of unsteady transonic flow about oscillating airfoils where flutter, dynamic stall, buffet and moving shock waves on these surfaces change the entire flow fields and aerodynamic characteristics, are still stiff problems that stimulate more work and studies to be done. To simulate these problems correctly a robust computer program is needed. This report shows the works have been done up to now, i.e., developing a computer program and verifying it by applying to steady viscous and inviscid flow calculations and inviscid flow about an oscillating airfoil.

Author

N95-34524# Science Univ. of Tokyo (Japan).

CALCULATION FOR AERODYNAMIC CHARACTERISTICS ON DELTA WING WITH LEADING-EDGE SEPARATED VORTEX EFFECT USING BOUNDARY ELEMENT METHOD

Abstract Only

KATSUHIRO KIKUCHI, AKIHIRO KIKUCHI, and MITSUNORI YANAGIZAWA *In* National Aerospace Lab., Special Publication of National Aerospace Laboratory p 153-158 16 Jun. 1994 In JAPANESE Avail: CASI HC A02/MF A03

In this paper, the method which allows the calculation of the characteristics for flow around a delta wing is described. Flow separations are certain to occur from the leading-edge on highly swept wings at moderate-to-high angles of attack. Since delta wing is considered as slender body, slender body theory is reported. So first, two-dimensional cross sections are generated by slicing three-dimensional model and the position and strength of leading-edge separation vortices is determined using vortex tracking method. In order to include the effect of leading-edge separation vortex a model is proposed. Some aerodynamic coefficients of delta wing are obtained from the present method and comparisons between numerical and experimental results show good agreement.

Author

N95-34525# Tokyo Univ. (Japan). Graduate School.
SIDEWALL-EFFECT OF THE WIND TUNNEL ON THE ESTIMATION OF THE AERODYNAMIC CHARACTERISTICS OF A DELTA WING Abstract Only

KOJI MIYAJI, KOZO FUJII, and KEIICHI KARASHIMA (National Aerospace Lab., Tokyo, Japan.) *In* National Aerospace Lab., Special Publication of National Aerospace Laboratory p 159-164 16 Jun. 1994 *In* JAPANESE
 Avail: CASI HC A02/MF A03

The effect of the sidewall of a wind tunnel on the flow over a delta wing is investigated numerically. The simulated results show the sidewall changes the flowfield remarkably. Boundary layers on the sidewall separate ahead of the wing and forms a horse-shoe vortex and this vortex changes the direction of the main flow and works for increasing the effective leading-edge sweep angle. As a result, aerodynamic characteristics of the delta wing change. Author

N95-34537# Daiko Ltd. (Japan).
PARALLEL COMPUTATION OF TRANSONIC FLOWS ABOUT AN AIRCRAFT CONFIGURATION USING MULTI-BLOCK STRUCTURED GRIDS Abstract Only

RYOZO ITO and SUSUMU TAKANASHI (National Aerospace Lab., Tokyo, Japan.) *In* National Aerospace Lab., Special Publication of National Aerospace Laboratory p 237-242 16 Jun. 1994 *In* JAPANESE
 Avail: CASI HC A02/MF A03

Three dimensional Navier-Stokes computation of transonic flows about ONERA-M5 has been carried out using the NAL's parallel vector computer called 'NWT'. the computational space around ONERA-M5 is decomposed into 14 blocks. The code is parallelized in two methods. The first one is sharing the computation for each block to each PE. The second one is combining the first one and the parallelization in each block. The performance of the parallelization is estimated by measuring the cpu-time for solving the Navier-Stokes equations. Validation of the computational results has also been done. Author

N95-34538# Tokyo Noko Univ. (Japan).
VECTOR-PARALLEL SIMULATIONS OF TRANSONIC WIND TUNNEL FLOWS ABOUT A FULLY CONFIGURED MODEL OF AIRCRAFT Abstract Only

YOKO TAKAKURA and SATORU OGAWA (National Aerospace Lab., Tokyo, Japan.) *In* National Aerospace Lab., Special Publication of National Aerospace Laboratory p 243-248 16 Jun. 1994 *In* JAPANESE
 Avail: CASI HC A02/MF A03

It has been tried continuously to numerically analyze NAL transonic wind-tunnel flows about a fully configured model of aircraft, ONERA-M5, to investigate the reliability of numerical computations; in these trials a multi-domain technique is used to realize the computations of flows about a complicated configuration, and in each domain thin-layer Navier-Stokes equations are solved by the Chakravarthy-Osher TVD scheme. In this time the simple vector-parallel algorithm of this multi-domain technique on NAL's NWT system is presented and simulations have been performed. Consequently the computed pressure, lift and drag coefficients have agreed well with experimental ones. Regarding the parallel performance, the parallel-computing time has been reduced to the computing time on the domain with the largest number of grid points, and communication time between PE's can be negligible. Author

N95-34544# Fujitsu Ltd., Tokyo (Japan).
COMPUTATIONS OF LOW SPEED FLOW ABOUT SPACE-PLANE Abstract Only

KISA MATSUSHIMA and SUSUMU TAKANASHI (National Aerospace Lab., Tokyo, Japan.) *In* National Aerospace Lab., Special Publication of National Aerospace Laboratory p 279-284 16 Jun. 1994 *In* JAPANESE
 Avail: CASI HC A02/MF A03

Parallel computation of flow fields around a space-plane has been conducted on the NWT at the National Aerospace Laboratory,

aiming to apply the compressible Navier-Stokes code we have simulated super/transonic flows to calculate low subsonic flow fields. Computational results show sufficient reliability in terms of predicting aerodynamic forces. Thus, we have come to have a prospect of making the present code a robust flow solver that with modifications can be applied from a low subsonic to a supersonic regime. To realize it, further effort is needed to attain the convergence efficiency of computation and to analyze the mechanism of microscopic flow phenomena. Author

N95-34546# Kyushu Univ., Kasuga (Japan) Dept. of Aeronautics and Astronautics.

NUMERICAL SIMULATIONS OF DYNAMIC STALL PHENOMENA IN LOW SPEED FLOWS Abstract Only

SHIGERU ASO and YUICHI KUMAMOTO *In* National Aerospace Lab., Special Publication of National Aerospace Laboratory p 291-296 16 Jun. 1994 *In* JAPANESE
 Avail: CASI HC A02/MF A03

In order to reveal the flow structure and mechanism of dynamic stall around airfoils, these phenomena have been investigated numerically by solving incompressible Navier-Stokes equations with third-order upwind scheme. In this paper, we have calculated separated flows around oscillating airfoils in pitch by moving mesh system. The airfoil used for calculations is NACA0012 and numerical simulations have conducted under $Re = 1.0 \times 10^{(exp 3)}$ and $3.5 \times 10^{(exp 4)}$. In case of $Re = 1.0 \times 10^{(exp 3)}$, we have investigated the influence of time divisions and densities of grids upon aerodynamic characteristics. Time divisions have few influences upon the tendency of hysteresis of $C_{(sub L)}$, but if the number of grid points increases, vibrations of the curves of $C_{(sub L)}$ at pitching down process become large. Further, comparisons between numerical simulations and experiments with a wind tunnel. Quite significant flow patterns due to dynamic stall are revealed. Author

N95-34547# Kyushu Univ., Kasuga (Japan) Dept. of Aeronautics and Astronautics.

NUMERICAL SIMULATION OF UNSTEADY VISCOUS FLOW AROUND AN AIRFOIL WITH OSCILLATING SPOILER Abstract Only

KOJI ISOGAI and MASAHIRO YOSHIDA (National Aerospace Lab., Tokyo, Japan.) *In* National Aerospace Lab., Special Publication of National Aerospace Laboratory p 297-302 16 Jun. 1994 *In* JAPANESE
 Avail: CASI HC A02/MF A03

Numerical simulations of unsteady viscous flows around an airfoil with oscillating spoiler have been performed using the compressible Navier-Stokes equations. The Yee-Harten Total Variation Diminishing (TVD) scheme and the Baldwin-Lomax algebraic turbulence model are employed. The unsteady pressure distributions on the 16 percent thick supercritical airfoil with oscillating spoiler in low subsonic and transonic Mach numbers have been calculated, being compared with the existing experimental data. Author

N95-34548# Ship Research Inst., Tokyo (Japan).
NUMERICAL SIMULATION OF TWO-DIMENSIONAL PAR-WIG Abstract Only

NOBUYUKI HIRATA *In* National Aerospace Lab., Special Publication of National Aerospace Laboratory p 303-308 16 Jun. 1994 *In* JAPANESE
 Avail: CASI HC A02/MF A03

In the recent trend of super high-speed ships, a PAR-WIG has been paid attention to again. A Power Augmented Ram Wing In Ground effect (= PAR-WIG) is a wing in ground effect, whose lift is enhanced by using the airflow of a thruster, which is placed in the upstream of the wing, so as to create a high ram pressure region under the wing. The PAR effect enables this vehicle to take off and land on at lower speed and supplies that structural weight and engine power can be reduced compared with the conventional WIGs. To understand the aerodynamic characteristics of a PAR-WIG, a two-dimensional NS solver for incompressible flow is developed. The solver is based on a finite-volume method whose

02 AERODYNAMICS

algorithm is a fractional step method. Through the solver, relations among strength of thrust, high ram pressure region under the wing and aerodynamic forces are considered. Author

N95-34552# Science Univ. of Tokyo (Japan).
GRID GENERATION AROUND AIRFOIL WITH A FLAP USING BOUNDARY ELEMENT METHOD Abstract Only
MASAMICHI IWASA and MITSUNORI YANAGIZAWA *In* National Aerospace Lab., Special Publication of National Aerospace Laboratory p 327-332 16 Jun. 1994 *In* JAPANESE
Avail: CASI HC A02/MF A03

In many cases, it is very difficult to generate uni-grid around complicated configurations. It has been used that the method for generation of the grid by simulating electric line of force and equipotential surface. But it is difficult to apply to dents in a body. This paper describes a method for generating uni-grid around a airfoil with a flap, having a exceeding dent, by simulating electric line of force and equipotential surface using boundary element method. The grid is mainly generated by dividing panels of wing into rather small panels. Author

N95-34750# Naval Postgraduate School, Monterey, CA.
AN LDV INVESTIGATION OF SUPPORT STRUCTURE INFLUENCE ON THE FLOW FIELD NEAR THE WINGTIP OF A STOVL CONFIGURATION IN HOVER M.S. Thesis
EDGAR R. ENOCHS Sep. 1994 134 p
(AD-A294126) Avail: CASI HC A07/MF A02

Acquisition phase zero (Concept Exploration) of the Advanced Short Takeoff/ Vertical Land (ASTOYL) aircraft development includes, among other tests, evaluation of forces and moments on a large-scale powered model (LSPM) suspended in the Outdoor Aerodynamic Research Facility (OARF) at the NASA Ames Research Center. This investigation assessed the influence of the OARF support structure upon the flow field through LDV measurements in the vicinity of the struts and the wingtip of a generic flat-plate model mounted in the sub-scale NPS ground effects test rig. The model was a twin subcritical jet configuration with the nozzles arranged in tandem. The test environment was saturation seeded using a smoke generator and LDV measurements were made in the entrained flow. Non-coincident measurements were made to determine the three component mean velocities at points in the region of interest and the component mean and composite mean velocities compared for configurations with struts present and struts removed. Variations were discernible in the component mean velocities between samples both in the same strut configuration and between the struts-installed and struts-removed configurations, but were generally small enough to be considered negligible. DTIC

N95-34763# Brown Univ., Providence, RI. Div. of Applied Mathematics.
HIGHER ORDER ACCURACY COMPUTATIONAL METHODS IN AERODYNAMICS USING PARALLEL ARCHITECTURES
Final Technical Report, Jan. 1993 - Jan. 1995
DAVID GOTTLIEB, C. W. SHU, P. FISCHER, and W. S. DON 24 Mar. 1995 29 p
(Contract(s)/Grant(s): F49620-93-1-0090)
(AD-A294167; AFOSR-95-0344TR) Avail: CASI HC A03/MF A01

In this research we presented the development and application of spectral shock capturing techniques as well as ENO finite difference and finite element methods for realistic problems. For genuinely time dependent problems, special care had to be taken in order to preserve accuracy. Small errors that do not show up in steady state calculations can be amplified and ruin the total accuracy. Time dependent boundary conditions may also pose problems. We addressed those issues in our research efforts. The recent advent of parallel computers poses a special challenge to the users of high-order methods. Issues in parallel computing for the simulations of incompressible and compressible flows has been treated. DTIC

03

AIR TRANSPORTATION AND SAFETY

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

N95-32486# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Mission Systems Panel.
LOW-LEVEL AND NAP-OF-THE-EARTH (NOE) NIGHT OPERATIONS [OPERATION DE NUIT A BASSE ALTITUDE ET EN RASE MOTTES]
Jan. 1995 204 p Presented at the Mission Systems Panel Symposium, Rome, Italy, 25-27 Oct. 1994
(AGARD-CP-563; ISBN-92-836-0009-6) Copyright Avail: CASI HC A10/MF A03

Tactical rotary wing and low-level, fixed wing aircraft operating in high threat areas require improvements in night and adverse weather conditions in order to increase survivability, improve operational performance, and reduce pilot workload. Recent developments and the results of on-going programs suggest that increased automation and optimized integration of sensors, guidance/navigation, control and display systems, and weapons provide approaches to greatly enhanced capability in night operation. The purpose of this symposium is to support the evolutions and envelopment of alternative core structures which will lead to the fielding of effective low-level and N.O.E. night operations systems for fixed and rotary wing aircraft. For individual titles, see N95-32487 through N95-32505.

N95-32488# Fabbrica Italiana Apparecchiature Radioelettriche S.p.A., Milan (Italy).
AN APPROACH TO SENSOR DATA FUSION FOR FLYING AND LANDING AID PURPOSE
G. BALZAROTTI, L. FIORI, B. MIDOLLINI, and G. VIGLIALORO *In* AGARD, Low-Level and Nap-of-the-Earth (NOE) Night Operations 8 p Jan. 1995
Copyright Avail: CASI HC A02/MF A03

Modern aircraft, operating in hostile environments, at night and in adverse weather conditions, are usually equipped with a number of sensors, both active and passive, which separately provide the pilot with data and images and represent a substantial aid during the mission. Novel techniques are currently under development to further improve the effectiveness of the mission by integrating and interpreting the produced data before making them available to the pilot. This paper analyzes the data fusion following a growing integration level criteria. The levels in the integration flow where the fusion is effectively applicable are investigated starting from raw signal (lowest level) up to processed data from sensors, even located on different sites (highest level). Schematically the integration levels considered in the paper will be the following: (1) sensor/pre-processing; (2) processing; (3) display; (4) operative modes; and (5) multiple platforms. Derived from text

N95-32499# Eltro G.m.b.H., Heidelberg (Germany).
LASER BASED OBSTACLE WARNING SENSORS FOR HELICOPTERS
W. BUECHTEMANN and M. EIBERT (Dornier Luftfahrt G.m.b.H., Friedrichshafen, Germany.) *In* AGARD, Low-Level and Nap-of-the-Earth (NOE) Night Operations 8 p Jan. 1995
Copyright Avail: CASI HC A02/MF A03

Helicopters and aircraft in low-level flight have a high risk to strike obstacles, in particular power lines and overhead wires down to the size of telephone wires. This risk increases when flying nap-of-the-earth (N.O.E.), at night and under poor visibility conditions. Existing night vision equipment cannot provide safe detection of these dangerous obstacles. For these reasons there has been, for quite some time, a widely accepted need for reliable means of detecting obstacles, particularly under all acceptable Low-Level and

N.O.E. flying conditions. Solutions to this problem, proposed and developed in the past, have been mainly based on millimeter wave technology. More recently, laser based system are being developed which offer good capabilities to solve this task without many of the shortcomings of the radar systems. The laser radar solution, on the other hand, has to prove its adequacy under limited visibility conditions. This paper presents laser radar developments in the thermal infrared (10 micron region) and near infrared spectral regions for helicopter obstacle warning systems. Both Dornier and Eltro have designed, built and demonstrated laser radar sensors for obstacle warning. Eltro has designed and built an experimental laser radar based on CO₂-lasers and heterodyne detection. Ranges in excess of 600 m against railway overhead wires and 1100 m against extended targets have been achieved. Dornier has designed, built and flight demonstrated a GaAs laser obstacle warning sensor operating at 0.9 micron. Merits and limitations of these technologies are being discussed. Derived from text

N95-32500# Army Night Vision Lab., Fort Belvoir, VA.
DEVELOPMENT AND FLIGHT TESTING OF AN OBSTACLE AVOIDANCE SYSTEM FOR US ARMY HELICOPTERS
 SANDRA L. HOLDER and ROBERT G. BRANIGAN *In* AGARD, Low-Level and Nap-of-the-Earth (NOE) Night Operations 10 p Jan. 1995

Copyright Avail: CASI HC A02/MF A03

Today's Army Aviator must fly both low and fast in order to survive against modern anti-aircraft weapons. Such flight brings him perilously close to wires, poles, trees and other obstacles. Helicopter collisions with such obstacles have been a long-standing concern for the United States Army. In order to address this issue, the Night Vision and Electronic Sensors Directorate (NVESD) has sponsored the development of an Obstacle Avoidance System (OASYS) capable of being integrated onto an aircraft and operated in real time. Under this program, two different systems have been fabricated and delivered. Both systems utilize direct detection laser radar sensors which operate in the eyesafe regime. The two systems differ primarily in the type of laser source used. The first system, developed by Northrop Corporation, utilizes a diode laser operating at 850 nm with an average repetition rate of 64 kHz. The second system, developed by Fibertek Inc., utilizes a diode-pumped solid-state laser operating at 1.54 microns with a repetition rate of 15 kHz. Both systems have been integrated onto helicopters and extensive flight evaluations have been completed. A number of important lessons have been learned regarding the individual technologies involved and obstacle avoidance as a whole. Both systems have been demonstrated to enhance mission effectiveness and flight safety. Furthermore, the technologies have been shown to be mature enough to justify proceeding to an Engineering and Manufacturing Development (EMD) phase in which issues relating to cost, volume and weight are addressed. Derived from text

N95-32705# General Accounting Office, Washington, DC. Accounting and Information Management Div.
REPORT TO THE CHAIRMAN, SUBCOMMITTEE ON AVIATION, COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION, US SENATE. AVIATION SAFETY: DATA PROBLEMS THREATEN FAA STRIDES ON SAFETY ANALYSIS SYSTEM

8 Feb. 1995 31 p

(GAO/AIMD-95-27; B-259097) Avail: CASI HC A03/MF A01; GAO, PO Box 6015, Gaithersburg, MD 20877 HC

Catastrophic aviation events, such as the recent airline crashes, have placed renewed attention on the Federal Aviation Administration's (FAA) oversight of the aviation community's compliance with safety regulations. To meet this challenge, FAA relies on a group of highly professional and committed aviation inspection and certification personnel. However, this group faces an enormous task: overseeing hundreds of domestic airlines and thousands of aircraft and personnel, not to mention the multitudes of other aviation community participants, such as flight training schools. To assist in this endeavor, FAA is acquiring an automated decision

support tool, called the Safety Performance Analysis System (SPAS). This system is intended to assist FAA in focusing its limited inspection and certification resources. Because of GAO's long-standing interest in helping FAA improve its inspection and certification programs, GAO reviewed FAA's development and deployment of SPAS to determine (1) whether FAA is effectively managing the acquisition of SPAS, including its data communication network, and (2) the extent to which SPAS will rely on Aviation Safety Analysis System databases and whether FAA is effectively addressing known data quality problems with the databases. Derived from text

N95-32784# General Accounting Office, Washington, DC. Resources, Community, and Economic Development Div.

REPORT TO THE CHAIRMAN, SUBCOMMITTEE ON AVIATION, COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION, US SENATE. AVIATION SAFETY: FAA CAN BETTER PREPARE GENERAL AVIATION PILOTS FOR MOUNTAIN FLYING RISKS

9 Dec. 1993 67 p

(GAO/RCED-94-15; B-254704) Avail: CASI HC A04/MF A01; GAO, PO Box 6015, Gaithersburg, MD 20877 HC

The FAA's oversight of general aviation safety in mountainous areas is examined. Specifically, the GAO was asked to identify (1) the extent to which mountainous areas present higher risks than nonmountainous areas for general aviation and (2) the actions that FAA is taking and should take to reduce the risks associated with mountain flying and the impact of those actions on general aviation. In addition, GAO was asked to examine the legal and safety issues involved with the prohibition imposed by Pitkin County, Colorado, on general aviation night operations at Aspen Airport. In analyzing National Transportation Safety Board (NTSB) data, GAO found that the general aviation accident rate was (1) nearly 40 percent higher for western states designated by FAA as mountainous than the rate for all other continental states in fiscal year 1992 and (2) 155 percent higher for a group of selected mountain airports than for a group of nonmountain airports with similar levels of flight operations between fiscal years 1983 and 1992. FAA alerts general aviation pilots about the hazards of flying in mountainous areas during the pilot certification process and at subsequent safety seminars. Many of the suggested actions that the FAA could take to more effectively promote mountain flying safety, such as issuing guidance that identifies special mountain airports with difficult operating conditions and recommends routes for takeoffs and landings at those airports, would impose little financial burden on the general aviation industry. Analysis indicates that night operations under visual flight rules at Aspen Airport would be hazardous, in contradiction to the conclusions of the FAA's 1992 study. CASI

N95-32885# General Accounting Office, Washington, DC. Resources, Community, and Economic Development Div.

AVIATION SECURITY: DEVELOPMENT OF NEW SECURITY TECHNOLOGY HAS NOT MET EXPECTATIONS. REPORT TO CONGRESSIONAL REQUESTERS

19 May 1994 59 p

(GAO/RCED-94-142; B-256584) Avail: CASI HC A04/MF A01; GAO, PO Box 6015, Gaithersburg, MD 20877 HC

This report examines the Federal Aviation Administration's (FAA) efforts to develop new equipment for detecting explosives and methods to improve aircraft survivability as mandated by the Aviation Security Improvement Act of 1990. Recommendations are made to ensure that (1) FAA's process for approving new explosive detection equipment can provide the aviation community and the flying public with effective and reliable technology and (2) FAA's research efforts are properly managed to meet the threats to aviation. FAA has made little progress towards meeting the act's goal for deploying new explosive detection systems. Although several devices show promise, technical problems are slowing the development and approval of the devices. Similarly, FAA's efforts to enhance aircraft survivability are promising but are several years from completion. In addition, FAA does not plan to test new explosive detection systems at airports during the certification process.

03 AIR TRANSPORTATION AND SAFETY

Other identified weaknesses in FAA's security research program are that FAA does not (1) conduct software reviews to evaluate system designs, (2) emphasize integrating different technologies into total systems, or (3) focus sufficient attention on human factors' issues. Purchasing the new security equipment will also place demands on the airlines throughout the next decade. However, FAA lacks a strategy to guide its and the airlines' efforts to implement this equipment. Several issues are identified that need to be resolved before Airport Improvement Program funds can be used for such purposes. CASI

N95-34766*# Nottingham Univ. (England).

A ROSE BY ANY OTHER NAME: CERTIFICATION SEEN AS PROCESS RATHER THAN CONTENT

JOHN R. WILSON *In* Embry-Riddle Aeronautical Univ., Daytona Beach, FL, Human Factors Certification of Advanced Aviation Technologies p 26-34 1994

Avail: CASI HC A02/MF A04

Green (1990) believes that the two main factors safeguarding flying from human error are both related to certification and regulation. First is the increasingly proceduralized nature of flying whereby as much as possible is reduced to a rule-based activity. Second is the emphasis placed upon training and competency checking of aircrew in simulators and in the air, both generally and for all particular types of aircraft flown. This leaves, believes Green, other human factors that are relatively unaddressed as yet and which can give rise to human reliability problems. These include: hardware factors and especially pilot/co-pilot relationships; and system factors including fatigue and cost/safety trade-offs. He also, importantly, identifies problems with the integration of the 'electronic crew member' following increased automation. Human reliability failures with artificial intelligence and automation, due to over-reliance on the system fail-safe mechanisms, or to operator under-confidence in the integrity or self-regulating capacity of the system, or to out-of-loop effects, are widely accepted as being due to deficiencies in plant design, planning, management and maintenance more than to 'operator error' - Reason's (1990) latent error or organization pathogens argument. Reliability failures in complex systems are well enough documented to give cause for concern and at least promote a debate on the merits of a full certification program. The purpose of this short paper is to seek out and explore what is valuable in certification, at the least to show that the benefits outweigh the disadvantages and at best to identify positive outcomes perhaps not obtainable in other ways. On both sides of the debate on certification there is general agreement on the need for a better human factors perspective and effort in complex aviation systems design. What is at issue is how this is to be promoted. It is incumbent upon opponents of certification to say how else such promotion be enabled. This is an exploratory and philosophical review, not a focused and specific one, and it will draw upon much that is not firmly in the domain of complex aviation systems. Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

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

N95-32490*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

FLIGHT TEST OF A LOW-ALTITUDE HELICOPTER GUIDANCE SYSTEM WITH OBSTACLE AVOIDANCE CAPABILITY

RICHARD E. ZELENKA, RAYMOND F. CLARK (Army Command/Control and Systems Integration Directorate, Fort Monmouth, NJ.), and ROBERT G. BRANIGAN (Army Night Vision Lab., Fort Belvoir, VA.) *In* AGARD, Low-Level and Nap-of-the-Earth (NOE) Night Operations 10 p Jan. 1995

Copyright Avail: CASI HC A02/MF A03

Military aircraft regularly conduct missions that include low-altitude, near-terrain flight in order to increase covertness and payload effectiveness. Civilian applications include airborne fire fighting, police surveillance, search and rescue, and helicopter emergency medical service. Several fixed-wing aircraft now employ terrain elevation maps and forward-pointed radars to achieve automated terrain following or terrain avoidance flight. Similar systems specialized to helicopters and their flight regime have not received as much attention. A helicopter guidance system relying on digitized terrain elevation maps has been developed that employs airborne navigation, mission requirements, aircraft performance limits, and radar altimeter returns to generate a valley-seeking, low-altitude trajectory between waypoints. The guidance trajectory is symbolically presented to the pilot on a helmet mounted display. This system has been flight tested to 150 ft (45.7 m) above ground level altitude at 80 kts, and is primarily limited by the ability of the pilot to perform manual detection and avoidance of unmapped hazards. In this study, a wide field of view laser radar sensor has been incorporated into this guidance system to assist the pilot in obstacle detection and avoidance, while expanding the system's operational flight envelope. The results from early flight tests of this system are presented. Low-altitude missions to 100 ft (30.5 m) altitude at 80n kts in the presence of unmapped natural and man-made obstacles were demonstrated while the pilot maintained situational awareness and tracking of the guidance trajectory. Further reductions in altitude are expected with continued flight testing. Derived from text

N95-33131# Central Research and Development Inst. Elektropribor, Saint Petersburg (Russia).

NAVIGATIONAL TECHNOLOGY OF DUAL USAGE

V. G. PESHEKHONOV, I. M. OKON, L. P. NESENYUK, and YU. P. BELOUS *In* AGARD, Dual Usage in Military and Commercial Technology in Guidance and Control 6 p Mar. 1995

Copyright Avail: CASI HC A02/MF A02

Under the new conditions of defense production conversion and basing on high technologies that were developed for the production of military navigation technology the Central R&D Institute 'Elektropribor' has been developing and starts manufacturing products for civil application. Part of the project is dual usage technology. Three trends of the research are considered in this paper: (1) a gimbaled-type inertial system used to inspect railway tracks and in inertial geodesy; (2) gyro-stabilized gravity meter for geological prospecting of oil and gas from ships and planes; and (3) shipborne integrated chartgraphic navigation-controlling system. Derived from text

N95-33134# Technische Univ., Brunswick (Germany). Inst. fuer Flugfuehrung.

EFFECTS OF THE SPECIFIC MILITARY ASPECTS OF SATELLITE NAVIGATION ON THE CIVIL USE OF GPS/GLONASS

DETLEF KAYSER and GUNTHER SCHAEZNER *In* AGARD, Dual Usage in Military and Commercial Technology in Guidance and Control 10 p Mar. 1995

Copyright Avail: CASI HC A02/MF A02

Satellite Navigation is one of today's most promising and prospering infrastructure technologies. The performance improvement of this technology in comparison to the 'conventional' terrestrial navigation systems can be seen in almost every aspect, e.g.: (1) accuracy (decimeter level); (2) coverage (worldwide); (3) availability (21 hrs); (4) dimension (4 dimensional navigation (space and time)); and (5) system capacity (unlimited number of users). This led to a widespread application of satellite navigation and an according fast growing figure of satellite navigation equipment in the civil market. Up to now however, the final breakthrough in a lot of commercial applications, like in the aviation industry and in the maritime business, has not been reached. Beside some still unsolved technical aspects, like the integrity problem, the fact that GPS and GLONASS are military systems is one of the main hurdles. This institutional

aspect, however, is not only an obstacle from the political point of view, but the military background of GPS/GLONASS led to lot of design features of the system, that have a strong influence on the use of the system in civil applications. This paper will describe details on the different areas in which the military design limits the use of the system.
Derived from text

N95-33135# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Brunswick (Germany). Inst. of Flight Guidance.

THE DLR RESEARCH PROGRAMME ON AN INTEGRATED MULTI SENSOR SYSTEM FOR SURFACE MOVEMENT GUIDANCE AND CONTROL

KURT KLEIN *In* AGARD, Dual Usage in Military and Commercial Technology in Guidance and Control 8 p Mar. 1995
Copyright Avail: CASI HC A02/MF A02

Based on the long-term experience in the field of Navigation and Air Traffic Control the Institute of Flight Guidance within the German Aerospace Research Establishment (DLR) is conducting a major effort to develop new solutions, system components and procedures for an integrated Surface Movement Guidance and Control System (SMGCS). In addition to and derived from the work on operational procedures, planning tools and HMI in our institute we are focusing our work on an integrated sensor concept to meet the requirements. SMGCS is to be regarded as an integrated concept that has a clearly defined modular approach to meet the particular requirements of a specific aerodrome. After outlining the conception several years ago a solution for the realization was evaluated in close co-operation with the DFS and the national industry. The objective of DLR research is: (1) to analyze the characteristics and to optimize as far as necessary the sensor candidates (e.g. DGPS, SSR Mode S Multilateration); (2) to evaluate the sensor information integration including data fusion algorithms; (3) to find solutions for the specific SMGCS data exchange problems via RF link; (4) to optimize the whole system loop in order to avoid interference by implementing modules into the system; and (5) to solve airfield operating problems by finding new functions within the SMGCS sensor domain. Although the main goal is the improvement of civil airport traffic, the work meets as well military operation problems. In addition, a lot of knowledge gained in military applications has to be considered. The research activities are funded by the DLR itself. To extend the theoretical and laboratory work to more realistic analysis an Experimental SMGCS is build up at the Braunschweig airport. This ESMGCS has the advantage of being very flexible with respect to the implementation of various subsystems and to tests in a real environment. Braunschweig airport is very suitable for experiments like this due to low traffic density and the available research infrastructure. Part of the ESMGCS will be a test environment that is based on the experiences gained during the MLS competition as well as during the development of the Avionics Flight Test System. Main part of the test environment is a measurement system for computing a reference situation assessment. The backbone of the ESMGCS is a high speed data network on fiber cable basis that connects the peripheral stations around the airfield to the master station. Different sensor subsystems or parts of these will be installed in the peripheral stations. The data fusion and the situation analysis are software processes within the master station. The derived situation information can be handed over to planning tools and to the tower simulator available in the DLR Institute of Flight Guidance.
Derived from text

N95-33136# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Etudes et de Recherche en Optique.

LOW-LEVEL DATA FUSION FOR LANDING RUNWAYS DETECTION

LAURE SLIWA and XAVIER BRIOTTET *In* AGARD, Dual Usage in Military and Commercial Technology in Guidance and Control 11 p Mar. 1995
Copyright Avail: CASI HC A03/MF A02

Data fusion brings reliability and robustness to both military and commercial systems. Data fusion allows in fact to fully apprehend a situation by using multisensors data redundancy and/or

complementarity. The presented piece of work particularly concerns fusion of redundant data just outcoming from electro-optical sensors. The used methods are low-level fusion techniques, only preceded by a calibration step. These fusion techniques take into account the radiometric- and not geometric-data content. This paper is divided in two parts: the theoretical approach, and the guidance application of detecting a potential runway. The theoretical approach, according to the proposed goal, raises two problems. The one of suiting the multisensors' configuration to the mission. And the one of evaluating data at every step from ground reality to fusion. It appears necessary to define quality criteria to evaluate every sensor acquisition within the mission scope. The optimization of these criteria defines the weighted combination at the pixel level of the multispectral images. A priori knowledge of road materials spectral signatures and definition of appropriate quality criteria are necessary to detect roads or runways by pixel fusion. They allow to define the appropriate configuration of spectral bands to merge so that the runway shows up clearly. This paper presents the obtained results from low-level fusion of five broad bands (approximately 100 nm wide). The main advantage of pixel fusion is the saving of processing time. On one hand, the multispectral data process is quick. On the other hand, the landing runway can be detected at long range, in a large field of view.
Derived from text

N95-33140# Lockheed-Fort Worth Co., Fort Worth, TX.
APPLICATION OF ADVANCED SAFETY TECHNIQUE TO RING LASER GYRO INERTIAL NAVIGATION SYSTEM INTEGRATION

JAMES BLAYLOCK, DONALD SWIHART (Wright Lab., Wright-Patterson AFB, OH.), and CHUCK STRIBULA (Aeronautical Systems Div., Wright-Patterson AFB, OH.) *In* AGARD, Dual Usage in Military and Commercial Technology in Guidance and Control 10 p Mar. 1995

Copyright Avail: CASI HC A02/MF A02

This paper documents the application of System-Wide Integrity Management (SWIM) to the integration of H-423 and LN-93 ring laser gyro (RLG) inertial navigation system (INS) units with the F-16 terrain following (TF) system. Safety modeling and mishap rate predictions are presented for F-16 TF with an RLG INS. This paper establishes that the H-423 and LN-93 RLG INS units are both safer for F-16 TF than the predecessor LN-39 gimbaled, mechanical-gyro INS. The RLG INS design enhancements described are primarily built-in test (BIT) modifications that were developed as a result of the in-depth SWIM critical signal path analysis. These enhancements are low-cost design improvements to the RLG INS units because they were discovered prior to the manufacturer's final operational flight program (OFP) for the production units. This paper discusses dual-use applications of the RLG INS to other military and civilian functions, with design enhancements resulting from the SWIM process. Other military applications include not only specialized control modes such as TF, but also all other phases of the military flight operations regime, since the INS is always active to provide current aircraft state information. Civilian uses can also benefit from the SWIM process improvement to the RLG INS because accurate, reliable, safe navigation with critical timing along congested air routes, in weather, and in dense traffic terminal areas is of paramount importance for passenger safety.
Derived from text

N95-33480# Massachusetts Inst. of Tech., Lexington, MA. Lincoln Lab.

GPS-SQUITTER INTERFERENCE ANALYSIS

VINCENT A. ORLANDO and WILLIAM H. HARMAN, III 6 Apr. 1995 42 p

(Contract(s)/Grant(s): DTFA01-93-Z-02012; F19628-95-C-0002) (AD-A293690; ATC-229) Avail: CASI HC A03/MF A01

GPS-Squitter is a system concept that merges the capabilities of Automatic Dependent Surveillance (ADS) and the Mode S beacon radar. The result is an integrated concept for seamless surveillance and data link that permits equipped aircraft to participate in ADS and/or beacon ground environments, offering many possibilities for transition from a beacon to an ADS-based environment. Since GPS-

04 AIRCRAFT COMMUNICATIONS AND NAVIGATION

Squitter and its associated data link share the 1030/1090-MHz beacon frequencies with other users (e.g., ground beacon radars and TCAS), there is some level of interaction between the operation of these various systems. One form of interaction is the effect on GPS-Squitter operation caused by the activities of other users. This effect, plus the effect of self-interference of GPS-Squitter Operation, determines the operational capacity of GPS-Squitter. The complementary process is the effect of the GPS-Squitter operation on the other users of the beacon frequencies. This report provides an analysis of the interference to other users of the 1030/1090-MHz beacon frequencies caused by GPS-Squitter operation. The principal interference effect is channel occupancy on the beacon frequencies that prevents the reception of a desired signal by a receiver. The basis for the analysis is to estimate the channel occupancy on the beacon frequencies and its effect on the operation of victim receivers on those frequencies. The analysis is performed separately for the two frequencies. The analysis of 1030-MHz interference estimates the effect of the 1030-MHz data link activity that may be associated with GPS-Squitter (such as differential correction broadcast and two-way data link) on the operation of a transponder receiver. The 1090-MHz analysis estimates similar interference effects on: (1) a terminal or en route sensor receiver, and (2) a TCAS receiver. DTIC

N95-34562# Massachusetts Inst. of Tech., Cambridge, MA. Aeronautical Systems Lab.

CURRENT ISSUES IN THE DESIGN AND INFORMATION CONTENT OF INSTRUMENT APPROACH CHARTS Final Report, period ending Nov. 1990

R. J. HANSMAN, JR. and MARK MYKITYSHYN Mar. 1995 74 p (Contract(s)/Grant(s): DTRS57-88-C-00078) (AD-A294752; DOT/FAA/AAR-95/1) Avail: CASI HC A04/MF A01

This report documents an analysis and interview effort conducted to identify common operational errors made using current Instrument Approach Plates (IAP), Standard Terminal Arrival Route (STAR) charts, Standard Instrument Departure (SID) charts, and the preferences of pilots regarding current chart format designs. In addition, pilot preferences or comments relevant to the presentation of IAP information in advanced electronic format were solicited and noted. The analysis included data from prior studies and a variety of accident, incident, and operational error databases. Representatives from flight operation user groups and charting organizations were interviewed to gain insight into operational errors, pilot preferences and the factors which influence chart design. The IAP user groups interviewed consisted primarily of training centers and individuals representing the full spectrum of IAP users (General Aviation, Corporate Aviation, Air Taxi Part 135 Operators, and Air Carrier Part 121 Operators). Cartographic organizations interviewed included Jeppesen Sanderson Inc., NOAA and the FAA. For comparison, a non-US based Carrier and chart provider (KLM) was queried by mail. DTIC

N95-34570# Air Force Inst. of Tech., Wright-Patterson AFB, OH. **THE EFFECTS OF DISPLAY LOCATION AND DIMENSIONALITY ON TAXIWAY NAVIGATION M.S. Thesis** JAMES W. LASSWELL 1995 83 p (AD-A294878; AFIT/CI-95-028) Avail: CASI HC A05/MF A01

This study investigated whether taxiway navigation is best supported by head-up or head-down presentation of either perspective (3-D conformal) or plan-view (2-D nonconformal) route guidance information. Thirty-two pilots taxied in low visibility conditions (300' RVR) in a high-fidelity simulator. Pilots were instructed to maximize speed while maintaining safe control of the aircraft as they taxied along a specified route. Pilots were randomly assigned to either the 2D or 3D display condition. Each subject completed half of the trials with the display in the head-up position, and half with the display in the head-down position. Expected events were presented in both near and far domains, while an unexpected event was presented in the far domain. Results revealed that, while pilots in both groups followed the cleared route with equal success, greater mean taxi speeds were supported by the 2D display, but lateral tracking error

showed a slight advantage for the 3D display. A significant number of pilots using the 2D display failed to detect and respond to the unexpected far domain event (ground traffic), resulting in six collisions. The practical and theoretical implications of these results are discussed. DTIC

N95-34770*# Civil Aviation Authority, Farnborough (England). **HUMAN FACTORS CERTIFICATION IN THE DEVELOPMENT OF FUTURE AIR TRAFFIC CONTROL SYSTEMS** ALYSON E. EVANS *In its* Human Factors Certification of Advanced Aviation Technologies p 87-96 1994 Avail: CASI HC A02/MF A04

If human factors certification of aviation technologies aims to encompass the wide range of issues which need to be addressed for any new system, then human factors involvement must be present throughout the whole design process in a manner which relates to final certification. A certification process cannot simply be applied to the final product of design. Standards and guidelines will be required by designers at the outset of design for reference in preparing for certification. The most effective use of human factors principles, methods, and measures is made as part of an iterative design process, leading to a system which reflects these as far as possible. This particularly applies where the technology is complex and may be represented by a number of components or sub-systems. Some aspects of the system are best certified during early prototyping, when there is still scope to make changes to software or hardware. At this stage in design, financial and/or time pressures will not rule out the possibility of necessary changes, as may be the case later. Other aspects of the system will be best certified during the final phases of design when the system is in a more complete form and in a realistic environment. Author

N95-34771*# Royal Air Force Inst. of Aviation Medicine, Farnborough (England).

QUALITY ASSURANCE AND RISK MANAGEMENT: PERSPECTIVES ON HUMAN FACTORS CERTIFICATION OF ADVANCED AVIATION SYSTEMS

ROBERT M. TAYLOR and IAIN S. MACLEOD (Aerosystems International, Yeovil, England.) *In* Embry-Riddle Aeronautical Univ., Daytona Beach, FL, Human Factors Certification of Advanced Aviation Technologies p 97-118 1994 Avail: CASI HC A03/MF A04

This paper is based on the experience of engineering psychologists advising the U.K. Ministry of Defense (MoD) on the procurement of advanced aviation systems that conform to good human engineering (HE) practice. Traditional approaches to HE in systems procurement focus on the physical nature of the human-machine interface. Advanced aviation systems present increasingly complex design requirements for human functional integration, information processing, and cognitive task performance effectiveness. These developing requirements present new challenges for HE quality assurance (QA) and risk management, requiring focus on design processes as well as on design content or product. A new approach to the application of HE, recently adopted by NATO, provides more systematic ordering and control of HE processes and activities to meet the challenges of advanced aircrew systems design. This systematic approach to HE has been applied by MoD to the procurement of mission systems for the Royal Navy Merlin helicopter. In MoD procurement, certification is a judicial function, essentially independent of the service customer and industry contractor. Certification decisions are based on advice from MoD's appointed Acceptance Agency. Test and evaluation (T&E) conducted by the contractor and by the Acceptance Agency provide evidence for certification. Certification identifies limitations of systems upon release to the service. Evidence of compliance with HE standards traditionally forms the main basis of HE certification and significant non-compliance could restrict release. The systems HE approach shows concern for the quality of processes as well as for the content of the product. Human factors certification should be concerned with the quality of HE processes as well as products. Certification should require proof of process as well as proof of content and performance.

QA criteria such as completeness, consistency, timeliness, and compatibility provide generic guidelines for progressive acceptance and certification of HE processes. Threats to the validity of certification arise from problems and assumptions in T&E methods. T&E should seek to reduce the risk of specification non-compliance and certification failure. Author

N95-34797# Battelle Memorial Inst., Columbus, OH.
**RESOURCE DOCUMENT FOR THE DESIGN OF
 ELECTRONIC INSTRUMENT APPROACH PROCEDURE
 DISPLAYS Final Report, Jul. 1993 - Dec. 1994**

MELANIE C. WRIGHT and TODD BARLOW Mar. 1995 238 p
 Sponsored by FAA
 (AD-A295108; DOT-VNTSC-FAA-95-9; DOT/FAA/RD-95/2) Avail:
 CASI HC A11/MF A03

Instrument approach procedure (ZAP) charts play a large role in contributing to the success or failure of approaches and landings. Paper ZAP charts have been criticized for excessive clutter, for text sizes that are too small to read, and for inadequate terrain representation. The electronic presentation of approach information may counteract these criticisms by providing automatic or pilot controlled filtering of the information displayed. However, without careful attention to human factors issues early in the design and development of electronic ZAPs (EZAP's), new problems may result. The goal of this project was to develop preliminary guidelines for designers and certifiers of EZAP's to assure that EZAP's help rather than hinder pilots during approach and Landing. To identify potential human factors problems in the design of EZAP's, current paper ZAP charts and the instrument approach task were studied. Pilots were interviewed and literature describing the information requirements of the task and the cognitive implications of the task were reviewed. A cognitive task analysis was performed. Specific features and functions were identified that may be beneficial to an EZAP. Literature was reviewed in the areas of cognitive psychology, human-computer interaction, and aviation to identify design concepts and principles for the design of these features and functions. Guidelines were developed from the design concepts and principles and, finally, prototypes of EZAP's were designed in accordance with the new guidelines. DTIC

N95-32699*# National Aeronautics and Space Administration.
 Ames Research Center, Moffett Field, CA.

**FULL-SCALE HINGELESS ROTOR PERFORMANCE AND
 LOADS**

RANDALL L. PETERSON
 Jun. 1995 829 p
 (NASA-TM-110356; A-950069; NAS 1.15:110356) Avail: CASI HC
 A99/MF A10

A full-scale BO-105 hingeless rotor system was tested in the NASA Ames 40- by 80-Foot Wind Tunnel on the rotor test apparatus. Rotor performance, rotor loads, and aeroelastic stability as functions of both collective and cyclic pitch, tunnel velocity, and shaft angle were investigated. This test was performed in support of the Rotor Data Correlation Task under the U.S. Army/German Memorandum of Understanding on Cooperative Research in the Field of Helicopter Aeromechanics. The primary objective of this test program was to create a data base for full-scale hingeless rotor performance and structural blade loads. A secondary objective was to investigate the ability to match flight test conditions in the wind tunnel. This data base can be used for the experimental and analytical studies of hingeless rotor systems over large variations in rotor thrust and tunnel velocity. Rotor performance and structural loads for tunnel velocities from hover to 170 knots and thrust coefficients ($C_{sub T}/\sigma$) from 0.0 to 0.12 are presented in this report. Thrust sweeps at tunnel velocities of 10, 20, and 30 knots are also included in this data set. Author

N95-32904 Old Dominion Univ., Norfolk, VA.
**THREE-DIMENSIONAL AERODYNAMIC SHAPE
 OPTIMIZATION USING DISCRETE SENSITIVITY ANALYSIS
 Ph.D. Thesis**

GREGORY WAYNE BURGREN 1994 154 p

Avail: Univ. Microfilms Order No. DA9423428

An aerodynamic shape optimization procedure based on discrete sensitivity analysis is extended to treat three-dimensional geometries. The function of sensitivity analysis is to directly couple computational fluid dynamics (CFD) with numerical optimization techniques, which facilitates the construction of efficient direct-design methods. The development of a practical three-dimensional design procedure entails many challenges, such as: (1) the demand for significant efficiency improvements over current design methods; (2) a general and flexible three-dimensional surface representation; and (3) the efficient solution of very large systems of linear algebraic equations. It is demonstrated that each of these challenges is overcome by: (1) employing fully implicit (Newton) methods for the CFD analyses; (2) adopting a Bezier-Bernstein polynomial parameterization of two- and three-dimensional surfaces; and (3) using preconditioned conjugate gradient-like linear system solvers. Whereas each of these extensions independently yields an improvement in computational efficiency, the combined effect of implementing all the extensions simultaneously results in a significant factor of 50 decrease in computational time and a factor of eight reduction in memory over the most efficient design strategies in current use. The new aerodynamic shape optimization procedure is demonstrated in the design of both two- and three-dimensional inviscid aerodynamic problems including a two-dimensional supersonic internal/external nozzle, two-dimensional transonic airfoils (resulting in supercritical shapes), three-dimensional transonic transport wings, and three-dimensional supersonic delta wings. Each design application results in realistic and useful optimized shapes. Dissert. Abstr.

N95-32928*# Arizona State Univ., Tempe, AZ. Dept. of Mechanical and Aerospace Engineering.

**DEVELOPMENT OF A COMPOSITE TAILORING
 PROCEDURE FOR AIRPLANE WING Progress Report**

ADITI CHATTOPADHYAY and SEN ZHANG 3 Aug. 1995 14 p
 (Contract(s)/Grant(s): NAG2-908)
 (NASA-CR-199081; NAS 1.26:199081) Avail: CASI HC A03/MF
 A01

The development of a composite wing box section using a higher order-theory is proposed for accurate and efficient estimation of both static and dynamic responses. The theory includes the effect of through-the-thickness transverse shear deformations which is important in laminated composites and is ignored in the classical approach. The box beam analysis is integrated with an aeroelastic analysis to investigate the effect of composite tailoring using a formal design optimization technique. A hybrid optimization procedure is proposed for addressing both continuous and discrete design variables. Derived from text

N95-33023*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.

**FLIGHT TEST OF A PROPULSION CONTROLLED
 AIRCRAFT SYSTEM ON THE NASA F-15 AIRPLANE**

FRANK W. BURCHAM, JR. and TRINDEL A. MAINE *In its An Electronic Workshop on the Performance Seeking Control and Propulsion Controlled Aircraft Results of the F-15 Highly Integrated Digital Electronic Control Flight Research Program* p 193-221 Jan. 1995

Avail: CASI HC A03/MF A03

Flight tests of the propulsion controlled aircraft (PCA) system on the NASA F-15 airplane evolved as a result of a long series of simulation and flight tests. Initially, the simulation results were very optimistic. Early flight tests showed that manual throttles-only control was much more difficult than the simulation, and a flight investigation was flown to acquire data to resolve this discrepancy. The PCA system designed and developed by MDA evolved as these discrepancies were found and resolved, requiring redesign of the PCA software and modification of the flight test plan. Small throttle step inputs were flown to provide data for analysis, simulation update, and control logic modification. The PCA flight tests quickly revealed less than desired performance, but the extensive flexibility built into the flight PCA software allowed rapid evaluation of alternate

04 AIRCRAFT COMMUNICATIONS AND NAVIGATION

gains, filters, and control logic, and within 2 weeks, the PCA system was functioning well. The initial objective of achieving adequate control for up-and-away flying and approaches was satisfied, and the option to continue to actual landings was achieved. After the PCA landings were accomplished, other PCA features were added, and additional maneuvers beyond those originally planned were flown. The PCA system was used to recover from extreme upset conditions, descend, and make approaches to landing. A heading mode was added, and a single engine plus rudder PCA mode was also added and flown. The PCA flight envelope was expanded far beyond that originally designed for. Guest pilots from the USAF, USN, NASA, and the contractor also flew the PCA system and were favorably impressed. Author

N95-33024*# Planning Research Corp., Edwards, CA.
DYNAMIC GROUND EFFECTS FLIGHT TEST OF THE NASA F-15 AIRCRAFT

STEPHEN CORDA *In* NASA. Dryden Flight Research Center, An Electronic Workshop on the Performance Seeking Control and Propulsion Controlled Aircraft Results of the F-15 Highly Integrated Digital Electronic Control Flight Research Program p 222-228 Jan. 1995

Avail: CASI HC A02/MF A03

Aerodynamic characteristics of an aircraft may significantly differ when flying close to the ground rather than when flying up and away. Recent research has also determined that dynamic effects (i.e., sink rate) influence ground effects (GE). A ground effects flight test program of the F-15 aircraft was conducted to support the propulsion controlled aircraft (PCA) program at the NASA Dryden Flight Research Center. Flight data was collected for 24 landings on seven test flights. Dynamic ground effects data were obtained for low- and high-sink rates, between 0.8 and 6.5 ft/sec, at two approach speed and flap combinations. These combinations consisted of 150 kt with the flaps down (30 deg deflection) and 170 kt with the flaps up (0 deg deflection), both with the inlet ramps in the full-up position. The aerodynamic coefficients caused by ground effects were estimated from the flight data. These ground effects data were correlated with the aircraft speed, flap setting, and sink rate. Results are compared to previous flight test and wind-tunnel ground effects data for various wings and for complete aircraft. Author

N95-33025*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.
DESIGN CHALLENGES ENCOUNTERED IN THE F-15 PCA FLIGHT TEST PROGRAM

TRINDEL A. MAINE, FRANK W. BURCHAM, JR., PETER SCHAEFER (University of Southern California, Los Angeles, CA.), and JOHN BURKEN *In its* An Electronic Workshop on the Performance Seeking Control and Propulsion Controlled Aircraft Results of the F-15 Highly Integrated Digital Electronic Control Flight Research Program 229-244 Jan. 1995

Avail: CASI HC A03/MF A03

The NASA Dryden Flight Research Center conducted flight tests of a propulsion-controlled aircraft system on an F-15 airplane. This system was designed to explore the feasibility of providing safe emergency landing capability using only the engines to provide flight control in the event of a catastrophic loss of conventional flight controls. Control laws were designed to control the flight path and bank angle using only commands to the throttles. While the program was highly successful, this paper concentrates on the challenges encountered using engine thrust as the only control effector. Compared to conventional flight control surfaces, the engines are slow, nonlinear, and have limited control effectiveness. This increases the vulnerability of the system to outside disturbances and changes in aerodynamic conditions. As a result, the PCA system had problems with gust rejection. Cross coupling of the longitudinal and lateral axis also occurred, primarily as a result of control saturation. The normally negligible effects of inlet airframe interactions became significant with the engines as the control effector. Flight and simulation data are used to illustrate these difficulties. Author

N95-33145# Aerodata Flugmesstechnik G.m.b.H., Brunswick (Germany).

INTEGRATED SPECIAL MISSION FLIGHT MANAGEMENT FOR A FLIGHT INSPECTION AIRCRAFT

A. REDEKER and M. HAVERLAND *In* AGARD, Dual Usage in Military and Commercial Technology in Guidance and Control 3 Mar. 1995

Copyright Avail: CASI HC A01/MF A02

Flight Inspection of military and civil radionavigation aids requires calibration aircraft with a complex mission equipment. The measurement patterns and their flight procedures differ from usual flight procedures, which cannot be performed with normal flight management/autopilot systems. On the other hand there is a requirement for an automatic guidance, in order to increase the reproducibility of calibration results and to assist the crew operating in areas with high traffic density. Special mission flight management systems, which are available on the market, are not an elegant solution for flight inspection applications. The flight inspection system (FIS) contains already all elements of a flight management system (FMS), and the FIS has more comprehensive information on navigational data. The system approach of an integrated FIS/FMS system is presented, where special mission profiles are generated and interfaced to the autopilot. Flight test results and operational experience are reported. Derived from text

N95-33311 California Univ., Davis, CA.
ANALYSIS AND DESIGN METHODOLOGY FOR CHORDWISE DEFORMABLE WINGS Ph.D. Thesis

YAU-SHEUN CHANG 1993 135 p

Avail: Univ. Microfilms Order No. DA9415898

Structural tailoring concepts have been developed to create wings with elastically produced camber for the purpose of increasing the lift generated by these wings. A new, simple structural model intended for use in aeroelastic tailoring studies of high aspect ratio wings is presented. The model is assumed to behave with Bernoulli-Euler type spanwise bending. Closed form expressions for all stiffnesses and compliances have been obtained by modifying the theory of Rehfield. Two primary and two secondary structural concepts have been created to produce chordwise camber deformations that result in enhanced lift. Two designs have been found that optimize the aerodynamic benefits of these wings. It appears that lift enhancements of sufficient magnitude can be produced to render this type of wing tailoring of practical interest. Two performance studies, one for the maximum chordwise camber curvature and the other for the maximum lift production, have been performed and discussed. Four distinct configuration designs are used for these studies. It has been shown that, with the aggressive utilization of elastic tailoring, increased performance and structural weight savings can be achieved. The influence of camber induced bending divergence on the configuration designs has been investigated and analyzed. The occurrence of a static instability of this type arises because wing bending produces positive camber, which, in turn, produces additional lift, and, hence, increased bending of the wing. For subsonic flight conditions, a bending type instability will not occur. The only instability is the torsional one. Finally, the effects of changing environmental conditions, elevated temperature and humidity, on the effective Poisson ratios and configuration designs for laminated carbon composites have been studied. It should be noted that much care is needed when designing a wing which will be subject to a wide range temperature and moisture extremes. Dissert. Abstr.

N95-34506# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.

REQUIREMENTS AND TRENDS OF COMPUTATIONAL AERODYNAMICS AS A TOOL FOR AIRCRAFT DESIGN

ANTONY JAMESON *In* National Aerospace Lab., Special Publication of National Aerospace Laboratory p 1-49 16 Jun. 1994

Avail: CASI HC A03/MF A03

This paper discusses steps needed for the implementation of computational simulation techniques which could meet industrial

needs. A critical issue examined in Section 3 is the choice of mathematical models: what level of complexity is needed to provide sufficient accuracy for aerodynamic design, and what is the impact on cost and turn-around. Section 4 addresses issues in the formulation of numerical algorithms which provide the fundamental building blocks for a numerical wind tunnel. Section 5 presents the results of some numerical calculations which require moderate computer resources and could be completed with the fast turn around needed for effective industrial use. Section 6 discusses automatic design procedures which can be used to produce optimum aerodynamic designs. Finally, Section 7 discusses the outlook for achieving the goal of a numerical wind tunnel. Author

N95-34541# Fujitsu Ltd., Tokyo (Japan).

NUMERICAL ANALYSIS AROUND THE WHOLE SST CONFIGURATION Abstract Only

TETSUO YAMAZAKI and TAKASHI UCHIDA (Japan Aircraft Development Corp., Tokyo, Japan.) *In* National Aerospace Lab., Special Publication of National Aerospace Laboratory p 261-265 16 Jun. 1994 *In* JAPANESE

Avail: CASI HC A01/MF A03

In designing the Second Generation of Supersonic Transport, the improvement of the lift to drag ratio at cruise condition is one of the most important subjects. This ratio affects the economic viability of the next SST, but there are some phenomena which degrade it. One of these is the wing-nacelle interference. We have applied a Euler method to a SST configuration which have 4 nacelles located under the aft wing. In this result the whole configuration has a higher inviscid lift to drag ratio than the sum of the wing-body configuration and 4 times of only one nacelle. And the inflow Mach number just upstream of a nacelle is less than the free stream Mach number and the flow is inclined, owing to the wing surface pressure. Therefore, it is necessary to investigate the wing-nacelle interference in more detail. Author

N95-34542# National Aerospace Lab., Tokyo (Japan).

APPLICATION OF CFD TECHNIQUE FOR HYFLEX AERODYNAMIC DESIGN Abstract Only

YUKIMITSU YAMAMOTO, SHIGEYA WATANABE (National Space Development Agency, Tokyo, Japan.), MITSUO ISHIGURO (Mitsubishi Heavy Industries Ltd., Tokyo, Japan.), and KOU OGASAWARA (Mitsubishi Heavy Industries Ltd., Tokyo, Japan.) *In its* Special Publication of National Aerospace Laboratory p 267-272 16 Jun. 1994 *In* JAPANESE

Avail: CASI HC A02/MF A03

An overview of the application of CFD technique for the HYFLEX (HYpersonic FLight EXperiment) aerodynamic design by using the numerical simulation codes in the supersonic and hypersonic speed ranges is presented. Roles of CFD required to make up for the short term of development and small amount of the wind tunnel test cases, application in the HYFLEX aerodynamic design and their application methods are described. The procedure of CFD code validation by the experimental data before design application is also presented. Finally, future view and subject of the CFD application for the development of hypersonic flight vehicle is shortly discussed. Author

N95-34583# Galaxy Scientific Corp., Pleasantville, NJ.

CORROSION OF FIRE-DAMAGED AIRCRAFT Final Report

WILLIAM T. WESTFIELD Apr. 1995 31 p
(Contract(s)/Grant(s): DTF A03-89-C-0043)
(AD-A294968; DOT/FAA/CT-94/89) Avail: CASI HC A03/MF A01

The Federal Aviation Administration (FAA) Western Pacific Regional Office issued a Significant Activity Report concerning a 5727 that experienced extensive corrosion, well beyond what would have normally been expected for an aircraft with its operational time and cycles. This incident triggered interest in the possible connection between fire, extinguishment, and subsequent increased incidence of corrosion. The FAA Technical Center requested an investigation of the potential for this connection to exist by perform-

ing an analysis of available data. Trends of aircraft operational hours, cycles, fire occurrence, and corrosion reports were developed. Data extending from 1974 to the present were accessed from the Aviation Research and Support database and the Service Difficulty Reports (SDRs) database, respectively. Sufficient data to support a connection between fire and subsequent related corrosion were not available. Twenty-two aircraft were analyzed and none exhibited a pattern of corrosion that could definitely be associated with fire smoke or extinguishment. This result was supported by consideration of the intensity of the fire, the extinguishing agent and the time between the occurrence of the fire and the corrosion reports. DTIC

N95-34793# Army Aeromedical Research Lab., Fort Rucker, AL. **TRANSMITTANCE CHARACTERISTICS OF US ARMY**

ROTARY-WING AIRCRAFT TRANSPARENCIES Final Report SEAN L. WENTWORTH, EVERETTE MCGOWIN, III, REBECCA H. IVEY, CLARENCE E. RASH, and WILLIAM E. MCLEAN Mar. 1995 40 p

(AD-A295035; USAARL-95-19) Avail: CASI HC A03/MF A01

This report documents a survey of the spectral and luminous transmittance characteristics of transparencies (windscreens) used in currently fielded U.S. Army rotary-wing aircraft. The survey was conducted in two phases. In the first phase, samples of windscreens from each aircraft type were evaluated in the laboratory for photopic (day) and scotopic (night) luminous transmittance. The spectral transmittance of each sample also was measured. Based on laboratory measurements of unused samples, all windscreens met specifications. However, field measurements on windscreens showed consistent failure of luminous transmittance requirements. This loss of transmittance is attributed to haze resulting from exposure to environmental factors. DTIC

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

N95-32497*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

A HIGHLY RELIABLE, HIGH PERFORMANCE OPEN AVIONICS ARCHITECTURE FOR REAL TIME NAP-OF-THE-EARTH OPERATIONS

RICHARD E. HARPER (Draper, Charles Stark Lab., Inc., Cambridge, MA.) and CARL ELKS *In* AGARD, Low-Level and Nap-of-the-Earth (NOE) Night Operations 14 p Jan. 1995
Copyright Avail: CASI HC A03/MF A03

An Army Fault Tolerant Architecture (AFTA) has been developed to meet real-time fault tolerant processing requirements of future Army applications. AFTA is the enabling technology that will allow the Army to configure existing processors and other hardware to provide high throughput and ultrahigh reliability necessary for TF/TA/NOE flight control and other advanced Army applications. A comprehensive conceptual study of AFTA has been completed that addresses a wide range of issues including requirements, architecture, hardware, software, testability, producibility, analytical models, validation and verification, common mode faults, VHDL, and a fault tolerant data bus. A Brassboard AFTA for demonstration and validation has been fabricated, and two operating systems and a flight-critical Army application have been ported to it. Detailed performance measurements have been made of fault tolerance and operating system overheads while AFTA was executing the flight application in the presence of faults. Derived from text

N95-32503# Sextant Avionique, Saint Medard en Jalles (France).

A HELMET MOUNTED DISPLAY FOR NIGHT MISSIONS AT LOW ALTITUDE [UN VISUEL DE CASQUE POUR LA MISSION DE NUIT A BASSE ALTITUDE]

JEAN-PIERRE CURSOLLE, ALAIN LEGER, and FRANCK LEPPERT

07 AIRCRAFT PROPULSION AND POWER

In AGARD, Low-Level and Nap-of-the-Earth (NOE) Night Operations 10 p Jan. 1995 In FRENCH
Copyright Avail: CASI HC A02/MF A03

The achievement of air to ground mission in a complex operational context, with bad meteorological conditions and, moreover by night is a very demanding task for the pilot. This mission requests a high situation awareness which can only be reached with specific, accurate and reliable means, such as sensors, displays or controls, perfectly integrated in the aircraft system. The mission can be successfully realized thanks to sensors performances. But, the use of FLIR or I(sup 2)T depends on a lot of conditions such as weather with bad effects on the efficiency. So images must be enhanced with symbols to be fully exploitable. Furthermore, the sensors have to be fully integrated, the efficiency depending on the interfaces such as displays and controls. The third Generation Helmet Mounted Display is an answer to this requirement but has to be fighter pilot customized. The conference will include a few operational requirements recall, the Sextant Gen 3 HMD description and will highlight the first symbology results issued from a ground simulation assessment.

Author

07

AIRCRAFT PROPULSION AND POWER

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

N95-32636# Allison Engine Co., Indianapolis, IN.
ALLISON ENGINE TESTING CMSX-4(REG SIGN) SINGLE CRYSTAL TURBINE BLADES AND VANES

P. S. BURKHOLDER, M. C. THOMAS, D. J. FRASIER, J. R. WHETSTONE, K. HARRIS (Cannon-Muskegon Corp., MI.), G. L. ERICKSON (Cannon-Muskegon Corp., MI.), S. L. SIKKENG (Cannon-Muskegon Corp., MI.), and J. M. ERIDON (Cannon-Muskegon Corp., MI.) 1995 16 p Presented at the 3rd International Charles Parsons Turbine Conference: Materials Engineering in Turbines and Compressors, Newcastle upon Tyne, UK, 25-27 Apr. 1995 (Contract(s)/Grant(s): DE-AC21-93MC-29257) (DE95-010308; DOE/MC-29257/95/C0452; CONF-950463-1) Avail: CASI HC A03/MF A01

A team approach utilizing simultaneous engineering has been used to develop CMSX-4 turbine airfoil components. CMSX-4 is a nickel-base single crystal superalloy containing 3% (wt) rhenium and a high 71% volume fraction of coherent (gamma)(prime) precipitate strengthening phase. The high level of balanced properties determined by extensive laboratory evaluation has been confirmed during engine testing the Allison AE 2100 and AE 301X engines, with the post-test condition of the components, including advanced Castcool(trademark) vane segments, being excellent. Also uncooled vane segments in CMSX-4 have exceeded engineering expectations. DOE

N95-32916*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

LOW-ORDER NONLINEAR DYNAMIC MODEL OF IC ENGINE-VARIABLE PITCH PROPELLER SYSTEM FOR GENERAL AVIATION AIRCRAFT

JACQUES C. RICHARD Jul. 1995 37 p (Contract(s)/Grant(s): RTOP 505-62-50) (NASA-TM-107006; E-9789; NAS 1.15:107006) Avail: CASI HC A03/MF A01

This paper presents a dynamic model of an internal combustion engine coupled to a variable pitch propeller. The low-order, nonlinear time-dependent model is useful for simulating the propulsion system of general aviation single-engine light aircraft. This model is suitable for investigating engine diagnostics and monitoring and for control design and development. Furthermore, the model may be extended to provide a tool for the study of engine emissions, fuel

economy, component effects, alternative fuels, alternative engine cycles, flight simulators, sensors, and actuators. Results show that the model provides a reasonable representation of the propulsion system dynamics from zero to 10 Hertz. Author

N95-32931*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

COMBUSTION-ACOUSTIC STABILITY ANALYSIS FOR PREMIXED GAS TURBINE COMBUSTORS

DOUGLAS DARLING, KRISHNAN RADHAKRISHNAN (NYMA, Inc., Brook Park, OH.), AYO OYEDIRAN (AYT Corp., Brook Park, OH.), and LIZABETH COWAN (Iowa State Univ. of Science and Technology, Ames, IA.) Aug. 1995 10 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; NAS3-27571; RTOP 537-02-21)

(NASA-TM-107024; E-9834; NAS 1.15:107024; AIAA PAPER 95-2470) Avail: CASI HC A02/MF A01

Lean, prevaporized, premixed combustors are susceptible to combustion-acoustic instabilities. A model was developed to predict eigenvalues of axial modes for combustion-acoustic interactions in a premixed combustor. This work extends previous work by including variable area and detailed chemical kinetics mechanisms, using the code LSENS. Thus the acoustic equations could be integrated through the flame zone. Linear perturbations were made of the continuity, momentum, energy, chemical species, and state equations. The qualitative accuracy of our approach was checked by examining its predictions for various unsteady heat release rate models. Perturbations in fuel flow rate are currently being added to the model. Author

N95-33009*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.

AN ELECTRONIC WORKSHOP ON THE PERFORMANCE SEEKING CONTROL AND PROPULSION CONTROLLED AIRCRAFT RESULTS OF THE F-15 HIGHLY INTEGRATED DIGITAL ELECTRONIC CONTROL FLIGHT RESEARCH PROGRAM

SHERYLL GOECKE POWERS, comp. Jan. 1995 256 p Workshop held in Edwards, CA, 1993 (NASA-TM-104278; H-2020; NAS 1.15:104278) Avail: CASI HC A12/MF A03

Flight research for the F-15 HIDECA (Highly Integrated Digital Electronic Control) program was completed at NASA Dryden Flight Research Center in the fall of 1993. The flight research conducted during the last two years of the HIDECA program included two principal experiments: (1) performance seeking control (PSC), an adaptive, real-time, on-board optimization of engine, inlet, and horizontal tail position on the F-15; and (2) propulsion controlled aircraft (PCA), an augmented flight control system developed for landings as well as up-and-away flight that used only engine thrust (flight controls locked) for flight control. In September 1994, the background details and results of the PSC and PCA experiments were presented in an electronic workshop, accessible through the Dryden World Wide Web (<http://www.dfrc.nasa.gov/dryden.html>) and as a compact disk. For individual titles, see N95-33010 through N95-33025.

N95-33010*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.

AN OVERVIEW OF INTEGRATED FLIGHT-PROPULSION CONTROLS FLIGHT RESEARCH ON THE NASA F-15 RESEARCH AIRPLANE

FRANK W. BURCHAM, JR., DONALD H. GATLIN, and JAMES F. STEWART In its An Electronic Workshop on the Performance Seeking Control and Propulsion Controlled Aircraft Results of the F-15 Highly Integrated Digital Electronic Control Flight Research Program p 1-28 Jan. 1995 Avail: CASI HC A03/MF A03

The NASA Dryden Flight Research Center has been conducting integrated flight-propulsion control flight research using the NASA F-15 airplane for the past 12 years. The research began with the digital electronic engine control (DEEC) project, followed by the F100 Engine Model Derivative (EMD). HIDECA (Highly Integrated Digital Electronic Control) became the umbrella name for a series of experiments including: the Advanced Digital Engine Controls System (ADECS), a twin jet acoustics flight experiment, self-repairing flight control system (SRFCS), performance-seeking control (PSC), and propulsion controlled aircraft (PCA). The upcoming F-15 project is ACTIVE (Advanced Control Technology for Integrated Vehicles). This paper provides a brief summary of these activities and provides background for the PCA and PSC papers, and includes a bibliography of all papers and reports from the NASA F-15 project. Author

N95-33011*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.

PERFORMANCE SEEKING CONTROL PROGRAM OVERVIEW

JOHN S. ORME *In its* An Electronic Workshop on the Performance Seeking Control and Propulsion Controlled Aircraft Results of the F-15 Highly Integrated Digital Electronic Control Flight Research Program p 31-36 Jan. 1995
Avail: CASI HC A02/MF A03

The Performance Seeking Control (PSC) program evolved from a series of integrated propulsion-flight control research programs flown at NASA Dryden Flight Research Center (DFRC) on an F-15. The first of these was the Digital Electronic Engine Control (DEEC) program and provided digital engine controls suitable for integration. The DEEC and digital electronic flight control system of the NASA F-15 were ideally suited for integrated controls research. The Advanced Engine Control System (ADECS) program proved that integrated engine and aircraft control could improve overall system performance. The objective of the PSC program was to advance the technology for a fully integrated propulsion flight control system. Whereas ADECS provided single variable control for an average engine, PSC controlled multiple propulsion system variables while adapting to the measured engine performance. PSC was developed as a model-based, adaptive control algorithm and included four optimization modes: minimum fuel flow at constant thrust, minimum turbine temperature at constant thrust, maximum thrust, and minimum thrust. Subsonic and supersonic flight testing were conducted at NASA Dryden covering the four PSC optimization modes and over the full throttle range. Flight testing of the PSC algorithm, conducted in a series of five flight test phases, has been concluded at NASA Dryden covering all four of the PSC optimization modes. Over a three year period and five flight test phases 72 research flights were conducted. The primary objective of flight testing was to exercise each PSC optimization mode and quantify the resulting performance improvements. Author

N95-33012*# Pratt and Whitney Aircraft, West Palm Beach, FL.
F-15 PROPULSION SYSTEM

MARK BUSHMAN and STEVEN G. NOBBS (McDonnell-Douglas Corp., Saint Louis, MO.) *In its* NASA. Dryden Flight Research Center, An Electronic Workshop on the Performance Seeking Control and Propulsion Controlled Aircraft Results of the F-15 Highly Integrated Digital Electronic Control Flight Research Program p 37-40 Jan. 1995

Avail: CASI HC A01/MF A03

A brief description of the NASA F-15 research aircraft propulsion system is given. The F-15 is powered by two PW1128 afterburning turbofan engines which are growth versions of the F100-PW-100 engine. The PW1128 is controlled by a full-authority digital electronic engine control (DEEC). The F-15 inlet is a two-dimensional, three-ramp, external compression design with partially cut back side plates. Each inlet is independently controlled by an electronic air inlet controller (EAIC). CASI

N95-33013*# McDonnell-Douglas Corp., Saint Louis, MO.

PSC ALGORITHM DESCRIPTION

STEVEN G. NOBBS *In its* NASA. Dryden Flight Research Center, An

Electronic Workshop on the Performance Seeking Control and Propulsion Controlled Aircraft Results of the F-15 Highly Integrated Digital Electronic Control Flight Research Program p 41-60 Jan. 1995

Avail: CASI HC A03/MF A03

An overview of the performance seeking control (PSC) algorithm and details of the important components of the algorithm are given. The onboard propulsion system models, the linear programming optimization, and engine control interface are described. The PSC algorithm receives input from various computers on the aircraft including the digital flight computer, digital engine control, and electronic inlet control. The PSC algorithm contains compact models of the propulsion system including the inlet, engine, and nozzle. The models compute propulsion system parameters, such as inlet drag and fan stall margin, which are not directly measurable in flight. The compact models also compute sensitivities of the propulsion system parameters to change in control variables. The engine model consists of a linear steady state variable model (SSVM) and a nonlinear model. The SSVM is updated with efficiency factors calculated in the engine model update logic, or Kalman filter. The efficiency factors are used to adjust the SSVM to match the actual engine. The propulsion system models are mathematically integrated to form an overall propulsion system model. The propulsion system model is then optimized using a linear programming optimization scheme. The goal of the optimization is determined from the selected PSC mode of operation. The resulting trims are used to compute a new operating point about which the optimization process is repeated. This process is continued until an overall (global) optimum is reached before applying the trims to the controllers. Author

N95-33014*# McDonnell-Douglas Corp., Saint Louis, MO.

PSC IMPLEMENTATION AND INTEGRATION

STEVEN NOBBS *In its* NASA. Dryden Flight Research Center, An Electronic Workshop on the Performance Seeking Control and Propulsion Controlled Aircraft Results of the F-15 Highly Integrated Digital Electronic Control Flight Research Program p 61-89 Jan. 1995

Avail: CASI HC A03/MF A03

Hardware and software design of the performance seeking control (PSC) for the NASA F-15 research aircraft are described. The hardware architecture, vehicle management system computer (VMSC), pilot interface, and PSC mode selection are discussed. The PSC software is distributed among the VMSC, central computer, digital electronic engine controls (DEEC's), and electronic air inlet controllers (EAIC's). The major PSC modules, VMSC logic, VMSC channel C memory requirements, VMSC channel C timing, and navigation control indicator (NCI) variables and where they are located are presented. CASI

N95-33015*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.

MINIMUM FUEL MODE EVALUATION

JOHN S. ORME and STEVEN G. NOBBS (McDonnell-Douglas Corp., Saint Louis, MO.) *In its* An Electronic Workshop on the Performance Seeking Control and Propulsion Controlled Aircraft Results of the F-15 Highly Integrated Digital Electronic Control Flight Research Program p 91-98 Jan. 1995

Avail: CASI HC A02/MF A03

The minimum fuel mode of the NASA F-15 research aircraft is designed to minimize fuel flow while maintaining constant net propulsive force (FNP), effectively reducing thrust specific fuel consumption (TSFC), during cruise flight conditions. The test maneuvers were at stabilized flight conditions. The aircraft test engine was allowed to stabilize at the cruise conditions before data collection initiated; data were then recorded with performance seeking control (PSC) not-engaged, then data were recorded with the PSC system engaged. The maneuvers were flown back-to-back to allow for direct comparisons by minimizing the effects of variations in the test day conditions. The minimum fuel mode was evaluated at subsonic and supersonic Mach numbers and focused on three altitudes: 15,000; 30,000; and 45,000 feet. Flight data were collected for part, military, partial, and

07 AIRCRAFT PROPULSION AND POWER

maximum afterburning power conditions. The TSFC savings at supersonic Mach numbers, ranging from approximately 4% to nearly 10%, are in general much larger than at subsonic Mach numbers because of PSC trims to the afterburner. Derived from text

N95-33016*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.

MINIMUM FAN TURBINE INLET TEMPERATURE MODE EVALUATION

JOHN S. ORME and STEVEN G. NOBBS (McDonnell-Douglas Corp., Saint Louis, MO.) *In its* An Electronic Workshop on the Performance Seeking Control and Propulsion Controlled Aircraft Results of the F-15 Highly Integrated Digital Electronic Control Flight Research Program p 99-110 Jan. 1995

Avail: CASI HC A03/MF A03

Measured reductions in turbine temperature which resulted from the application of the F-15 performance seeking control (PSC) minimum fan turbine inlet temperature (FTIT) mode during the dual-engine test phase is presented as a function of net propulsive force and flight condition. Data were collected at altitudes of 30,000 and 45,000 feet at military and partial afterburning power settings. The FTIT reductions for the supersonic tests are less than at subsonic Mach numbers because of the increased modeling and control complexity. In addition, the propulsion system was designed to be optimized at the mid supersonic Mach number range. Subsonically at military power, FTIT reductions were above 70 R for either the left or right engines, and repeatable for the right engine. At partial afterburner and supersonic conditions, the level of FTIT reductions were at least 25 R and as much as 55 R. Considering that the turbine operates at or very near its temperature limit at these high power settings, these seemingly small temperature reductions may significantly lengthen the life of the turbine. In general, the minimum FTIT mode has performed well, demonstrating significant temperature reductions at military and partial afterburner power. Decreases of over 100 R at cruise flight conditions were identified. Temperature reductions of this magnitude could significantly extend turbine life and reduce replacement costs. Derived from text

N95-33017*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.

MAXIMUM THRUST MODE EVALUATION

JOHN S. ORME and STEVEN G. NOBBS (McDonnell-Douglas Corp., Saint Louis, MO.) *In its* An Electronic Workshop on the Performance Seeking Control and Propulsion Controlled Aircraft Results of the F-15 Highly Integrated Digital Electronic Control Flight Research Program p 111-120 Jan. 1995

Avail: CASI HC A02/MF A03

Measured reductions in acceleration times which resulted from the application of the F-15 performance seeking control (PSC) maximum thrust mode during the dual-engine test phase is presented as a function of power setting and flight condition. Data were collected at altitudes of 30,000 and 45,000 feet at military and maximum afterburning power settings. The time savings for the supersonic acceleration is less than at subsonic Mach numbers because of the increased modeling and control complexity. In addition, the propulsion system was designed to be optimized at the mid supersonic Mach number range. Recall that even though the engine is at maximum afterburner, PSC does not trim the afterburner for the maximum thrust mode. Subsonically at military power, time to accelerate from Mach 0.6 to 0.95 was cut by between 6 and 8 percent with a single engine application of PSC, and over 14 percent when both engines were optimized. At maximum afterburner, the level of thrust increases were similar in magnitude to the military power results, but because of higher thrust levels at maximum afterburner and higher aircraft drag at supersonic Mach numbers the percentage thrust increase and time to accelerate was less than for the supersonic accelerations. Savings in time to accelerate supersonically at maximum afterburner ranged from 4 to 7 percent. In general, the maximum thrust mode has performed well, demonstrating significant thrust increases at military and maximum afterburner power. Increases of up to 15 percent at typical combat-type flight

conditions were identified. Thrust increases of this magnitude could be useful in a combat situation. Author

N95-33018*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.

RAPID DECELERATION MODE EVALUATION

TIMOTHY R. CONNERS, STEVEN G. NOBBS (McDonnell-Douglas Corp., Saint Louis, MO.), and JOHN S. ORME *In its* An Electronic Workshop on the Performance Seeking Control and Propulsion Controlled Aircraft Results of the F-15 Highly Integrated Digital Electronic Control Flight Research Program p 121-128 Jan. 1995

Avail: CASI HC A02/MF A03

Aircraft with flight capability above 1.4 normally have an RPM lockup or similar feature to prevent inlet buzz that would occur at low engine airflows. This RPM lockup has the effect of holding the engine thrust level at the intermediate power (maximum non-afterburning). For aircraft such as military fighters or supersonic transports, the need exists to be able to rapidly slow from supersonic to subsonic speeds. For example, a supersonic transport that experiences a cabin decompression needs to be able to slow/descend rapidly, and this requirement may size the cabin environmental control system. For a fighter, there may be a desire to slow/descend rapidly, and while doing so to minimize fuel usage and engine exhaust temperature. Both of these needs can be aided by achieving the minimum possible overall net propulsive force. As the intermediate power thrust levels of engines increase, it becomes even more difficult to slow rapidly from supersonic speeds. Therefore, a mode of the performance seeking control (PSC) system to minimize overall propulsion system thrust has been developed and tested. The rapid deceleration mode reduces the engine airflow consistent with avoiding inlet buzz. The engine controls are trimmed to minimize the thrust produced by this reduced airflow, and moves the inlet geometry to degrade the inlet performance. As in the case of the other PSC modes, the best overall performance (in this case the least net propulsive force) requires an integrated optimization of inlet, engine, and nozzle variables. This paper presents the predicted and measured results for the supersonic minimum thrust mode, including the overall effects on aircraft deceleration. Author

N95-33019*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.

PERFORMANCE SEEKING CONTROL EXCITATION MODE

GERARD SCHKOLNIK *In its* An Electronic Workshop on the Performance Seeking Control and Propulsion Controlled Aircraft Results of the F-15 Highly Integrated Digital Electronic Control Flight Research Program p 133-142 Jan. 1995

Avail: CASI HC A02/MF A03

Flight testing of the performance seeking control (PSC) excitation mode was successfully completed at NASA Dryden on the F-15 highly integrated digital electronic control (HIDEC) aircraft. Although the excitation mode was not one of the original objectives of the PSC program, it was rapidly prototyped and implemented into the architecture of the PSC algorithm, allowing valuable and timely research data to be gathered. The primary flight test objective was to investigate the feasibility of a future measurement-based performance optimization algorithm. This future algorithm, called AdAPT, which stands for adaptive aircraft performance technology, generates and applies excitation inputs to selected control effectors. Fourier transformations are used to convert measured response and control effector data into frequency domain models which are mapped into state space models using multiterm frequency matching. Formal optimization principles are applied to produce an integrated, performance optimal effector suite. The key technical challenge of the measurement-based approach is the identification of the gradient of the performance index to the selected control effector. This concern was addressed by the excitation mode flight test. The AdAPT feasibility study utilized the PSC excitation mode to apply separate sinusoidal excitation trims to the controls - one aircraft, inlet first ramp (cow), and one engine, throat area. Aircraft control and response data were recorded using on-board instrumentation and

analyzed post-flight. Sensor noise characteristics, axial acceleration performance gradients, and repeatability were determined. Results were compared to pilot comments to assess the ride quality. Flight test results indicate that performance gradients were identified at all flight conditions, sensor noise levels were acceptable at the frequencies of interest, and excitations were generally not sensed by the pilot. Author

N95-33020*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.
PERFORMANCE SEEKING CONTROL (PSC) FOR THE F-15 HIGHLY INTEGRATED DIGITAL ELECTRONIC CONTROL (HIDEC) AIRCRAFT Summary

JOHN S. ORME *In its* An Electronic Workshop on the Performance Seeking Control and Propulsion Controlled Aircraft Results of the F-15 Highly Integrated Digital Electronic Control Flight Research Program p 146-156 Jan. 1995
 Avail: CASI HC A03/MF A03

The performance seeking control algorithm optimizes total propulsion system performance. This adaptive, model-based optimization algorithm has been successfully flight demonstrated on two engines with differing levels of degradation. Models of the engine, nozzle, and inlet produce reliable, accurate estimates of engine performance. But, because of an observability problem, component levels of degradation cannot be accurately determined. Depending on engine-specific operating characteristics PSC achieves various levels performance improvement. For example, engines with more deterioration typically operate at higher turbine temperatures than less deteriorated engines. Thus when the PSC maximum thrust mode is applied, for example, there will be less temperature margin available to be traded for increasing thrust. Derived from text

N95-33021*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Center, Edwards, CA.
BACKGROUND AND PRINCIPLES OF THROTTLES-ONLY FLIGHT CONTROL

FRANK W. BURCHAM, JR. *In its* An Electronic Workshop on the Performance Seeking Control and Propulsion Controlled Aircraft Results of the F-15 Highly Integrated Digital Electronic Control Flight Research Program p 159-169 Jan. 1995
 Avail: CASI HC A03/MF A03

There have been many cases in which the crew of a multi-engine airplane had to use engine thrust for emergency flight control. Such a procedure is very difficult, because the propulsive control forces are small, the engine response is slow, and airplane dynamics such as the phugoid and dutch roll are difficult to damp with thrust. In general, thrust increases are used to climb, thrust decreases to descend, and differential thrust is used to turn. Average speed is not significantly affected by changes in throttle setting. Pitch control is achieved because of pitching moments due to speed changes, from thrust offset, and from the vertical component of thrust. Roll control is achieved by using differential thrust to develop yaw, which, through the normal dihedral effect, causes a roll. Control power in pitch and roll tends to increase as speed decreases. Although speed is not controlled by the throttles, configuration changes are often available (lowering gear, flaps, moving center-of-gravity) to change the speed. The airplane basic stability is also a significant factor. Fuel slosh and gyroscopic moments are small influences on throttles-only control. The background and principles of throttles-only flight control are described. Author

N95-33022*# McDonnell-Douglas Corp., Saint Louis, MO.
PROPULSION CONTROLLED AIRCRAFT DESIGN AND DEVELOPMENT

EDWARD A. WELLS and JAMES M. URNES, SR. *In* NASA. Dryden Flight Research Center, An Electronic Workshop on the Performance Seeking Control and Propulsion Controlled Aircraft Results of the F-15 Highly Integrated Digital Electronic Control Flight Research Program p 170-192 Jan. 1995
 Avail: CASI HC A03/MF A03

This paper describes the design, development, and ground testing of the propulsion controlled aircraft (PCA) flight control system. A backup flight control system which uses only engine thrust, the PCA system utilizes collective and differential thrust changes to steer an aircraft that experiences partial or complete failure of the hydraulically actuated control surfaces. The objective of the program was to investigate, in flight, the throttles-only control capability of the F-15, using manual control, and also an augmented PCA mode in which computer-controlled thrust was used for flight control. The objective included PCA operation in up-and-away flight and, if performance was adequate, a secondary objective to make actual PCA landings. The PCA design began with a feasibility study which evaluated many control law designs. The study was done using off-line control analysis, simulation, and on-line manned flight simulator tests. Control laws, cockpit displays, and cockpit controls were evaluated by NASA test pilots. A flight test baseline configuration was selected based on projected flight performance, applicability to transport and fighter aircraft, and funding costs. During the PCA software and hardware development, the initial design was updated as data became available from throttle-only flight experiments conducted by NASA on the F-15. This information showed basic airframe characteristics that were not observed in the F-15 flight simulator and resulted in several design changes. After the primary objectives of the PCA flight testing were accomplished, additional PCA modes of operation were developed and implemented. The evolution of the PCA system from the initial feasibility study, control law design, simulation, hardware-in-the-loop tests, pilot-in-the-loop tests, and ground tests is presented. Author

N95-33208*# NYMA, Inc., Brook Park, OH.
NUMERICAL SIMULATION OF SUPERSONIC FLOW USING A NEW ANALYTICAL BLEED BOUNDARY CONDITION Final Report

G. J. HARLOFF and G. E. SMITH AIAA Aug. 1995 21 p
 (Contract(s)/Grant(s): NAS3-27186; RTOP 505-62-20)
 (NASA-CR-198368; E-9807; NAS 1.26:198368) Avail: CASI HC A03/MF A01

A new analytical bleed boundary condition is used to compute flowfields for a strong oblique shock wave/boundary layer interaction with a baseline and three bleed rates at a freestream Mach number of 2.47 with an 8 deg shock generator. The computational results are compared to experimental Pitot pressure profiles and wall static pressures through the interaction region. An algebraic turbulence model is employed for the bleed and baseline cases, and a one equation model is also used for the baseline case where the boundary layer is separated. Author

N95-33250 Defence Science and Technology Organisation, Melbourne (Australia). Airframes and Engines Div.
WATER MODEL TESTS ON THE ALLISON T56 SERIES 3 COMBUSTION SYSTEM

GRANT T. MCCABE Mar. 1995 31 p Original contains color illustrations
 (DSTO-TR-0139; AR-007-138) Avail: Issuing Activity (DSTO Aeronautical and Maritime Research Lab., GPO Box 4331, Melbourne, Victoria 3001, Australia)

A modification was developed for the combustion system of the Allison T56 Series 3 turboprop engine which has resulted in an engine that has: (1) a lower smoke emission; (2) a lower specific fuel consumption; and (3) a combustor with potentially increased durability or life. In-service testing of the combustor has proven all the above advantages; however, the formation of hard carbon in the combustor and its subsequent release has resulted in increased erosion in the turbine section of the engine. Further development was undertaken to remedy this problem without affecting the overall gains offered by the modification. This report covers part of this work and in particular details flow field investigations made using a water flow model of the combustor liner. A comprehensive understanding of the flow mechanisms within the standard liner, the low smoke modification (LSM) liner, and proposed revisions of the LSM liner

07 AIRCRAFT PROPULSION AND POWER

has now been obtained. It is anticipated that modifications arising from the present investigation will reduce, if not completely eliminate, hard carbon formation in the revised LSM (RLSM) form.

Author

N95-34507# Ishikawajima-Harima Heavy Industries Co. Ltd., Tokyo (Japan).

DESIGN OF SECONDARY FLOW CONTROL CASCADE USING NUMERICAL SIMULATION Abstract Only

Y. OHKITA, H. KODAMA, K. KIKUCHI (National Aerospace Lab., Tokyo, Japan.), O. NOZAKI (National Aerospace Lab., Tokyo, Japan.), and A. TAMURA (National Aerospace Lab., Tokyo, Japan.) *In* National Aerospace Lab., Special Publication of National Aerospace Laboratory p 51-55 16 Jun. 1994 *In* JAPANESE
Avail: CASI HC A01/MF A03

The trend of axial turbomachine design is toward higher blade loadings which places more emphasis on secondary flow effects and the associated losses. Measurements of these complex three-dimensional flows in high speed compressor cascades has proven to be very difficult. On the other hand, a sophisticated numerical simulation can predict these flows and the losses successfully. This paper presents the results of a design which aims to reduce secondary flow and the losses at endwall regions of compressor stators, using numerical simulations. a comparison with the results obtained in rig tests will be also presented.

Author

N95-34511# Mitsubishi Heavy Industries Ltd., Tokyo (Japan).

VERIFICATION OF TURBINE CASCADE FLOW WITH TIP CLEARANCE Abstract Only

KUNIHIRO SHIMIZU, YOSHIKI MIYAKE, OSAMU NOZAKI (National Aerospace Lab., Tokyo, Japan.), KAZUO KIKUCHI (National Aerospace Lab., Tokyo, Japan.), and ATSUHIRO TAMURA (National Aerospace Lab., Tokyo, Japan.) *In* National Aerospace Lab., Special Publication of National Aerospace Laboratory p 75-80 16 Jun. 1994 *In* JAPANESE
Avail: CASI HC A02/MF A03

This paper presents verification results of a single stage turbine cascade with tip clearance. The Flow through turbine cascades is calculated by using stage analysis code (CAS3DM) based on Chakravarthy-Osher's TVD scheme developed by National Aerospace Laboratory. The results show good agreements with the experimental data on the total pressure loss of the stator and the total pressure and total temperature distributions of the rotor, indicating the effectiveness of the code as a design tool for estimating loss of the cascade.

Author

N95-34513# Mitsubishi Heavy Industries Ltd., Tokyo (Japan).

CALCULATION OF SUPERSONIC COMBUSTION IN SCRAMJET ENGINES Abstract Only

HIDEYUKI TAGUCHI and YOSHIHIRO KAWAMATA (Tohoku Univ., Japan.) *In* National Aerospace Lab., Special Publication of National Aerospace Laboratory p 87-92 16 Jun. 1994 *In* JAPANESE
Avail: CASI HC A02/MF A03

A numerical simulation code has been carried out to predict flow fields in supersonic combustion ramjet (SCRAMJET) engines. In order to solve supersonic combustion flow fields in the engine, a chemical model was implemented to a 2D/3D supersonic flow simulation code. The purpose of this study was to make a fast and easy code for estimation of sub-scale engine tests. In this study, the Reynolds averaged compressible Navier-Stokes equations and the chemical species continuity equations were solved. The FDS method with the MUSCL approach and the diagonalized IAF method were used to solve the N-S equations. Chemical reactions of hydrogen-air mixture were calculated by the Rogers mode (5-species and 2-equations). Turbulent viscosity was calculated by the Baldwin-Lomax model. Calculations of supersonic combustion were conducted for a simplified model of the SCRAMJET engine. The results showed reasonable phenomena of the supersonic combustion.

Author

N95-34560# Tokyo Univ. (Japan).

STATIC PRESSURE DROP BY SWIRLING FLOW OF AN INTERNAL COOLING AIR SYSTEM THROUGH A TURBINE SHAFT Abstract Only

TADAHARU KISHIBE and SHOJIRO KAJI *In* National Aerospace Lab., Special Publication of National Aerospace Laboratory p 375-381 16 Jun. 1994 *In* JAPANESE
Avail: CASI HC A02/MF A03

High thermal efficiency of the gas turbine is dependent on high turbine entry temperature, which is limited by the turbine blade and nozzle guide vane materials. Cooling these components with internal air system allows their environmental operating temperature to exceed their melting point. The cooling air is taken from the compressor and passes through in the hollow turbine shaft. Generally, it is assumed that any troublesome phenomenon by swirling flow does not occur if the cooling air enters the hollow shaft with the relative tangential velocity equal to zero, i.e., the absolute tangential velocity equal to the circumferential speed of the shaft at the air inlet. In this calculation for an internal cooling air system, however, it is observed that unexpectedly even the relative tangential velocity grows as the rotational speed of the shaft increases, and as a result, static pressure drops remarkably.

Author

N95-34805 Washington Univ., Seattle, WA.

INVESTIGATION OF STARTING AND IGNITION TRANSIENTS IN THE THERMALLY CHOKED RAM ACCELERATOR Ph.D. Thesis

EDWARD ALONZA BURNHAM, JR. 1993 189 p
Avail: Univ. Microfilms Order No. DA9416991

An experimental investigation of the starting transients of the thermally choked ram accelerator is presented. A highly instrumented tube section and instrumentation inserts provide high resolution experimental pressure, luminosity, and electromagnetic data of the starting transients. Detonations are used to estimate induction and reaction times at elevated pressures. Data obtained prior to and following the entrance diaphragm show detailed development of shock systems in both combustible and inert mixtures. With an evacuated launch tube, starting the diffuser is possible at any Mach number above the Kantrowitz Mach number. The detrimental effects and possible solutions of higher launch tube pressures and excessive obturator leakage (blow-by) are discussed. Ignition of a combustible mixture is demonstrated with both perforated and solid obturators. The relative advantages and disadvantages of each are discussed. The source of ignition is identified and discussed. Numerical simulations of various features using Van Leer splitting or advection upwind splitting method (AUSM) are shown and related to experimental observations. Data obtained from these starting experiments enhance the understanding of the ram accelerator, as well as assist in the validation of unsteady, chemically reacting CFD codes.

Dissert. Abstr.

N95-34306# Systems Technology, Inc., Hawthorne, CA.

PROPOSED INCORPORATION OF MISSION-ORIENTED FLYING QUALITIES INTO MIL-STD-1797A Final Report, 15 May 1992 - 15 Aug. 1994

DAVID G. MITCHELL, ROGER H. HOH, BIMAL L. APONSO, and DAVID H. KLYDE Oct. 1994 452 p Prepared in cooperation with HOH Aeronautics, Inc.
(Contract(s)/Grant(s): F33615-92-C-3604)
(AD-A294211; TR-1291-1; WL-TR-94-3162) Avail: CASI HC A20/MF A04

The effort documented in this report was undertaken to revise the flying qualities military standard, MIL-STD-1797A, in both form and content. It was felt that mission-oriented requirements on new systems would expand the applicability of the standard to all tasks performed in an operational environment. This allows replacement of Flight Phases and reference to aircraft weight with a series of Mission- Task-Elements. Demonstration maneuvers are included to be an independent assessment of handling qualities. Additionally, much of the work done in the definition of flying quality criteria in the twelve years since the MIL-STD was originally proposed has been

incorporated. These modifications deal generally with task amplitude, system response type, and control feel system characteristics. Two other important changes are the guidance provided on use of alternative requirements and the linking of flying qualities Levels and the Cooper-Harper Handling Qualities Rating Scale. The results of this effort are expected to be a cornerstone in the process to create MIL-STD-1797B and will be subject to critical review by the aerospace industry as well as a Tri-Service Review Team. DTIC

N95-34772*# University of Central Florida, Orlando, FL.
USER TYPE CERTIFICATION FOR ADVANCED FLIGHT CONTROL SYSTEMS

RICHARD D. GILSON and DAVID W. ABBOTT *In* Embry-Riddle Aeronautical Univ., Daytona Beach, FL, Human Factors Certification of Advanced Aviation Technologies p 119-123 1994
 Avail: CASI HC A01/MF A04

Advanced avionics through flight management systems (FMS) coupled with autopilots can now precisely control aircraft from takeoff to landing. Clearly, this has been the most important improvement in aircraft since the jet engine. Regardless of the eventual capabilities of this technology, it is doubtful that society will soon accept pilotless airliners with the same aplomb they accept driverless passenger trains. Flight crews are still needed to deal with inputting clearances, taxiing, in-flight rerouting, unexpected weather decisions, and emergencies; yet it is well known that the contribution of human errors far exceed those of current hardware or software systems. Thus human errors remain, and are even increasing in percentage as the largest contributor to total system error. Currently, the flight crew is regulated by a layered system of certification: by operation, e.g., airline transport pilot versus private pilot; by category, e.g., airplane versus helicopter; by class, e.g., single engine land versus multi-engine land; and by type (for larger aircraft and jet powered aircraft), e.g., Boeing 767 or Airbus A320. Nothing in the certification process now requires an in-depth proficiency with specific types of avionics systems despite their prominent role in aircraft control and guidance. Author

N95-34806 California Univ., Los Angeles, CA.
A STOCHASTIC ADAPTIVE CONTROL APPLICATION TO FLIGHT SYSTEMS Ph.D. Thesis

GUOHUA H. WANG 1994 119 p
 Avail: Univ. Microfilms Order No. DA9418925

We present the results of our study of stochastic adaptive control theory and its applications to flight control systems. The stochastic adaptive control (SAC) problem of interest may be described as follows: given a stochastic system represented by linear state and observation equations with uncertain parameters, find an adaptive control law which minimizes a quadratic cost functional. We have designed an optimal stochastic adaptive controller for the important class of SAC problems where the system control derivatives are uncertain. Our SAC design incorporates a state and parameter estimator, and a LQG controller, and is automatic (in that it utilizes the state noise process as the identifying excitation). We have established that the parameter estimates converge almost surely, that the adaptive controls are asymptotically optimal, and that the adaptively controlled system is L_2 stable. We have also examined, through computer simulations, several important aspects of the practical application of our SAC to the problem of an aircraft being flown in atmospheric turbulence where the gust response in the angle of attack is to be minimized. The results suggest effectively that the parameter estimation algorithm converges so that optimal performance is achieved rapidly, i.e. the gust response in the angle of attack is reduced quickly to the minimum level achievable when the control derivatives are perfectly known. Simulations also indicate that the SAC design performs well in heavy turbulence. In fact, the rate of adaptation increase with the gust noise level. It is further demonstrated that the SAC performs well when the control derivatives vary slowly. Based upon the speed of adaptation, a threshold value of the wind gust intensity, which

determines if the SAC can adapt parameter changes in an admissible period of time, is approximated. Finally, some future studies are suggested. Dissert. Abstr.

09

RESEARCH AND SUPPORT FACILITIES (AIR)

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

N95-32759# General Accounting Office, Washington, DC.
FACT SHEET FOR CONGRESSIONAL REQUESTERS. AIRPORT COMPETITION: ESSENTIAL AIR SERVICE SLOTS AT O'HARE INTERNATIONAL AIRPORT

4 Mar. 1994 19 p
 (GAO/RCED-94-118FS; B-256330) Avail: CASI HC A03/MF A01; GAO, PO Box 6015, Gaithersburg, MD 20877 HC

This fact sheet responds to a request for information on the availability of air travel between small airports in the Midwest and Chicago's O'Hare International Airport. The Essential Air Service (EAS) program was established in 1978 to guarantee continued service from small airports following deregulation. The program maintains a link between small airports with insufficient enplanements to support service to hub airports, guaranteeing residents of small communities access to the national air travel network. This study found (1) overall service to O'Hare has declined, but some communities have experienced increased service; (2) commuter aviation services in the midwest are becoming increasingly concentrated; (3) fares between small midwestern airports and O'Hare generally are not higher than those to other hubs; (4) airport and airline officials believe O'Hare could accommodate more air traffic through more efficient slot allocation; and (5) improvements at O'Hare are yielding capacity increases. Derived from text

N95-32786# General Accounting Office, Washington, DC. Resources, Community, and Economic Development Div.
REPORT TO THE CHAIRMAN, SUBCOMMITTEE ON TRANSPORTATION AND RELATED AGENCIES, COMMITTEE ON APPROPRIATIONS, US SENATE. AIRPORT IMPROVEMENT PROGRAM: RELIEVER AIRPORT SET-ASIDE FUNDS COULD BE REDIRECTED

30 Jun. 1994 30 p
 (GAO/RCED-94-226; B-257609) Avail: CASI HC A03/MF A01; GAO, PO Box 6015, Gaithersburg, MD 20877 HC

A review of a particular set-aside of the Airport Improvement Program (AIP) that provides AIP funds for projects at general aviation airports called 'relievers' is presented. This set-aside was created by Congress to (1) reduce congestion at commercial airports by improving reliever airports and (2) provide general aviation with additional access to airports. FAA does not consider general aviation to be a significant factor in congestion at commercial airports today. Further, FAA and aviation industry group officials consider access to general aviation facilities to be sufficient - and often more than sufficient - in most areas where relievers are located. FAA still plans to continue to designate 5 percent of all AIP funds to add to the \$2 billion already set aside since 1982 for reliever airport projects. However, FAA does not know whether funding projects at relievers has actually reduced congestion or improved general aviation access to airports, and it has not analyzed whether the relatively small growth in general aviation traffic projected for the next 12 years justifies the expenditure. It is concluded that reliever airport set-aside funds could be redirected. One option is to reduce the number of airports designated as relievers so that only those that currently have the facilities to accommodate large general aviation aircraft - the only forecasted growth segment of general aviation - would be included in the set-aside. A second option is to eliminate

09 RESEARCH AND SUPPORT FACILITIES (AIR)

the designation altogether and have these airports compete with all other general aviation airports for general aviation development funds. CASI

N95-32888# General Accounting Office, Washington, DC. Resources, Community, and Economic Development Div.
REPORT TO THE CHAIRMAN, SUBCOMMITTEE ON TRANSPORTATION AND RELATED AGENCIES, COMMITTEE ON APPROPRIATIONS, US SENATE. AIRPORT IMPROVEMENT PROGRAM: THE MILITARY AIRPORT PROGRAM HAS NOT ACHIEVED INTENDED IMPACT
30 Jun. 1994 34 p
(GAO/RCED-94-209; B-256001) Avail: CASI HC A03/MF A01; GAO, PO Box 6015, Gaithersburg, MD 20877 HC

One set-aside of the Airport Improvement Program (AIP) - the Military Airport Program (MAP) - was established in 1990 to assist current and former military airports located in congested metropolitan areas in converting to civilian airports. This report focuses on whether (1) MAP airports were selected in accordance with program goals of enhancing capacity system-wide and providing conversion-related assistance and (2) FAA has effectively allocated MAP funds to ensure that they are having their intended impact. As implemented, MAP is not having its intended impact. Nine of the 12 airports in MAP do not meet key legislatively established program goals. FAA has not established clear criteria to define what it considers a program-related need, identified airports with such needs located near congested metropolitan areas, or developed an effective strategy or plan for allocating program funds among selected airports. As a result, FAA has no basis for assessing the overall impact of MAP investments and determining if selected airports merit continued participation.

CASI

N95-34342# Army Armament Research, Development and Engineering Center, Picatinny Arsenal, NJ.
ANECHOIC CHAMBER UPGRADE Final Report, Jan. - Aug. 1994

STEVEN WEISS and ANDREW LESHCHYSHYN May 1995 21 p
(AD-A294375; ARAED-TR-95009) Avail: CASI HC A03/MF A01

Hardware and software upgrades have been made recently to an anechoic chamber at the Adelphi Laboratory Center (ALC). A new data acquisition system (using Scientific Atlanta equipment) has been installed and connected to a Dell 386 personal computer. This computer has been dedicated to the chamber to be used solely for data acquisition and analysis. The computer can be connected to the ALC facility network so that data can be downloaded to any location within the ALC campus. DTIC

N95-34344# Dayton Univ., OH. Research Inst.
PERCEPTUAL DIMENSIONS OF SIMULATED SCENES RELEVANT FOR VISUAL LOW-ALTITUDE FLIGHT Interim Report, Jun. 1988 - Nov. 1993

JAMES A. KLEISS Apr. 1995 29 p
(Contract(s)/Grant(s): F33615-90-C-0005)
(AD-A294385; AL/HR-TR-1994-0170) Avail: CASI HC A03/MF A01

Previous experiments using multidimensional scaling reveal that pilots flying at low altitudes perceive two types of detail in real-world scenes: (1) hills and ridges, and (2) discrete scene elements exemplified by large objects or groups of objects. The present experiments sought to determine the extent to which these types of detail can be effectively rendered in computer-generated flight simulator scenes. In Experiment 1, subjects rated the visual similarity between simulated scenes exhibiting a range of different fea-

tures. Ratings were analyzed with multidimensional scaling which revealed that subjects perceived variation in three types of detail: (1) texture on the terrain, (2) objects, and (3) hills. Evidence for a dimension related to texture on the terrain arose from comparisons involving completely featureless surfaces which were not represented in real-world scenes. Field of view was reduced in Experiment 2 and results revealed a change in perceived detail. Texture, objects and hills were perceived in scenes, but they were perceived as being a single type of detail contributing to global scene complexity. Taken together, present results indicate that detail important in real-world scenes can be effectively rendered in simulated scenes. Indeed, present scenes exhibited an even richer variety of detail than real-world scenes used previously. Nevertheless, what is important in scenes is not directly related to specific scene features but to more abstract forms of information mediated by those features. DTIC

N95-34362# Dayton Univ., OH. Research Inst.
ALTITUDE CUING EFFECTIVENESS OF TERRAIN TEXTURE CHARACTERISTICS IN SIMULATED LOW-ALTITUDE FLIGHT Final Technical Report, May 1989 - Jan. 1993

HAROLD D. WARNER, GARY L. SERFOSS, and DAVID C. HUBBARD Mar. 1995 48 p Limited Reproducibility: Document partially illegible

(Contract(s)/Grant(s): F33615-90-C-0005)
(AD-A294369; AL/HR-TR-1994-0168) Avail: CASI HC A03/MF A01

Two experiments were conducted to determine the altitude cuing effectiveness of various terrain texture characteristics in simulated low-altitude flight. In Experiment 1, we compared the effects of five different texture conditions, two types of subjects (pilots versus nonpilots), and direction of altitude change (ascent versus descent) on altitude change discriminability. Results indicated that performance varied significantly as a function of texture, pilots were more sensitive than nonpilots to changes in altitude, and simulated descents were easier to discriminate than ascents. Experiment 2 involved an investigation of the effects of four of the five texture conditions previously used, direction of altitude change, and two levels of texture contrast that simulated normal daytime and dawn/dusk lighting on the detection of change in altitude. We again observed that descents were more discriminable than ascents, but unlike the first experiment, performance did not vary as a function of texture. Further, simulated dawn/dusk terrain lighting did not adversely affect performance. DTIC

N95-34514# National Aerospace Lab., Tokyo (Japan).
NUMERICAL SIMULATION OF HIGH ENTHALPY SHOCK TUNNEL Abstract Only

KATSUHIRO ITOH and MASAHIRO TAKAHASHI (Queensland Univ., Brisbane, Australia.) *In its* Special Publication of National Aerospace Laboratory p 93-98 16 Jun. 1994 In JAPANESE
Avail: CASI HC A02/MF A03

One of the most important problems on a development of a reentry vehicle is the prediction of real gas effect. In order to obtain the real gas data of reentry by ground test, the hypervelocity wind tunnel having extremely high reservoir condition, in which temperature and pressure are up to 10,000K and 1,500atm, is required. A free piston shock tunnel is the most useful facility which can produce such hypervelocity flow. The National Aerospace Laboratory is planning to develop the large free piston shock tunnel which can simulate the reentry of HOPE. In the present paper, CFD applications to the design and operation of the free piston shock tunnel are studied. The two topics are presented. One is the quasi-1D simulation to predict actual performances of free piston shock tunnels. Other is the axisymmetric 2D simulation of the reflected shock-boundary layer interactions to clarify the mechanism of the driver gas contamination. 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.

N95-34500# Air Force Systems Command, Wright-Patterson AFB, OH. National Air Intelligence Center.

THERMAL DESIGN OF RETURNABLE SATELLITES

XU JIWAN 25 Apr. 1995 26 p Transl. into ENGLISH from Zhongguo Kongjian Kexue Jishu, China, Nr. 6, 1990 p 49-56 (AD-A294113; NAIC-ID(RS)T-0558-93) Avail: CASI HC A03/MF A01

This introduces China's returnable satellite thermal control design plans. On the basis of the special characteristics of China's returnable type satellites, it describes the applications of thermal inertia methods in thermal design. Comparisons between ground heat experiment data and flight telemetry temperature data clearly show that the two agree together well. Heat control system operations were normal. Satellite body and satellite interior instrument temperatures all fell relatively well into required ranges. DTIC

11

CHEMISTRY AND MATERIALS

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

A95-96273

NEW EXPERIMENTAL APPROACH TO DETERMINE INITIAL FATIGUE QUALITY WITH FASTENER HOLES

WEI ZHI YI Univ of Nanjing Aeronautics and Astronautics, Nanjing, China Engineering Fracture Mechanics (ISSN 0013-7944) vol. 48, no. 5 July 1994 p. 749-753 refs (BTN-94-EIX94522406136) Copyright

A new experimental approach to determine Initial Fatigue Quality (IFQ) with fastener holes is presented. Theoretical analysis and experiments show the IFQs for each fastener hole on multi-pin joints are in mutual independence during the life test. When small cracks appear on the hole edges, the load distribution for each hole does not change significantly. It is found that replacing traditional dog-bone specimens by specimens with multi-pin joints increases the efficiency more than 10 times. Author (EI)

A95-96655

MODELLING WEAR AT INTERMITTENTLY SLIPPING HIGH SPEED INTERFACES

J. PADOVAN Univ of Akron, Akron, OH, United States and P. PADOVAN Computers and Structures (ISSN 0045-7949) vol. 52, no. 4 August 17 1994 p. 795-812 refs (BTN-94-EIX94511433698) Copyright

A literal multitude of mechanical devices have component parts which undergo intermittent slipping at high speed interfaces. This paper develops a methodology and associated algorithms to model the intermittent wearing process in such zones. This includes the handling of thermomechanically-chemically induced material degradation and its effects on the progressive wearing of the contacting surface. In this context the formulation and associated algorithms must be able to cope with the diversity of problem scales, i.e., macrokinetics and kinematics and local stress, strain, heat transfer, chemistry and material removal. Due to the intermittency of slipping, the model must cope with fluctuating energy transfer rates and the

concomitant effects on the evolving history. For the purposes of demonstration, the model is applied to define tire wear induced during antilock braking system (ABS) controlled stops of aircraft. The generality of the overall scheme is such that a wide variety of problems can be handled, i.e., brake interfaces, clutches, gear pairs, machinery, friction welding, and so on. Author (EI)

A95-96664

RESIDUAL STRENGTH OF COMPOSITES WITH MULTIPLE IMPACT DAMAGE

R. JONES Monash Univ, Clayton, Australia Composite Structures (ISSN 0263-8223) vol. 28, no. 4 1994 p. 347-356 refs (BTN-94-EIX94511433967) Copyright

In recent years attention has focused on damage interaction, with particular emphasis on multi-site damage. Whilst most attention has focused on fuselage lap joints, related problems occur in composite structures which are subjected to multiple impact damage. This paper reveals that for composites there is little interaction between damaged regions, provided they are separated by more than one diameter. This methodology was verified via a coupon test program and an experimental evaluation of two damaged F/A-18 horizontal stabilators. Author (EI)

N95-33278*# Federal Aviation Administration, Atlantic City, NJ.

GAS CHROMATOGRAPHY/ION MOBILITY SPECTROMETRY AS A HYPHENATED TECHNIQUE FOR IMPROVED EXPLOSIVES DETECTION AND ANALYSIS

AL MERCADO and PAUL MARSDEN (Science Applications International Corp., San Diego, CA.) In NASA. Johnson Space Center, Third International Workshop on Ion Mobility Spectrometry p 168-189 Apr. 1995

Avail: CASI HC A03/MF A03

Ion Mobility Spectrometry (IMS) is currently being successfully applied to the problem of on-line trace detection of plastic and other explosives in airports and other facilities. The methods of sample retrieval primarily consist of batch sampling for particulate residue on a filter card for introduction into the IMS. The sample is desorbed into the IMS using air as the carrier and negative ions of the explosives are detected, some as an adduct with a reagent ion such as Cl(-). Based on studies and tests conducted by different airport authorities, this method seems to work well for low vapor pressure explosives such as RDX and PETN, as well as TNT that are highly adsorptive and can be found in nanogram quantities on contaminated surfaces. Recently, the changing terrorist threat and the adoption of new marking agents for plastic explosives has meant that the sample introduction and analysis capabilities of the IMS must be enhanced in order to keep up with other detector developments. The IMS has sufficient analytical resolution for a few threat compounds but the IMS Plasmogram becomes increasingly more difficult to interpret when the sample mixture gets more complex. Derived from text

N95-33408# Lawrence Livermore National Lab., Livermore, CA.

MACHINABILITY STUDY OF AERMET 100

DWIGHT V. SQUIRE, CHOL K. SYN, and BRADLEY L. FIX 8 Feb. 1995 14 p

(Contract(s)/Grant(s): W-7405-ENG-48)

(DE95-011532; UCRL-ID-119964) Avail: CASI HC A03/MF A01

Machinability of Aermet 100, an ultrahigh strength alloy developed for Navy by Carpenter Technology as a candidate material for aircraft landing gear application, was studied by performing single-point turning tests. Coated and uncoated carbides, ceramic, and cermet cutting tool inserts of a square geometry (SNG 432 type) were used. Round stock workpieces were tested in the as-received, unaged condition and without using any cutting fluid. The turning tests for each tool material were conducted by (1) first establishing the cutting conditions that would allow the continued generation of broken chips during a given cutting test; (2) measuring intermittently the flank wear as a function of cutting time under such established cutting conditions for discontinuous broken chips; and (3) determining the tool life using the criteria specified in the ISO Standard 3685:

12 ENGINEERING

1993(E). Cutting tools except some uncoated carbide and ceramic were used with a mechanical chip breaker to induce chip breakage and avoid the generation of long continuous chips. The results obtained include the optimal cutting conditions for discontinuous chips, tool wear - cutting time curves, and records of tool life and tool failure mode for each tool material. From the measured tool life and cutting conditions, the amount of material removed by each cutting material was calculated. Coated carbide with CVD tri-phase coating showed the longest tool life that exceeded the twelve minute criterion and removed the highest amount of material per tool. Other tools failed by cutting edge chipping and their lives were shorter.

DOE

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.

A95-96373 NEW EIGENSOLUTIONS AND MODAL ANALYSIS FOR GYROSCOPIC/ROTOR SYSTEMS, PART 1: UNDAMPED SYSTEMS

W. WANG Carleton Univ, Ottawa, Ont, Canada and J. KIRKHOPE Journal of Sound and Vibration (ISSN 0022-460X) vol. 175, no. 2 August 11 1994 p. 159-170 refs (BTN-94-EIX94522410219) Copyright

This paper presents new eigensolution methods for calculation of the whirl frequencies and critical speeds for gyroscopic/rotor systems without any cross-coupling except gyroscopic forces, and shows that there exists a set of real eigenvectors which constructs a basis for the vector space of such a gyroscopic system. It is shown that the original complex eigenvalue problem can be rearranged into a real eigenvalue problem in terms of two real symmetric matrices which are directly assembled from the original mass, gyroscopic and stiffness matrices. Then a closed form response is derived, and the characteristics of the response are analytically examined by using the real modes. Two numerical examples are presented.

Author (EI)

A95-96374 NEW EIGENSOLUTIONS AND MODAL ANALYSIS FOR GYROSCOPIC/ROTOR SYSTEMS, PART 2: PERTURBATION ANALYSIS FOR DAMPED SYSTEMS

W. WANG Carleton Univ, Ottawa, Ont, Canada and J. KIRKHOPE Journal of Sound and Vibration (ISSN 0022-460X) vol. 175, no. 2 August 11 1994 p. 171-183 refs (BTN-94-EIX94522410220) Copyright

This paper presents a perturbation technique for damped rotor systems with no cross-couplings except gyroscopic effects. As shown, the equation of motion of such a system can be rearranged into a state equation with symmetric coefficient matrices. Based on the eigensolution analysis of the undamped rotor systems, a perturbation analysis for the eigensolution and the response of slightly damped rotor systems is developed, where the damped eigenvectors are expressed as linear combinations of the undamped ones. Only one set of eigenvectors needs to be calculated to decouple the equations of motion because of the symmetrical properties.

Author (EI)

A95-96378 MODAL PARAMETERS FOR CRACKED ROTORS: MODELS AND COMPARISONS

L. HAMIDI Univ of Sherbrooke, Sherbrooke, Que, Canada, J. B.

PIAUD, H. PASTOREL, W. M. MANSOUR, and M. MASSOUD Journal of Sound and Vibration (ISSN 0022-460X) vol. 175, no. 2 August 11 1994 p. 265-278 refs (BTN-94-EIX94522410226) Copyright

Two mathematical models for the study of modal parameters of cracked rotors are presented in this paper. The first model follows a Rayleigh-Ritz approach and the second is based on a finite element strategy. Both models can handle rotating rotors with variable cross-sections, carrying any number of disks, supported on several bearings and having one or more cracks along its length. To validate the above-mentioned models, an exact analytical solution was developed for an idealized rotating rotor with no disks, supported on two bearings and having one crack. This is referred to as the reference case. The paper reports typical results in dimensionless form as obtained from the two models and these are compared with the reference case. Two modal indices were used for presenting the results. One of the indices is proposed and used for the first time by the authors. Recommendations for future work are included in this paper.

Author (EI)

A95-96559 LDV MEASUREMENTS IN SEPARATED FLOW ON AN ELLIPTIC WING MOUNTED AT AN ANGLE OF ATTACK ON A WALL

R. N. PARTHASARATHY Univ of Oklahoma, Norman, OK, United States, A. I. SIRVIENTE, and V. C. PATEL Journal of Fluids Engineering, Transactions of the ASME (ISSN 0098-2202) vol. 116, no. 2 June 1994 p. 258-264 refs (BTN-94-EIX94441380518) Copyright

The flow around a half-ellipsoid with axes ratio 12:6:1 mounted on a plane wall at an angle of attack of 25deg and at a Reynolds number of 47,000 (based on the maximum chord) was studied using a three-dimensional LDV system. In this paper the mean velocity distributions in a volume enclosing the separated region and the near wake are described. The flow is shown to be consistent with the findings of Johnson (1991) based on flow visualization and related topological analysis. The flow on most of the pressure side was attached and laminar, while that on the suction side and in the wake was separated and turbulent. The region of separation had mean negative streamwise velocities as large as 25 percent of the freestream velocity, and the reversed-flow region extended up to one chord length behind the body. The measurements clearly reveal the complex vortex structure that arises from the three-dimensional separation.

Author (EI)

A95-96579 VAN DER POL ABSORBER FOR ROTOR VIBRATIONS

L. CVETICANIN Faculty of Technical Sciences, Novi Sad, Yugoslavia and R. MARETIC Journal of Sound and Vibration (ISSN 0022-460X) vol. 173, no. 2 June 2 1994 p. 145-155 refs (BTN-94-EIX94441385106) Copyright

A type of vibration damper applied to a rotor is described. The damping properties of the absorber are non-linear. The damper transforms the whirling motion of the rotor to a periodic one-line motion. An analytical procedure is developed for analyzing the motion of the non-linear rotor. It is based on the well known asymptotic method of Bogoliubov and Mitropolski. The mathematical model of the rotor is a system of two coupled second order non-linear differential equations. The steady state motion for such a system is always in one direction, which is proved by applying the Hopf bifurcation theorem. The angular position of the vibration motion is obtained analytically.

Author (EI)

N95-32492# Army Communications-Electronics Command, Fort Monmouth, NJ. Space and Terrestrial Communications Directorate.

TACTICAL LOW-LEVEL HELICOPTER COMMUNICATIONS
BERNARD V. RICCIARDI, GEORGE H. HAGN (SRI International Corp., Arlington, VA.), and GERALD AUGUST (SRI International Corp., Menlo Park, CA.) In AGARD, Low-Level and Nap-of-the-

Earth (NOE) Night Operations 13 p Jan. 1995
Copyright Avail: CASI HC A03/MF A03

This paper identifies a systems approach to communications requirements, defines a helicopter communications system model, and describes some potential paths for future investigation and development to improve helicopter communications. The primary focus is on external communications to other helicopters and to ground stations. Derived from text

N95-32501# Defence Research Agency, Bedford (England).
THE ANGLO-FRENCH COMPACT LASER RADAR DEMONSTRATOR PROGRAMME

G. M. HOGG, K. HARRISON, and S. MINISCLOU (STTE, Paris, France.) *In* AGARD, Low-Level and Nap-of-the-Earth (NOE) Night Operations 8 p Jan. 1995
Copyright Avail: CASI HC A02/MF A03

CLARA is an Anglo-French Compact Laser Radar technical demonstrator program. It is a multi-mode CO2 laser radar, the primary mode being cable and obstacle warning, with additional modes including terrain following and a range of targeting modes. The 3 1/2 year program will provide both France and the UK with a podded equipment in 1996. The UK will carry out fixed wing trials and France will fit their pod on a helicopter. The flight trials data are being exchanged between the two countries. Derived from text

N95-32689*# Auburn Univ., AL. Dept. of Mechanical Engineering.
INFLUENCE OF BACKUP BEARINGS AND SUPPORT STRUCTURE DYNAMICS ON THE BEHAVIOR OF ROTORS WITH ACTIVE SUPPORTS Annual Status Report
GEORGE T. FLOWERS Jun. 1995 39 p
(Contract(s)/Grant(s): NAG3-1507)
(NASA-CR-199080; NAS 1.26:199080) Avail: CASI HC A03/MF A01

Progress made in the current year is listed, and the following papers are included in the appendix: Steady-State Dynamic Behavior of an Auxiliary Bearing Supported Rotor System; Dynamic Behavior of a Magnetic Bearing Supported Jet Engine Rotor with Auxiliary Bearings; Dynamic Modelling and Response Characteristics of a Magnetic Bearing Rotor System with Auxiliary Bearings; and Synchronous Dynamics of a Coupled Shaft/Bearing/Housing System with Auxiliary Support from a Clearance Bearing: Analysis and Experiment. For individual titles, see N95-32690 through N95-32693.

N95-32690*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
STEADY-STATE DYNAMIC BEHAVIOR OF AN AUXILIARY BEARING SUPPORTED ROTOR SYSTEM

HUAJUN XIE (Auburn Univ., AL.), GEORGE T. FLOWERS (Auburn Univ., AL.), and CHARLES LAWRENCE *In* Auburn Univ., Influence of Backup Bearings and Support Structure Dynamics on the Behavior of Rotors with Active Supports 11 p Jun. 1995 Presented at the ASME International Mechanical Engineering Congress and Exposition: Symposium on Nonlinear and Stochastic Dynamics, Chicago, IL, 13-18 Nov. 1994
Avail: CASI HC A03/MF A01

This paper investigates the steady-state responses of a rotor system supported by auxiliary bearings in which there is a clearance between the rotor and the inner race of the bearing. A simulation model based upon the rotor of a production jet engine is developed and its steady-state behavior is explored over a wide range of operating conditions for various parametric configurations. Specifically, the influence of rotor imbalance, support stiffness, and damping is studied. It is found that imbalance may change the rotor responses dramatically in terms of frequency contents at certain operating speeds. Subharmonic responses of 2nd order through 10th order are all observed except the 9th order. Chaotic phenomenon is also observed. Jump phenomena (or double-valued responses) of both hard-spring type and soft-spring type are shown to

occur at low operating speeds for systems with low auxiliary bearing damping or large clearance even with relatively small imbalance. The effect of friction between the shaft and the inner race of the bearing is also discussed. Author

N95-32691*# Auburn Univ., AL. Dept. of Mechanical Engineering.
DYNAMIC BEHAVIOR OF A MAGNETIC BEARING SUPPORTED JET ENGINE ROTOR WITH AUXILIARY BEARINGS

GEORGE T. FLOWERS, HUAJUN XIE, and S. C. SINHA *In* its Influence of Backup Bearings and Support Structure Dynamics on the Behavior of Rotors with Active Supports 6 p Jun. 1995 Presented at the First Industry/University Symposium on High Speed Transport Vehicles, Greensboro, NC, 4-6 Dec. 1994
Avail: CASI HC A02/MF A01

This paper presents a study of the dynamic behavior of a rotor system supported by auxiliary bearings. The steady-state behavior of a simulation model based upon a production jet engine is explored over a wide range of operating conditions for varying rotor imbalance, support stiffness, and damping. Interesting dynamical phenomena, such as chaos, subharmonic responses, and double-valued responses, are presented and discussed. Author

N95-32692*# Auburn Univ., AL. Dept. of Mechanical Engineering.
DYNAMIC MODELLING AND RESPONSE CHARACTERISTICS OF A MAGNETIC BEARING ROTOR SYSTEM WITH AUXILIARY BEARINGS

APRIL M. FREE, GEORGE T. FLOWERS, and VICTOR S. TRENT *In* its Influence of Backup Bearings and Support Structure Dynamics on the Behavior of Rotors with Active Supports 8 p Jun. 1995 Presented at the 15th Biennial ASME Vibrations Conference, Boston, MA, 17-21 Sep. 1995
Avail: CASI HC A02/MF A01

Auxiliary bearings are a critical feature of any magnetic bearing system. They protect the soft iron core of the magnetic bearing during an overload or failure. An auxiliary bearing typically consists of a rolling element bearing or bushing with a clearance gap between the rotor and the inner race of the support. The dynamics of such systems can be quite complex. It is desired to develop a rotordynamic model which describes the dynamic behavior of a flexible rotor system with magnetic bearings including auxiliary bearings. The model is based upon an experimental test facility. Some simulation studies are presented to illustrate the behavior of the model. In particular, the effects of introducing sideloads from the magnetic bearing when one coil fails is studied. Author

N95-32693*# Auburn Univ., AL.
SYNCHRONOUS DYNAMICS OF A COUPLED SHAFT/ BEARING/HOUSING SYSTEM WITH AUXILIARY SUPPORT FROM A CLEARANCE BEARING: ANALYSIS AND EXPERIMENT

JAMES L. LAWEN, JR. and GEORGE T. FLOWERS *In* its Influence of Backup Bearings and Support Structure Dynamics on the Behavior of Rotors with Active Supports 8 p Jun. 1995 Presented at the International Gas Turbine and Aeroengine Congress and Exposition, Houston, TX, 5-8 Jun. 1995 Submitted for publication in the Transactions of the ASME
(Contract(s)/Grant(s): NGT-70312)
Avail: CASI HC A02/MF A01

This study examines the response of a flexible rotor supported by load sharing between linear bearings and an auxiliary clearance bearing. The objective is to develop a better understanding of the dynamical behavior of a magnetic bearing supported rotor system interacting with auxiliary bearings during a critical operating condition. Of particular interest is the effect of coupling between the bearing/housing and shaft vibration on the rotordynamical responses. A simulation model is developed and a number of studies are performed for various parametric configurations. An experimental investigation is also conducted to compare and verify the rotordynamic

12 ENGINEERING

behavior predicted by the simulation studies. A strategy for reducing synchronous shaft vibration through appropriate design of coupled shaft/bearing/housing vibration modes is identified. Author

N95-32787# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany). Abt. Operative Planung.
A NONLINEAR VORTEX LATTICE METHOD FOR UNSTEADY FLOW WITH SEPARATED VORTEX
ZHENG-YIN YE Dec. 1994 33 p Sponsored by Alexander von Humboldt Foundation
(DLR-FB-94-32; CSD-95-98140) Avail: CASI HC A03/MF A01; DLR, Abt. Operative Planung, D-51140 Cologne, Germany, HC

An improved nonlinear vortex lattice method to simulate steady and unsteady flows for wings with leading edge and/or tip vortex separation at moderate or high angles of attack is presented. A type of vortex lattice shape along the leading edge is introduced and a multistep method for determining the position of the free vortex sheets which move downstream in the flow field is presented. This method can predict much more stable results for wings with leading edge separated vortex when undergoing very rapid and large amplitude movements. The calculated airloads agree well with the experiments. Author

N95-32822*# Michigan Univ., Ann Arbor, MI. Radiation Lab.
SIMULATION OF PATCH AND SLOT ANTENNAS USING FEM WITH PRISMATIC ELEMENTS AND INVESTIGATIONS OF ARTIFICIAL ABSORBER MESH TERMINATION SCHEMES
J. GONG, T. OZDEMIR, J VOLAKIS, and M. NURNBERGER Jul. 1995 91 p
(Contract(s)/Grant(s): NAG1-1478)
(NASA-CR-198974; NAS 1.26:198974; REPT-030601-5-T) Avail: CASI HC A05/MF A01

Year 1 progress can be characterized with four major achievements which are crucial toward the development of robust, easy to use antenna analysis code on doubly conformal platforms. (1) A new FEM code was developed using prismatic meshes. This code is based on a new edge based distorted prism and is particularly attractive for growing meshes associated with printed slot and patch antennas on doubly conformal platforms. It is anticipated that this technology will lead to interactive, simple to use codes for a large class of antenna geometries. Moreover, the codes can be expanded to include modeling of the circuit characteristics. An attached report describes the theory and validation of the new prismatic code using reference calculations and measured data collected at the NASA Langley facilities. The agreement between the measured and calculated data is impressive even for the coated patch configuration. (2) A scheme was developed for improved feed modeling in the context of FEM. A new approach based on the voltage continuity condition was devised and successfully tested in modeling coax cables and aperture fed antennas. An important aspect of this new feed modeling approach is the ability to completely separate the feed and antenna mesh regions. In this manner, different elements can be used in each of the regions leading to substantially improved accuracy and meshing simplicity. (3) A most important development this year has been the introduction of the perfectly matched interface (PMI) layer for truncating finite element meshes. So far the robust boundary integral method has been used for truncating the finite element meshes. However, this approach is not suitable for antennas on nonplanar platforms. The PMI layer is a lossy anisotropic absorber with zero reflection at its interface. (4) We were able to interface our antenna code FEMA_CYL (for antennas on cylindrical platforms) with a standard high frequency code. This interface was achieved by first generating equivalent magnetic currents across the antenna aperture using the FEM code. These currents were employed as the sources in the high frequency code. Derived from text

N95-32902 Michigan Univ., Ann Arbor, MI.
NEAR-LIMIT DROP DEFORMATION AND SECONDARY BREAKUP Ph.D. Thesis
LIEN-PENG HSIANG 1994 149 p

Avail: Univ. Microfilms Order No. DA9423210

An experimental study of the deformation and breakup of liquid drops subjected to both shock wave and steady disturbances is described, emphasizing effects of Weber number, We , and Ohnesorge number, Oh , for various deformation and breakup regimes. Measurements included pulsed shadowgraphy and holography to find drop deformation and drag properties prior to breakup, as well as drop sizes and velocities after breakup. Simplified phenomenological theories were used to help interpret and correlate the measurements. For shock wave disturbances, drop deformation and breakup regimes were identified in terms of We and Oh : regimes at low Oh included no deformation, nonoscillatory deformation, oscillatory deformation, bag breakup, multimode breakup, and shear breakup as We is increased. For We less than 1000, breakup no longer is possible for Oh greater than 10 while 5 percent deformation no longer is possible for Oh greater than 1000. Unified temporal scaling of deformation and breakup processes was observed in terms of a characteristic breakup time that largely was a function of Oh . Prior to breakup, the drag coefficient evolved from the properties of spheres to those of thin disks as drop deformation progressed. Measurements of drop properties after secondary breakup were limited to low Oh conditions. Drop size distributions after breakup satisfied Simmon's universal root normal distribution function in all three breakup regimes, after removing the core drop from the drop population for shear breakup. The Sauter mean diameter after breakup was correlated successfully, independent of the breakup regime, based on consideration of drop stripping in the shear breakup regime. The size and velocity of the core drop after shear breakup were correlated separately, based on the observation that the end of drop stripping corresponded to a constant Eotvos number. The relative velocities of the drop liquid were significantly reduced during secondary breakup, due both to the large drag coefficients caused by drop deformation and the reduced relaxation times of small drops. These effects were correlated successfully, using phenomenological theory. For steady disturbances, significant drop deformation (roughly 5 percent) began at a We of roughly unity, with the deformation regime ending due to the onset of breakup at We in the range of 10-20. These transitions were relatively unaffected by Oh . Another transition, between dome- and bowl-shaped drops (related to the transition between bag and shear breakup), was correlated mainly in terms of We and Re for present conditions. Drop deformation for steady disturbances was relatively independent of dispersed/continuous phase density ratios but generally was smaller than for shock wave disturbances at comparable conditions due to the absence of overshoot from inertial effects. In contrast, drop drag coefficients, normalized by the drag coefficient of a solid sphere at the same Re , was correlated quite well by the degree of deformation alone. Dissert. Abstr.

N95-32920 Rutgers - The State Univ., New Brunswick, NJ.
MODAL IDENTIFICATION AND ITS APPLICATIONS TO DAMAGE DETECTION IN VIBRATING STRUCTURES Ph.D. Thesis
SANTOSH RATAN 1994 169 p
Avail: Univ. Microfilms Order No. DA9421828

The present research is concerned with the development and application of identification of various parameters in a vibrating structure. The various applications of the identification procedures include modification in the modeling of a structure, detecting damages, and knowing a boundary condition in a given structure. This is achieved in two steps: identification of the eigensolution, and using the identified eigensolution to detect cracks and other parameters. The first step is based on the scheme developed by Baruh, Khatri, and Boka. This scheme uses a transient vibration response and the knowledge of the mass properties of the system. The scheme is applied to an experimental data set and it is found that the analytical model of the structure was very close to exact, but a small correction was required. A new concept called 'residue' is introduced to detect cracks in a vibrating structure. Residue is based on the modeled mass and stiffness matrix and the identified eigenvalues and eigenvectors of the structure. This method is successfully applied to a truss

structure. A modified definition of 'residue' is proposed for the application of crack detection in a rotating system. This modification is necessary as an extra gyroscopic effect is associated with a rotating system. The modified method is used to detect a crack in rotors. In some practical cases, it is unavoidable that the system's mass properties are incorrectly known. In such situations the crack detection scheme and identification of stiffness properties can be erroneous. To combat this situation a new scheme to identify mass parameters is introduced. This scheme uses approximate mass properties of the system and the identified eigenvalues and eigenvectors of the system. The known mass parameters act as constraints in the identification procedure. Hence, an iterative method is resulted. The method, in conjunction with known constraints, can identify the mass parameters with high accuracy. Finally, these developed methods are applied to more general cases where more than one property of the system are unknown or wrongly known. To handle a general case, a sequential identification scheme is developed where one or more of the identification schemes developed are used in a sequence. This sequence is not known a priori, and depends on the outcome of each step. Several examples are solved in this dissertation to illustrate the ideas and validate the various propositions. Dissert. Abstr.

N95-32930*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

REVIEW OF COMBUSTION-ACOUSTIC INSTABILITIES

AYO OYEDIRAN (AYT Corp., Brook Park, OH.), DOUGLAS DARLING, and KRISHNAN RADHAKRISHNAN (NYMA, Inc., Brook Park, OH.) Aug. 1995 12 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): NAS3-27571; NAS3-27186; RTOP 537-02-21)

(NASA-TM-107020; E-9825; NAS 1.15:107020; AIAA PAPER 95-2469) Avail: CASI HC A03/MF A01

Combustion-acoustic instabilities occur when the acoustic energy increase due to the unsteady heat release of the flame is greater than the losses of acoustic energy from the system. The problem of combustion-acoustic instability is a concern in many devices for various reasons, as each device may have a unique mechanism causing unsteady heat release rates and many have unique boundary conditions. To accurately predict and quantify combustion-acoustic stabilities, the unsteady heat release rate and boundary conditions need to be accurately determined. The present review brings together work performed on a variety of practical combustion devices. Many theoretical and experimental investigations of the unsteady heat release rate have been performed, some based on perturbations in the fuel delivery system particularly for rocket instabilities, while others are based on hydrodynamic processes as in ramjet dump combustors. The boundary conditions for rocket engines have been analyzed and measured extensively. However, less work has been done to measure acoustic boundary conditions in many other combustion systems. Author

N95-33059# Royal Inst. of Tech., Stockholm (Sweden). Dept. of Numerical Analysis and Computing Science.

TURBULENCE MODELS IN THE NAVIER-STOKES SIMULATION OF AIRFOIL STALL

CARLOS WEBER 1993 63 p Prepared in cooperation with Stockholm Univ., Sweden

(TRITA-NA-9312) Avail: CASI HC A04/MF A01

The low-speed flow around a two-dimensional airfoil near stall has been calculated, using a Navier-Stokes multiblock flow solver with a cell-centered finite volume technique and explicit Runge Kutta time-stepping scheme. Two different turbulence models have been implemented in the code: the Baldwin-Lomax model and the Kappa-Tau model. The computations were carried out for angles of attack of 7.2 degrees, 12.3 degrees, and 13.2 degrees. The latter is hereby close to the stall limit. Comparison of computed data with experimental data show that the Baldwin-Lomax model is in quite good agreement with the experiments, although the wall shear stresses are calculated too small. But it fails to predict the separation zone at

high angles of attack and therefore the lift coefficients near stall are over-predicted. Small differences between the medium and fine grid show that the latter might be fine enough to yield sufficient results. During the computations using the Kappa-Tau model several problems with the range of the Kappa- and Tau-values appeared which led to some modifications in the code. The results of the Kappa-Tau model are in rather poor agreement with the experimental data. Nevertheless an improvement of the viscous forces compared to the Baldwin-Lomax model can be seen. The poor results are probably due to the fact that the grid sizes for the Kappa-Tau model are still too coarse and the stretching of the grid is too large. Computations with finer grid sizes have to be carried out to show if the results can be improved. CASI

N95-33137# Eurocopter Deutschland G.m.b.H., Munich (Germany).

HELIRADAR: A ROTATING ANTENNA SYNTHETIC APERTURE RADAR FOR HELICOPTER ALLWEATHER OPERATIONS

W. KREITMAIR-STECK and A. P. WOLFRAMM (Deutsche Aerospace A.G., Munich, Germany.) In AGARD, Dual Usage in Military and Commercial Technology in Guidance and Control 8 p Mar. 1995 Copyright Avail: CASI HC A02/MF A02

Today, available radar instruments cannot be applied for flight guidance purposes due to lack of resolution and ground elevation information. On the other side, optical sensors such as infrared systems provide an excellent resolution but are nearly blind at adverse weather conditions such as fog and rain. A new radar technology called ROSAR (Synthetic Aperture Radar based on ROTating antennas) promises to overcome the deficiencies of the traditional radar systems. On the basis of encouraging research work on ROSAR-technology and an investigation of the feasibility of a piloting system based on these ideas, Eurocopter Deutschland and Deutsche Aerospace started a development program called HeliRadar to develop a ROSAR-based piloting system. This device should be able to provide photolike images even under extreme visibility conditions. Details on the investigation and the resulting concepts for synthetic vision based flight guidance at Eurocopter will be given. Following an introduction to the basics of ROSAR-technology, the technical concept of HeliRadar will be presented. The paper concludes with a discussion of the perspectives for civil and military applications. Derived from text

N95-33143# SPEEL Ltd., Prague (Czechoslovakia).

SOLID-STATE DATA RECORDER, NEXT DEVELOPMENT AND USE

J. VIDIECAN, J. KOZAK, K. HORAK, and J. SVOBODA In AGARD, Dual Usage in Military and Commercial Technology in Guidance and Control 10 p Mar. 1995

Copyright Avail: CASI HC A02/MF A02

The use of data recorders on-board aircraft for crash and later for maintenance and logistic purposes is well known. Due to higher requirements for safety and economy of ground transport vehicles operation, such devices are already used in selected types of these vehicles. The use of new technology - solid-state memories - enables the increase of technical parameters of such recorders (number of registered parameters, MTBF), reduces the mass, space and requirements on technical assistance during operation. In this paper a technical description of such recorders for aircraft and ground based vehicles is given. Also, results of recent applications of these devices and different methods and software for evaluation are also presented. Derived from text

N95-33754*# Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA.

IN-FLIGHT RADIOMETRIC CALIBRATION OF AVIRIS IN 1994

ROBERT O. GREEN, JAMES E. CONEL (California Univ., Santa Barbara, CA.), MARK HELMLINGER (California Univ., Santa Barbara, CA.), JEANNETTE VANDENBOSCH (California Univ., Santa Barbara, CA.), and PAVEL HAJEK (California Univ., Santa Barbara, CA.) In its Summaries of the Fifth Annual JPL Airborne Earth

12 ENGINEERING

Science Workshop. Volume 1: AVIRIS Workshop p 83-86 23 Jan. 1995

Avail: CASI HC A01/MF A02

The AVIRIS sensor must be calibrated at the time it measures spectra from the ER-2 airborne platform in order to achieve research and application objectives that are both quantitative and physically based. However, the operational environment inside the Q-bay of the ER-2 at 20 km altitude differs from that in the AVIRIS laboratory with respect to temperature, pressure, vibration, and high-frequency electromagnetic fields. Experiments at surface calibration targets are used in each flight season to confirm the accuracy of AVIRIS in-flight radiometric calibrations. For these experiments, the MODTRAN radiative transfer code is constrained by using in situ measurements to independently predict the upwelling spectral radiance arriving at AVIRIS for a specific calibration target. AVIRIS calibration is validated in flight by comparing the MODTRAN-predicted radiance to the laboratory-calibrated radiance measured by the AVIRIS sensor for the same time over the calibration target. We present radiometric calibration results for the AVIRIS in-flight calibration experiment held at the beginning of the 1994 flight season. Derived from text

N95-34343# Cambridge Hydrodynamics, Inc., Princeton, NJ.
NUMERICAL STUDIES OF TURBULENCE FREE SURFACE FLOWS AND UNSTEADY PROPELLER FLOWS Final Report, 1 Jan. 1990 - 31 Mar. 1995

STEVEN A. ORSZAG, VADIM BORUE, ILYA STAROSELSKY, and YANSI ZHANG 31 Mar. 1995 62 p
(Contract(s)/Grant(s): N00014-90-C-0039)
(AD-A294377) Avail: CASI HC A04/MF A01

Two main problems have been studied, viz. the structure of turbulence near a free surface and the Reynolds-averaged solution of unsteady propeller/hydrofoil flows by the renormalization group (RNG) two-equation turbulence transport model. A variety of free-surface turbulence simulations demonstrate the key modifications in turbulence structure due to the free surface. In addition, we determine the modifications in surface wave spectra due to the turbulence beneath the free surface as typically represented by a renormalized dispersion relation. The results for unsteady hydrofoils show the power of the RNO method in robustly and accurately treating large-scale unsteady and transitional flows, a marked improvement over previous turbulence transport models. DTIC

N95-34449 Department of the Navy, Washington, DC.
ENERGY ABSORPTION DEVICE FOR SHOCK LOADING Patent

C. D. HOWARD, inventor (to Navy), DONALD E. LAGRANGE, inventor (to Navy), DAVID A. BEATTY, inventor (to Navy), and DAVID C. LITTMAN, inventor (to Navy) 28 Feb. 1995 5 p Filed 30 Jun. 1993

(AD-D017476; US-PATENT-5,393,016; US-PATENT-APPL-SN-083602; US-PATENT-CLASS-244-138) Avail: US Patent and Trademark Office

A shock energy absorbing device provides shock protection for the riser line employed to attach an aerodynamic deceleration device to a primary body during deployment of the system into an airstream. During deployment, for example, by dropping an unopened parachute and attached load or by rocket delivery of the unopened parachute and attached load, the parachute is made to open at a desired altitude whereupon very large shock tension forces are generated which are applied to the line. In order to protect the line from failing under these forces and to reduce the requirement for a bulky, heavy line, a shock absorber is provided in the form of a block having one or more breakable web portions formed therein and through which the riser line is threaded. Upon deployment of the system into an airstream, the shock tension forces operate to fracture some or all of the breakable web portions thereby dissipating the shock energy generated during deployment and protecting the riser line from failure. DTIC

N95-34508# Tokyo Univ. (Japan). Graduate School.
A STUDY ON THE CONVERGENCE OF A 3-D EULER CODE

FOR CASCADE FLOW CALCULATIONS Abstract Only

DAISAKU MASAKI and SHOJIRO KAJI In National Aerospace Lab., Special Publication of National Aerospace Laboratory p 57-62 16 Jun. 1994 In JAPANESE

Avail: CASI HC A02/MF A03

A three-dimensional Euler code for cascade flow calculation has been developed to investigate unsteady flow phenomena such as rotating stall or surge. The time-dependent Euler solvers provide a single approach for subsonic, transonic and supersonic flows, and have inherent shock capturing capability. So they can provide important information of flow field such as shock location and pressure distribution. Moreover, they form a very essential part of N-S solvers, so it is important to develop a robust, accurate, and convergent Euler code. During this development, an insight which is thought to be important is obtained. There exists ambiguity about 'Roe's averaging' on density, and it was found that if this density average is used in appropriate ways, it is not only analytically incorrect, but can have detrimental effects on numerical simulations. The example for such a case is shown. also, the result for a transonic compressor rotor cascade at its design point is presented. Author

N95-34512# Ishikawajima-Harima Heavy Industries Co. Ltd., Tokyo (Japan).

A STUDY OF SUPERSONIC MIXING FLOW FIELD WITH RAMP INJECTOR Abstract Only

YOSHIYUKI YAMANE, SEIICHI SAWAGUCHI, YASUNORI ANDO, SHIGERU ASO (Kyushu Univ., Kasuga, Japan), and MASAHIRO FUKUDA (National Aerospace Lab., Tokyo, Japan.) In National Aerospace Lab., Special Publication of National Aerospace Laboratory p 81-86 16 Jun. 1994 In JAPANESE
Avail: CASI HC A02/MF A03

The purposes of the present paper are to investigate the structure of supersonic mixing flow field in ram/scramjet combustor and to develop the CFD code which will be used for the design of the combustor. One type of parallel injection method with ramp injector has been studied numerically and experimentally. The patterns of shock waves obtained by numerical simulations agreed with experimental results in schlieren photograph. Comparisons of static pressure distributions on the wall surface showed good agreement qualitatively. Numerical results captured the structures of flow field clearly, which were generating process of a pair of streamwise vortices and vortical roll-up of the jet. Oblique shocks made injectant gas lift off from wall surface, as found in calculations and experiments. According to these results, it could be said that the CFD code used in this study was useful for investigation of fuel-air mixing in supersonic flow field with parallel injection. From the numerical results, it was confirmed that the streamwise vortices generated by ramp injector and interaction between mixing field and oblique shocks were key factors for enhancement of fuel-air mixing in ram/scramjet combustor. Author

N95-34530# National Aerospace Lab., Tokyo (Japan).
DIRECT NUMERICAL SIMULATION OF INCOMPRESSIBLE HOMOGENEOUS ISOTROPIC TURBULENCE USING NWT Abstract Only

KIYOSHI YAMAMOTO, IWAO HOSOKAWA (University of Electro-Communications, Tokyo, Japan.), and SHIN-ICHI OIDE (University of Electro-Communications, Tokyo, Japan.) In its Special Publication of National Aerospace Laboratory p 195-200 16 Jun. 1994 In JAPANESE

Avail: CASI HC A02/MF A03

Direct numerical simulation (DNS) of incompressible homogeneous isotropic turbulence is conducted by the use of the Numerical Wind Tunnel (NWT), a parallel computer introduced to NAL last year. The DNS with 512 mesh points in space can be calculated by the NWT with 128 processor elements. The fully developed turbulent fields, velocity and temperature, are obtained by the DNS which used the Fourier spectral method for calculation of the Navier-stokes equation and the diffusion equation. The energy spectrum obtained takes the $K^{-5/3}$ power law in the inertial subrange. The probability distribution function has the Gaussian distribution for the

velocity, but exponential function for the various velocity derivatives. The intense vorticity concentrates into short tube-like regions in space, but the temperature gradient into sheet-like regions. Author

N95-34533# National Aerospace Lab., Tokyo (Japan).
**PERFORMANCE EVALUATION OF THE NWT WITH
 INCOMPRESSIBLE NS CODE Abstract Only**

TAKASHI NAKAMURA and MASAHIRO YOSHIDA *In its* Special Publication of National Aerospace Laboratory p 213-218 16 Jun. 1994 In JAPANESE
 Avail: CASI HC A02/MF A03

We parallelized an incompressible CFD code to evaluate the effectiveness of the Numerical Wind Tunnel (NWT) for a code with small operations per grid point. The original CFD code is based on the MAC method and solved by the SOR method. Since the SOR iterative algorithm is not suitable for vector computers nor parallel computers, various methods to vectorize have been proposed. We chose the red and black method, a modified version. This method imposes smaller operations per grid point and less time of data transfer per iteration than compressible CFD codes with IAF methods. This study shows the parallelization performance on the NWT with the code. Author

N95-34536# National Aerospace Lab., Tokyo (Japan).
**AN UNSTEADY SIMULATION OF A CENTRIFUGAL
 COMPRESSOR STAGE USING THE NWT Abstract Only**

TAKASHI YAMANE *In its* Special Publication of National Aerospace Laboratory p 231-235 16 Jun. 1994 In JAPANESE
 Avail: CASI HC A01/MF A03

Numerical calculations have been performed for the analysis of the impeller/diffuser interaction flow field of a centrifugal compressor using the Numerical Wind Tunnel (NWT) system. The three dimensional unsteady simulation took enormous calculation time but the parallel processing on the NWT solved its problem. The calculation using 16 processor elements (PE) achieved 11 times faster speed than on a single PE. Author

N95-34539# Kawasaki Heavy Industries Ltd., Tokyo (Japan). Technical Inst.

**A LARGE SCALE 3D NAVIER-STOKES ANALYSIS USING
 NAL-NWT Abstract Only**

TAKUJI KISHIMOTO *In* National Aerospace Lab., Special Publication of National Aerospace Laboratory p 249-253 16 Jun. 1994 In JAPANESE
 Avail: CASI HC A01/MF A03

Parallelization of 3D Navier-Stokes analysis using a structured multi-block grid has been achieved by a domain decomposition method with message passing procedure. Modification of existent solver can be done easily, because added procedures for parallelization are only the domain decomposition routine and the inter domain communication of boundary conditions between each neighboring subdomains, that is message passing procedure, and there is no need to modify main routines. NWT(Numerical Wind Tunnel) of National Aerospace Laboratory(NAL) was used in order to investigate the effect of parallelization. A parallelized flow analysis around alone swept wing using about 1 million grid points and 4PE(Processor Element)s was accelerated about 3 times faster than using single PE. We also got the result that a larger scale flow analysis around complete configuration of ONERA-M5 model using over 5 million grid points and 16PEs was accelerated about 12 times faster than using FACOM VP-400. Author

N95-34540# Kawasaki Heavy Industries Ltd., Tokyo (Japan). Technical Inst.

**ROLE OF COMPUTATIONAL FLUID DYNAMICS IN
 AERONAUTICAL ENGINEERING. NUMBER 12:
 FORMULATION AND VERIFICATION OF UNI-PARTICLE
 UPWIND SCHEMES FOR THE EULER EQUATIONS Abstract
 Only**

EIJI SHIMA and TADAMASA JOUNOUCHI (National Aerospace Lab., Tokyo, Japan.) *In* National Aerospace Lab., Special Publica-

tion of National Aerospace Laboratory p 255-260 16 Jun. 1994 In JAPANESE

Avail: CASI HC A02/MF A03

A new approach to construct upwind schemes for the Euler equations is shown. This approach uses a simple flux splitting with the mass flux of some approximate Riemann solver. Two schemes based on this approach, which are SFS2 (Simplified Flux Splitting 2) and SHUS (Simple High-resolution Upwind Scheme), are proposed and are verified by some tests. Both schemes are as simple, robust and accurate for discontinuities and boundary layers as any other existing scheme. Author

N95-34597# Iowa State Univ. of Science and Technology, Ames, IA.

**NONLINEAR STABILITY OF UNSTEADY VISCOUS FLOW
 Final Technical Report**

A. P. ROTHMAYER 25 Apr. 1995 98 p
 (Contract(s)/Grant(s): F49620-92-J-0097)
 (AD-A294931; AFOSR-95-0382TR) Avail: CASI HC A05/MF A02

The stability and development of unsteady separation on airfoil leading edges has been investigated. In particular, attention was focused on investigations of 2D unsteady incompressible flow past a parabola at angle of attack which models the leading edge of many airfoils. This study has direct application to leading edge stall (LES) and thin airfoil stall as well as unsteady flow past leading edges. The general character of much of this study allows for application to other classes of unsteady boundary layer flow. DTIC

N95-34818# Arnold Engineering Development Center, Arnold AFS, TN.

**SUBSCALE STUDY OF ENGINE BELLMOUTH INLET
 VORTICES IN TEST CELL R1D Final Report, Oct. 1992 -
 Sep. 1994**

JAMES A. REED and ROBERT S. HIERS, JR. May 1995 124 p
 (AD-A294993; AEDC-TR-95-5) Avail: CASI HC A06/MF A02

A technology program was conducted in Test Cell R1D concerning bellmouth flow quality. Flow visualization was used to determine the presence of inlet vortices. It was shown that these vortices can be eliminated using a 45-deg conical extension attached to the bellmouth inlet. Design guidelines were developed to assist in determining acceptable cone angles and axial and radial gaps between the conical extension and the bellmouth inlet. DTIC

N95-32685# National Renewable Energy Lab., Golden, CO.

**TECHNIQUES FOR THE DETERMINATION OF LOCAL
 DYNAMIC PRESSURE AND ANGLE OF ATTACK ON A
 HORIZONTAL AXIS WIND TURBINE**

D. E. SHIPLEY, M. S. MILLER, M. C. ROBINSON, M. W. LUTTGES, and D. A. SIMMS May 1995 57 p
 (Contract(s)/Grant(s): DE-AC36-83CH-10093)
 (DE95-009204; NREL/TP-442-7393) Avail: CASI HC A04/MF A01

Data from the National Renewable Energy Laboratory's Combined Experiment has been utilized to develop techniques for indirectly calculating the instantaneous local dynamic pressure and angle of attack on a horizontal axis wind turbine. First, an analytic model based upon inflow geometry relative to the wind turbine was developed for both parameters. Second, dynamic pressure and angle of attack were inferred from the pressure required to normalize the blade stagnation point to $C_{(sub\ p)} = 1.0$. Third, rotor blade pressure profiles were compared to those from wind tunnel tests to determine angle of attack. Test results are shown over a variety of typical inflow conditions and are corroborated by measured data. Differences between the calculated and measured values are also discussed. DOE

N95-32823*# Georgia Inst. of Tech., Atlanta, GA. School of Electrical and Computer Engineering.

**AIRBORNE PASSIVE POLARIMETRIC MEASUREMENTS OF
 SEA SURFACE ANISOTROPY AT 92 GHZ**

D. B. KUNKEE and A. J. GASIEWSKI 1994 3 p
 (Contract(s)/Grant(s): NAG5-1490)

12 ENGINEERING

(NASA-CR-197288; NAS 1.26:197288) Avail: CASI HC A01/MF A01

The potential for remote sensing of ocean wave direction using passive polarimetric microwave observations was investigated. A fixed-beam 91.65 GHz polarimetric radiometer was mounted on the NASA DC-8 aircraft during the Tropical Ocean Global Atmosphere/Coupled Ocean Atmosphere Response Experiment (TOGA/COARE January - February 1993). Several experiments were performed during which the DC-8 was flown in constant bank-angle turns at approximately 1.5 km altitude to obtain azimuthal scans of the sea surface at fixed observation angles. Data at 65 deg from nadir are consistent with previous findings using 19 and 37 GHz Special Sensor Microwave Imager (SSM/1) satellite observations and support the claim that a broadband emission mechanism is responsible for the azimuthal brightness signatures. Accordingly, a tilted-facet geometrical optics (GO) model of the surface was developed to investigate emission from deterministic and random striated surfaces. Laboratory measurements of polarimetric emission at 92 GHz from small-amplitude water-waves corroborate this model. Author

N95-33141# Saint Petersburg Inst. of Aerospace Instrumentation, Saint Petersburg (Russia).

SEA WAVE PARAMETERS, SMALL ALTITUDES AND DISTANCES MEASUREMENTS DESIGN FOR MOVEMENT CONTROL SYSTEMS OF SHIPS, WING-IN-SURFACE EFFECT CRAFTS AND SEAPLANES

A. V. NEBYLOV, A. P. VANAYEV, and V. V. CHERNYAVETS *In* AGARD, Dual Usage in Military and Commercial Technology in Guidance and Control 12 p Mar. 1995
Copyright Avail: CASI HC A03/MF A02

Advanced methods and means of controlled sea vehicle moving parameters and sea-way ones measurement are considered. Both directly measuring tasks and possibilities of control quality increasing of displacement and undisturbance ships and sea flying vehicles under conditions of active wave disturbances are analyzed. Design principles, some structural features and expected quality characteristics of device, being developed, for meter altitudes and distances measuring based on special phase radioaltimeter and inertial sensor integration are observed. When functioning in the sea-waves profile tracking mode, high measuring accuracy of sea-way and vehicle vertical moving parameters is provided. The mounting of several devices both on the left and on the right sides of vehicle allows to reconstruct the field of sea wave disturbances and to check roll and pitch parameters and draught or clearance as well. The conditions to be fulfilled for determining the main sea wave spread direction are investigated. Derived from text

N95-33642# Lawrence Livermore National Lab., Livermore, CA. **UNITIZED REGENERATIVE FUEL CELLS FOR SOLAR RECHARGEABLE AIRCRAFT AND ZERO EMISSION VEHICLES**

FRED MITLITSKY, NICHOLAS J. COLELLA, and BLAKE MYERS 6 Sep. 1994 8 p Presented at the Fuel Cell Seminar, San Diego, CA, 28 Nov. - 1 Dec. 1994 Submitted for publication (Contract(s)/Grant(s): W-7405-ENG-48) (DE95-010684; UCRL-JC-117130; CONF-941109-3) Avail: CASI HC A02/MF A01

A unitized regenerative fuel cell (URFC) produces power and electrolytically regenerates its reactants using a single stack of reversible cells. URFC'S have been designed for high altitude long endurance (HALE) solar rechargeable aircraft (SRA), zero emission vehicles (ZEV's), hybrid energy storage/propulsion systems for long duration satellites, energy storage for remote (off-grid) power sources, and peak shaving for on-grid applications. URFC's have been considered using hydrogen/oxygen, hydrogen/air, or hydrogen/halogen chemistries. This discussion is limited to the lightweight URFC energy storage system designs for span-loaded HALE SRA using hydrogen/oxygen, and for ZEV's using hydrogen/air with oxygen supercharging. Overlapping and synergistic development and testing opportunities for these two technologies will be highlighted. DOE

N95-33748*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.

CORRECTION OF THIN CIRRUS EFFECTS IN AVIRIS IMAGES USING THE SENSITIVE 1.375-MICRON CIRRUS DETECTING CHANNEL

BO-CAI GAO (Universities Space Research Association, Greenbelt, MD.) and YORMAN J. KAUFMAN *In* JPL, Summaries of the Fifth Annual JPL Airborne Earth Science Workshop. Volume 1: AVIRIS Workshop p 59-62 23 Jan. 1995
Avail: CASI HC A01/MF A02

Using spectral imaging data acquired with the Airborne Visible Infrared Imaging Spectrometer (AVIRIS) from an ER-2 aircraft at 20 km altitude during various field programs, it was found that narrow channels near the center of the strong 1.38-micrometer water vapor band are very effective in detecting thin cirrus clouds. Based on this observation from AVIRIS data, Gao and Kaufman proposed to put a channel centered at 1.375 micrometers with a width of 30 nm on the Moderate Resolution Imaging Spectrometer (MODIS) for remote sensing of cirrus clouds from space. The sensitivity of the 1.375-micrometer MODIS channel to detect thin cirrus clouds during the day time is expected to be one to two orders of magnitude better than the current infrared emission techniques. As a result, much larger fraction of the satellite data is expected to be identified as being covered by cirrus clouds, some of them so thin that their obscuration of the surface is very small. In order to make better studies of surface reflectance properties, thin cirrus effects must be removed from satellite images. Therefore, there is a need to study radiative properties of thin cirrus clouds, so that a strategy for correction or removal of the thin cirrus effects, similar to the correction of atmospheric aerosol effect, can be formed. In this extended abstract, we describe an empirical approach for removing/correcting thin cirrus effects in AVIRIS images using channels near 1.375 microns - one step beyond the detection of cirrus clouds using these channels. Author

N95-33749*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.

REMOTE SENSING OF SMOKE, CLOUDS, AND RADIATION USING AVIRIS DURING SCAR EXPERIMENTS

BO-CAI GAO (Universities Space Research Association, Greenbelt, MD.), LORRAINE REMER (Science Systems and Applications, Inc., Greenbelt, MD.), and YORMAN J. KAUFMAN *In* JPL, Summaries of the Fifth Annual JPL Airborne Earth Science Workshop. Volume 1: AVIRIS Workshop p 63-65 23 Jan. 1995
Avail: CASI HC A01/MF A02

During the past two years, researchers from several institutes joined together to take part in two SCAR experiments. The SCAR-A (Sulfates, Clouds And Radiation - Atlantic) took place in the mid-Atlantic region of the United States in July, 1993. Remote sensing data were acquired with the Airborne Visible Infrared Imaging Spectrometer (AVIRIS), the MODIS Airborne Simulator (MAS), and a RC-10 mapping camera from an ER-2 aircraft at 20 km. In situ measurements of aerosol and cloud microphysical properties were made with a variety of instruments equipped on the University of Washington's C-131A research aircraft. Ground based measurements of aerosol optical depths and particle size distributions were made using a network of sunphotometers. The main purpose of SCAR-A experiment was to study the optical, physical and chemical properties of sulfate aerosols and their interaction with clouds and radiation. Sulfate particles are believed to affect the energy balance of the earth by directly reflecting solar radiation back to space and by increasing the cloud albedo. The SCAR-C (Smoke, Clouds And Radiation - California) took place on the west coast areas during September - October of 1994. Sets of aircraft and ground-based instruments, similar to those used during SCAR-A, were used during SCAR-C. Remote sensing of fires and smoke from AVIRIS and MAS imagers on the ER-2 aircraft was combined with a complete in situ characterization of the aerosol and trace gases from the C-131A aircraft of the University of Washington and the Cessna aircraft from the U.S. Forest Service. The comprehensive data base acquired during SCAR-A and SCAR-C will contribute to a better understanding of the role of clouds and aerosols in global change studies. The

data will also be used to develop satellite remote sensing algorithms from MODIS on the Earth Observing System. Author

N95-33760*# Colorado Univ., Boulder, CO. Center for the Study of Earth from Space.

INTEGRATION OF AIRSAR AND AVIRIS DATA FOR TRAIL CANYON ALLUVIAL FAN, DEATH VALLEY, CALIFORNIA

KATHRYN S. KIEREIN-YOUNG *In* JPL, Summaries of the Fifth Annual JPL Airborne Earth Science Workshop. Volume 1: AVIRIS Workshop p 109-112 23 Jan. 1995 Sponsored by SIR-C project (Contract(s)/Grant(s): NGT-50728) Avail: CASI HC A01/MF A02

Combining quantitative geophysical information extracted from the optical and microwave wavelengths provides complementary information about both the surface mineralogy and morphology. This study combines inversion results from two remote sensing instruments, a polarimetric synthetic aperture radar, AIRSAR, and an imaging spectrometer, AVIRIS, for Trail Canyon alluvial fan in Death Valley, California. The NASA/JPL Airborne Synthetic Aperture Radar (AIRSAR) is a quad-polarization, three frequency instrument. AIRSAR collects data at C-band = 5.66 cm, L-band = 23.98 cm, and P-band = 68.13 cm. The data are processed to four-looks and have a spatial resolution of 10 m and a swath width of 12 km. The AIRSAR data used in this study were collected as part of the Geologic Remote Sensing Field Experiment (GRSFE) over Death Valley on 9/14/89. The Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) is a NASA/JPL instrument that flies in an ER-2 aircraft at an altitude of 20 km. AVIRIS uses four spectrometers to collect data in 224 spectral channels from 0.4 micrometer to 2.45 micrometer. The width of each spectral band is approximately 10 nm. AVIRIS collects data with a swath width of 11 km and a pixel size of 20 m. The AVIRIS data used in this study were collected over Death Valley on 5/31/92.

Author

N95-33799*# Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA.

TIMS OBSERVATIONS OF SURFACE EMISSIVITY IN HAPEX-SAHEL

THOMAS SCHMUGGE (Food and Drug Administration, Bethesda, MD.), SIMON HOOK, and ANNE KAHLE *In its* Summaries of the Fifth Annual JPL Airborne Earth Science Workshop. Volume 2: TIMS Workshop p 37 23 Jan. 1995 Avail: CASI HC A01/MF A01

The Thermal Infrared Multispectral Scanner (TIMS) was flown on the NASA C-130 aircraft for a series of 12 flights during HAPEX-Sahel at altitudes ranging from 0.25 to 6 km (0.6 to 15 m resolution). TIMS provides coverage of the 8 to 12 micrometer thermal infrared band in 6 contiguous channels. Thus it is possible to observe the spectral behavior of the surface emissivity over this wavelength interval. Derived from text

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.

A95-96241
NEURO-CONTROLLERS FOR ADAPTIVE HELICOPTER HOVER TRAINING

K. KRISHNAKUMAR Univ of Alabama, Tuscaloosa, AL, United States, S. SAWHNEY, and R. WAI *IEEE Transactions on Systems, Man and Cybernetics* (ISSN 0018-9472) vol. 24, no. 8 August 1994 p. 1142-1152 refs (BTN-94-EIX94522407592) Copyright

This paper presents an application of artificial neural networks

in adaptive helicopter hover training of novice student pilots. The design of the adaptive trainer utilizes the hypothesis that novices can be trained to fly a helicopter system automatically (with no human interaction) if the helicopter system adapts to the learning curve of the student. Two different techniques based on the above approach are presented. In the first technique, the helicopter system actively enforces optimality by augmenting the novice's control inputs by amounts necessary to satisfy desired performance criteria. The second technique uses relaxed performance criteria that are not initially optimal, but approach optimality in a graded fashion, based on the learning curve of the student. Adaptive neuro-controllers, together with a critic model, are used to implement the adaptive helicopter system. The results using simulated student models verify the approach adopted, and show that the adaptive neuro-controllers allow the helicopter system to adapt to the novice's learning curve. Author (EI)

A95-96299
PARTIALLY IMPLICIT METHOD FOR SIMULATING VISCOUS AEROFOIL FLOWS

K. J. BADCOCK Univ of Glasgow, Glasgow, United Kingdom *International Journal for Numerical Methods in Fluids* (ISSN 0271-2091) vol. 19, no. 3 August 15 1994 p. 259-268 refs (BTN-94-EIX94522406680) Copyright

A partially implicit method for the unsteady compressible Navier-Stokes equations is developed. The method is based on an explicit treatment of streamwise fluxes and an implicit treatment of normal fluxes. This leads to a linear system which is generated by an efficient finite difference procedure and which is block pentadiagonal. The method is tested on a shock-induced oscillatory flow over an aerofoil. Parallel implementations of an explicit, fully implicit and partially implicit method are investigated.

Author (EI)

N95-32494# GEC-Marconi Avionics Ltd., Rochester (England).
A TACTICAL NAVIGATION AND ROUTEING SYSTEM FOR LOW-LEVEL FLIGHT

C. HEWITT and S. A. BROATCH *In* AGARD, Low-Level and Nap-of-the-Earth (NOE) Night Operations 10 p Jan. 1995 Copyright Avail: CASI HC A02/MF A03

Many types of offensive air operations need to be carried out at low level in order to ensure survivability and to maximize the probability of mission success. However, such a flight trajectory is workload intensive and leaves little room for pilot error. It would be highly beneficial if the activities of in-flight route planning, obstacle, threat and terrain avoidance, and time and fuel monitoring could be automated. This paper presents an integrated solution to this automation problem based on the effective exploitation of terrain and mission databases. The requirements of the component parts of this system are presented. These include: (1) an optimum routing algorithm, together with the criteria used in selecting the optimum four dimensional route for all mission scenarios; (2) a ground and obstacle collision avoidance system which enables the pilot to fly low, while providing timely warnings of imminent high terrain and obstacles; and (3) the navigation accuracy required to support the optimum routing and collision avoidance systems. The paper then describes a number of systems that have been developed by GEC-Marconi Avionics with the support of the Defence Research Agency (DRA), UK Ministry of Defence. The first is an optimum routing algorithm which uses terrain and mission databases to generate an optimum route, taking account of threats, terrain, obstacles, time and fuel constraints. A description of a predictive Ground and Obstacle Collision Avoidance Technique (GOCAT) is then presented. This uses a terrain and obstacle database to assess whether the current and future aircraft trajectory is safe. Finally the navigation requirements to support these systems are discussed and a solution based on integrated INS, GPS, Map Referenced Navigation (MRN) and Edge Detection Navigation (EDN) is described.

Derived from text

N95-32496# Defence Research Agency, Farnborough, Hampshire (England).

THE APPLICATION OF HELICOPTER MISSION SIMULATION TO NAP-OF-THE-EARTH OPERATIONS

P. R. BIRKETT and D. W. RODEN *In* AGARD, Low-Level and Nap-of-the-Earth (NOE) Night Operations 5 p Jan. 1995

Copyright Avail: CASI HC A01/MF A03

This paper describes some of the system trade-offs and integration issues associated with the next generation of battlefield helicopters operating in the NOE environment. The interactions between weapons, sensors, aircrew and the platform itself are discussed and their influence on the effectiveness of the helicopter as a total system is considered. Finally, an approach to the study of helicopter system integration is presented. The 'multipleman-in-the-loop' mission simulator, HOVERS, is described and its application to a typical trade-off issue discussed. Derived from text

N95-33008# Commonwealth Scientific and Industrial Research Organization, Highett, Victoria (Australia). Div. of Building, Construction, and Engineering.

EXPERT SYSTEMS AND ARTIFICIAL INTELLIGENCE APPLICATIONS IN ENGINEERING DESIGN AND INSPECTION

RON SHARPE, JACEK GIBERT, and STEPHEN OAKES *In* Defence Science and Technology Organisation, Industrial and Engineering Applications of Artificial Intelligence and Expert Systems: Invited and Additional Papers p 99-109 May 1995

Avail: Issuing Activity (DSTO Aeronautical and Maritime Research Lab., PO Box 4331, Melbourne, Victoria 3001, Australia)

The CSIRO Division of Building, Construction, and Engineering (CSIRO DBCE) provides the major Australian source of science and technology required to service the needs of Australia's construction and related engineering sectors. Close links to Australian industry enable the division to identify industry needs and potential applications for new scientific knowledge and to apply this knowledge through collaborative research activities. The paper presents three representative examples of the way in which advanced artificial intelligence (AI) techniques are currently being applied for engineering design and inspection. The first is the Windloader expert system used to determine wind forces on structures to comply with the Australian Standard AS 1170.2. The second is the BCAider expert system for the Building Code of Australia (BCA), which is now used by over 500 architects, engineers, regulators, and fire authorities. The PIRAT system (Pipe Inspection Real-time Assessment Technique) is a patented robotic inspection system which moves through a sewer system assessing pipe conditions through a combination of machine vision and artificial intelligence. Derived from text

N95-33142# Lucas Electronics, Birmingham (England).

THE APPLICATION OF ADA AND FORMAL METHODS TO A SAFETY CRITICAL ENGINE CONTROL SYSTEM

W. C. DOLMAN, A. M. ASHDOWN, and K. J. MCCALLION (Ministry of Defence, London, England.) *In* AGARD, Dual Usage in Military and Commercial Technology in Guidance and Control 13 p Mar. 1995

Copyright Avail: CASI HC A03/MF A02

The procurement executive of the UK Ministry of Defense, MoD (PE) identified Ada as the single preferred high level language for the implementation of defense real time operational systems from 1 July 1987. This meant that projects selecting an implementation language after that time must select Ada, unless there are sound and documented reasons for using an alternative. MoD (PE) therefore decided to invite proposals for the High Order Language Demonstrator (HOLD) to examine the applicability of Ada to an aero gas turbine full authority digital engine control (FADEC), and awarded the contract to Lucas Electronics, Birmingham. This paper describes the work carried out by Lucas Electronics on this contract. Derived from text

N95-33396*# SRI International Corp., Menlo Park, CA.
FORMAL VERIFICATION OF AN AVIONICS

MICROPROCESSOR Final Report

MANDAYAM SRIVAS, K. and STEVEN P. MILLER (Rockwell International Corp., Cedar Rapids, IA.) Jul. 1995 106 p
(Contract(s)/Grant(s): NAS1-18969; RTOP 505-64-10-13)
(NASA-CR-4682; NAS 1.26:4682; ECU-8200-270) Avail: CASI HC A06/MF A02

Formal specification combined with mechanical verification is a promising approach for achieving the extremely high levels of assurance required of safety-critical digital systems. However, many questions remain regarding their use in practice: Can these techniques scale up to industrial systems, where are they likely to be useful, and how should industry go about incorporating them into practice? This report discusses a project undertaken to answer some of these questions, the formal verification of the AAMPS microprocessor. This project consisted of formally specifying in the PVS language a rockwell proprietary microprocessor at both the instruction-set and register-transfer levels and using the PVS theorem prover to show that the microcode correctly implemented the instruction-level specification for a representative subset of instructions. Notable aspects of this project include the use of a formal specification language by practicing hardware and software engineers, the integration of traditional inspections with formal specifications, and the use of a mechanical theorem prover to verify a portion of a commercial, pipelined microprocessor that was not explicitly designed for formal verification. Author

N95-33712 Oregon State Univ., Corvallis, OR.

NONLINEAR ADAPTIVE CONTROL OF HIGHLY MANEUVERABLE HIGH PERFORMANCE AIRCRAFT Ph.D. Thesis

SUL CHO 1993 125 p

Avail: Univ. Microfilms Order No. DA9413708

This thesis presents an effective control design methodology using a one-step-ahead prediction adaptive control law and an adaptive control law based on a Lyapunov function. These control laws were applied to a highly maneuverable, high performance aircraft, in particular, a modified F/A-18. An adaptive controller is developed to maneuver an aircraft at a high angle of attack even if the aircraft is required to fly over a highly nonlinear flight regime. The adaptive controller is based on linear, bilinear, and nonlinear prediction models with input constraints. It is shown that the linear, bilinear, and nonlinear adaptive controllers can be constructed to minimize the given cost function or Lyapunov function with respect to the control input at each step. The control is calculated such that the system follows the reference trajectory, and such that control signal remains within its constraints. From several simulation results, the nonlinear controller is more effective than the linear controller as the angle of attack is increased. This thesis shows that nonlinear control can be utilized effectively to control high performance aircraft such as the F-18 aircraft for rapid maneuvers with large changes in angle of attack even if the nonlinear feedback controller operates with a higher-order (more delay terms) linear model reference. Dissert. Abstr.

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.

N95-32836*# NYMA, Inc., Brook Park, OH.

COMPUTATION OF NOISE RADIATION FROM TURBOFANS: A PARAMETRIC STUDY Final Contractor Report

M. NALLASAMY Cleveland, OH NASA Jul. 1995 37 p Original contains color illustrations

(Contract(s)/Grant(s): NAS3-27186; RTOP 538-03-11)

(NASA-CR-198359; E-9747; NAS 1.26:198359) Avail: CASI HC A03/MF A01; 7 functional color pages

This report presents the results of a parametric study of the turbofan far-field noise radiation using a finite element technique. Several turbofan noise radiation characteristics of both the inlet and the aft ducts have been examined through the finite element solutions. The predicted far-field principal lobe angle variations with duct Mach number and cut-off ratio compare very well with the available analytical results. The solutions also show that the far-field lobe angle is only a function of cut-off ratio, and nearly independent of the mode number. These results indicate that the finite element codes are well suited for the prediction of noise radiation characteristics of a turbofan. The effects of variations in the aft duct geometry are examined. The ability of the codes to handle ducts with acoustic treatments is also demonstrated. Author

N95-33831*# McDonnell-Douglas Aerospace, Long Beach, CA.
FAN NOISE PREDICTION ASSESSMENT Final Report
 PAUL H. BENT May 1995 37 p
 (Contract(s)/Grant(s): NAS1-20103; RTOP 538-03-11-01)
 (NASA-CR-195051; NAS 1.26:195051; CRAD-9310-TR-0128) Avail:
 CASI HC A03/MF A01

This report is an evaluation of two techniques for predicting the fan noise radiation from engine nacelles. The first is a relatively computational intensive finite element technique. The code is named ARC, an abbreviation of Acoustic Radiation Code, and was developed by Eversman. This is actually a suite of software that first generates a grid around the nacelle, then solves for the potential flowfield, and finally solves the acoustic radiation problem. The second approach is an analytical technique requiring minimal computational effort. This is termed the cutoff ratio technique and was developed by Rice. Details of the duct geometry, such as the hub-to-tip ratio and Mach number of the flow in the duct, and modal content of the duct noise are required for proper prediction. Author

N95-34549# National Aerospace Lab., Tokyo (Japan).
DIRECT ANALYSIS OF TRANSONIC ROTOR NOISE WITH CFD TECHNIQUE Abstract Only
 TAKASHI AOYAMA and SHIGERU SAITO *In its* Special Publication of National Aerospace Laboratory p 309-314 16 Jun. 1994 In JAPANESE
 Avail: CASI HC A02/MF A03

Three-dimensional Euler equations are directly solved to analyze the High-Speed Impulsive (HSI) noise of a helicopter motor by using CFD technique. The MSI noise is one of the most important sources of helicopter noise. It is generated on the advancing side of a helicopter caused by the shock wave on a blade surface. Although the method which solves the Ffowcs-Williams and Hawkings equation has been often used to analyze the subsonic rotor noise, it doesn't success to predict the transonic rotor noise such as the HSI noise. With the advance of CFD technique, the calculation of the HSI noise is recently performed by the combined method of CFD with the Kirchhoff's equation or by the direct simulation using CFD technique. The latter has not been studied enough because huge number of grids are needed to capture the propagation of sound from a blade to an observer located in a far field. So, the powerful supercomputer of NAL, Numerical Wind Tunnel (NWT) is employed to calculate the RSI noise of a non-lifting hovering rotor directly by using the method. The numerical method to solve the governing equation is an implicit finite-difference scheme which utilizes a higher-order upwind scheme based on TVD. As a result, it is observed that the calculated wave form is in very good agreement with an experimental data at sonic cylinder. The agreement is not very good at about three rotor radii but is reasonable at about two rotor radii. Author

N95-34551# Nagoya Univ., Nagoya (Japan). Dept. of Aeronautical Engineering.
A SIMULATION OF DAMPING PROCESS OF PENDULUM MOTION DUE TO AERODYNAMIC FORCES Abstract Only
 CASMARA NAKAMURA and YOSHIAKI NAKAMURA *In* National Aerospace Lab., Special Publication of National Aerospace Laboratory p 321-326 16 Jun. 1994 In JAPANESE
 Avail: CASI HC A02/MF A03

A numerical simulation is presented for the flow around a circular cylinder in a free-pendulum motion. In this motion, the aerodynamic forces are exerted on the body and affect the body motion. In this case, the motion will damp out due to its forces. For this problem, the Navier-Stokes equations are solved by a finite difference - finite volume method, where the u-v-p formulation is employed. A multi-grid technique is also employed to solve the pressure Poisson equation. The results are well compared with potential flow solutions. Author

17

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.

N95-33198# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
AGARD INDEX OF PUBLICATIONS: 1992-1994 [AGARD INDEX DES PUBLICATIONS 1992-1994]
 Jul. 1995 503 p
 (AGARD-INDEX-92-94; ISBN-92-836-1019-9) Copyright Avail:
 CASI HC A22/MF A04

This volume provides abstracts and indexes for AGARD unclassified publications published during the period 1992-1994. Full bibliographical citations and abstracts for all the documents in this publication are given in the abstract section, which is organized in the major subject divisions and specific categories used by NASA in abstract journals and bibliographies. The major subject divisions are listed, together with a note for each that defines its scope and provides any cross-references. Category breaks in the abstract section are identified by category number and title, and a scope note. Within each category, the abstracts are arranged by series and year. Six indexes - Subject (based on NASA Thesaurus nomenclature), Personal Author, Corporate Source, Panel, Report/Accession Number, and Accession Number - are included. Sample entries are shown on the first page of each index. This publication was sponsored by the Technical Information Committee of AGARD (TIC), and compiled by NASA's Center for AeroSpace Information (CASI). Author

N95-34236*# Hughes Aircraft Co., Culver City, CA.
ADVANCED DATA VISUALIZATION AND SENSOR FUSION: CONVERSION OF TECHNIQUES FROM MEDICAL IMAGING TO EARTH SCIENCE Abstract Only
 RICHARD C. SAVAGE, CHIN-TU CHEN (Chicago Univ., Chicago, IL.), CHARLES PELIZZARI (Chicago Univ., Chicago, IL.), and VEERABHADRAN RAMANATHAN (Chicago Univ., Chicago, IL.) *In* Colorado Univ., Applied Information Systems Research Program (AISRP) Workshop 3 Meeting Proceedings 1 p 1993
 Avail: CASI HC A01/MF A03

Hughes Aircraft Company and the University of Chicago propose to transfer existing medical imaging registration algorithms to the area of multi-sensor data fusion. The University of Chicago's algorithms have been successfully demonstrated to provide pixel by pixel comparison capability for medical sensors with different characteristics. The research will attempt to fuse GOES (Geostationary Operational Environmental Satellite), AVHRR (Advanced Very High Resolution Radiometer), and SSM/I (Special Sensor Microwave Imager) sensor data which will benefit a wide range of researchers. The algorithms will utilize data visualization and algorithm development tools created by Hughes in its EOSDIS (Earth Observation SystemData/Information System) prototyping. This will maximize the work on the fusion algorithms since support software (e.g. input/output routines) will already exist. The research will produce a portable software library with documentation for use by other researchers. Author

AVAILABILITY OF CITED PUBLICATIONS

OPEN LITERATURE ENTRIES (A95-60000 Series)

Inquiries and requests should be addressed to NASA Center for AeroSpace Information, 800 Elkridge Landing Road, Linthicum Heights, MD 21090-2934. Orders are also taken by telephone, (301) 621-0390, e-mail, help@sti.nasa.gov, and fax, (301) 621-0134. Please refer to the accession number when requesting publications.

STAR ENTRIES (N95-10000 Series)

One or more sources from which a document announced in *STAR* is available to the public is ordinarily given on the last line of the citation. The most commonly indicated sources and their acronyms or abbreviations are listed below, and their addresses are listed on page APP-3. If the publication is available from a source other than those listed, the publisher and his address will be displayed on the availability line or in combination with the corporate source line.

Avail: CASI. Sold by the NASA Center for AeroSpace Information. Prices for hard copy (HC) and microfiche (MF) are indicated by a price code following the letters HC or MF in the *STAR* citation. Current values for the price codes are given in the tables on page APP-5.

NOTE ON ORDERING DOCUMENTS: When ordering publications from NASA CASI, use the N accession number or other report number. It is also advisable to cite the title and other bibliographic identification.

Avail: SOD (or GPO). Sold by the Superintendent of Documents, U.S. Government Printing Office, in hard copy.

Avail: BLL (formerly NLL): British Library Lending Division, Boston Spa, Wetherby, Yorkshire, England. Photocopies available from this organization at the price shown. (If none is given, inquiry should be addressed to the BLL.)

Avail: DOE Depository Libraries. Organizations in U.S. cities and abroad that maintain collections of Department of Energy reports, usually in microfiche form, are listed in *Energy Research Abstracts*. Services available from the DOE and its depositories are described in a booklet, *DOE Technical Information Center - Its Functions and Services* (TID-4660), which may be obtained without charge from the DOE Technical Information Center.

Avail: ESDU. Pricing information on specific data, computer programs, and details on Engineering Sciences Data Unit (ESDU) topic categories can be obtained from ESDU International Ltd. Requesters in North America should use the Virginia address while all other requesters should use the London address, both of which are on page APP-3.

Avail: Fachinformationszentrum Karlsruhe. Gesellschaft für wissenschaftlich-technische Information mbH 76344 Eggenstein-Leopoldshafen, Germany.

Avail: HMSO. Publications of Her Majesty's Stationery Office are sold in the U.S. by Pendragon House, Inc. (PHI), Redwood City, CA. The U.S. price (including a service and mailing charge) is given, or a conversion table may be obtained from PHI.

Avail: Issuing Activity, or Corporate Author, or no indication of availability. Inquiries as to the availability of these documents should be addressed to the organization shown in the citation as the corporate author of the document.

Avail: NASA Public Document Rooms. Documents so indicated may be examined at or purchased from the National Aeronautics and Space Administration (JBD-4), Public Documents Room (Room 1H23), Washington, DC 20546-0001, or public document rooms located at NASA installations, and the NASA Pasadena Office at the Jet Propulsion Laboratory.

Avail: NTIS. Sold by the National Technical Information Service. Initially distributed microfiche under the NTIS SRIM (Selected Research in Microfiche) are available. For information concerning this service, consult the NTIS Subscription Section, Springfield, VA 22161.

Avail: Univ. Microfilms. Documents so indicated are dissertations selected from *Dissertation Abstracts* and are sold by University Microfilms as xerographic copy (HC) and microfilm. All requests should cite the author and the Order Number as they appear in the citation.

Avail: US Patent and Trademark Office. Sold by Commissioner of Patents and Trademarks, U.S. Patent and Trademark Office, at the standard price of \$1.50 each, postage free.

Avail: (US Sales Only). These foreign documents are available to users within the United States from the National Technical Information Service (NTIS). They are available to users outside the United States through the International Nuclear Information Service (INIS) representative in their country, or by applying directly to the issuing organization.

Avail: USGS. Originals of many reports from the U.S. Geological Survey, which may contain color illustrations, or otherwise may not have the quality of illustrations preserved in the microfiche or facsimile reproduction, may be examined by the public at the libraries of the USGS field offices whose addresses are listed on page APP-3. The libraries may be queried concerning the availability of specific documents and the possible utilization of local copying services, such as color reproduction.

FEDERAL DEPOSITORY LIBRARY PROGRAM

In order to provide the general public with greater access to U.S. Government publications, Congress established the Federal Depository Library Program under the Government Printing Office (GPO), with 53 regional depositories responsible for permanent retention of material, inter-library loan, and reference services. At least one copy of nearly every NASA and NASA-sponsored publication, either in printed or microfiche format, is received and retained by the 53 regional depositories. A list of the regional GPO libraries, arranged alphabetically by state, appears on the inside back cover of this issue. These libraries are *not* sales outlets. A local library can contact a regional depository to help locate specific reports, or direct contact may be made by an individual.

PUBLIC COLLECTION OF NASA DOCUMENTS

An extensive collection of NASA and NASA-sponsored publications is maintained by the British Library Lending Division, Boston Spa, Wetherby, Yorkshire, England for public access. The British Library Lending Division also has available many of the non-NASA publications cited in *STAR*. European requesters may purchase facsimile copy or microfiche of NASA and NASA-sponsored documents, those identified by both the symbols # and * from FIZ—Fachinformation Karlsruhe—Bibliographic Service, D-76344 Eggenstein-Leopoldshafen, Germany and TIB—Technische Informationsbibliothek, P.O. Box 60 80, D-30080 Hannover, Germany.

STANDING ORDER SUBSCRIPTIONS

NASA SP-7037 supplements and annual index are available from the NASA Center for AeroSpace Information (CASI) on standing order subscription. Standing order subscriptions do not terminate at the end of a year, as do regular subscriptions, but continue indefinitely unless specifically terminated by the subscriber.

ADDRESSES OF ORGANIZATIONS

British Library Lending Division
Boston Spa, Wetherby, Yorkshire
England

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

Commissioner of Patents and Trademarks
U.S. Patent and Trademark Office
Washington, DC 20231

Pendragon House, Inc.
899 Broadway Avenue
Redwood City, CA 94063

Department of Energy
Technical Information Center
P.O. Box 62
Oak Ridge, TN 37830

Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402

European Space Agency-
Information Retrieval Service ESRIN
Via Galileo Galilei
00044 Frascati (Rome) Italy

University Microfilms
A Xerox Company
300 North Zeeb Road
Ann Arbor, MI 48106

Engineering Sciences Data Unit International
P.O. Box 1633
Manassas, VA 22110

University Microfilms, Ltd.
Tylers Green
London, England

Engineering Sciences Data Unit
International, Ltd.
251-259 Regent Street
London, W1R 7AD, England

U.S. Geological Survey Library National Center
MS 950
12201 Sunrise Valley Drive
Reston, VA 22092

Fachinformationszentrum Karlsruhe
Gesellschaft für wissenschaftlich-technische
Information mbH
76344 Eggenstein-Leopoldshafen, Germany

U.S. Geological Survey Library
2255 North Gemini Drive
Flagstaff, AZ 86001

Her Majesty's Stationery Office
P.O. Box 569, S.E. 1
London, England

U.S. Geological Survey
345 Middlefield Road
Menlo Park, CA 94025

NASA Center for AeroSpace Information
800 Elkridge Landing Road
Linthicum Heights, MD 21090-2934

U.S. Geological Survey Library
Box 25046
Denver Federal Center, MS914
Denver, CO 80225

National Aeronautics and Space Administration
Scientific and Technical Information Office (JT)
Washington, DC 20546-0001

NASA CASI PRICE CODE TABLE

(Effective January 1, 1995)

CASI PRICE CODE	NORTH AMERICAN PRICE	FOREIGN PRICE
A01	\$ 6.00	\$ 12.00
A02	9.00	18.00
A03	17.50	35.00
A04-A05	19.50	39.00
A06-A09	27.00	54.00
A10-A13	36.50	73.00
A14-A17	44.50	89.00
A18-A21	52.00	104.00
A22-A25	61.00	122.00
A99	Call For Price	Call For Price

IMPORTANT NOTICE

For users not registered at the NASA CASI, prepayment is required. Additionally, a shipping and handling fee of \$1.00 per document for delivery within the United States and \$9.00 per document for delivery outside the United States is charged.

For users registered at the NASA CASI, document orders may be invoiced at the end of the month, charged against a deposit account, or paid by check or credit card. NASA CASI accepts American Express, Diners' Club, MasterCard, and VISA credit cards. There are no shipping and handling charges. To register at the NASA CASI, please request a registration form through the NASA Access Help Desk at the numbers or addresses below.

RETURN POLICY

Effective June 1, 1995, the NASA Center for AeroSpace Information will gladly replace or make full refund on items you have requested if we have made an error in your order, if the item is defective, or if it was received in damaged condition and you contact us within 30 days of your original request. Just contact our NASA Access Help Desk at the numbers or addresses listed below.

NASA Center for AeroSpace Information
800 Elkridge Landing Road
Linthicum Heights, MD 21090-2934
Telephone: (301) 621-0390
E-mail: help@sti.nasa.gov
Fax: (301) 621-0134

REPORT DOCUMENT PAGE

1. Report No. NASA SP-7037 (324)	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Aeronautical Engineering A Continuing Bibliography (Supplement 324)		5. Report Date December 1995	
		6. Performing Organization Code JT	
7. Author(s)		8. Performing Organization Report No.	
		10. Work Unit No.	
9. Performing Organization Name and Address NASA Scientific and Technical Information Office		11. Contract or Grant No.	
		13. Type of Report and Period Covered Special Publication	
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546-0001		14. Sponsoring Agency Code	
		15. Supplementary Notes	
16. Abstract This report lists 149 reports, articles and other documents recently announced in the NASA STI Database.			
17. Key Words (Suggested by Author(s)) Aeronautical Engineering Aeronautics Bibliographies		18. Distribution Statement Unclassified - Unlimited Subject Category - 01	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 76	22. Price A05/HC

FEDERAL REGIONAL DEPOSITORY LIBRARIES

ALABAMA

AUBURN UNIV. AT MONTGOMERY LIBRARY

Documents Dept.
7300 University Dr.
Montgomery, AL 36117-3596
(205) 244-3650 Fax: (205) 244-0678

UNIV. OF ALABAMA

Amelia Gayle Gorgas Library

Govt. Documents
P.O. Box 870266
Tuscaloosa, AL 35487-0266
(205) 348-6046 Fax: (205) 348-0760

ARIZONA

DEPT. OF LIBRARY, ARCHIVES, AND PUBLIC RECORDS

Research Division
Third Floor, State Capitol
1700 West Washington
Phoenix, AZ 85007
(602) 542-3701 Fax: (602) 542-4400

ARKANSAS

ARKANSAS STATE LIBRARY

State Library Service Section
Documents Service Section
One Capitol Mall
Little Rock, AR 72201-1014
(501) 682-2053 Fax: (501) 682-1529

CALIFORNIA

CALIFORNIA STATE LIBRARY

Govt. Publications Section
P.O. Box 942837 - 914 Capitol Mall
Sacramento, CA 94337-0091
(916) 654-0069 Fax: (916) 654-0241

COLORADO

UNIV. OF COLORADO - BOULDER

Libraries - Govt. Publications
Campus Box 184
Boulder, CO 80309-0184
(303) 492-8834 Fax: (303) 492-1881

DENVER PUBLIC LIBRARY

Govt. Publications Dept. BSG
1357 Broadway
Denver, CO 80203-2165
(303) 640-8846 Fax: (303) 640-8817

CONNECTICUT

CONNECTICUT STATE LIBRARY

231 Capitol Avenue
Hartford, CT 06106
(203) 566-4971 Fax: (203) 566-3322

FLORIDA

UNIV. OF FLORIDA LIBRARIES

Documents Dept.
240 Library West
Gainesville, FL 32611-2048
(904) 392-0366 Fax: (904) 392-7251

GEORGIA

UNIV. OF GEORGIA LIBRARIES

Govt. Documents Dept.
Jackson Street
Athens, GA 30602-1645
(706) 542-8949 Fax: (706) 542-4144

HAWAII

UNIV. OF HAWAII

Hamilton Library
Govt. Documents Collection
2550 The Mall
Honolulu, HI 96822
(808) 948-8230 Fax: (808) 956-5968

IDAHO

UNIV. OF IDAHO LIBRARY

Documents Section
Rayburn Street
Moscow, ID 83844-2353
(208) 885-6344 Fax: (208) 885-6817

ILLINOIS

ILLINOIS STATE LIBRARY

Federal Documents Dept.
300 South Second Street
Springfield, IL 62701-1796
(217) 782-7596 Fax: (217) 782-6437

INDIANA

INDIANA STATE LIBRARY

Serials/Documents Section
140 North Senate Avenue
Indianapolis, IN 46204-2296
(317) 232-3679 Fax: (317) 232-3728

IOWA

UNIV. OF IOWA LIBRARIES

Govt. Publications
Washington & Madison Streets
Iowa City, IA 52242-1166
(319) 335-5926 Fax: (319) 335-5900

KANSAS

UNIV. OF KANSAS

Govt. Documents & Maps Library
6001 Malott Hall
Lawrence, KS 66045-2800
(913) 864-4660 Fax: (913) 864-3855

KENTUCKY

UNIV. OF KENTUCKY

King Library South
Govt. Publications/Maps Dept.
Patterson Drive
Lexington, KY 40506-0039
(606) 257-3139 Fax: (606) 257-3139

LOUISIANA

LOUISIANA STATE UNIV.

Middleton Library
Govt. Documents Dept.
Baton Rouge, LA 70803-3312
(504) 388-2570 Fax: (504) 388-6992

LOUISIANA TECHNICAL UNIV.

Prescott Memorial Library
Govt. Documents Dept.
Ruston, LA 71272-0046
(318) 257-4962 Fax: (318) 257-2447

MAINE

UNIV. OF MAINE

Raymond H. Fogler Library
Govt. Documents Dept.
Orono, ME 04469-5729
(207) 581-1673 Fax: (207) 581-1653

MARYLAND

UNIV. OF MARYLAND - COLLEGE PARK

McKeldin Library
Govt. Documents/Maps Unit
College Park, MD 20742
(301) 405-9165 Fax: (301) 314-9416

MASSACHUSETTS

BOSTON PUBLIC LIBRARY

Govt. Documents
666 Boylston Street
Boston, MA 02117-0286
(617) 536-5400, ext. 226
Fax: (617) 536-7758

MICHIGAN

DETROIT PUBLIC LIBRARY

5201 Woodward Avenue
Detroit, MI 48202-4093
(313) 833-1025 Fax: (313) 833-0156

LIBRARY OF MICHIGAN

Govt. Documents Unit
P.O. Box 30007
717 West Allegan Street
Lansing, MI 48909
(517) 373-1300 Fax: (517) 373-3381

MINNESOTA

UNIV. OF MINNESOTA

Govt. Publications
409 Wilson Library
309 19th Avenue South
Minneapolis, MN 55455
(612) 624-5073 Fax: (612) 626-9353

MISSISSIPPI

UNIV. OF MISSISSIPPI

J.D. Williams Library
106 Old Gym Bldg.
University, MS 38677
(601) 232-5857 Fax: (601) 232-7465

MISSOURI

UNIV. OF MISSOURI - COLUMBIA

106B Ellis Library
Govt. Documents Sect.
Columbia, MO 65201-5149
(314) 882-6733 Fax: (314) 882-8044

MONTANA

UNIV. OF MONTANA

Mansfield Library
Documents Division
Missoula, MT 59812-1195
(406) 243-6700 Fax: (406) 243-2060

NEBRASKA

UNIV. OF NEBRASKA - LINCOLN

D.L. Love Memorial Library
Lincoln, NE 68588-0410
(402) 472-2562 Fax: (402) 472-5131

NEVADA

THE UNIV. OF NEVADA LIBRARIES

Business and Govt. Information
Center
Reno, NV 89557-0044
(702) 784-6579 Fax: (702) 784-1751

NEW JERSEY

NEWARK PUBLIC LIBRARY

Science Div. - Public Access
P.O. Box 630
Five Washington Street
Newark, NJ 07101-7812
(201) 733-7782 Fax: (201) 733-5648

NEW MEXICO

UNIV. OF NEW MEXICO

General Library
Govt. Information Dept.
Albuquerque, NM 87131-1466
(505) 277-5441 Fax: (505) 277-6019

NEW MEXICO STATE LIBRARY

325 Don Gaspar Avenue
Santa Fe, NM 87503
(505) 827-3824 Fax: (505) 827-3888

NEW YORK

NEW YORK STATE LIBRARY

Cultural Education Center
Documents/Gift & Exchange Section
Empire State Plaza
Albany, NY 12230-0001
(518) 474-5355 Fax: (518) 474-5786

NORTH CAROLINA

UNIV. OF NORTH CAROLINA - CHAPEL HILL

Walter Royal Davis Library
CB 3912, Reference Dept.
Chapel Hill, NC 27514-8890
(919) 962-1151 Fax: (919) 962-4451

NORTH DAKOTA

NORTH DAKOTA STATE UNIV. LIB.

Documents
P.O. Box 5599
Fargo, ND 58105-5599
(701) 237-8886 Fax: (701) 237-7138

UNIV. OF NORTH DAKOTA

Chester Fritz Library
University Station
P.O. Box 9000 - Centennial and
University Avenue
Grand Forks, ND 58202-9000
(701) 777-4632 Fax: (701) 777-3319

OHIO

STATE LIBRARY OF OHIO

Documents Dept.
65 South Front Street
Columbus, OH 43215-4163
(614) 644-7051 Fax: (614) 752-9178

OKLAHOMA

OKLAHOMA DEPT. OF LIBRARIES

U.S. Govt. Information Division
200 Northeast 18th Street
Oklahoma City, OK 73105-3298
(405) 521-2502, ext. 253
Fax: (405) 525-7804

OKLAHOMA STATE UNIV.

Edmon Low Library
Stillwater, OK 74078-0375
(405) 744-6546 Fax: (405) 744-5183

OREGON

PORTLAND STATE UNIV.

Branford P. Millar Library
934 Southwest Harrison
Portland, OR 97207-1151
(503) 725-4123 Fax: (503) 725-4524

PENNSYLVANIA

STATE LIBRARY OF PENN.

Govt. Publications Section
116 Walnut & Commonwealth Ave.
Harrisburg, PA 17105-1601
(717) 787-3752 Fax: (717) 783-2070

SOUTH CAROLINA

CLEMSON UNIV.

Robert Muldrow Cooper Library
Public Documents Unit
P.O. Box 343001
Clemson, SC 29634-3001
(803) 656-5174 Fax: (803) 656-3025

UNIV. OF SOUTH CAROLINA

Thomas Cooper Library
Green and Sumter Streets
Columbia, SC 29208
(803) 777-4841 Fax: (803) 777-9503

TENNESSEE

UNIV. OF MEMPHIS LIBRARIES

Govt. Publications Dept.
Memphis, TN 38152-0001
(901) 678-2206 Fax: (901) 678-2511

TEXAS

TEXAS STATE LIBRARY

United States Documents
P.O. Box 12927 - 1201 Brazos
Austin, TX 78701-0001
(512) 463-5455 Fax: (512) 463-5436

TEXAS TECH. UNIV. LIBRARIES

Documents Dept.
Lubbock, TX 79409-0002
(806) 742-2282 Fax: (806) 742-1920

UTAH

UTAH STATE UNIV.

Merrill Library Documents Dept.
Logan, UT 84322-3000
(801) 797-2678 Fax: (801) 797-2677

VIRGINIA

UNIV. OF VIRGINIA

Alderman Library
Govt. Documents
University Ave. & McCormick Rd.
Charlottesville, VA 22903-2498
(804) 824-3133 Fax: (804) 924-4337

WASHINGTON

WASHINGTON STATE LIBRARY

Govt. Publications
P.O. Box 42478
16th and Water Streets
Olympia, WA 98504-2478
(206) 753-4027 Fax: (206) 586-7575

WEST VIRGINIA

WEST VIRGINIA UNIV. LIBRARY

Govt. Documents Section
P.O. Box 6069 - 1549 University Ave.
Morgantown, WV 26506-6069
(304) 293-3051 Fax: (304) 293-6638

WISCONSIN

ST. HIST. SOC. OF WISCONSIN LIBRARY

Govt. Publication Section
816 State Street
Madison, WI 53706
(608) 264-6525 Fax: (608) 264-6520

MILWAUKEE PUBLIC LIBRARY

Documents Division
814 West Wisconsin Avenue
Milwaukee, WI 53233
(414) 286-3073 Fax: (414) 286-8074

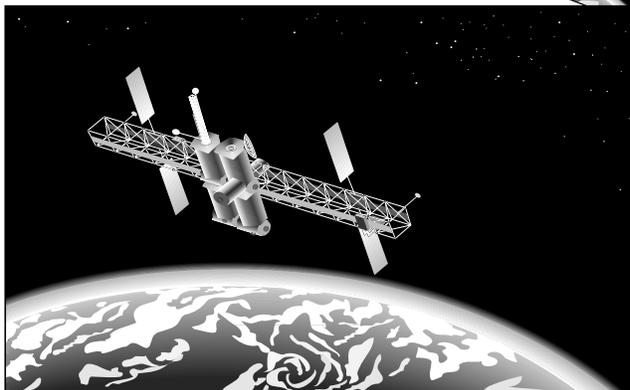
The New NASA Video Catalog is Here

**Internet
Access Available**

<http://www.sti.nasa.gov/STI-homepage.html>

Now!

(Select STI Program Publications)



Free!

To order your free copy, call the NASA Access Help Desk at (301) 621-0390, fax to (301) 621-0134, or e-mail to help@sti.nasa.gov

EXPLORE THE UNIVERSE

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