NASA SP-7085 (04)
October 1992

LARGE SPACE STRUCTURES AND SYSTEMS IN THE SPACE STATION ERA

A BIBLIOGRAPHY WITH INDEXES

NASA
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NASA
National Aeronautics and Space Administration
Scientific and Technical Information Program
Washington, DC 1992

NOTE TO AUTHORS OF PROSPECTIVE ENTRIES:

This bibliography compiles results from a complete search of the *STAR* and *IAA* files of the NASA STI Database, supplemented with a perusal of their printed versions. Although many technical areas relate to Large Space Structures and Space Stations, only those reports which directly address these subjects are included. To insure the inclusion of your work in this bibliography, use the words large space structure or space station in the title, abstract or suggested key words.

INTRODUCTION

This bibliography is designed to aid researchers and managers engaged in the development of technology, configurations and procedures that enhance the efficiency of current and future versions of space stations or other large space structures. It merges two earlier semiannual NASA Special Publications, NASA SP-7046, *Technology for Large Space Systems*, produced 1979-1989, and NASA SP-7056, *Space Station Systems*, produced from 1983-1989.

This literature survey lists 1211 reports, articles, and other documents announced between July 1, 1991 and December 30, 1991 in *Scientific and Technical Aerospace Reports (STAR)*, and *International Aerospace Abstracts (IAA)*.

The coverage includes references that define major systems and subsystems, servicing and support requirements, procedures, operations, and missions. It also includes analytical and experimental techniques and mathematical models required to investigate the different systems/subsystems, and to conduct trade studies of different configurations, designs, and scenarios.

The references appear in categories which are described with scope notes in the Table of Contents. These categories are unique to this publication only and differ from those found in *STAR* and *IAA*.

Each reference consists of a bibliographic citation and an abstract, if available, and appears with the original accession numbers from the respective announcement journals.

References appear in each category in this order:

(1) *IAA* entries in ascending accession number order with the form A91-10000, followed by,

(2) *STAR* entries in ascending accession number order with the form N91-10000.

After the abstract section there are seven indexes, viz., subject, personal author, corporate source, foreign technology, contract number, report number, and accession number. The subject index terms are from the *NASA Thesaurus*.

George F. Lawrence, *Space Station Office*
John J. Ferrainolo, *Technical Library Branch*

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TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

ACCESSION NUMBER → **N91-13363*#** Research Inst. for Advanced Computer Science, Moffett Field, CA. ← CORPORATE SOURCE

TITLE → **FACTORS SHAPING THE EVOLUTION OF ELECTRONIC DOCUMENTATION SYSTEMS**

AUTHORS → CHRISTOPHER J. DEDE, TIM R. SULLIVAN, and JACQUE R. SCACE 1990 128 p

PUBLICATION DATE

AVAILABILITY SOURCE

CONTRACT NUMBER → (Contract NCC9-16)

REPORT NUMBERS → (NASA-CR-187257; NAS 1.26:187257) Avail: CASI HC A07/MF A02

The main goal is to prepare the space station technical and managerial structure for likely changes in the creation, capture, transfer, and utilization of knowledge. By anticipating advances, the design of Space Station Project (SSP) information systems can be tailored to facilitate a progression of increasingly sophisticated strategies as the space station evolves. Future generations of advanced information systems will use increases in power to deliver environmentally meaningful, contextually targeted, interconnected data (knowledge). The concept of a Knowledge Base Management System is emerging when the problem is focused on how information systems can perform such a conversion of raw data. Such a system would include traditional management functions for large space databases. Added artificial intelligence features might encompass co-existing knowledge representation schemes; effective control structures for deductive, plausible, and inductive reasoning; means for knowledge acquisition, refinement, and validation; explanation facilities; and dynamic human intervention. The major areas covered include: alternative knowledge representation approaches; advanced user interface capabilities; computer-supported coöperative work; the evolution of information system hardware; standardization, compatibility, and connectivity; and organizational impacts of information intensive environments. Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

ACCESSION NUMBER → **A91-27359*** California Univ., La Jolla.

TITLE → **A SPACE PARASOL AS A COUNTERMEASURE AGAINST THE GREENHOUSE EFFECT**

AUTHOR'S AFFILIATION

AUTHOR → H. S. HUDSON (California, University, La Jolla) British Interplanetary Society, Journal (ISSN 0007-084X), vol. 44, March 1991, p. 139-141. refs ← JOURNAL DATE

JOURNAL TITLE

CONTRACT NUMBER → (Contract NSG-7161)

Copyright

It is suggested that the deployment of a 'space parasol' at the L1 Langrangian point of the earth-sun system would serve to intercept some desired fraction of the solar radiant energy, thereby lessening the impact of the greenhouse effect. The parasol satellites are described and possible orbit configurations are discussed. Orbital possibilities include Low Earth Orbit Geosynchronous orbit, and L1 which appears to be the best option Structural strength, control, and use of extraterrestrial material in the construction of the parasol are discussed. L.K.S.

LARGE SPACE STRUCTURES AND SYSTEMS IN THE SPACE STATION ERA

A Bibliography (Suppl. 04)

OCTOBER 1992

ABSTRACTS

01

OVERALL DESIGN AND EVOLUTIONARY GROWTH

System requirements for proposed missions, mission models, overall conceptual configuration and arrangement studies. Analyses for future required technology. Identification and description of technology for the elements of a complete space station.

A91-34018* National Aeronautics and Space Administration, Washington, DC.
STATUS OF THE INTERNATIONAL SPACE STATION AND ITS CAPABILITIES
R. H. KOHRS and CAROLYN S. GRINER (NASA, Washington, DC) (Columbus VI - Symposium on Space Station Utilization, 6th, Bremen, Federal Republic of Germany, Apr. 24-26, 1990, Proceedings. A91-34016 13-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 11, no. 2, 1991, p. 61-63.
Copyright

This paper describes the major changes made in Space Station Program since the July-October 1989 configuration/budget reviews, held to realign the program with the anticipated near-term funding reduction in the U.S. The changes introduced will affect the power system, the development of a new high-pressure spacesuit for the Station EVAs, the propulsion system for altitude maintenance, the number of airlocks, the utility runs of coolant to external payloads, and the laboratory support equipment, with some of these systems being improved and others to be eliminated. I.S.

A91-38399
STATION OF PROBLEMS AND PROGRESS
DAVID WHITEHOUSE *Space (ISSN 0267-954X), vol. 7, May-June 1991, p. 10-12.*
Copyright

The status of the Space Station Freedom program is assessed, with particular emphasis on the maintenance problem and criticism of the program by scientists. It is argued that it would be wrong to let any of the technical or scientific squabbles kill the Space Station. It is concluded that what is needed is a compelling spokesman to say that the Space Station is more than the sum of its parts and a series of seemingly inadequate justifications. B.J.

A91-38931#
POSSIBLE USES OF THE EXTERNAL TANK IN ORBIT
L. F. RONQUILLO and F. F. BAILLIF (Martin Marietta Manned Space Systems, New Orleans, LA) IN: Space commercialization: Launch vehicles and programs; Symposium on Space Commercialization: Roles of Developing Countries, Nashville, TN, Mar. 5-10, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 60-71. refs
Copyright

Ways in which the National Space Transportation System (NSTS) can be enhanced through utilization of the External Tank (ET) in orbit are discussed. The ET can be modified either prior to launch or in orbit to fit an individual user's needs for a low-cost, single or multidisciplinary facility. An ET-derived facility can provide the low cost associated with mass-produced systems and retains the flexibility to satisfy a wide range of users. Attention is given to the Shuttle-C system, resource availability, configuration and operations, the aft cargo carrier, and the ET as a gamma-ray imaging telescope. Diagrams illustrating the Shuttle-C configuration, the NSTS, the ET components, the aft cargo carrier, the unmanned platform, the LO2 tank profile, and the ET gamma-ray imaging telescope are provided. The ET's excellent cost-benefit ratio offers the leverage necessary to overcome the risk and delay of economic returns and bring space-based operations within the reach of private industry or developing countries. P.D.

A91-38952#
OUTPOST CONCEPT - A TRANSPORTATION AND SERVICE PLATFORM IN LOW-EARTH ORBIT
THOMAS C. TAYLOR, JOHN D. HODGE, and WILLIAM A. GOOD (Global Outpost, Inc., Alexandria, VA) IN: Space commercialization: Platforms and processing; Symposium on Space Commercialization: Roles of Developing Countries, Nashville, TN, Mar. 5-10, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1-18. refs
Copyright

The Outpost concept, postulating a number of economic and technological advantages provided by a low-orbit platform derived from the external tank (ET) of the Space Shuttle, is presented. This concept makes it possibe for developing nations and commercial organizations to participate in the commercial development of space by providing low-cost facilities for experimentation and research. The topics discussed include preliminary commercial platform services, experiment accomodations, technology development, and ET utilization. The feasibility of an Outpost platform in orbit by 1992 is indicated. O.G.

A91-39825
SPACE STATION ARCHITECTURE
R. P. HAVILAND British Interplanetary Society, Journal (ISSN 0007-094X), vol. 44, June 1991, p. 275-288.
Copyright

Concepts of a large space station are developed in terms of the architectural principles. The topics discussed include space station shape, the supply line from earth, the supply-waste problem, principles of closed-cycle processing, the human environment, the space station as a rocket and as a satellite, the station as a power-plant, and the station as a farm. The approach presented suggests that the station should be large, easily accomodate the add-it-up needs, and allow growth to 10 times as much activity and to 10 times as much space. A station of 30-40-ft-radius spheres with a wheel radius of about 300 ft is considered to be right. O.G.

A91-51626
SPACE MISSION ANALYSIS AND DESIGN
JAMES R. WERTZ, ED. (Microcosm, Inc., Torrance, CA) and WILEY J. LARSON, ED. (U.S. Air Force Academy, Colorado Springs, CO) Dordecht, Netherlands, Kluwer Academic Publishers, 1991, 832 p.

No individual items are abstracted in this volume.
Copyright

This volume presents papers in the fields of space mission analysis and design process, mission evaluation, requirements definition, space mission geometry, and an introduction to astrodynamics. Also presented are the space environment and survivability, defining and sizing space payloads, spacecraft manufacture and test, spacecraft computer systems, space logistics and reliability, and international spacecraft design experience. R.E.P.

A91-54579
SYSTEM TESTABILITY ANALYSES IN THE SPACE STATION FREEDOM PROGRAM
BRIAN A. KELLEY, ERASMO D'URSO (Harris Corp., Government Support Systems Div., Syosset, NY), RAUL REYES, and TOM TREFFNER (McDonnell Douglas Space Systems Co., Space Station Div., Huntington Beach, CA) IN: IEEE/AIAA/NASA Digital Avionics Systems Conference, 9th, Virginia Beach, VA, Oct. 15-18, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 21-26. refs
Copyright

A testability analysis of the integrated space station systems preliminary design was performed using the Harris Corporation's System Testability Analyzer (HSTA), a computer-based system testability analysis tool. The results of this analysis are useful for providing preliminary indicators of the station-level testability and identifying potential fault detection and/or isolation shortfalls inherent in the design. A review of the concepts and approaches available for testability analysis is given, and the specifics of the Space Station Freedom integrated systems testability analysis follow. Finally, a summary and conclusions derived are detailed. I.E.

A91-55801
SPACE UTILIZATION AND APPLICATIONS IN THE PACIFIC; PROCEEDINGS OF THE 3RD PACIFIC BASIN INTERNATIONAL SYMPOSIUM ON ADVANCES IN SPACE SCIENCE TECHNOLOGY AND ITS APPLICATIONS, LOS ANGELES, CA, NOV. 6-8, 1989
PETER M. BANIUM, ED., GAYLE L. MAY, ED., TATSUO YAMANAKA, ED., and JIA-CHI YANG, ED. Symposium sponsored by AAS, Japanese Rocket Society, and Chinese Society of Astronautics. San Diego, CA, Univelt, Inc., 1990, 764 p. For individual items see A91-55802 to A91-55854.
Copyright

Advances in space science technology and its applications are reviewed. Consideration is given to international and national space programs, Pacific Basin development through satellite technology, advanced communication needs for the Pacific, meeting educational needs through satellite technology, Pacific spaceports, the Space Station and the Pacific Basin, TT&C requirements/onboard electronics technology, space transportation systems, thermophysics, robotics in space, astrodynamics, advanced launch vehicle technology, and large space structures technology. O.G.

A91-55821* NASA Space Station Program Office, Reston, VA.
SPACE STATION FREEDOM - TECHNOLOGY R&D AND TEST FACILITY FOR THE 21ST CENTURY
ALAN C. HOLT (NASA, Space Station Freedom Program Office, Reston, VA) IN: Space utilization and applications in the Pacific; Proceedings of the 3rd Pacific Basin International Symposium on Advances in Space Science Technology and its Applications, Los Angeles, CA, Nov. 6-8, 1989. San Diego, CA, Univelt, Inc., 1990, p. 229-245. refs
(AAS PAPER 89-624) Copyright

Development of the SSF is considered in terms of a primary stimulus for technology research and development activities in the early 21st century. The utilization and operations management organization, the ground facilities, and the associated international agreements will form the basis for all future major space projects, including lunar and Mars missions and outposts. Problems discussed include SSF technology R&D accommodations, Pacific Basin cooperative R&D opportunities, Pacific Basin cooperative R&D candidates, and space infrastructure cooperative projects. O.G.

A91-55825
SCIENTIFIC, COMMERCIAL, AND SPACE CONSTRUCTION USES OF SHUTTLE EXTERNAL FUEL TANKS
GEORGE W. MORGENTHALER (Colorado, University, Boulder) and RANDOLPH H. WARE (University Corporation for Atmospheric Research; External Tanks Corp., Boulder, CO) IN: Space utilization and applications in the Pacific; Proceedings of the 3rd Pacific Basin International Symposium on Advances in Space Science Technology and its Applications, Los Angeles, CA, Nov. 6-8, 1989. San Diego, CA, Univelt, Inc., 1990, p. 283-299. refs
(AAS PAPER 89-628) Copyright

Recent progress in planning the scientific and commercial use of Shuttle External Tanks (ETs) is reviewed. Emphasis is placed on the development of unique payload modules and thrusters which can be attached to ETs and which will efficiently adapt ETs for low-cost use in space. It is concluded that the ET, a currently underutilized national space asset, has many potential scientific, commercial, and programmatic applications. It is feasible to use the ETs for suborbital and orbital purposes. ET attachment modules are currently being developed, and commercial bases through which companies, universities, and foreign governments may obtain an access to ETs in space are being prepared. O.G.

N91-21187# General Accounting Office, Washington, DC.
SPACE STATION: NASA'S SEARCH FOR DESIGN, COST, AND SCHEDULE STABILITY CONTINUES
Mar. 1991 41 p
(GAO/NSIAD-91-125) Avail: CASI HC A03/MF A01

The General Accounting Office (GAO) reports on its investigations of the space station plans, focusing on changes in the design, estimated cost, and schedule. Also reviewed were budget requests and congressional funding, and the impact on the space station's cost and capabilities of the 1989 program review done by the National Aeronautics and Space Administration (NASA) to stabilize the space station's design and schedule at achievable funding levels. NASA is described as being in phase 3 of 5 in the space station program. These phases are: (1) concept; (2) definition and preliminary design (ending with award of contracts for the next two phases); (3) detailed design; (4) development, manufacture, and assembly of components; and (5) operation. The last two phases will overlap and continue throughout the station's expected 30-year life. GAO identifies the primary objectives for the space station as advances in materials and life sciences. It also discusses changes that NASA has made to the program to reduce risk, weight, power, maintenance, and costs, and the tradeoffs that were required to achieve improvements. GAO suggests that NASA's cost estimates could be more helpful to Congress if required in a different format. J.P.S.

N91-22142*# Massachusetts Inst. of Tech., Cambridge.
PROPOSAL FOR A REMOTELY MANNED SPACE STATION
MARVIN MINSKY *In* NASA. Lewis Research Center, Vision-21: Space Travel for the Next Millennium p 58-67 Apr. 1990
Avail: CASI HC A02/MF A06 CSCL 22B

The United States is in trouble in space. The costs of the proposed Space Station Freedom have grown beyond reach, and the present design is obsolete. The trouble has come from imagining that there are only two alternatives: manned vs. unmanned. Both choices have led us into designs that do not appear to be practical. On one side, the United States simply does not possess the robotic technology needed to operate or assemble a sophisticated unmanned space station. On the other side, the manned designs that are now under way seem far too costly and dangerous, with all of its thousands of extravehicular activity (EVA) hours. More would be accomplished at far less cost by proceeding in a different way. The design of a space station made of modular, Erector Set-like parts is proposed which is to be assembled using earth-based remotely-controlled binary-tree telerobots. Earth-based workers could be trained to build the station in space using simulators. A small preassembled spacecraft would be launched with a few telerobots, and then, telerobots could be ferried into orbit along with stocks of additional parts. Trained terrestrial workers would remotely assemble a larger station, and materials for additional power and life support systems could be launched. Finally, human scientists and explorers could be sent to the space station. Other aspects of such a space station program are discussed. Author

N91-22168*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ADVANCED SPACECRAFT: WHAT WILL THEY LOOK LIKE AND WHY

HUMPHREY W. PRICE *In* NASA. Lewis Research Center, Vision-21: Space Travel for the Next Millennium p 371-390 Apr. 1990

Avail: CASI HC A03/MF A06 CSCL 22B

The next century of spaceflight will witness an expansion in the physical scale of spacecraft, from the extreme of the microspacecraft to the very large megaspacecraft. This will respectively spawn advances in highly integrated and miniaturized components, and also advances in lightweight structures, space fabrication, and exotic control systems. Challenges are also presented by the advent of advanced propulsion systems, many of which require controlling and directing hot plasma, dissipating large amounts of waste heat, and handling very high radiation sources. Vehicle configuration studies for a number of theses types of advanced spacecraft were performed, and some of them are presented along with the rationale for their physical layouts. Author

N91-27090*# Houston Univ., TX. Dept. of Applied Mathematical Sciences.

COMPOUND ESTIMATION PROCEDURES IN RELIABILITY Final Report

RON BARNES *In its* NASA/ASEE Summer Faculty Fellowship Program, 1990, Volume 1 16 p Dec. 1990

(Contract NGT-44-005-803)

Avail: CASI HC A03/MF A03 CSCL 14D

At NASA, components and subsystems of components in the Space Shuttle and Space Station generally go through a number of redesign stages. While data on failures for various design stages are sometimes available, the classical procedures for evaluating reliability only utilize the failure data on the present design stage of the component or subsystem. Often, few or no failures have been recorded on the present design stage. Previously, Bayesian estimators for the reliability of a single component, conditioned on the failure data for the present design, were developed. These new estimators permit NASA to evaluate the reliability, even when few or no failures have been recorded. Point estimates for the latter evaluation were not possible with the classical procedures. Since different design stages of a component (or subsystem) generally have a good deal in common, the development of new statistical procedures for evaluating the reliability, which consider the entire failure record for all design stages, has great intuitive appeal. A typical subsystem consists of a number of different components and each component has evolved through a number of redesign stages. The present investigations considered compound estimation procedures and related models. Such models permit the statistical consideration of all design stages of each component and thus incorporate all the available failure data to obtain estimates for the reliability of the present version of the component (or subsystem). A number of models were considered to estimate the reliability of a component conditioned on its total failure history from two design stages. It was determined that reliability estimators for the present design stage, conditioned on the complete failure history for two design stages have lower risk than the corresponding estimators conditioned only on the most recent design failure data. Several models were explored and preliminary models involving bivariate Poisson distribution and the Consael Process (a bivariate Poisson process) were developed. Possible short comings of the models are noted. An example is given to illustrate the procedures. These investigations are ongoing with the aim of developing estimators that extend to components (and subsystems) with three or more design stages. Author

N91-31201*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

RESTRUCTURED FREEDOM CONFIGURATION CHARACTERISTICS

PATRICK A. TROUTMAN, MICHAEL L. HECK, RENJITH R. KUMAR, and DANIEL D. MAZANEK (Analytical Mechanics Associates, Inc., Hampton, VA.) Jun. 1991 66 p

(Contract RTOP 476-50-02-02)

(NASA-TM-104057; NAS 1.15:104057) Avail: CASI HC A04/MF A01 CSCL 22B

In Jan. 1991, the LaRc SSFO performed an assessment of the configuration characteristics of the proposed pre-integrated Space Station Freedom (SSF) concept. Of particular concern was the relationship of solar array operation and orientation with respect to spacecraft controllability. For the man-tended configuration (MTC), it was determined that torque equilibrium attitude (TEA) seeking Control Moment Gyroscope (CMG) control laws could not always maintain attitude. The control problems occurred when the solar arrays were tracking the sun to produce full power while flying in an arrow or gravity gradient flight mode. The large solar array articulations that sometimes result from having the functions of the alpha and beta joints reversed on MTC induced large product of inertia changes that can invalidate the control system gains during an orbit. Several modified sun tracking techniques were evaluated with respect to producing a controllable configuration requiring no modifications to the CMG control algorithms. Another assessment involved the permanently manned configuration (PMC) which has a third asymmetric PV unit on one side of the transverse boom. Recommendations include constraining alpha rotations for MTC in the arrow and gravity gradient flight modes and perhaps developing new non-TEA seeking control laws. Recommendations for PMC include raising the operational altitude and moving to a symmetric configuration as soon as possible. Author

02

POLICIES AND INTERNATIONAL COOPERATION

Descriptions, interfaces and requirements of international payload systems, subsystems and modules considered as part of the space station system and other international space station activities such as Soviet Salyut.

A91-34016

COLUMBUS VI - SYMPOSIUM ON SPACE STATION UTILIZATION, 6TH, BREMEN, FEDERAL REPUBLIC OF GERMANY, APR. 24-26, 1990, PROCEEDINGS

Symposium supported by Ministero dell'Universita e della Ricerca Scientifica e Tecnologica, ASI, ESA, et al. Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 11, no. 2, 1991, 65 p. For individual items see A91-34017 to A91-34024.

Copyright

Topics discussed include orbital and ground infrastructures of the International Space Station, manned interaction in space, and the Columbus utilization preparation. Papers are presented on the status of the International Space Station and its capabilities, the Columbus Programme overview with emphasis on the Space Segment activities, the Japanese Experiment Module program status, and the role and the buildup of the European Astronauts Centre. Other papers are on Columbus-astronaut training in the Crew Training Complex at DLR, user support, and preparatory programs for the International Space Station utilization, with emphasis on the French program. I.S.

A91-34017
PREPARING FOR COLUMBUS UTILIZATION
FREDRIK ENGSTROEM (ESA, Paris, France) (Columbus VI - Symposium on Space Station Utilization, 6th, Bremen, Federal Republic of Germany, Apr. 24-26, 1990, Proceedings. A91-34016 13-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 11, no. 2, 1991, p. 55-59.
Copyright

This paper discusses the objectives and the utilization potential of Columbus-module laboratories, which will give the European users a permanent access to manned and semiautomatic space laboratories with accommodations and resources superior to those of the Spacelab and Eureca. Special attention is given to the Columbus Exploitation Programme, to be initiated in 1993, which will cover both the system operations and utilization costs; the program will allocate the accommodation space and the access rights to Columbus on the basis of the financial share within the Exploitation Program. I.S.

A91-34019
COLUMBUS PROGRAMME OVERVIEW WITH EMPHASIS ON SPACE SEGMENT ACTIVITIES
G. ALTMANN (ESTEC, Noordwijk, Netherlands; ESA, Paris, France) (Columbus VI - Symposium on Space Station Utilization, 6th, Bremen, Federal Republic of Germany, Apr. 24-26, 1990, Proceedings. A91-34016 13-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 11, no. 2, 1991, p. 65-76.
Copyright

The Columbus Programme represents Europe's contribution, in cooperation with the U.S.A., Japan and Canada to the International Space Station Freedom. The present status of the program is described including a brief summary of the current status of the three flight configurations: Columbus Attached Laboratory; Columbus Free-Flying Laboratory; and Columbus Polar Platform. Furthermore, an overview is given on the evolution of some programmatic aspects of the program over the past 2 years.
Author

A91-34020
JAPANESE EXPERIMENT MODULE PROGRAM STATUS
KIYOSHI HIGUCHI (NASDA, Tokyo, Japan) (Columbus VI - Symposium on Space Station Utilization, 6th, Bremen, Federal Republic of Germany, Apr. 24-26, 1990, Proceedings. A91-34016 13-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 11, no. 2, 1991, p. 77-82.
Copyright

The design and structural characteristics of the Japanese Experiment Module (JEM) for the Space Station Freedom, and of its three subunits (the Pressurized Module, the Experiment Logistics Module, and the Exposed Facility) are examined, with special attention given to the JEM-payload accommodation interfaces. The program status and the preparations for JEM operation and utilization are discussed. Tables listing the primary characteristics of the JEM system are presented as well as diagrams illustrating the salient features of the module. I.S.

A91-34023
USER SUPPORT
F. UNZ (DLR, Cologne, Federal Republic of Germany) (Columbus VI - Symposium on Space Station Utilization, 6th, Bremen, Federal Republic of Germany, Apr. 24-26, 1990, Proceedings. A91-34016 13-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 11, no. 2, 1991, p. 99-102.
Copyright

This paper discusses the conceptual basis for the European User Support Organization (USO) and the activities of the USO Definition Team, together with the results of these activities. The developed concept is based on a building block structure which can be implemented with use of existing structures and according to the requirements of individual Columbus participating member states. A first validation of this concept has been performed. I.S.

A91-34024
PREPARATORY PROGRAMS FOR THE INTERNATIONAL SPACE STATION UTILIZATION - EMPHASIS ON THE FRENCH PROGRAM
ALAIN ESTERLE and RICHARD BONNEVILLE (CNES, Paris, France) (Columbus VI - Symposium on Space Station Utilization, 6th, Bremen, Federal Republic of Germany, Apr. 24-26, 1990, Proceedings. A91-34016 13-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 11, no. 2, 1991, p. 103-108.
Copyright

Preparatory programs for the utilization of the International Space Station (ISS) and the Columbus laboratory are discussed, with special attention given to the differences between the parameters of the current project design and those of the presently available space systems including the Soviet systems. These differences are both quantitative (i.e., more diverse and ambitious objectives of the ISS) and qualitative (many new elements will be developed in parallel with the flight segment of the ISS). I.S.

A91-34934#
CANADA'S ROLE IN PUSHING BACK THE FRONTIERS OF SPACE
IAN H. ROWE (Spar Aerospace, Ltd., Weston, Canada) IN: CASI Conference on Astronautics, 6th, Ottawa, Canada, Nov. 19-21, 1990, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1990, p. 77-82.

Canada has developed, and continues to refine, world-class capabilities in four fields of space research: ionospheric and magnetospheric science, satellite communications, remote sensing, and manned space flight. These bases of expertise are now to be oriented toward such goals as the polar-orbiting Small Canadian Satellite, the communications implications of space-plasma physics and solar-terrestrial relationships, atmospheric remote sensing studies, novel microgravity-processed materials, and manned-mission life sciences studies. Attention is given to the activities of the Canadian Universities Advanced Design Program.
O.C.

A91-38970#
JAPANESE APPROACH TO THE SPACE STATION
YASUSHI HORIKAWA (NASDA, Tokyo, Japan) IN: Space commercialization: Platforms and processing; Symposium on Space Commercialization: Roles of Developing Countries, Nashville, TN, Mar. 5-10, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 296-315.
Copyright

The Japanese Experimental Module (JEM) design is described, and Japanese approaches to effective space environment utilization are discussed, including an experiment system depending on Space Shuttle use for the First Materials Processing Test and the International Microgravity Laboratory. Particular attention is given to microgravity experiments using a drop tower on the ground, aircraft, a small of expendable launch vehicle, and the H-II launch vehicle. O.G.

A91-38971#
JAPAN'S SPACE DEVELOPMENT ACTIVITIES FOR THE PRACTICAL APPLICATION FIELD
RYU-I-CHI NAGASHIMA and TADAHICO INADA (NASDA, Tokyo, Japan) IN: Space commercialization: Platforms and processing; Symposium on Space Commercialization: Roles of Developing Countries, Nashville, TN, Mar. 5-10, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 316-335.
Copyright

Japan's space development activities implemented by the National Space Development Agency of Japan (NASDA) for the practical application field are introduced. The N-I, N-II, H-I, and H-II launch vehicles developed under NASDA programs are characterized. Engineering Test Satellite V (ETS-V), launched by the H-I launch vehicle in August 1987, established basic technology for bus systems needed for three-axis-stabilized geostationary satellites and confirmed the performance apogee boost motors. H-II Orbiting Plane (HOPE) is to be launched by H-II launch vehicle to perform recovery of experimental products from the Space Station and to provide logistics to platforms in the latter half of the 1990s. Key technologies for HOPE development are briefly described. O.G.

A91-39968
COLUMBUS COMES TO THE CRUNCH
STEPHANE CHENARD Interavia Space Markets (ISSN 0258-4212), vol. 6, no. 6, 1990, p. 296-301.
Copyright
The ESA Council has yet to authorize expenditure of the largest part of the budget defined in 1987 for the 'In-Orbit Infrastructure' plan, of which the Columbus system (encompassing a Space Station Freedom-associated Attached Pressurized Module, the Columbus Free Flyer, and an unmanned Polar Platform) is an essential element. Some uncertainty in Columbus planning derives from current reviews of the Space Station, which may substantially alter its configuration and thereby entail Columbus component redesign efforts; some delays experienced to date are also associated with reallocations of responsibilities among contractors, the imposition of stricter cost controls by ESA, budgetary uncertainties of ESA member governments, and the comparative lack of interest in Columbus' microgravity research focus among potential users. O.C.

A91-42863
COLUMBUS MISSION PLANNING CONCEPT
W. SALTER (Marcol Group, Ltd., Space Div., Bristol, England) British Interplanetary Society, Journal (ISSN 0007-094X), vol. 44, July 1991, p. 307-316.
Copyright
A new mission planning concept, based on a layered approach and adopted for the Columbus project, is described from the European point of view, concentrating on the lowest level, the execution level, and the Attached and Free Flying Laboratories. The layered approach has been developed to meet special requirements of the Columbus program, which include simultaneous planning for two flight elements, accommodating users of many nationalities and in many locations, decentralized planning, and an operational planning of some 30 years. The approach encompasses three levels: the strategic level, at which the candidate payloads are proposed; the tactical level, primarily involved with the manifesting of experiments to particular flights, and the execution level,responsible for the detailed scheduling of experiment operations. It is suggested that this concept will allow the users the flexibility to make the best use of the facilities that will be offered by the two Columbus elements. O.G.

A91-47575
THE EXPLOITATION OF SPACE AND DEVELOPING COUNTRIES (INTERNATIONAL-LAW PROBLEMS) [OSVOENIE KOSMOSA I RAZVIVAIUSHCHIESIA STRANY /MEZHDUNARODNO-PRAVOVYE PROBLEMY/]
VLADIMIR M. POSTYSHEV Moscow, Izdatel'stvo Nauka, 1990, 192 p. In Russian. refs
Copyright
The contribution of developing countries to the creation of an international legal order in the domain of space activities is discussed. Particular attention is given to the organization of international collaboration in the interests of the peaceful exploration and exploitation of space. The following areas of such exploitation are considered: the remote sensing of earth resources, direct TV broadcasting, the utilization of the geostationary orbit, and the exploitation of lunar resources. L.M.

A91-48026* National Air and Space Museum, Washington, DC.
A SPACEFARING NATION - PERSPECTIVES ON AMERICAN SPACE HISTORY AND POLICY
MARTIN J. COLLINS, ED. (National Air and Space Museum, Washington, DC) and SYLVIA D. FRIES, ED. (NASA, Washington, DC) Washington, DC, Smithsonian Institution Press, 1991, 261 p. For individual items see A91-48027 to A91-48034.
Copyright
The present volume on perspectives on American space history and policy discusses decision-making, space science and scientific communities, postwar aeronautical research in the federal laboratory, and civilian and military remote sensing and reconnaissance. Attention is given to the interpenetration of science, technology, and politics; space 'sociology'; and space technology and planetary science from 1950 to 1985. Other topics addressed include the aeronautics infrastructure as it applies to aeronautics history, the Lewis Research Center and its transition to space, the relationship between NASA and the users of earth resources data, and methodology for researching a classified system for space reconnaissance. P.D.

A91-48027* American Univ., Washington, DC.
THE SPACE STATION DECISION - POLITICS, BUREAUCRACY, AND THE MAKING OF PUBLIC POLICY
HOWARD E. MCCURDY (American University, Washington, DC) IN: A spacefaring nation - Perspectives on American space history and policy. Washington, DC, Smithsonian Institution Press, 1991, p. 9-28. refs
(Contract NASW-4067)
Copyright
The lack of consensus that dominates the conception of major scientific and technological programs is demonstrated via a comparison of the decisions to build the Space Station and the Space Transportation System, and the decision to go to the moon. It is argued that the way political reality conditions administrative behavior in NASA is shown by the decision to promote international cooperation prior to program approval. It is concluded that so long as NASA remains a government agency, its officials will struggle to learn how to balance professional accountability with political reality. P.D.

A91-50258
TELESPAZIO'S WAY TO SPACE - THE SPACE TECHNOLOGY BRANCH
G. MOCCI (Telespazio S.p.A., Rome, Italy) British Interplanetary Society, Journal (ISSN 0007-084X), vol. 44, Sept. 1991, p. 415-420. refs
Copyright
The development of the Telespazio Space Technology Department is the focus of this review of the Italian national program. The Space Technology branch is concerned primarily with on-orbit operation preparation, training and simulation, and space system engineering and quality control. The involvement of Telespazio is described with regards to project development, and specific projects are mentioned for each category of activity. Specific national and international projects mentioned include Sirio-2, Olympus, Italsat, Sax, and Columbus, and the types of technical intervention for some of the projects are also listed. Telespazio currently comprises the Space and On-Orbit Support-System Strategic Business Unit. C.C.S.

A91-52225* American Univ., Washington, DC.
THE SPACE STATION DECISION - INCREMENTAL POLITICS AND TECHNOLOGICAL CHOICE
HOWARD E. MCCURDY (American University, Washington, DC) Research supported by NASA;. Baltimore, MD, Johns Hopkins University Press, 1990, 298 p. refs
(Contract NASW-4067)
Copyright
Using primary documents and interviews with participants, this book describes the events that led up to the 1984 decision that NASA should build a permanently occupied, international space station in low earth orbit. The role that civil servants in NASA played in initiating the program is highlighted. The trail of the Space Station proposal as its advocates devised strategies to push it through the White House policy review process is followed. The critical analysis focuses on the way in which 'incrementalism' (the tendency of policy makers to introduce incremental changes

once projects are under way) operated in connection with the Space Station program. The book calls for a commitment to a long-range space policy. B.J.

A91-53449
THE UTILIZATION OF JEM FOR SCIENTIFIC AND TECHNOLOGICAL INVESTIGATION
T. NISHINAGA (Tokyo, University, Japan) (Microgravity research: Material and fluid sciences; Proceedings of Symposium 11 of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A91-53401 23-29) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 7, 1991, p. 375-380. refs
Copyright
The general design and the scientific equipment of the Japanese Experimental Module (JEM), which will be attached to the Space Station Freedom core, are briefly reviewed. The JEM is designed as a microgravity laboratory for materials processing experiments and fundamental materials research. The experimental facilities to be installed in the module include isothermal, gradient heating, zone melting, and levitation furnaces, solution and vapor growth facilities, a fluid physics experiment facility, a wettability measurement facility, and a physical and chemical experiment facility. V.L.

A91-55422
USSR-FRANCE: COOPERATION IN SPACE [SSSR-FRANTSIIA: KOSMICHESKOE SOTRUDNICHESTVO]
BORIS P. KONOVALOV Moscow, Izdatel'stvo Mashinostroenie, 1990, 200 p. In Russian.
Copyright
This book comprises a popular account of the second Soviet-French space flight. The Soyuz TM-7 spacecraft, which was launched on Nov. 26, 1988, carried a French cosmonaut along with two Soviet cosmonauts. The mission involved the docking with the Mir orbital complex, on which numerous scientific and technological experiments were carried out. Some of the experiments are described in detail. L.M.

A91-55822
CURRENT STATUS OF THE SPACE STATION PROGRAM IN JAPAN
TAKEHIKO KATO (NASDA, Washington Liaison Office, Reston, VA), AKIRA TANAKA, and YASUSHI HORIKAWA (NASDA, Space Station Program Promotion Office, Tokyo, Japan) IN: Space utilization and applications in the Pacific; Proceedings of the 3rd Pacific Basin International Symposium on Advances in Space Science Technology and its Applications, Los Angeles, CA, Nov. 6-8, 1989. San Diego, CA, Univelt, Inc., 1990, p. 247-258.
(AAS PAPER 89-625) Copyright
Japanese Experiment Module (JEM) design concept is presented. The JEM consists of a pressurized module, an exposed facility, logistics modules, and a manipulator system. Particular attention is given to the JEM operations and utilization concept and the JEM information network system concept. O.G.

N91-21160# Norwegian Space Center, Oslo.
DEVELOPMENT OF NORWEGIAN SPACE ACTIVITIES
PAAL SOERENSEN *In its* From Earth to Space and Back: Selected Papers on Norwegian Space Activities p 3-5 Mar. 1990
Avail: CASI HC A01/MF A01
The history of Norwegian involvement in space activities is summarized. A full member of ESA since 1987, Norwegian space activities have extended in scope and depth. The development strategy of the Norwegian Space Agency is outlined. Considerable interest has been shown by Norwegian business in the Ariane 5, Columbus and Hermes programs. A remote sensing service called ERS-1 planned for development from 1989 to 1992 is outlined. The major research and development and manufacturing companies in Norway are members of the Norwegian Industrial Forum for Space Activities (NIFRO). The companies belonging to this group are listed. ESA

N91-21977# Committee on Commerce, Science, and Transportation (U.S. Senate).
NASA AUTHORIZATIONS
Washington GPO 1990 619 p Hearings before the Committee on Commerce, Science, and Transportation, 101st Congress, 2d Session, 9 Mar., 28 Mar., 3 Apr., 3 May, 10 May, and 15 May 1990
(S-HRG-101-981; GPO-30-598) Avail: Subcommittee on Scoience, Technology, and Space, Senate, Washington, DC HC free; also available SOD HC $17.00 as 552-070-09349-4
Presented are the hearings on the National Aeronautics and Space Administration's fiscal year 1991 budget request before the Subcommittee on Science, Technology, and Space of the Committee on Commerce, Science, and Transportation of the U.S. Senate of the 101st Congress, second session. Oral and written testimony and submittals for the record are included. The six days of hearings covered an overview of NASA, the space shuttles and space station, the Mission to the Planet Earth, aeronautics and space technology, space science and applications, and commercial space programs.

N91-21979# Committee on Commerce, Science, and Transportation (U.S. Senate).
NASA SPACE SHUTTLE/SPACE STATION
In its NASA Authorizations p 57-120 1990
Avail: Subcommittee on Science, Technology, and Space, Senate, Washington, DC HC free; also available SOD HC $17.00 as 552-070-09349-4
Opening statements by subcommittee members and a prepared statement by the National Aeronautics and Space Administration's Associate Administrator for the Office of Space Flight are followed by responses to questions submitted to NASA prior to the hearings. Discussions stressed the necessity of funding stability to the safety and continued use of space shuttles, and the importance of shuttles to other NASA programs. In presenting the budget request for the Space Station Freedom, NASA Management emphasized that NASA's objectives have not changed, that progress has been substantial, that adjustments to the program have not affected its basic integrity, and that full funding for FY 1991-1993 is essential, not only to complete the Space Station on schedule and keep costs down, but also to avoid significant and adverse impact on the space programs of NASA's international partners. J.P.S.

N91-22182*# Advisory Committee on the Future of the US Space Program, Washington, DC.
REPORT OF THE ADVISORY COMMITTEE ON THE FUTURE OF THE US SPACE PROGRAM
Dec. 1990 65 p Prepared for NASA, Washington Original contains color illustrations
(NASA-TM-104952; NAS 1.15:104952) Avail: CASI HC A04/MF A01; 13 functional color pages CSCL 22A
The United States' civil space program was rather hurriedly formulated some three decades ago on the heels of the successful launch of the Soviet Sputnik. A dozen humans have been placed on the Moon and safely returned to Earth, seven of the other eight planets have been viewed at close range, including the soft landing of two robot spacecraft on Mars, and a variety of significant astronomical and other scientific observations have been accomplished. Closer to Earth, a network of communications satellites has been established, weather and ocean conditions are now monitored and reported as they occur, and the Earth's surface is observed from space to study natural resources and detect sources of pollution. Problems and perspectives of the program are given as seen by the committee. The committee finds that there are nine concerns about the space program which are deserving of attention. The responsibilities of the agency are given. The space agenda becomes one of what can and should the U.S. afford for its space program. Also given is a concept of what the committee believes is a balanced space program. The programs international role is defined and some final observations and recommendations are made. Author

N91-22210# National Space Development Agency, Tokyo (Japan).
JEM GROUND CONTROL SYSTEM
YOSHIYUKI HASEGAWA, YASUSHI HORIKAWA, and AKIRA TANAKA *In* ESA, Ground Data Systems for Spacecraft Control p 127-130 Oct. 1990
Copyright Avail: CASI HC A01/MF A06

The Japanese Experimental Module (JEM) to be launched by the Space Transportation System (STS), attached to the Space Station, and activated and verified in-orbit is described. JEM will be utilized internationally as a multipurpose laboratory. While NASA is the focal point for the Space Station systems operation, NASDA is planning to establish a ground control system at Tsukuba Space Center/(TKSC) as a single point of contact with NASA systems to integrate Japanese technical expertise. To support JEM system and Japanese payload operations, NASDA will develop the JEM Operations Center at TKSC. The JEM Operation Center will have management and integration, flight control, payload operation control, engineering support, user support, and logistics support capabilities. ESA

N91-22928*# National Aeronautics and Space Administration, Washington, DC.
THE OFFICE OF SPACE SCIENCE AND APPLICATIONS STRATEGIC PLAN, 1990: A STRATEGY FOR LEADERSHIP IN SPACE THROUGH EXCELLENCE IN SPACE SCIENCE AND APPLICATIONS
1990 70 p
(NASA-TM-104950; NAS 1.15:104950) Avail: CASI HC A04/MF A01 CSCL 05A

A strategic plan for the U.S. space science and applications program during the next 5 to 10 years was developed and published in 1988. Based on the strategies developed by the advisory committees of both the National Academy of Science and NASA, the plan balances major, moderate, and small mission initiatives, the utilization of the Space Station Freedom, and the requirements for a vital research base. The Office of Space Science and Applications (OSSA) strategic plan is constructed around five actions: establish a set of programmatic themes; establish a set of decision rules; establish a set of priorities for missions and programs within each theme; demonstrate that the strategy will yield a viable program; and check the strategy for consistency within resource constraints. The OSSA plan is revised annually. This OSSA 1990 Strategic Plan refines the 1989 Plan and represents OSSA's initial plan for fulfilling its responsibilities in two major national initiatives. The Plan is now built on interrelated, complementary strategies for the core space science and applications program, for the U.S. Global Change Research Program, and for the Space Exploration Initiative. The challenge is to make sure that the current level of activity is sustained through the end of this century and into the next. The 1990 Plan presents OSSA's strategy to do this. B.G.

N91-24839# Mardon (Austin Albert), Lethbridge (Alberta).
INTERNATIONAL STANDARDIZATION IN SPACE SYSTEMS
AUSTIN ALBERT MARDON 1990 48 p
(PB91-135988) Avail: CASI HC A03/MF A01 CSCL 20C

The Agreement on the Rescue of Astronauts, the Return of Astronauts, and Objects Launched into Outer Space of 1968 (assistance agreement) is an international treaty that could become a legal testbed for the elaboration, strengthening, and expansion of the space law regime. A revised and expanded assistance agreement could be the result of a proactive stance to introduce standardization of human and machine rescue systems. It could also strengthen general attempts to reduce man made environmental hazards in the outer space environment. GRA

N91-27103*# Houston Univ., TX.
NASA/ASEE SUMMER FACULTY FELLOWSHIP PROGRAM, 1990, VOLUME 2
RICHARD B. BANNEROT, ed. and STANLEY H. GOLDSTEIN, ed. (National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.) Dec. 1990 177 p Program held in Houston, TX, 1990
(Contract NGT-44-005-803)
(NASA-CR-185637-VOL-2; NAS 1.26:185637-VOL-2) Avail: CASI HC A09/MF A02 CSCL 05B

The 1990 Johnson Space Center (JSC) National Aeronautics and Space Administration (NASA)/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program was conducted by the University of Houston-University Park and Johnson Space Centers (JSC). A compilation of the final reports on the research projects is presented. The following topics are covered: the Space Shuttle; the Space Station; lunar exploration; mars exploration; spacecraft power supplies; mars rover vehicle; mission planning for the Space Exploration Initiative; instrument calibration standards; a lunar oxygen production plant; optical filters for a hybrid vision system; dynamic structural analysis; lunar bases; pharmacodynamics of scopolamine; planetary spacecraft cost modeling; and others.

N91-27187# Joint Publications Research Service, Arlington, VA.
REEVALUATION OF SPACE PROGRAM COSTS, PRIORITIES URGED
V. GOLOVACHEV *In its* JPRS Report: Science and Technology. USSR: Space p 58-59 7 Feb. 1991 Transl. into ENGLISH from *TRUD* (Moscow, USSR), 2 Aug. 1990 p 3
Avail: CASI HC A01/MF A01

The following subject areas are covered: Mir complex; EVAs; spaceborne experiments; cosmonauts' performance; costs of manned flights; the manned space programs; orbital assembly; and satellite communication. Author

N91-30176# Norwegian Space Center, Oslo.
ACTIVITIES REPORT OF THE NORWEGIAN SPACE CENTER Annual Report, 1989 [NORSK ROMSENTER, AARSBERETNING 1989]
1989 19 p In NORWEGIAN
(ETN-91-98904) Avail: CASI HC A03/MF A01

An overview of the contribution of the Norwegian Space Center to 1989 space activities is presented. A summary table of cost breakdown is given with the 1988 figures given as comparison. Contributions to telecommunication systems, the Columbus Space Station, hypersonic space transport (including the West German Saenger vehicle), remote sensing observation and the Cassini/Huygen mission are outlined. An administration graphic of the center is included. ESA

03

MANAGEMENT SYSTEMS AND LOGISTICAL SUPPORT

Scheduling and logistical support for space systems. Includes *descriptions of ground-based support and research facilities.*

A91-32375
THEORY OF MICROWAVE DISCHARGE IN A LOW-PRESSURE GAS [K TEORII SVCH RAZRIADA V GAZE NIZKOGO DAVLENIIA]
IU. R. ALANAKIAN (Opytno-Konstruktorskoe Biuro Gorizont, USSR) Fizika Plazmy (ISSN 0367-2921), vol. 17, Jan. 1991, p. 97-101. In Russian.
Copyright

A study is made of the structure of plasma in the vicinity of a threshold microwave field under conditions of discharge in a low-pressure free gas (i.e., when walls absorbing charged particles are absent). A system of equations is obtained which describes plasma parameters near the threshold, including electron temperature and density, plasma dimensions, and the magnitude of the threshold microwave electric field. By using these equations, the threshold microwave field is determined as a function of electron temperature. V.L.

A91-32956#
A PNEUMATIC/ELECTRIC SUSPENSION SYSTEM FOR SIMULATING ON-ORBIT CONDITIONS
DAVID A. KIENHOLZ (CSA, Engineering, Inc., Palo Alto, CA) ASME, Winter Annual Meeting, Dallas, TX, Nov. 25-30, 1990. 7 p. refs
(ASME PAPER 90-WA/AERO-8)

Accurate simulation on earth of the unconstrained boundary conditions of space is a classic problem in dynamic testing. It has become both more important and more difficult with the advent of large, flexible orbiting structures such as Space Station Freedom. A new suspension system is presented which is designed to provide an accurate ground simulation of on-orbit dynamics for structures with fundamental flexural frequencies as low as 1.0 Hz. Using a combination of passive pneumatic and active electromechanical subsystems, it offers a wide payload range, very low stiffness, zero static deflection, and zero friction. The electromechanical subsystem offers other useful features such as dc stiffness enhancement and active cancellation of the moving mass of the suspension device. The concept and hardware are described; test results are given, and the usage of several variants of the system in current aerospace programs is described. Author

A91-34021
THE EUROPEAN ASTRONAUTS CENTRE - ITS ROLE AND BUILD-UP
ANDRES RIPOLL (ESA, European Astronauts Centre, Cologne, Federal Republic of Germany) (Columbus VI - Symposium on Space Station Utilization, 6th, Bremen, Federal Republic of Germany, Apr. 24-26, 1990, Proceedings. A91-34016 13-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 11, no. 2, 1991, p. 83-89.
Copyright

This paper describes the European Astronauts Centre (AEC), which will be set up to coordinate the establishment of the necessary facilities for astronaut training in the operation and utilization of a manned in-orbit infrastructure planned by ESA and to develop a European astronauts corps. Special attention is given to the training concept, the training facilities, and the procedures to be used for training astronauts. In the near future, ESA astronauts will participate in manned space missions as a final step of preparation for manned space flight in ESA's modules. I.S.

A91-34022
COLUMBUS ASTRONAUT TRAINING IN THE CREW TRAINING COMPLEX AT DLR
HANSULRICH STEIMLE (DLR, Cologne, Federal Republic of Germany) (Columbus VI - Symposium on Space Station Utilization, 6th, Bremen, Federal Republic of Germany, Apr. 24-26, 1990, Proceedings. A91-34016 13-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 11, no. 2, 1991, p. 91-98.
Copyright

The Crew Training Complex (CTC) that is being built at DLR, (Cologne, Germany) is described together with the elements of the training program for European astronauts. Special attention is given to the individual CTC facilities and their use, the typical training flow, the overall astronaut training sequence, and the Columbus/Hermes crew preparation. I.S.

A91-34949#
SPACECRAFT VERIFICATION AT THE DAVID FLORIDA LABORATORY
ROLF MAMEN (Canadian Space Agency, Ottawa, Canada) IN: CASI Conference on Astronautics, 6th, Ottawa, Canada, Nov. 19-21, 1990, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1990, p. 252-262. refs

A development status and performance capabilities evaluation is presented for the complete spacecraft and spacecraft subsystems testing facilities of the Canadian Space Agency's David Florida Laboratory (DFL). Testing capabilities encompass thermal verification, dynamic (vibration and modal analysis) testing, and RFI/EMC measurements. Various ancilliary support services can furnish materials, mass properties, and outgassing measurements. The full range of the DFL's capabilities are currently being used in support of ESA's Olympus program and the Telesat Canada Anik-E satellites; prospective Radarsat and Space Station Freedom testing tasks are anticipated to require further testing technology developments, such as improved deployment suspensions for large lightweight structures. O.C.

A91-35478
UPGRADED MODAL TEST FACILITY FOR DYNAMIC TESTING OF SPACECRAFT STRUCTURES
CARL R. VOORHEES (General Electric Co., Astro Space Div., Princeton, NJ) IN: International Modal Analysis Conference, 8th, Kissimmee, FL, Jan. 29-Feb. 1, 1990, Proceedings. Vol. 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1990, p. 1-7.
Copyright

The techniques and equipment used to perform modal survey testing at an upgraded facility in connection with developing a test-verified spacecraft model are described. Performance on a modal test of the NASA UARS spacecraft is presented. The upgrades included an increased simultaneous channel count in the data acquisition system, an enhanced data handling and signal conditioning system in response to the large number of signals, and increased data flow between components of the test system (facilitated by a new network). A digital implementation of the multiphase-step-sine method was added to perform impact, random, and sine tests. The new multichannel data acquisition and control system improved test data acquisition times and test capabilities. The four-shaker step-sine system is competiitve with more costly existing turn-key systems, and meets the requirements for designing and testing new generation spacecraft structures. C.C.S.

A91-38942#
ARIANE TRANSFER VEHICLE - LOGISTIC SUPPORT TO SPACE STATION FREEDOM
C. COUGNET, C. RICAUD (Matra Espace, Toulouse, France), and N. DEUTSCHER (MBB/ERNO, Bremen, Federal Republic of Germany) IN: Space commercialization: Launch vehicles and programs; Symposium on Space Commercialization: Roles of Developing Countries, Nashville, TN, Mar. 5-10, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 255-269.
Copyright

The attractiveness of the Ariane 5 and Ariane transfer vehicle (ATV) is described: it avoids the one-sidedness of the National STS, it increases the lift capacity to meet the demands of the Space Station, and it offers a system independent of, but consistent with, the STS in providing backup contingency capability. The Ariane 5/ATV system is able to launch and transfer any cargo module to the Space Station Freedom (SSF) and dispose of it at the end of the mission. Consideration is given to Space Station and SSF logistic support, and ATV operations and design. Diagrams are provided to illustrate the ATV's requirements and capability; an ATV mission toward the SSF; ATV design and components; the ATV's attitude, layout, and the architecture of the main propulsion system and avionic; and the ATV's performance. It is demonstrated that the Ariane 5/ATV system would be an adequate complement to the NSTS for logistic support of the SSF. P.D.

A91-38955#
PLANNING FOR SPACE STATION FREEDOM LABORATORY PAYLOAD INTEGRATION
HARVEY J. WILLENBERG and LARRY P. TORRE (Boeing Aerospace and Electronics, Huntsville, AL) IN: Space commercialization: Platforms and processing; Symposium on Space Commercialization: Roles of Developing Countries, Nashville, TN, Mar. 5-10, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 61-68. Previously announced in STAR as N90-26047.
Copyright

Space Station Freedom is being developed to support extensive misions involving microgravity research and applications.

Requirements for on-orbit payload integration and the simultaneous payload integration of multiple mission increments will provide the stimulus to develop new streamlined integration procedures in order to take advantage of the increased capabilities offered by Freedom. The United States Laboratory and its user accommodations are described. The process of integrating users' experiments and equipment into the United States Laboratory and the Pressurized Logistics Modules is described. This process includes the strategic and tactical phases of Space Station utilization planning. The support that the Work package 01 Utilization Office will provide to the users and hardware developers, in the form of Experiment Integration Engineers, early accommodation assessments, and physical integration of experiment equipment, is described. Plans for integrated payload analytical integration are also described.

A91-38956#
SPACE STATION APPLICATION OF LESSONS LEARNED FROM SPACE SHUTTLE INTEGRATED OPERATIONAL PROTOTYPES
MICHAEL J. WISKERCHEN (DYSE Corp., Stanford, CA) IN: Space commercialization: Platforms and processing; Symposium on Space Commercialization: Roles of Developing Countries, Nashville, TN, Mar. 5-10, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 69-83.
Copyright

The system engineering methodology based on the concurrent engineering approach for the development of a long-term, inexpensive and efficient space operation capability is described. It is recommended to maintain an iterative engineering process throughout the full life cycle of a project for incorporating dynamically changing requirements and technology. The process is driven by information obtained from risk assessment analysis and rapid prototyping test beds that are carried out by technology-user-design engineering teams. O.G.

A91-39837* Control Dynamics Co., Huntsville, AL.
NASA/MSFC LARGE SPACE STRUCTURES GROUND TEST FACILITY
VICTORIA L. JONES (Control Dynamics Co., Huntsville, AL) and HENRY B. WAITES (NASA, Marshall Space Flight Center, Huntsville, AL) IN: NASA-UCLA Workshop on Computational Techniques in Identification and Control of Flexible Flight Structures, Lake Arrowhead, CA, Nov. 2-4, 1989, Proceedings. Los Angeles, CA, Optimization Software, Inc., 1990, p. 3-18.
Copyright

The NASA/MFSC Large Space Structures Ground Test Facility (LSS GTF) is described in terms of the testing, evaluation, and implementation of control and system identification techniques for typical large space structures. The GTF comprises Control, Astrophysics, and Structures Experiment in Space (CASES) GTF which is being developed and the operational Single Structure Control (SSC) laboratory (an LSS flexible beam suspended vertically with sensor and actuator systems, a real-time computer system, a disturbance system, and an optical pointing system). The configuration of the laboratory and the systems used are set forth in terms of monitoring simulated disturbances. The Shuttle-based CASES experiment involves a 105-foot boom as part of an X-ray experiment, and the control of this structure will be tested at the CASES GTF. The actuation, measurement, sensor, and computer systems are described, and the configuration of the GTF is given. C.C.S.

A91-39838* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ACTIVE CONTROL TEST ON THE MINI-MAST
RAYMOND C. MONTGOMERY and DAVE GHOSH (NASA, Langley Research Center, Hampton, VA) IN: NASA-UCLA Workshop on Computational Techniques in Identification and Control of Flexible Flight Structures, Lake Arrowhead, CA, Nov. 2-4, 1989, Proceedings. Los Angeles, CA, Optimization Software, Inc., 1990, p. 19-22.
Copyright

A Linear Quadratic Gaussian (LQG) design process is presented and applied to a large flexible ground test facility, the Mini-Mast, for validation. For the design, nine displacement sensors were used. Three torque wheel actuators were used for damping augmentation. Results were dramatic, indicating an improvement in damping from 3 percent to 30 percent of critical. The tests proved the effectiveness of the procedure in designing effective vibration damping systems. Author

A91-39839
THE ASTREX TESTBED FOR LARGE/PRECISION SPACE STRUCTURES - INITIAL CAPABILITY AND NEAR-TERM RESEARCH
GREGORY A. NORRIS (USAF, Astronautics Laboratory, Edwards AFB, CA) IN: NASA-UCLA Workshop on Computational Techniques in Identification and Control of Flexible Flight Structures, Lake Arrowhead, CA, Nov. 2-4, 1989, Proceedings. Los Angeles, CA, Optimization Software, Inc., 1990, p. 23-37. Previously announced in STAR as N90-21091.
Copyright

Future DOD, NASA, and SDI space systems will be larger than any spacecraft flown before. The economics of placing these large space systems (LSS) into orbit dictates that they be as low in mass as possible. The combination of very large size and relatively low mass produces systems which possess little structural rigidity. This flexibility causes severe technical problems when combined with the precise shape and pointing requirements associated with many future LSS missions. Development of new control technologies which can solve these problems and enable future LSS missions is under way, but a test bed is needed for demonstration and evaluation of the emerging control hardware (sensors and actuators) and methodologies. In particular, the need exists for a facility which enables both large angle slewing and subsequent pointing/shape control of a variety of flexible bodies. The Air Force Astronautics Laboratory (AFAL) has conceived the Advanced Space Structures Technology Research Experiments (ASTREX) facility to fill this need. An overview of the ASTREX facility is given. Author

A91-41630#
A STANDARDIZED SPACECRAFT RESUPPLY INTERFACE
JOSEPH M. CARDIN (Moog, Inc., Space Products Div., East Aurora, NY) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. refs
(AIAA PAPER 91-1841) Copyright

The history of automated fluid and electrical resupply interfaces for NASA spacecraft missions is reviewed, with a focus on the Automated Umbilical Connector System and the Automated Fluid Interface System, and a Universal Resupply Interface System (URIS) recently developed on the basis of these interfaces is described and illustrated with drawings and photographs. URIS comprises two major elements, an active type I tanker section and a passive type II spacecraft section. URIS features a noncontact docking scheme, accommodation for spacecraft misalignment, internal absorption of pressure-induced loads, electrical and thermal-control redundancy, and multiple connector sites (4 and 8-10 for the small and large versions, respectively). An installation of URIS in the standard Three-Point Docking Mechanism is shown. D.G.

A91-48532* Booz-Allen and Hamilton, Inc., Reston, VA.
ASSESSING AVAILABILITY OF SPACE STATION FREEDOM
STEPHEN J. GIZINSKI, III and STEVEN Y. SCHONDORF (Booz, Allen and Hamilton, Inc., Space Systems and Technology Div., Reston, VA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 1-4, 1990. 8 p. refs
(Contract NASW-4300)
(SAE PAPER 901792) Copyright

An availability assessment process developed by the Space Station Freedom Program Office Operations Organization is reviewed. The process under consideration is aimed at highlighting design attributes which hamper operations for development of appropriate design alternatives. O.G.

A91-49658*# Control Dynamics Co., Huntsville, AL.
NASA/MSFC LARGE SPACE STRUCTURES GROUND TEST FACILITY
VICTORIA L. JONES (Control Dynamics Co., Huntsville, AL), ANGELIA P. BUKLEY, and ALAN F. PATTERSON (NASA, Marshall Space Flight Center, Huntsville, AL) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 792-806.
(AIAA PAPER 91-2694) Copyright

This paper describes the NASA/MSFC Large Space Structures Ground Test Facility (LSS GTF) which has been developed for the purpose of implementing, testing, and evaluating LSS control and system identification techniques on representative large space structures. The facility presently consists of two laboratories: the Single Structure Control (SSC) Laboratory, which has been operational since 1984, and the Controls and Structures Experiment in Space (CASES) GTF which is presently under development. Test results from several experiments in the SSC laboratory are presented. The results of component testing and boom modal tests are presented for the CASES facility. Author

A91-50263
THE DRS GROUND SEGMENT FACILITIES AT THE FUCINO SPACE CENTRE
A. TUOZZI (Telespazio S.p.A., Rome, Italy) British Interplanetary Society, Journal (ISSN 0007-084X), vol. 44, Sept. 1991, p. 453-460.
Copyright

The European Data Relay System (DRS) is described in terms of the projected function of providing communications between low-earth-orbiting (LEO) satellites and ground terminals. Two geostationary satellites communicate via three interorbit links, including S-band, Ka-band, and optical band capability, with the LEO which previously served ground-support networks located throughout Europe. The earth stations within the feeder-link coverage are accessible by 20/30 GHz links, which the DRS can serve, rendering the ground stations redundant. The DRS can facilitate the communications of several European in-orbit systems including Columbus, the Polar Platforms, and Hermes. The projected advantages of the system include: increased low-earth-orbit coverage area; minimal data-distribution problems due to direct acquisition of the DRS feeder link; and the reduction and possible elimination of the need for data storage on the board. C.C.S.

A91-51221* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SHARP - AUTOMATED MONITORING OF SPACECRAFT HEALTH AND STATUS
DAVID J. ATKINSON, MARK L. JAMES, and R. G. MARTIN (JPL, Pasadena, CA) IN: Applications of artificial intelligence VIII; Proceedings of the Meeting, Orlando, FL, Apr. 17-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 859-869. Previously announced in STAR as N91-20671. refs
Copyright

Briefly discussed here are the spacecraft and ground systems monitoring process at the Jet Propulsion Laboratory (JPL). Some of the difficulties associated with the existing technology used in mission operations are highlighted. A new automated system based on artificial intelligence technology is described which seeks to overcome many of these limitations. The system, called the Spacecraft Health Automated Reasoning Prototype (SHARP), is designed to automate health and status analysis for multi-mission spacecraft and ground data systems operations. The system has proved to be effective for detecting and analyzing potential spacecraft and ground systems problems by performing real-time analysis of spacecraft and ground data systems engineering telemetry. Telecommunications link analysis of the Voyager 2 spacecraft was the initial focus for evaluation of the system in real-time operations during the Voyager spacecraft encounter with Neptune in August 1989. Author

A91-54145
THE ARIANE TRANSFER VEHICLE (ATV) SYSTEM STUDIES
U. THOMAS and A. THIRKETTLE (ESA, Directorate for Space Transportation Systems, Noordwijk, Netherlands) ESA Bulletin (ISSN 0376-4265), no. 67, Aug. 1991, p. 71-77.
Copyright

Two distinct concepts of the Ariane transfer vehicle (ATV) are compared which incorporate existing ATV technology and offer logistics delivery at competitive costs. One concept is based on the Ariane-5 upper stage and the Vehicle Equipment Bay, and the other does not include Ariane-5 functions so that existing upper-stage limitations can be eliminated. Both concepts are required to accomplish the same transport, rendezvous, and berthing maneuvers and allow for controlled destructive reentry. An ATV reference mission is outlined, and key ATV design drivers are listed which include safety requirements, debris protection, and propulsion criteria. The Ariane-5 upgrade is the most cost-effective design although the second design is more operationally efficient. The ATV can potentially be used to relieve the schedule of the shuttle flights required for building the Space Station Freedom. C.C.S.

A91-55547* Douglas Aircraft Co., Inc., Long Beach, CA.
AI IN MANUFACTURING
JOHN E. GROSS (Douglas Aircraft Co., Long Beach, CA), RICK MINATO (Northrop Corp., Aircraft Div., Hawthorne, CA), DAVID M. SMITH (Lockheed Aeronautical Systems Co., Marietta, GA), R. B. LOFTIN (Houston, University, TX), and ROBERT T. SAVELY (NASA, Johnson Space Center, Houston, TX) Aerospace America (ISSN 0740-722X), vol. 29, Oct. 1991, p. 32-39, 46.
Copyright

AI techniques are shown to have been useful in such aerospace industry tasks as vehicle configuration layouts, process planning, tool design, numerically-controlled programming of tools, production scheduling, and equipment testing and diagnosis. Accounts are given of illustrative experiences at the production facilities of three major aerospace defense contractors. Also discussed is NASA's autonomous Intelligent Computer-Aided Training System, for such ambitious manned programs as Space Station Freedom, which employs five different modules to constitute its job-independent training architecture. O.C.

N91-22189# European Space Agency, Paris (France).
GROUND DATA SYSTEMS FOR SPACECRAFT CONTROL
W. R. BURKE, comp. Oct. 1990 682 p In ENGLISH and FRENCH Symposium held in Darmstadt, Fed. Republic of Germany, 26-29 Jun. 1990
(ISSN 0379-6566)
(ESA-SP-308; ISBN-92-9092-074-2; ETN-91-99263) Copyright
Avail: CASI HC A99/MF A06

Control system architectures involved in telemetry and telecommand structures are discussed. The use of packet transmission as a means of coping with increasing levels of onboard automation and autonomy is reviewed. The software aspects of control station equipment and the networks connecting stations and control centers are examined. Mission management systems designed to cover the planning and optimization aspects of all the resources involved in space missions are studied. Mission management requirements from scientific, Earth observation and telecommunication missions are analyzed in terms of long, medium and short term planning aspects.

N91-22233# Aeritalia S.p.A., Turin (Italy). Space Systems Group.
THE COLUMBUS APM CENTRE FLEXIBLE AND EFFICIENT ENGINEERING SUPPORT
LUCIANO BATTOCCHIO, DAVID R. HARRIS, and LORENZO SARLO *In* ESA, Ground Data Systems for Spacecraft Control p 263-269 Oct. 1990
Copyright Avail: CASI HC A02/MF A06

Columbus Attached Pressurized Module (APM) operations, beginning with final testing before loading into the Shuttle, are integrated into the overall Space Station Freedom and Columbus scenarios. These operations, both ground and flight, are supported by an engineering support center, the APMC (APM Center), connected to both Columbus and NASA in orbit infrastructures (IOI). The APMC must fulfill several different roles. The requirements for some roles are reasonably well defined, at least in outline. The requirements for others are still to be defined. Creation of a system for the center which allows all of these roles to be played efficiently and effectively, and when required concurrently is discussed. ESA

N91-22238# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (Germany, F.R.).
MARS: A GENERIC MISSION PLANNING TOOL
A. KELLNER, N. SCHIELOW, and F. ZAPP *In* ESA, Ground Data Systems for Spacecraft Control p 297-303 Oct. 1990
Prepared in cooperation with Erno Raumfahrttechnik G.m.b.H.
Copyright Avail: CASI HC A02/MF A06

A Mission Activities and Resources Scheduler (MARS) is described. It is a mission planning tool for both automatic and interactive generation of spacecraft timelines of realistic complexity, which has been extensively tested during Columbus, Hermes, and Eureca mission planning. It is in operational use for Eureca maneuver planning. It is being extended to full distributed mission planning capability for the Columbus mission planning scenario under the ESA contract New Expert Planning Tool for Users in a Networked Environment (NEPTUNE). The main features of the planning tools used for Columbus, Hermes, and Eureca mission planning are discussed. ESA

N91-22244# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (Germany, F.R.). Space Systems Group.
COLUMBUS GENERIC ELEMENT MANAGEMENT AND PLANNING CONCEPT
J. SVED and H. LUTTMANN *In* ESA, Ground Data Systems for Spacecraft Control p 337-342 Oct. 1990 Previously announced as N91-12742 Prepared in cooperation with Erno Raumfahrttechnik G.m.b.H.
Copyright Avail: CASI HC A02/MF A06

The status of development of the Columbus onboard autonomous control function concept known as the System and Mission Management (SMM) is outlined. The complementary execution timeline planning methodology, that uses Columbus era computer tools is described. The possibility of condensing the documentation tree for payload integration with respect to the operation planning and execution support information is discussed. The use of the Columbus generic element manager command mechanism and data structure to this end is analyzed. ESA

N91-22290# European Space Agency. European Space Operations Center, Darmstadt (Germany, F.R.).
THE ESOC SPACECRAFT PERFORMANCE EVALUATION SYSTEM (SPES)
F. SELL and J. F. KAUFELER *In its* Ground Data Systems for Spacecraft Control p 631-634 Oct. 1990
Copyright Avail: CASI HC A01/MF A06

The Spacecraft Performance Evaluation System (SPES) developed to cope with the increasing complexity of equipment carried by spacecraft is described. The SPES stores spacecraft related life time data in a central repository and provides user friendly and flexible retrieval access. Retrieved data can be presented in a variety of ways on user workstations. SPES is implemented as a system of cooperating jobs on the central ESOC offline computer and on personal computer workstations. As it is functionally decoupled from the mission control systems, ESA external users can use it without inherent risks. The SPES is currently used for the Hipparcos and will be used for ERS-1, Eureca and other missions. ESA

N91-22354# Engineering Mechanics Association, Inc., Torrance, CA.
AIAA/AFOSR WORKSHOP ON MICROGRAVITY SIMULATION IN GROUND VALIDATION TESTING OF LARGE SPACE STRUCTURES Final Report, Sep. 1989 - Sep. 1990
TIMOTHY K. HASSELMAN 15 Oct. 1990 33 p Workshop held in Denver, CO, 1-2 Nov. 1989
(Contract F49620-89-C-0130)
(AD-A231507; EMA-TR-90-1153; AFOSR-91-0040TR) Avail: CASI HC A03/MF A01 CSCL 22B

This report summarizes the proceedings of the Workshop on Microgravity Simulation in Ground Validation testing of Large Space Structures. The workshop was conceived and organized as a follow-on activity to an earlier study. The objective of the initial study was to provide a cursory review of available techniques against assessed needs in the specific area of dynamic testing of large structures. The intent of the workshop was to broaden the scope of this initial investigation by involving national experts in areas relevant to issues identified in the initial study. The workshop focused on present and future needs. An overview session covering both military and civil space objectives was followed by a session on Space Structures Experimental Programs and Facilities, sessions on On-orbit Dynamics Modeling and Simulation, and sessions on Advanced Suspension Devices and Systems. The workshop concluded with a panel discussion which addressed current issues and needs. GRA

N91-22731*# Research Inst. for Computing and Information Systems, Houston, TX.
PORTABLE COMMON EXECUTION ENVIRONMENT (PCEE) PROJECT REVIEW: PEER REVIEW Final Report
C. DOUGLASS LOCKE (International Business Machines Corp., Bethesda, MD.) 8 Mar. 1991 23 p
(Contract NCC9-16)
(NASA-CR-188016; NAS 1.26:188016) Avail: CASI HC A03/MF A01 CSCL 09B

The purpose of the review was to conduct an independent, in-depth analysis of the PCEE project and to provide the results of said review. The review team was tasked with evaluating the potential contribution of the PCEE project to the improvement of the life cycle support of mission and safety critical (MASC) computing components for large, complex, non-stop, distributed systems similar to those planned for such NASA programs as the space station, lunar outpost, and manned missions to Mars. Some conclusions of the review team are as follow: The PCEE project was given high marks for its breath of vision on the overall problem with MASC software; Correlated with the sweeping vision, the Review Team is very skeptical that any research project can successfully attack such a broad range of problems; and several recommendations are made such as to identify the components of the broad solution envisioned, prioritizing them with respect to their impact and the likely ability of the PCEE or others to attack them successfully, and to rewrite its Concept Document differentiating the problem description, objectives, approach, and results so that the project vision becomes assessible to others. Author

N91-22766*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
RSM 1.0 USER'S GUIDE: A RESUPPLY SCHEDULER USING INTEGER OPTIMIZATION
LARRY A. VITERNA, ROBERT D. GREEN, and DAVID M. REED (Wittenberg Univ., Springfield, OH.) May 1991 43 p
(Contract RTOP 474-12-10)
(NASA-TM-104380; E-6185; NAS 1.15:104380) Avail: CASI HC A03/MF A01 CSCL 09B

The Resupply Scheduling Model (RSM) is a PC based, fully menu-driven computer program. It uses integer programming techniques to determine an optimum schedule to replace components on or before a fixed replacement period, subject to user defined constraints such as transportation mass and volume limits or available repair crew time. Principal input for RSJ includes properties such as mass and volume and an assembly sequence. Resource constraints are entered for each period corresponding to the component properties. Though written to analyze the electrical power system on the Space Station Freedom, RSM is quite general and can be used to model the resupply of almost any system subject to user defined resource constraints. Presented here is a step by step procedure for preparing the input, performing the analysis, and interpreting the results. Instructions for installing the program and information on the algorithms are given. Author

N91-22777*# Mitre Corp., Houston, TX.
A FAILURE DIAGNOSIS AND IMPACT ASSESSMENT PROTOTYPE FOR SPACE STATION FREEDOM
CAROLYN G. BAKER and CHRISTOPHER A. MARSH *In* NASA. Goddard Space Flight Center, The 1991 Goddard Conference on Space Applications of Artificial Intelligence p 97-111 May 1991
(Contract NAS9-18057)
Avail: CASI HC A03/MF A03 CSCL 09B

NASA is investigating the use of advanced automation to enhance crew productivity for Space Station Freedom in numerous areas, one being failure management. A prototype is described that diagnoses failure sources and assesses the future impacts of those failures on other Freedom entities. Author

N91-22778*# Mitre Corp., Houston, TX.
A FAILURE RECOVERY PLANNING PROTOTYPE FOR SPACE STATION FREEDOM
DAVID G. HAMMEN and CHRISTINE M. KELLY *In* NASA. Goddard Space Flight Center, The 1991 Goddard Conference on Space Applications of Artificial Intelligence p 113-127 May 1991
(Contract NAS9-18057)
Avail: CASI HC A03/MF A03 CSCL 09B

NASA is investigating the use of advanced automation to enhance crew productivity for Space Station Freedom in numerous areas, including failure management. A prototype is described that uses various advanced automation techniques to generate courses of action whose intents are to recover from a diagnosed failure, and to do so within the constraints levied by the failure and by Freedom's configuration and operating conditions. Author

N91-22895# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Cologne (Germany, F.R.).
USER SUPPORT AND GROUND SUPPORT PROGRAM, WITH THE EXAMPLE OF EURECA [NUTZERUNTERSTUETZUNG UND BODENBEGLEITPROGRAMM AM BEISPIEL VON EURECA]
B. PAETZ and G. OTTO *In its* Fourth Summer School on Microgravity: Conference Summaries and Forum Lectures p 123-132 Aug. 1990 In ENGLISH and GERMAN
Avail: CASI HC A02/MF A03

The tasks of the Microgravity User Support Center (MUSC) are defined. MUSC offers the function of a User Support and Operation Center (USOC). The concept of a ground support program is given, and the mission support program tasks are detailed. Preparation work is currently being done for the second German Spacelab Mission, the European Retrieval Carrier (EURECA), and the ESA unmanned experimentation platform. ESA

N91-22938# Mitre Corp., Houston, TX.
NASA-JOHNSON SPACE CENTER
SANDRA ANDERSON *In* NIST, Proceedings of the Federal Information Processing Standards (FIPS) Workshop on Information Resource Dictionary System (IRDS) Applications p 133-141 Dec. 1988
Avail: CASI HC A02/MF A03

The Information Resource Dictionary System (IRDS) is becoming more and more recognized as an integral part of the management of data at Johnson Space Center (JSC). The initial impetus for using a global IRDS came from the Space Station Program (SSP). The IRDS standard was specified in the Technical and Management Information System (TMIS) Request for Proposal (RFP). The TMIS is an SSP-wide information system supporting the technical and administrative needs of the NASA centers, the international partners, and the customers. The focus of this talk is the general use of the IRDS at the JSC. Author

N91-28193*# National Aeronautics and Space Administration, Washington, DC.
SPACE TRANSPORTATION PROPULSION TECHNOLOGY SYMPOSIUM. VOLUME 2: SYMPOSIUM PROCEEDINGS
May 1991 693 p Symposium held in State College, PA, 25-29 Jun. 1990
(NASA-CP-3112-VOL-2; NAS 1.55:3112-VOL-2) Avail: CASI HC A99/MF A06 CSCL 21H

The Space Transportation Propulsion Symposium was held to provide a forum for communication within the propulsion technology developer and user communities. Emphasis was placed on propulsion requirements and initiatives to support current, next generation, and future space transportation systems, with the primary objectives of discerning whether proposed designs truly meet future transportation needs and identifying possible technology gaps, overlaps, and other programmatic deficiencies. Key space transportation propulsion issues were addressed through four panels with government, industry, and academia membership. The panels focused on systems engineering and integration; development, manufacturing and certification; operational efficiency; and program development and cultural issues.

N91-28195*# National Aeronautics and Space Administration, Washington, DC.
NASA'S ADVANCED SPACE TRANSPORTATION SYSTEM LAUNCH VEHICLES
DARRELL R. BRANSCOME *In its* Space Transportation Propulsion Technology Symposium. Volume 2: Symposium Proceedings p 39-67 May 1991
Avail: CASI HC A03/MF A06 CSCL 21H

Some insight is provided into the advanced transportation planning and systems that will evolve to support long term mission requirements. The general requirements include: launch and lift capacity to low earth orbit (LEO); space based transfer systems for orbital operations between LEO and geosynchronous equatorial orbit (GEO), the Moon, and Mars; and Transfer vehicle systems for long duration deep space probes. These mission requirements are incorporated in the NASA Civil Needs Data Base. To accomplish these mission goals, adequate lift capacity to LEO must be available: to support science and application missions; to provide for construction of the Space Station Freedom; and to support resupply of personnel and supplies for its operations. Growth in lift capacity must be time phased to support an expanding mission model that includes Freedom Station, the Mission to Planet Earth, and an expanded robotic planetary program. The near term increase in cargo lift capacity associated with development of the Shuttle-C is addressed. The joint DOD/NASA Advanced Launch System studies are focused on a longer term new cargo capability that will significantly reduce costs of placing payloads in space. Author

N91-29209*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
RESOURCE ENVELOPE CONCEPTS FOR MISSION PLANNING
K. Y. IBRAHIM, J. D. WEILER, and J. C. TOKAZ (Sverdrup Technology, Inc., Huntsville, AL.) Aug. 1991 74 p
(NASA-TP-3139; M-666; NAS 1.60:3139) Avail: CASI HC A04/MF A01 CSCL 22B

Seven proposed methods for creating resource envelopes for Space Station Freedom mission planning are detailed. Four reference science activity models are used to illustrate the effect of adding operational flexibility to mission timelines. For each method, a brief explanation is given along with graphs to illustrate the application of the envelopes to the power and crew resources. The benefits and costs of each method are analyzed in terms of resource utilization. In addition to the effect on individual activities, resource envelopes are analyzed at the experiment level. Author

N91-30187*# Boeing Aerospace and Electronics Co., Seattle, WA.
CONCEPTUAL DESIGNS STUDY FOR A PERSONNEL LAUNCH SYSTEM (PLS) Final Report, 23 Oct. 1989 - 1 Dec. 1990
E. D. WETZEL 1 Dec. 1990 811 p Original contain color

illustrations
(Contract NAS9-18255)
(NASA-CR-185647; NAS 1.26:185647) Avail: CASI HC A99/MF A10; 6 functional color pages CSCL 22D

A series of conceptual designs for a manned, Earth to Low Earth Orbit transportation system was developed. Non-winged, low L/D vehicle shapes are discussed. System and subsystem trades emphasized safety, operability, and affordability using near-term technology. The resultant conceptual design includes lessons learned from commercial aviation that result in a safe, routine, operationally efficient system. The primary mission for this Personnel Launch System (PLS) would be crew rotation to the SSF; other missions, including satellite servicing, orbital sortie, and space rescue were also explored. Author

N91-32846*# Research Inst. for Advanced Computer Science, Moffett Field, CA.
COLLABORATION TECHNOLOGY AND SPACE SCIENCE
BARRY M. LEINER, R. L. BROWN, and R. F. HAINES Jul. 1990 13 p Presented at the 41st Congress of the International Astronautical Federation, Oct. 1990 Previously announced in IAA as A91-13736 Submitted for publication
(Contract NCC2-387)
(NASA-CR-188861; NAS 1.26:188861; RIACS-TR-90-25) Avail: CASI HC A03/MF A01 CSCL 09B

A summary of available collaboration technologies and their applications to space science is presented as well as investigations into remote coaching paradigms and the role of a specific collaboration tool for distributed task coordination in supporting such teleoperations. The applicability and effectiveness of different communication media and tools in supporting remote coaching are investigated. One investigation concerns a distributed check-list, a computer-based tool that allows a group of people, e.g., onboard crew, ground based investigator, and mission control, to synchronize their actions while providing full flexibility for the flight crew to set the pace and remain on their operational schedule. This autonomy is shown to contribute to morale and productivity. Author

04

SPACE ENVIRONMENTS

The external environment of space including debris or meteoroid hazards, electrical and plasma interactions, and the presence of atomic oxygen or other chemical species.

A91-33415
A NEURAL NETWORK MODEL OF THE RELATIVISTIC ELECTRON FLUX AT GEOSYNCHRONOUS ORBIT
H. C. KOONS and D. J. GORNEY (Aerospace Corp., Space Sciences Laboratory, Los Angeles, CA) Journal of Geophysical Research (ISSN 0148-0227), vol. 96, April 1, 1991, p. 5549-5556. refs
(Contract F04701-88-C-0089)
Copyright

A neural network has been developed to model the temporal variations of relativisitic electron flux at geosynchronous orbit based on model inputs consisting of 10 consecutive values of the daily-summed planetary goemagnetic index. The network provides results which are significantly more accurate than linear prediction filters. The model can be used to infer geosynchronous electron fluxes for periods in which direct measurements are not available or are contaminated by background from solar proton events. It has direct applicabilty to the analysis of satellite anomalies which are thought to be due to the deep dielectric charging process. The model also provides a simple and accurate framework for studying other aspects of the behavior of the geosynchronous electron environment, including its dependence on the solar cycle and the relative phase of Jupiter. It provides a capability for simulating conditions which rarely occur in nature, such as prolonged steady state conditions or discrete impulse responses. C.D.

A91-34965#
RADIATION MONITORING FOR LONG DURATION SPACE FLIGHTS
I. THOMSON and G. MACKAY (Thomson and Nielsen Electronics, Ltd., Ottawa, Canada) IN: CASI Conference on Astronautics, 6th, Ottawa, Canada, Nov. 19-21, 1990, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1990, p. 464-475. Canadian Space Agency-supported research.

A review of space radiation issues is presented along with a description of new, direct-reading electronic radiation monitoring techniques and their applications to problems in space. It is shown that miniature silicon sensors may be utilized for the separate measurement of trapped high energy protons and electrons, and cosmic rays. These sensors have also been studied at very high energy low atomic number particles, e.g., He at 1200 MeV and the results are practically the same as for lower energy protons. Therefore, this sensor can be utilized as a dosimeter for total dose measurements for trapped particles and low Z cosmic rays, all of which have essentially the same biological effects. R.E.P.

A91-36976 Iowa Univ., Iowa City.
CONTROL OF PLASMA WAVES ASSOCIATED WITH THE SPACE SHUTTLE BY THE ANGLE BETWEEN THE ORBITER'S VELOCITY VECTOR AND THE MAGNETIC FIELD
IVER H. CAIRNS and DONALD A. GURNETT (Iowa, University, Iowa City) Journal of Geophysical Research (ISSN 0148-0227), vol. 96, May 1, 1991, p. 7591-7601. refs
(Contract NAGW-1488; NAG3-449)
Copyright

Plasma measurements on several Space Shuttle missions indicated presence of an active and complex plasma wave environment. Using data obtained during the free-flight portion of the Spacelab 2 mission, it is shown that the amplitude and the spectral character of some of these waves are controlled by the angle between the magnetic field and the Shuttle's velocity vector V(T) relative to the ionospheric plasma, the so-called V-parallel/V(T) effect. A linear theory is developed in which the waves are Doppler-shifted lower hybrid waves driven by pickup instabilities involving ring- or beamlike distributions of water ions. Implications of these results for future Shuttle missions and orbiting platforms subject to outgassing of water are discussed. I.S.

A91-36978
MESOTHERMAL PLASMA FLOW AROUND A NEGATIVELY WAKE SIDE BIASED CYLINDER
ERIC COGGIOLA and AMAURY SOUBEYRAN (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) Journal of Geophysical Research (ISSN 0148-0227), vol. 96, May 1, 1991, p. 7613-7621. ONERA-supported research. refs
Copyright

A numerical investigation was carried out of the wake potential and density perturbations caused by the presence of a large negative voltage on a sector situated on the wake side of a spacecraft moving at orbital speed through the ionosphere. The spacecraft is represented as an infinite cylinder moving in an unmagnetized plasma. The rest of the cylinder's surface is biased to a moderate negative voltage representing floating potential. It is shown that, in the case of large Debye ratio (spacecraft size much larger than Debye length), the geometrical wake is almost ion-empty for a high differential bias voltage on the sector, and that in the case of low Debye ratio and low Mach number, ion focusing effects can lead to the formation of a high-ion-density strip parallel to the surface when the differential bias is made very large. In the latter case, the results show evidence of an ionic emptying effect in the near wake and in the midwake. A mechanism to explain this result is proposed. Ion collection on the biased sector is also addressed. Author

A91-38361#

SOME REFLECTIONS REGARDING THE RESPONSIBILITY THAT PERTAINS TO THE CASE OF POLLUTION DUE TO SPACE ACTIVITIES [ALGUNAS REFLEXIONES ACERCA DE LA RESPONSABILIDAD A REGIR EN CASO DE CONTAMINACION POR ACTIVIDADES ESPACIALES]

MARIA L. FLORES DE SAPRIZA (Ministerio de Relaciones Exteriores, Montevideo, Uruguay) IN: Space Conference of the Americas, San Jose, Costa Rica, Mar. 12-16, 1990, Proceedings. Vol. 1 - Reports. San Jose, Costa Rica, Ministerio de Ciencia y Tecnologia, 1990, p. 351-360. In Spanish. refs

The paper examines the definition of responsibility anticipated in the case of damages resulting from space activity. The notions of space and space activity are defined with respect to pollution, and the possible scope of the pollution itself is described. Three classes of responsibility - subjective, objective, and absolute - are set forth and described in terms of existing statutes and resolutions regarding lunar pollution. Specific references to previous treaties and space laws are examined, and resolutions are proposed based on the existing ideas. The responsibility for pollution is defined as absolute and based on fault, and should be considered objectively in cases where no precedent exists. The importance of the subject and the need for classification of pollution-related incidents are emphasized. C.C.S.

A91-38362#

POLLUTION OF NEAR-EARTH SPACE AND A PROJECT REGARDING INTERNATIONAL RESPONSIBILITY FOR DAMAGING CONSEQUENCES OF ACTIONS NOT PROHIBITED BY INTERNATIONAL LAW [CONTAMINACION DEL ESPACIO ULTRATERRESTRE ADYACENTE A LA TIERRA Y EL PROYECTO SOBRE LA RESPONSABILIDAD INTERNACIONAL POR CONSECUENCIAS PERJUDICIALES DE ACTOS NO PROHIBIDOS POR EL DERECHO INTERNACIONAL]

MARIA L. FLORES DE SAPRIZA (Ministerio de Relaciones Exteriores, Montevideo, Uruguay) IN: Space Conference of the Americas, San Jose, Costa Rica, Mar. 12-16, 1990, Proceedings. Vol. 1 - Reports. San Jose, Costa Rica, Ministerio de Ciencia y Tecnologia, 1990, p. 360-364. In Spanish.

The application of a project regarding responsibility for the damaging consequences of actions not prohibited by international law is proposed in connection with the pollution of near-earth space. Justification of the initiative is presented, concepts such as pollution and near-earth space are clarified, and the proposed scope of the application is defined. It is concluded that international law should be applied even to those cases where the pollution does not meet these criteria. A legal standard can be established to protect the natural resources of near earth space. C.C.S.

A91-39139

GENERATION OF ACCELERATED PLASMA ELECTRONS AND THE MEASUREMENT OF ELECTRICAL POTENTIAL OF A SPACECRAFT IN IONOSPHERIC EXPERIMENTS WITH ELECTRON BEAM INJECTION [GENERATSIIA USKORENNYKH ELEKTRONOV PLAZMY I IZMERENIE ELEKTRICHESKOGO POTENTSIALA KA V IONOSFERNYKH EKSPERIMENTAKH S INZHEKTSIEI ELEKTRONNYKH PUCHKOV]

A. IU. BOGOMOLOV and V. A. FEDOROV (AN SSSR, Radiotekhnicheskii Institut, Moscow, USSR) Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, Mar.-Apr. 1991, p. 278-281. In Russian. refs

Copyright

This paper investigated the effect of accelerated electrons generated in plasma under certain conditions on the measurements of the spacecraft's electrical potential in ionospheric experiments with electron beam injection. Results of calculations show that accelerated electrons may significantly affect instrumental measurements of the spacecraft's electrical potential. The effect occurs only in regions in which the generation of accelerated electrons is possible. I.S.

A91-40395 Michigan Univ., Ann Arbor.

OBSERVATIONS OF PLASMA WAVE TURBULENCE GENERATED AROUND LARGE IONOSPHERIC SPACECRAFT - EFFECTS OF MOTIONALLY INDUCED EMF AND OF ELECTRON BEAM EMISSION

T. NEUBERT, B. E. GILCHRIST, P. M. BANKS (Michigan, University, Ann Arbor), S. SASAKI (Institute of Space and Astronautical Science, Sagamihara, Japan), P. R. WILLIAMSON (Stanford University, CA) et al. Journal of Geophysical Research (ISSN 0148-0227), vol. 96, June 1, 1991, p. 9639-9654. refs

(Contract NAGW-1566; NAG5-607; NAS8-35350; F19628-89-K-0040)

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Plasma wave turbulence generated during electron beam injections, spacecraft potential variation, and neutral gas emissions of the Charge 2 sounding rocket experiment are reported. Charge 2 used a mother-daughter spacecraft connected by a tether. The data indicate that two processes are at work. One involves oscillations in the spacecraft potential that are picked up via the tether by the receiver aboard the daughter spacecraft. The other involves plasma noise generated by currents collected by the daughter. C.D.

A91-40413#

SPACE DEBRIS AND MICROMETEORITE EVENTS EXPERIENCED BY WL EXPERIMENT 701 IN PROLONGED LOW EARTH ORBIT

D. S. MCKNIGHT, R. E. DUEBER (U.S. Air Force Academy, Colorado Springs, CO), and E. W. TAYLOR (USAF, Phillips Laboratory, Kirtland AFB, NM) Journal of Geophysical Research (ISSN 0148-0227), vol. 96, June 1, 1991, p. 9829-9833. refs

Air Force Systems Command Weapons Laboratory experiment 701 (Space Environment Effects on Fiber Optic Systems) was housed aboard the Long Duration Exposure Facility and placed into orbit on April 6, 1984, by the Shuttle Challenger. It was retrieved 69 months later by the Shuttle Columbia on January 12, 1990. During this period in orbit, the experiment experienced numerous debris or micrometeorite impacts. Impact flux values, crater characteristics, and shock phenomena on the experiment's space-exposed surfaces were observed to be similar to returned materials of the Solar Max satellite. This paper presents the analysis of preliminary data, describes data reduction techniques, and outlines areas of future study. Author

A91-40614* Physical Sciences, Inc., Andover, MA.

LASER SUPPORTED DETONATION WAVE SOURCE OF ATOMIC OXYGEN FOR AEROSPACE MATERIAL TESTING

ROBERT H. KRECH and GEORGE E. CALEDONIA (Physical Sciences, Inc., Andover, MA) IN: Current topics in shock waves; Proceedings of the International Symposium on Shock Waves and Shock Tubes, 17th, Bethlehem, PA, July 17-21, 1989. New York, American Institute of Physics, 1990, p. 377-382. NASA-supported research. refs

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A pulsed high-flux source of nearly monoenergetic atomic oxygen was developed to perform accelerated erosion testing of spacecraft materials in a simulated low-earth orbit (LEO) environment. Molecular oxygen is introduced into an evacuated conical expansion nozzle at several atmospheres pressure through a pulsed molecular beam valve. A laser-induced breakdown is generated in the nozzle throat by a pulsed CO2 TEA laser. The resulting plasma is heated by the ensuing laser-supported detonation wave, and then it rapidly expands and cools. An atomic oxygen beam is generated with fluxes above 10 to the 18th atoms per pulse at 8 + or - 1.6 km/s with an ion content below 1 percent for LEO testing. Materials testing yielded the same surface oxygen enrichment in polyethylene samples as observed on the STS mission, and scanning electron micrographs of the irradiated polymer surfaces showed an erosion morphology similar to that obtained on low earth orbit. P.D.

A91-42087

THE SPACE RADIATION ENVIRONMENT [L'ENVIRONNEMENT RADIATIF SPATIAL]

J.-C. BOUDENOT (Thomson-CSF, Bagneux, France) L'Onde Electrique (ISSN 0030-2430), vol. 71, May-June 1991, p. 62-68. In French. refs

Copyright

The various components of the space radiation environment are examined, including the radiation belts, solar-flare radiation, cosmic rays, and the solar wind. The impact of the environment on space vehicles is then considered, with particular attention given to the cumulative dose and heavy ions. The influence of orbit parameters is taken into account in this evaluation. B.J.

A91-42487

RADIATION SURVEY OF THE LDEF SPACECRAFT

S. E. KING, G. W. PHILLIPS, R. A. AUGUST, J. C. RITTER (U.S. Navy, Naval Research Laboratory, Washington, DC), J. H. CUTCHIN (Sachs/Freeman Associates, Landover, MD) et al. (1990 Nuclear Science Symposium, Arlington, VA, Oct. 23-26, 1990, Proceedings. A91-42475 17-35) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 38, pt. 1, April 1991, p. 525-530. refs

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The authors report the first complete gamma-ray survey of a large spacecraft, the Long Duration Exposure Facility (LDEF). The survey was conducted using an array of germanium detectors from the U.S. Naval Research Laboratory and individual detectors from the Institute for Space Science and Technology to study the accumulation and distribution of radioisotopes induced in the wide variety of materials present on the LDEF. Na-22, Be-7, Mn-54, and the positron annihilation line were all strongly observed. Traces of Co-56, Co-57, and Co-60 were also observed. The most striking feature of the data was the unexpected distribution of Be-7, which was predominately present on the leading surfaces of the spacecraft. The evidence clearly indicates an accretion of the Be-7 onto the surface of the LDEF. This is the first known observation of the deposition of a radioisotope onto the surface of a spacecraft. Be-7 is a spallation product of cosmic rays on nitrogen and oxygen in the upper atmosphere. To explain the surface density of 5.4 x 10 to the 5th atoms/sq cm, it must be assumed that the light Be-7 atom is transported up from lower altitudes. I.E.

A91-42488

PERFORMANCE OF A BGO DETECTOR IN LOW EARTH ORBIT

P. S. HASKINS, J. E. MCKISSON, D. W. ELY, A. G. WEISENBERGER, T. A. BALLARD (Florida, University, Gainesville) et al. (1990 Nuclear Science Symposium, Arlington, VA, Oct. 23-26, 1990, Proceedings. A91-42475 17-35) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 38, pt. 1, April 1991, p. 531-535. SDIO-sponsored research. refs

Copyright

A 7.6-cm x 7.6-cm BGO (bismuth germanate) detector was flown in the middeck of the Space Shuttle Columbia on August 8-13, 1989, as part of the Shuttle Activation Monitor (SAM) experiment. One of the goals of this experiment was to compare the performance of the BGO to that of NaI in the same environment. Twenty-four hours of data in 5-min time bins were recorded with each detector in each of two locations in a high-inclination orbit (57 deg, 300 km). Pre- and post-flight low-background counting was performed for identification of activities induced by the space radiation environment. A number of isotopes attributed to induced activity from exposure to the space radiation environment have been tentatively identified. I.E.

A91-42510*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

A FULLY COUPLED FLOW SIMULATION AROUND SPACECRAFT IN LOW EARTH ORBIT

C. R. JUSTIZ and R. M. SEGA (NASA, Johnson Space Center, Houston, TX) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 10 p. refs

(AIAA PAPER 91-1500) Copyright

The primary objective of this investigation is to provide a full flow simulation of a spacecraft in low earth orbit (LEO). Due to the nature of the environment, the simulation includes the highly coupled effects of neutral particle flow, free stream plasma flow, nonequilibrium gas dynamics effects, spacecraft charging and electromagnetic field effects. Emphasis is placed on the near wake phenomenon and will be verified in space by the Wake Shield Facility (WSF) and developed for application to Space Station conditions as well as for other spacecraft. The WSF is a metallic disk-type structure that will provide a controlled space platform for highly accurate measurements. Preliminary results are presented for a full flow around a metallic disk. Author

A91-42522*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

A CHARGING STUDY OF THE ACTS SATELLITE USING NASCAP

JOEL L. HERR (NASA, Lewis Research Center, Cleveland; Sverdrup Technology, Inc., Brook Park, OH) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 12 p. refs

(Contract NAS3-25266)

(AIAA PAPER 91-1471) Copyright

The results of a charging study conducted with the NASA Charging Analyzer Program (NASCAP) using a model of the Advanced Communications Technology Satellite (ACTS) are presented. The electrostatic discharge mechanisms are described including the field and potential threshold values that were monitored during the NASCAP simulation. Particular attention is given to the charging behavior of the ACTS inclined antennas. The data obtained indicate that the possibility of a discharge occurring in the immediate vicinity of the antennas is minimal when the semiconducting paint layer on the antenna's front surface has sufficient surface conductivity. It is shown that the metallized multilayer insulating blanket ACTS design provides good electrostatic discharge control. O.G.

A91-42637# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

METEOROID AND ORBITAL DEBRIS RECORD OF THE LONG DURATION EXPOSURE FACILITY'S FRAME

MICHAEL ZOLENSKY (NASA, Johnson Space Center, Houston, TX), DALE ATKINSON (POD Associates, Albuquerque, NM), THOMAS SEE (Lockheed Engineering and Sciences Co., Houston, TX), MARTHA ALLBROOKS (Systems Science and Software, Albuquerque, NM), CHARLES SIMON (Washington University, Saint Louis, MO), MIRIA FINCKENOR (NASA, Marshall Space Flight Center, Huntsville, AL) et al. Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Mar.-Apr. 1991, p. 204-209. SDIO-supported research. refs

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The gravity stabilization feature of the NASA Long Duration Exposure Facility (LDEF), which was recovered in January 1990 after 5.7 years of continuous exposure to the LEO environment, has allowed the resolution of the flux and trajectories of impacting meteoroids and space-debris particulates. Attention is presently given to the stereoscopic video imaging results obtained for the large impact features on the LDEF's aluminum frame. Extreme directionalities appear to typify impacting particulates larger than 0.1 mm in diameter; this is not explainable in light of current models. Recommendations for further LDEF analyses to ensure the safe design of future spacecraft are presented. O.C.

A91-42638*# McDonnell-Douglas Space Systems Co., Houston, TX.

NEW METHOD FOR ESTIMATING LOW-EARTH-ORBIT COLLISION PROBABILITIES

JOHN D. VEDDER and JILL L. TABOR (McDonnell Douglas Space Systems Co., Houston, TX) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Mar.-Apr. 1991, p. 210-215. refs

(Contract NAS9-17650)
Copyright
An unconventional but general method is described for estimating the probability of collision between an earth-orbiting spacecraft and orbital debris. This method uses a Monte Caralo simulation of the orbital motion of the target spacecraft and each discrete debris object to generate an empirical set of distances, each distance representing the separation between the spacecraft and the nearest debris object at random times. Using concepts from the asymptotic theory of extreme order statistics, an analytical density function is fitted to this set of minimum distances. From this function, it is possible to generate realistic collision estimates for the spacecraft. Author

A91-43391*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
REFLECTIVE OVERCOATS FOR RADIATION CONTROL SURFACES
SUSAN M. WHITE (NASA, Ames Research Center, Moffett Field, CA) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 11 p. refs
(AIAA PAPER 91-1320) Copyright
Theoretical models are developed to predict the surface properties of a coating layer composed of particles of a known size distribution, applied to an opaque substrate, such as a metal or reaction cured glass (RCG). The surface temperature attained at radiative equilibrium by an overcoated surface subject to a given heat flux is calculated. The incident radiation was assumed to exhibit the spectral distribution characteristic of a black body at different temperatures or equivalently, having different peak wavelengths, with the energy level scaled to give a range of desired surface radiative heat fluxes. This approach allows a straightforward comparison of the thernal response of a surface to incident radiation having the energy predominantly in a characteristic wavelength band and a well-defined spectral distribution. The ratio of the radiative heat flux to the total heat flux was varied, and the different geometric and material parameters of such overcoat layers were explored. The model was applied to representative surface heating rates to the Aeroasssisted Flight Experiment (AFE) and to Aeroassisted Space Transfer Vehicles (ASTVs). The predicted radiative energy flux to the surface of the AFE vehicle gives a single-point comparison of the surface temperatures attained with and without a selective-reflector overcoat on the vehicle surface. The specific objective of this work is to identify the most desirable radiative properties of an overcoat/substrate system for this environment. Author

A91-43430*# SECA, Inc., Huntsville, AL.
ESTIMATED ACCURACY OF METHOD OF CHARACTERISTICS VISCOUS PLUME SOLUTIONS FOR AN ORBIT PLUME INDUCED ENVIRONMENT PREDICTION
SHELDON D. SMITH (Seca, Inc., Huntsville, AL) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 15 p. refs
(Contract NAS8-38243)
(AIAA PAPER 91-1364) Copyright
A study has been performed to determine an estimate of the accuracy of rocket exhaust plume induced spacecraft environments calculated with the more widely used computational methods. Calculations of plume flowfields and plume induced environments using Method of Characteristic (MOC) based models are compared with both experimental results and direct simulation Monte Carlo (DSMC) results to determine the applicability and accuracy of Method of Characteristic models. Author

A91-44493*# Contel Federal Systems, Inc., Chantilly, VA.
ENVIRONMENT-INDUCED ANOMALIES ON THE TDRS AND THE ROLE OF SPACECRAFT CHARGING
S. DAUGHTRIDGE (Contel Federal Systems, Chantilly, VA), H. B. GARRETT, and A. WHITTLESEY (JPL, Pasadena, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, May-June 1991, p. 324-329. Previously cited in issue 06, p. 777, Accession no. A90-19720. refs
Copyright

A91-44496*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ORBITAL DEBRIS ENVIRONMENT FOR SPACECRAFT IN LOW EARTH ORBIT
DONALD J. KESSLER (NASA, Johnson Space Center, Houston, TX) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, May-June 1991, p. 347-351. Previously cited in issue 13, p. 1965, Accession no. A90-32048. refs
Copyright

A91-47380 Iowa Univ., Iowa City.
PLASMA WAVES OBSERVED IN THE NEAR VICINITY OF THE SPACE SHUTTLE
IVER H. CAIRNS and DONALD A. GURNETT (Iowa, University, Iowa City) Journal of Geophysical Research (ISSN 0148-0227), vol. 96, Aug. 1, 1991, p. 13,913-13,929. refs
(Contract NAGW-1488; NAG3-449)
Copyright
The observational characteristics are listed and a theoretical analysis is presented for plasma waves observed near the Space Shuttle during the Spacelab 2 mission. The characteristics of the plasma are listed including the frequency distributions of wave-electric fields, amplitude and frequency variations, and relationships such as that between wavenumber and wave frequency. Linear theory is used to describe the plasma by incorporating the Doppler-shifted lower hybrid waves driven by beamlike distributions of water ions. The theoretical description can explain the generation of waves that satisfy four conditions which are consistent with the observed plasma. Spatial inhomogeneities and nonlinear effects are shown to change the predicted linear spectrum, and the ratio of wave energy to thermal plasma energy shows that strong nonlinear turbulence effects are significant. The results are of interest to the optimization of conditions for observing natural or artificially generated plasma waves from the Space Shuttle. C.C.S.

A91-47386* Northeastern Univ., Boston, MA.
TEMPORAL STUDY OF WAKE FORMATION BEHIND A CONDUCTING BODY
S. MEASSICK, C. CHAN, Y. QIAN, T. SRODA, T. AZAR (Northeastern University, Boston, MA) et al. Journal of Geophysical Research (ISSN 0148-0227), vol. 96, Aug. 1, 1991, p. 13,985-13,995. refs
(Contract NAGW-1572)
Copyright
The temporal evolution of the wake of a conducting body is studied experimentally in a pulsed plasma device. Three-dimensional measurements of the plasma potential, density, particle energy distribution, and ion currents are measured throughout the near- and mid-wake regions during the wake formation. It is found that the potential behind the conducting body is initially negative. This negative potential is caused by the higher mobility of the electrons, allowing them to flow into the ion free wake region. The negative potential in the wake region induces an electric field that pulls ions into the region behind the conducting body. However, the dominant factor in determining the length of the near wake is the thermal energy spread of the ions. At later times, as the sheath forms around the conducting body, ions are deflected by the potential gradient in the sheath region. This deflection, in addition to the thermal energy spread of the ions, determines the length of the near wake. Author

A91-47626
ASTEROID AND SPACECRAFT DYNAMICS; PROCEEDINGS OF THE TOPICAL MEETING OF THE INTERDISCIPLINARY SCIENTIFIC COMMISSION B AND P (MEETINGS B4 AND P1) OF THE COSPAR 28TH PLENARY MEETING, THE HAGUE, NETHERLANDS, JUNE 25-JULY 6, 1990
W.-H. IP, ED. (Max-Planck-Institut fuer Aeronomie, Katlenburg-Lindau, Federal Republic of Germany), H. J. MELOSH,

ED. (Arizona, University, Tucson), and B. A. C. AMBROSIUS, ED. (Delft University of Technology, Netherlands) Meetings sponsored by COSPAR and IAGA. Advances in Space Research (ISSN 0273-1177), vol. 11, no. 6, 1991, 228 p. For individual items see A91-47627 to A91-47653.
Copyright

The present topical meetings on asteroid and spacecraft dynamics discuss cometary and asteroidal interactions with planetary atmospheres and advances in spacecraft dynamics. Attention is given to the properties of comets, asteroids, and terrestrial planet impactors, small comet statistics and the probability of detection in Ly-alpha, and close encounters of near-earth asteroids during 1900-2100. Also discussed are impact crater processes, the oceanic impact of large objects, atmospheric impact processes, and global consequences of radiation impulse caused by comet impact. Topics addressed include the contribution of satellite laser ranging to geodesy and geodynamics, the role of laser-determined objects in geodesy and geophysics, atmospheric density parameters from Seasat laser ranging, decay of debris in geostationary transfer orbit, accuracy assessment of GPS satellite orbits, and spectral representation of satellite-to-satellite tracking observables. P.D.

A91-47646
DECAY OF DEBRIS IN GEOSTATIONARY TRANSFER ORBIT
GUY JANIN (ESA, European Space Operations Centre, Darmstadt, Federal Republic of Germany) of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A91-47626 20-12) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 6, 1991, p. 161-166. refs
Copyright

Current difficulties encountered in the prediction of reentry of objects on highly eccentric orbits are reported, with emphasis on debris on geostationary transfer orbits (GTO). It is shown how the atmospheric drag, acting at perigee, may considerably change the orbit's evolution. For GTO, the effect of the drag at perigee may render the prediction of the reentry date of debris on a high eccentricity orbit totally uncertain. P.D.

A91-47878#
BRINGING BACK A LONG LOOK AT SPACE
ERIC J. LERNER Aerospace America (ISSN 0740-722X), vol. 29, Aug. 1991, p. 28-31.
Copyright

The delayed return of the Long Duration Exposure Facility (LDEF) satellite, designed to study in depth the LEO environment and its effects on systems, space materials, and organisms is reviewed. The plants, materials, and microorganisms on board LDEF got through six years in good shape, including a variety of plant seeds that were exposed on the outside of the LDEF, still having 40-50 percent germination rates when returned to earth. Two puzzling features were the discovery of some mysterious heavy ion cosmic rays and, possibly, the main component of interplanetary dust in the solar system. Many graphite composite materials, optical components, and whole systems ranging from solid rockets to fiber optic devices survived their six years in space without any major degradation in function. R.E.P.

A91-48191
RADIATION OF ION ACOUSTIC WAVES IN A DISPERSIVE POSITIVE ION-NEGATIVE ION PLASMA
JAMIE L. COONEY, MATTHEW T. GAVIN, and KARL E. LONNGREN (Iowa, University, Iowa City) IEEE Transactions on Plasma Science (ISSN 0093-3813), vol. 19, June 1991, p. 545-547. refs
(Contract NSF ECS-90-06921)
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Experimental results that illustrate some properties of the radiation of a longitudinal ion acoustic wave launched from a solid metal disk antenna inserted in a dispersive positive-ion-negative-ion plasma are presented. The negative ions replace the free electrons in the plasma and increase the electron Debye length, hence increasing the dispersion of the plasma. It is observed that the radiation of waves in a dispersive media is significantly more complicated than in a nondispersive media. It is not possible to draw one universal radiation pattern for the radiation of the waves in this case, since so many frequency components are present in the wave and they change as the wave evolves. I.E.

A91-48847
ORBITAL DEBRIS DETECTION - TECHNIQUES AND ISSUES
NICHOLAS L. JOHNSON and DAVID J. NAUER (Teledyne Brown Engineering, Colorado Springs, CO) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, July-Aug. 1991, p. 465-469. Previously cited in issue 13, p. 1970, Accession no. A90-32030. refs
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A91-49499
INSTRUMENTATION AND PRELIMINARY RESULTS FOR MONITORING PENETRATING RADIATION ON THE MIR ORBITAL COMPLEX [APPARATURA I PREDVARITEL'NYE REZUL'TATY DLIA MONITORINGA PRONIKAIUSHCHEI RADIATSII NA ORBITAL'NOM KOMPLEKSE 'MIR']
L. S. BRATOLIUBOVA-TSULUKIDZE, IU. P. GORDEEV, V. I. LIAGUSHIN, T. N. MARKELOVA, O. IU. NECHAEV, M. I. PANASIUK, M. A. SARAEVA, L. A. SMIRNOV, P. I. SHAVRIN, and V. IA. SHIRIAEVA Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, May-June 1991, p. 487-490. In Russian. refs
Copyright

A91-49562
ECOLOGICAL ASPECTS OF THE EFFECT OF ROCKETS AND SPACECRAFT ON THE MAGNETOSPHERE AND NEAR SPACE [EKOLOGICHESKIE ASPEKTY VOZDEISTVIIA RAKETNO-KOSMICHESKOI TEKHNIKI NA MAGNITOSFERU I BLIZHNII KOSMOS]
V. B. SHUSHKOVA and A. A. KHANAN'IAN (NPO Taifun, Obninsk, USSR) Geomagnetizm i Aeronomiia (ISSN 0016-7940), vol. 31, May-June 1991, p. 570-572. In Russian. refs
Copyright

The paper reviews the main types of anthropogenic pollution of near-earth space associated with the destruction of spacecraft and the operation of rocket engines. It is noted that space debris, including the radioactive variety, is a present danger, while global changes of the environment (depletion of the ionosphere, increase in the density of the exosphere, climatic changes, etc.) may occur with the further intensification of space activity. L.M.

A91-49813* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
CHARACTERIZATION AND CALIBRATION OF THE EOIM-III FLIGHT MASS SPECTROMETER IN A HIGH VELOCITY OXYGEN ATOM BEAM
S. L. KOONTZ (NASA, Johnson Space Center, Houston, TX), J. B. CROSS (Los Alamos National Laboratory, NM), D. HUNTON (USAF, Geophysics Laboratory, Hanscom AFB, MA), and E. LAN (McDonnell Douglas Space Systems Co., Huntington Beach, CA) IN: Materials degradation in low earth orbit (LEO); Proceedings of the Symposium, 119th Annual Meeting of the Minerals, Metals, and Materials Society, Anaheim, CA, Feb. 17-22, 1990. Warrendale, PA, Minerals, Metals, and Materials Society, 1990, p. 155-174. refs
Copyright

Calibration and characterization of the quadrupole mass spectrometer component of the Evaluation of Oxygen Effects on Materials III (EOIM-III) space-flight experiment are reported in this paper. A high-velocity atom beam system was used to characterize the response of the flight mass spectrometer to high velocity oxygen atoms as well as the reaction/scattering products formed when the atom beam struck a surface. Carbon dioxide, carbon monoxide, and water were observed to form in the mass spectrometer whenever high velocity oxygen atoms were present. The major gaseous products formed from high-velocity atom-beam polymer reactions were easily detected and identified. Author

A91-51797
PREDICTION OF SOLAR AND GEOMAGNETIC ACTIVITY FOR LOW-FLYING SPACECRAFT
R. MUGELLESI (ESA, European Space Operations Centre, Darmstadt, Federal Republic of Germany) and D. J. KERRIDGE (NERC, British Geological Survey, Edinburgh, Scotland) ESA Journal (ISSN 0379-2285), vol. 15, no. 2, 1991, p. 123-134. refs
Copyright

The SOLMAG software, currently being used for mission analysis and planning work for ESA's Eureca and ERS missions is described. Performance of the software in the prediction of geomagnetic and solar activity for low-flying spacecraft is discussed. Attention is given to solar and geomagnetic indices, relationships between sunspot number and F10.7, and forecasting of solar and geomagnetic activity. The prediction method adopted is a linear regression technique and utilizes all the available historical data. R.E.P.

A91-52000
SPACECRAFT-GENERATED IONS
R. C. OLSEN and C. W. NORWOOD (U.S. Naval Postgraduate School, Monterey, CA) Journal of Geophysical Research (ISSN 0148-0227), vol. 96, Sept. 1, 1991, p. 15,951-15,962. Research supported by U.S. Naval Postgraduate School. refs

Electrostatic analyzer measurements of ions on the Scatha satellite show evidence of locally generated ions. These measurements come during periods of large negative charging (about -100 to -10,000 V) at or near geosynchronous altitude. Ions are observed at energies below the satellite potential, which, in the absence of scattering, must have been generated on or near the satellite surface. Differential charging measurements from the surface satellite potential monitor indicated that there were surfaces with the proper magnitude of differential charging to provide a source for the observed ions. Application of the Sigmund-Thompson theories on sputtering show that ambient 10- to 100-keV O(+) on glass could provide a yield of 0.5-1.0 particles per incident ion. Roughly 2-4 percent of this yield is ionized. This is sufficient to explain the flux levels observed. Particle tracking using the NASA charging analyzer program (NASCAP) showed that the energies measured provided a sweep of trajectories along the satellite surface, but no specific source was identified. Author

A91-52590
ENERGY SPECTRA OF HIGH-ENERGY ELECTRONS AND POSITRONS UNDER THE EARTH'S RADIATION BELT [ENERGETICHESKIE SPEKTRY ELEKTRONOV I POZITRONOV VYSOKIKH ENERGII POD RADIATSIONNYM POIASOM ZEMLI]
S. A. VORONOV, A. M. GAL'PER, S. V. KOLDASHOV, L. V. MASLENNIKOV, V. V. MIKHAILOV, and A. V. POPOV Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, July-Aug. 1991, p. 567-575. In Russian. refs
Copyright

Mir magnetic-spectrometer measuremnets of electron and positron spectra in the 10-200 MeV range under the radiation belt are presented. A comparison with other data shows that the spectrum of the electrons and positrons is close to the power spectrum E exp -2 in the energy range from 8 MeV to several GeV, which disagrees with calculations of electron flux intensity based on the pi-mu-e decay model. L.M.

A91-52999
SIMULATING SPACE IMPACTS
IAN PARKER Aerospace Composites and Materials (ISSN 0954-5832), vol. 3, Sept. 1991, p. 14, 15, 17.
Copyright

The need for simulating space debris impacts in the laboratory, in order to develop spacecraft protection systems, has led to the development of a hypervelocity impact-generation facility using both light gas gun and electromechanical accelerator techniques to reach muzzle velocities of the order of 7.5 and 9.0 km/sec. Firings can be conducted at the rate of two per day. New launchers are under development which will be capable of accelerating particles to 20 km/sec. O.C.

A91-54998
BRDF MEASUREMENTS FOR CONTAMINATION ASSESSMENT IN A SPACECRAFT ENVIRONMENT
TIMOTHY L. HOWARD, PATRICIA M. GEORGE, and ROBERT F. FISHER (Aerojet, Electronic Systems Div., Azusa CA) IN: Optical system contamination: Effects, measurement, control II; Proceedings of the Meeting, San Diego, CA, July 10-12, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 266-279. refs
Copyright

The design of a scatterometer used for in situ studies of optical surface contamination is reviewed, and dual-wavelength (0.633, 10.6 micron) BRDF measurements are presented which were made on molecular contaminants adsorbed onto cryogenically cooled mirrors. The results are compared to others obtained from the literature, and the BRDF increase from contaminants is analyzed using a simple theory based on Rayleigh scattering. Author

A91-55003* *National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.*
SURFACE ACCOMMODATION OF MOLECULAR CONTAMINANTS
PHILIP T. CHEN, RANDY J. HEDGELAND (NASA, Goddard Space Flight Center, Greenbelt, MD), and SHAUN R. THOMSON (EER Systems Corp., Seabrook, MD) IN: Optical system contamination: Effects, measurement, control II; Proceedings of the Meeting, San Diego, CA, July 10-12, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 327-336. refs
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Theoretical consideration and supporting data are presented regarding the nature of the transport mechanisms which cause the adsorption of gases on spacecraft surfaces. Particular attention is given to the concept of a sticking coefficient which is the ratio of the thermally accommodated mass to the total incident mass. Existing molecular accommodation data are examined in terms of spacecraft applications and recent contamination-control data are introduced. Two distinct yet linked concepts emerge which are the accommodation and sticking coefficients, and surface roughness contributes significantly to both coefficients. A general equation regarding the coefficients is developed, and the data are found to fit the equation basically. It is concluded that a more precise characterization of the coefficients can be obtained through experimentation under simulated spacecraft conditions. C.C.S.

A91-55006* Vanderbilt Univ., Nashville, TN.
ROLE OF LOW-ENERGY NEUTRAL N2 BEAM-SURFACE INTERACTIONS LEADING TO SPACECRAFT GLOW
ALAN V. BARNES, ROYAL G. ALBRIDGE, JINING QI, MANFRED RIEHL-CHUDOBA, CHANG-NIAN SUN, P. W. WANG, and NORMAN H. TOLK (Vanderbilt University, Nashville, TN) IN: Optical system contamination: Effects, measurement, control II; Proceedings of the Meeting, San Diego, CA, July 10-12, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 362-368. refs
(Contract NAS8-37744; NAS8-37748; AF-AFOSR-90-0030)
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Measurements of the optical spectra of surfaces undergoing bombardment by N2 and N2(+) in an ultrahigh vacuum environment provide information related to the origin of spacecraft flow and erosion. This work is complementary to other measurements, in which O and O(+) beams are utilized. These efforts are part of a broad program whose goal is the understanding of interactions between surfaces and low-energy charged and neutral particles. Author

A91-55007
LABORATORY STUDY OF ELECTROSTATIC CHARGING OF CONTAMINATED ULYSSES SPACECRAFT THERMAL BLANKETS
A. T. CHEN, C. G. SHAW, and J. H. MABE (Boeing Aerospace

and Electronics, Seattle, WA) IN: Optical system contamination: Effects, measurement, control II; Proceedings of the Meeting, San Diego, CA, July 10-12, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 369-381. refs
(Contract F04701-85-C-0101)
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A laboratory study has been performed to investigate the effects of contamination on the electrostatic charging phenomena of spacecraft thermal blankets for the Ulysses mission. Induced contamination by the upperstage PAM-S Star-48B motor nozzle postburn outgassing was studied for three types of electrically conductive thermal blankets: indium-tin-oxide-coated, electrodag-coated, and aluminized Kapton. Blanket samples were irradiated with 50 eV electrons at temperatures ranging from 25 C to -100 C and contaminant-deposition thicknesses ranging from 200 to 3000 A (assuming specific gravity of 1.0). The experimental results show that the charging characteristics of all three contaminated blankets are similar. Charge accumulation was observed to be a strong function of contaminant deposition temperature, and a nonlinear function of primary electron flux.
Author

A91-55314
THE EARTH'S DUST CLOUD AND ATMOSPHERIC OXYGEN [PYLEVOE OBLAKO ZEMLI I ATMOSFERNYI KISLOROD]
V. N. LEBEDINETS (Institut Eksperimental'noi Meteorologii, Obninsk, USSR) Astronomicheskii Vestnik (ISSN 0320-930X), vol. 25, May-June 1991, p. 350-363. In Russian. refs
Copyright

Hypotheses on 'minicomets' and on the few-percent content of high molecular organic components in their snow nuclei are examined. They show the physical mechanism of the formation of the earth's dust cloud with a dust concentration 2 to 3 orders higher than the background content in interplanetary space. The influx of minicomets is the main source of oxygen through the whole column of the atmosphere, and of water in the thermosphere, mesosphere, and upper stratosphere. It is found that swarms of minicomets may exist in the orbits of large comets, an encounter with which results in a short-term increase in the dust content in the upper atmosphere and circumterrestrial space. P.D.

A91-55555* Vanderbilt Univ., Nashville, TN.
OPTICAL GLOW SPECTRA ARISING FROM LOW-ENERGY N2, N2(+) AND ELECTRON BOMBARDMENT OF MGF2 SURFACES
J. QI, A. V. BARNES, S. L. ESPY, M. RIEHL-CHUDOBA, C.-N. SUN, R. G. ALBRIDGE, and N. H. TOLK (Vanderbilt University, Nashville, TN) Applied Physics Letters (ISSN 0003-6951), vol. 59, Oct. 14, 1991, p. 1954-1956. refs
(Contract AF-AFOSR-90-0030; NAS8-37744; NAS8-37748)
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Photon emission spectra resulting from the impact of N2, N2(+), and electron beams on magnesium fluoride in an ultrahigh vacuum environment were measured and compared for beam energies in the range 200-2000 eV. Unexpectedly, only the ion- and electron-induced spectra exhibited broad fluorescence. The observed data suggest that the broad fluorescence arising from low-energy ion bombardment is due primarily to the transfer of electronic energy to the surface by resonance or Auger neutralization. Since molecular nitrogen is a major constituent of the atmosphere at orbital altitudes, these measurements bear directly on radiation-induced glow and erosion processes on surfaces of spacecraft in low-earth orbit. Author

N91-21166# Norwegian Defence Research Establishment, Kjeller.
NORWEGIAN STUDIES OF PLASMA MODIFICATIONS AROUND SPACECRAFT AND HOW THESE AFFECT THE VEHICLE POTENTIAL
BERNT N. MAEHLUM *In* Norwegian Space Center, From Earth to Space and Back: Selected Papers on Norwegian Space Activities p 33-38 Mar. 1990 Previously announced in IAA as A90-26855
Avail: CASI HC A02/MF A01

The Norwegian Defence Research Establishment (NDRE) is actively invloved in studies of various types of disturbances created by spacecraft in the Earth's ionosphere and the associated vehicle charging. Studies based on cooperative experiments with scientists from all over the world, including active and passive instruments on spacecaft and in the laboratory are described. The possibility of electrostatic breakdown in onboard spacecraft electronics due to a high build up in potential gradients is discussed. Involvement of the NDRE in helping develop a system of plasma interaction monitors for the Space Station Freedom is discussed. ESA

N91-21881# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
THE STUDY OF PLASMA CLOUDS AROUND LARGE ACTIVE SPACE STRUCTURES Final Report, May 1986 - Dec. 1989
DANIEL HASTINGS 7 Nov. 1989 85 p
(Contract F19628-86-K-0018)
(AD-A230634; GL-TR-89-0306) Avail: CASI HC A05/MF A01 CSCL 20I

Large spacecraft such as the Space Shuttle perturb the natural environment by releasing contaminants into the atmosphere through outgassing, chemical dumps, and thruster firings. A fluid model was developed to describe the large scale structure of the contminant plasma cloud. The model is two dimensional with the structure along the magnetic field being averaged out. The model predicts that an important parameter is the parallel length scale of the cloud since this determines the effective length over which electrons can be drawn to short out the ions flowing perpendicular to the magnetic field. In addition, a significant amount of work was done on the small scale kinetic processes that occur in the contaminant cloud and that cannot be explained by the fluid model. These small scale processes include instabilities in the cloud, ion acceleration by the cloud and anomalies ionization in the cloud.
GRA

N91-24217*# Southwest Research Inst., San Antonio, TX.
SEPAC DATA ANALYSIS IN SUPPORT OF THE ENVIRONMENTAL INTERACTION PROGRAM Final Technical Report
C. S. LIN 31 Mar. 1991 51 p
(Contract NAS8-32488; SWRI PROJ. 15-4865-009)
(NASA-CR-188179; NAS 1.26:188179) Avail: CASI HC A04/MF A01 CSCL 22B

The main objective is to conduct data analyses of SEPAC data and computer modeling to investigate spacecraft environment effects associated with injection of electron beam, plasma clouds, and neutral gas clouds from the Shuttle Orbiter. To understand the dependence of spacecraft charging potential on beam density and other plasma parameters, a two dimensional electrostatic particle code was used to simulate the injection of electron beams from an infinite conductor into a plasma. The ionization effects on spacecraft charging are examined by including interactions of electrons with neutral gases. A survey of the simulation results is presented and discussed. Author

N91-24224*# Sverdrup Technology, Inc., Brook Park, OH.
A CHARGING STUDY OF ACTS USING NASCAP Final Report
JOEL L. HERR May 1991 12 p Presented at the 22nd Fluid Dynamics, Plasma Dynamics, and Lasers Conference, Honolulu, HI, 24-26 Jun. 1991; sponsored by AIAA
(Contract NAS3-25266; RTOP 506-41-41)
(NASA-CR-187088; E-6079; NAS 1.26:187088) Avail: CASI HC A03/MF A01 CSCL 22B

The NASA Charging Analyzer Program (NASCAP) computer code is a three dimensional finite element charging code designed to analyze spacecraft charging in the magnetosphere. Because of the characteristics of this problem, NASCAP can use an quasi-static approach to provide a spacecraft designer with an understanding of how a specific spacecraft will interact with a geomagnetic substorm. The results of the simulation can help designers evaluate the probability and location of arc discharges of charged surfaces on the spacecraft. A charging study of NASA's Advanced Communication Technology Satellite (ACTS) using NASCAP is reported. The results show that the ACTS metalized multilayer insulating blanket design should provide good electrostatic discharge control. Author

N91-26192# Phillips Lab., Edwards AFB, CA.
THE EFFECTS OF SPACE DEBRIS ON SOLAR PROPULSION Final Report, Jun. - Jul. 1990
MARK SKIBINSKI Mar. 1991 35 p
(Contract AF PROJ. 3056)
(AD-A235257; PL-TR-91-3001) Avail: CASI HC A03/MF A01 CSCL 22B

This research sought to determine the impact of space debris on solar propulsion for orbital transfer missions from low Earth Orbit (LEO) to Geosynchronous Earth Orbit (GEO). Orbital debris is a major concern because the present solar propulsion development calls for two 40 x 30 m inflatable concentrators which present a large area for space debris impact. The initial questions to be researched were: (1) How much extra inflationary gas will be required to make up for meteoroid and artificial space debris leaks? and (2) What is the probability of a catastrophic collision with the concentrators? Numerous debris models and many assumptions were used to calculate answers for these questions, but overall the inflatable reflectors were judged to be a plausible concept. It is plausible in that the amount of helium inflatent needed to keep the concentrators rigid is an acceptable weight (12 lbm). Also the probability of a catastrophic collision for a 40 day mission is minimal (0.1 percent). Further research and computer simulation is needed to better define the man-made debris distribution for elliptical (transfer) orbits due to their constant changing altitude. GRA

N91-26637*# Alabama Univ., Huntsville. Dept. of Physics.
THEORETICAL AND EXPERIMENTAL STUDIES RELEVANT TO INTERPRETATION OF AURORAL EMISSIONS Annual Report
CHARLES E. KEFFER 24 Jun. 1991 623 p
(Contract NAG8-834)
(NASA-CR-188491; NAS 1.26:188491) Avail: CASI HC A99/MF A06 CSCL 04A

The accomplishments achieved over the past year are detailed with emphasis on the interpretation or auroral emissions and studies of potential spacecraft-induced contamination effects. Accordingly, the research was divided into two tasks. The first task is designed to add to the understanding of space vehicle induced external contamination. An experimental facility for simulation of the external environment for a spacecraft in low earth orbit was developed. The facility was used to make laboratory measurements of important phenomena required for improving the understanding of the space vehicle induced external environment and its effect on measurement of auroral emissions from space-based platforms. A workshop was sponsored to provide a forum for presentation of the latest research by nationally recognized experts on space vehicle contamination and to discuss the impact of this research on future missions involving space-based platforms. The second task is to add an ab initio auroral calculation to the extant ionospheric/thermospheric global modeling capabilities. Once the addition of the code was complete, the combined model was to be used to compare the relative intensities and behavior of various emission sources (dayglow, aurora, etc.). Such studies are essential to an understanding of the types of vacuum ultraviolet (VUV) auroral images which are expected to be available within two years with the successful deployment of the Ultraviolet Imager (UVI) on the ISTP POLAR spacecraft. In anticipation of this, the second task includes support for meetings of the science working group for the UVI to discuss operational and data analysis needs. Taken together, the proposed tasks outline a course of study designed to make significant contributions to the field of space-based auroral imaging. Author

N91-27172# RADEX, Inc., Bedford, MA.
A PARAMETRIC STUDY OF THE RELEASE OF CO2 IN SPACE Report, Dec. 1990 - Jan. 1991
A. SETAYESH 31 Jan. 1991 22 p
(Contract F19628-89-C-0068)
(AD-A236271; RX-R-91011; PL-TR-91-2052; SR-6) Avail: CASI HC A03/MF A01 CSCL 07B

SOCRATES (Spacecraft/Orbiter Contamination Representation Accounting for Transiently Emitted Species), which has been developed to account for contamination on spacecraft, has been used to simulate the CO2 reaction with atomic oxygen and hydrogen at altitudes of 500 to 800 km. The computerized simulation shows that the reactions of H atoms with CO2 and O with CO2 generate measurable quantities of radiation at the fundamental frequencies of carbon monoxide and OH. The intensity of these emissions was studied as a function of altitude and time. GRA

N91-27192# Institute for Defense Analyses, Alexandria, VA.
TOPICS IN HYPERVELOCITY IMPACT SHIELDING FOR SPACE ASSETS Final Report, May - Oct. 1989
PETER KYSAR Oct. 1990 64 p
(AD-A235810; AD-E501384; IDA-D-675; IDA/HQ-89-34916) Avail: CASI HC A04/MF A01 CSCL 19J

The growing quantities of debris resulting from past and ongoing space operations pose an increasing threat to future space operations. Additional debris may result from anti-satellite (ASAT) weapons tests. The deployment of an ASAT pellet ring could place many tons of debris in space. The threat of debris to spacecraft, from whatever source, is a matter of increasing concern to both NASA and DoD. All future space operations must recognize the danger of space debris and suitable protection procedures must be provided. Protection from unreasonable debris damage requires an understanding of both the debris population and of the phenomena involved in hypervelocity impact. Collisions between objects orbiting the earth usually involve speeds in excess of the speeds acceptable for the classical collision regime. Collisions at such speeds have a little understood and a much debated complex phenomenology. The future development of space will require a greater understanding of hypervelocity issues. GRA

N91-27193# Lockheed Missiles and Space Co., Palo Alto, CA.
ONR-307 EXPERIMENT ON THE COMBINED RELEASE AND RADIATION EFFECTS SATELLITE (CRRES) Interim Technical Report, Jul. 1988 - Mar. 1991
R. M. ROBINSON and R. R. VONDRAK 1 Mar. 1991 96 p
(Contract N00013-83-C-0476)
(AD-A236241) Avail: CASI HC A05/MF A01 CSCL 22A

The Combines Release and Radiation Effects Satellites (CRRES) geosynchronous transfer orbit with an apogee of 35,786 km makes it an ideal platform to study problems related to the radiation belts and its effects on spacecraft systems. The instrumentation on CRRES can be broadly divided into three categories: (1) engineering experiments, (2) radiation belt experiments, and (3) plasma and fields experiments. The ONR-307 payload consists of three different types of instruments that acquire data on the composition of the plasma in the energy range from 0.5 to 1000 keV and on energetic electrons from 20 to 5000 keV and protons from 500 keV to 100 MeV. The data from these instruments provide important information for modeling radiation belt particle populations and understanding the sources and losses of these particles. The ONR-307 instruments were initialized by August 7, 1990 and have been operating flawlessly throughout the CRRES mission. Initial results show that the data quality is excellent. A period of high magnetic activity in late August has been selected for detailed study by the CRRES science team. Data analysis is continuing and future efforts will concentrate on the validation of the data and coordinated measurements with other CRRES instruments. GRA

N91-27961*# Iowa Univ., Iowa City. Dept. of Physics and Astronomy.
INTERPRETATION OF PLASMA DIAGNOSTICS PACKAGE RESULTS IN TERMS OF LARGE SPACE STRUCTURE PLASMA INTERACTIONS Final Technical Report, 10 Jul. 1983 - 1 Aug. 1991
WILLIAM S. KURTH 1 Aug. 1991 942 p

(Contract NAG3-449)
(NASA-CR-188651; NAS 1.26:188651) Avail: CASI HC A99/MF A10 CSCL 20I

The Plasma Diagnostics Package (PDP) is a spacecraft which was designed and built at The University of Iowa and which contained several scientific instruments. These instruments were used for measuring Space Shuttle Orbiter environmental parameters and plasma parameters. The PDP flew on two Space Shuttle flights. The first flight of the PDP was on Space Shuttle Mission STS-3 and was a part of the NASA/Office of Space Science payload (OSS-1). The second flight of the PDP was on Space Shuttle Mission STS/51F and was a part of Spacelab 2. The interpretation of both the OSS-1 and Spacelab 2 PDP results in terms of large space structure plasma interactions is emphasized. Author

N91-28102*# Morgan State Univ., Baltimore, MD. Dept. of Physics.
A DENSITOMETRIC ANALYSIS OF IIAO FILM FLOWN ABOARD THE SPACE SHUTTLE TRANSPORTATION SYSTEM STS #3, 7, AND 8
ERNEST C. HAMMOND, JR. *In* Alabama A & M Univ., NASA-HBCU Space Science and Engineering Research Forum Proceedings p 283-293 1989
Avail: CASI HC A03/MF A04 CSCL 14E

Since the United States of America is moving into an age of reusable space vehicles, both electronic and photographic materials will continue to be an integral part of the recording techniques available. Film as a scientifically viable recording technique in astronomy is well documented. There is a real need to expose various types of films to the Shuttle environment. Thus, the main objective was to look at the subtle densitometric changes of canisters of IIaO film that was placed aboard the Space Shuttle 3 (STS-3). Author

N91-29470# Naval Postgraduate School, Monterey, CA.
LITHIUM ION SOURCE FOR SATELLITE CHARGE CONTROL M.S. Thesis
TAE I. SONG Jun. 1990 59 p
(AD-A238272) Avail: CASI HC A04/MF A01 CSCL 09A

A lithium ion source using thermal emission from mineral beta-eucryptite was investigated as a possible control device for spacecraft charging. This source can be used for control of positively charged spacecraft potentials in sunlight and differentially charged spacecraft surfaces in shadow. The dependence is studied of the emitted ion current on several parameters: source temperature (power input), source bias potentials and potentials applied to simulated spacecraft geometries. Saturation current of about 5.8 micro amp were measured at an extraction potentials of 100 Volts from a source of 0.317 sq cm surface area with a power input of 18 Watts. The lifetime due to ion exhaustion was found to be approx. 200 hours for this compact source. The results indicate that this type of ion source may represent an effective charge control device for spacecraft. GRA

N91-31199 Routes, Inc., Kanata (Ontario).
STUDY OF SPACE QUALIFICATION SPECIFICATIONS Final Report
WILLIAM PAYNE, RONALD BUCKINGHAM, FREDERICK DANIELS, and PETER E. TOWNSEND 17 Apr. 1990 347 p
(Contract NDH-3600-1-9-3594-01-SV)
(CTN-91-60201) Avail: CASI HC A15

Spacecraft design, manufacture, environmental testing, launch and mission operations all require precise specifications. Space-based projects involving hardware or software procurement require both standard specifications and project specific specifications. This document contains a compilation of reference material and information sources on space environmental qualification which may be used to establish environmental specifications for Canadian Forces space-based hardware procurement. Sources evaluated fall into three main classes: standard military documents, documents available from government agencies and institutions, and commercially produced documents. They include: peer review technical journals, hard copy abstract services, trade magazines, standard reference works, and newsletters. A list of 244 publications related to military satellite procurement and space system engineering is provided. In addition aerospace related collections in libraries in the Ottawa area are described and evaluated. Canadian, American and European sources from which relevant technical documents may be purchased are described. Online search services and document ordering services are evaluated and online databases of special relevance are listed. CISTI

N91-32579*# Southwest Research Inst., San Antonio, TX.
SEPAC DATA ANALYSIS IN SUPPORT OF THE ENVIRONMENTAL INTERACTION PROGRAM Final Report, Nov. 1987 - Apr. 1991
CHIN S. LIN 31 Mar. 1991 52 p
(Contract NAS8-32488; SWRI PROJ. 15-4865-009)
(NASA-CR-184201; NAS 1.26:184201) Avail: CASI HC A04/MF A01 CSCL 13B

Data analyses of the Space Experiments with Particle Accelerators (SEPAC) data and computer modeling were conducted to investigate spacecraft environmental effects associated with injection of electron beams, plasma clouds, and neutral gas clouds from the Shuttle orbiter. The data analysis indicates that Extremely Low Frequency oscillations from 150 to 200 Hz were seen in the Langmuir probe current when the beam was fired in a continuous mode. The strongest oscillations occurred when the ambient pressure was augmented by neutral gas releases from the SEPAC plasma accelerator magnetoplasma-dynamic (MPD) arcjet. To understand the dependence of spacecraft charging potential on beam density and other plasma parameters, a two-dimensional electrostatic particle code was used to simulate the injection of electron beams from an infinite conductor into a plasma. The simulations show that the conductor charging potential depends critically on the reflection coefficient of the conductor surface, which is defined as the percentage of incident particles reflected by the conductor. The ionization effects on spacecraft charging were examined by including interactions of electrons with neutral gas. The simulations show that the conductor charging potential decreases with increasing neutral background density due to the production of secondary electrons near the conductor surface. The simulations also indicate that the beam radius is generally proportional to the beam electron gyroradius when the conductor is charged to a large potential. It appears that the charge buildup at the beam stagnation point causes the beam radial expansion. A survey of the simulation results suggests that the ratio of the beam radius to the beam electron gyroradius increases with the square root of beam density and decreases inversely with beam injection velocity. These results are useful for explaining the spacecraft charging phenomena observed during SEPAC experiments from Spacelab 1. Author

05

MATERIALS

Descriptions and analyses of different structural materials, films, coatings or bonding materials. Mechanical properties of spacecraft construction materials. Descriptions of the effects of natural and induced space environments.

A91-33392*# Alabama Univ., Huntsville.
RESPONSE OF SPACECRAFT WINDOW MATERIALS TO HYPERVELOCITY PROJECTILE IMPACT
WILLIAM P. SCHONBERG (Alabama, University, Huntsville) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Jan.-Feb. 1991, p. 118-123. refs
(Contract NAS8-36955)
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This paper presents the results of an investigation of the

response of window materials to hypervelocity projectile impact. Window impact damage is characterized according to the nature and extent of surface and internal damage. Analysis of the test data indicates that, for single-pane specimens, the extent of the damage to the test specimens can be written as functions of the impact parameters of the original projectile and the geometric and material properties of the projectile/ window system. These functions can be used to perform parameter-sensitivity studies and to evaluate hypothetical design applications and configurations.
Author

A91-34266
MECHANICAL AND THERMOPHYSICAL PROPERTIES FOR DIMENSIONALLY STABLE HIGH MODULUS GRAPHITE/EPOXY COMPOSITES
CHRIS BLAIR and JERRY ZAKRZEWSKI (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) (SAMPE, International Technical Conference, 22nd, Boston, MA, Nov. 6-8, 1990) SAMPE Quarterly (ISSN 0036-0821), vol. 22, April 1991, p. 2-7.
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A comparative account is given of the mechanical properties and moisture-absorption characteristics of low coefficient of thermal expansion (CTE) quasi-isotropic laminates of carbon/epoxy composition suitable for space structures and other dimensionally critical structural components. The quasi-isotropic stacking sequence is a 12-ply, (0, 30, 30, 90, 120, 150 deg)s, which has been determined to be the sequence most nearly exhibiting zero-CTE in the laminate plane. Two of the epoxy resin systems, Hexcel F584 and 3M SP-500, absorb less moisture than the baseline system. Four carbon fiber/epoxy matrix combinations are judged suitable for space structural uses. O.C.

A91-34289
BASIC MATERIAL DATA AND STRUCTURAL ANALYSIS OF FIBRE COMPOSITE COMPONENTS FOR SPACE APPLICATION
H. BANSEMIR and O. HAIDER (MBB GmbH, Munich, Federal Republic of Germany) (Non-metallic materials and composites at low temperatures; Proceedings of the Conference, Heidelberg, Federal Republic of Germany, May 17, 18, 1990. A91-34276 13-23) Cryogenics (ISSN 0011-2275), vol. 31, April 1991, p. 298-306. Previously announced in STAR as N91-11811. refs
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Fiber composites are widely used for space applications such as antennas, solar arrays, and support structures for cryogenic tanks. For the calculation of the mechanical behavior of composite structures basic material data is presented. Main mechanical properties are thermal conductivity, thermal expansion, stiffness, and strength for the unidirectional material. Special fiber orientations and lay ups are used in order to optimize the laminates, taking special requirements into account. The optimized design for some composite parts for different space applications are shown, especially pointing out the aspects of the structural analysis and the tests performed to check the calculations. Author

A91-35094
MINIMUM-GAGE, MAXIMUM-STIFFNESS GRAPHITE/THERMOPLASTIC SPACECRAFT STRUCTURES
R. E. GARVEY, J. B. ANDRIULLI, J. W. MCKEEVER, and R. V. RUDNESS (Oak Ridge National Laboratory, TN) Polymer Composites (ISSN 0272-8397), vol. 12, April 1991, p. 108-118. refs
(Contract DE-AC05-84OR-21400)
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Advanced thermoplastic matrix composite materials have been studied for use in aircraft applications since about 1980. This Strategic Defense Initiative Organization/Air Force project was initiated in 1987 to study the suitability of this class of materials for use in spacecraft applications. This paper will report on the following work in progress: development of ultrahigh-modulus, pitch-fiber-reinforced thermoplastic composites; the development of thin-ply graphite/thermoplastic materials for gage-limited spacecraft applications; and producibility demonstrations for generic spacecraft structures including open frames and T and L members, circular and square-tube truss configurations, and stiffened-skin modules. Author

A91-36680* Lockheed Missiles and Space Co., Palo Alto, CA.
USE OF GRAPHITE EPOXY COMPOSITES IN THE SOLAR-A SOFT X-RAY TELESCOPE
B. K. JURCEVICH and M. E. BRUNER (Lockheed Research Laboratories, Palo Alto, CA) IN: Advances in optical structure systems; Proceedings of the Meeting, Orlando, FL, Apr. 16-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 406-415. Research supported by Lockheed Independent Research Program. refs
(Contract NAS8-37334)
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This paper describes the use of composite materials in the Soft X-Ray Telescope (SXT). One of the primary structural members of the telescope is a graphite epoxy metering tube. The metering tube maintains the structural stability of the telescope during launch as well as the focal length through various environmental conditions. The graphite epoxy metering tube is designed to have a negative coefficient of thermal expansion to compensate for the positive expansion of titanium structural supports. The focus is maintained to + or - 0.001 inch by matching the CTE of the composite tube to the remaining structural elements. Author

A91-36685
THE APPLICATION OF COMPOSITE MATERIALS TO SPACEBORNE RADIOMETER INSTRUMENT DESIGN
ROBERT A. HOOKMAN and GEORGE E. ZURMEHLY (ITT Defense, ITT Aerospace Communications Div., Fort Wayne, IN) IN: Advances in optical structure systems; Proceedings of the Meeting, Orlando, FL, Apr. 16-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 465-474. Research supported by ITT Corp.
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The stability and coregistration requirements for future radiometric instrument designs spawn the need for a totally integrated instrument structure and thermal control scheme. To meet the requirements of the future Geostationary meteorological missions an Ultra Stable Instrument Structure (USIS) will be needed. An instrument structure of lightweight construction is described that takes advantage of composite materials that combine high stiffness, low density along with low Coefficient of Thermal Expansion (CTE). In addition, this paper will outline the mission objectives, the operating environment and stability requirements needed for future spaceborne radiometer structures. A conceptual design of a composite instrument structure along with its thermal control system will be outlined, and various design trade-offs will be presented. Author

A91-36689* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE DEVELOPMENT OF COMPOSITE MATERIALS FOR SPACECRAFT PRECISION REFLECTOR PANELS
STEPHEN S. TOMPKINS, DAVID E. BOWLES, JOAN G. FUNK, TIMOTHY W. TOWELL (NASA, Langley Research Center, Hampton, VA), and J. A. LAVOIE (Lockheed Engineering and Sciences Co., Hampton, VA) IN: Advances in optical structure systems; Proceedings of the Meeting, Orlando, FL, Apr. 16-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 512-523. refs
Copyright

One of the critical technology needs for large precision reflectors required for future astrophysics and optical communications is in the area of structural materials. Therefore, a major area of the Precision Segmented Reflector Program at NASA is to develop lightweight composite reflector panels with durable, space environmentally stable materials which maintain both surface figure and required surface accuracy necessary for space telescope applications. Results from the materials research and development program at NASA Langley Research Center are discussed. Advanced materials that meet the reflector panel requirements are identified. Thermal, mechanical and durability properties of candidate materials after exposure to simulated space environments are compared to the baseline material. Author

A91-36690

COEFFICIENT OF THERMAL AND MOISTURE EXPANSION AND MOISTURE ABSORPTION FOR DIMENSIONALLY STABLE QUASI-ISOTROPIC HIGH MODULUS GRAPHITE FIBER/EPOXY COMPOSITES

CHRIS BLAIR and JERRY ZAKRZEWSKI (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Advances in optical structure systems; Proceedings of the Meeting, Orlando, FL, Apr. 16-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 524-535.

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In order to develop dimensionally space stable laminate composite structures a detailed understanding of moisture absorption of composite laminates and the effect of 'dryout' on the shrinkage of laminate structures in the space environment is required. Several new epoxy resins have recently been introduced which are reported to absorb less moisture than the baseline epoxy resins currently used for fabrication of space structures. These are 3M's SP-500, Hexcel F-584 and Toray 3631 and are all modified structural epoxy resins. This study describes the mechanical properties and moisture absorption of these laminates as well as detailing the coefficient of thermal expansion and moisture expansion for quasi-isotropic graphite laminates made from these resin systems. Author

A91-36849

LDEF MISSION UPDATE - COMPOSITES IN SPACE

R. C. TENNYSON, G. E. MABSON, W. D. MORISON, and J. KLEIMAN (Toronto, University, Downsview, Canada) Advanced Materials and Processes (ISSN 0882-7958), vol. 139, May 1991, p. 33-36.

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Preliminary results are presented of the NASA Long-Duration Exposure Facility (LDEF) composite-materials experiment. This experiment included samples made of epoxy-matrix composites containing boron, carbon, and aramid fibers. A custom data-acquisition system was designed and built to record the output of 16 thermal/strain gages every 16 hours for 371 days. Results of initial analyses of the composite-material samples are discussed. The thermal-model predictions are in good agreement with test data up to the initial 300 orbital days. The polymer-matrix composites outgassed for 40 to 120 days depending on the material system, and outgassing caused significant permanent dimensional changes that must be factored into the design of low-distortion laminates. Low-incident-angle atomic oxygen eroded the composite-material samples that were located about 80 deg off the ram direction. R.E.P.

A91-38835

PIEZO LINEAR ACTUATORS FOR ADAPTIVE TRUSS STRUCTURES

K. TAKAHARA, F. KUWAO, M. SHIGEHARA, T. KATOH, S. MOTOHASHI (Toshiba Corp., Kanagawa, Japan) et al. IN: Adaptive structures; Proceedings of the ASME Winter Annual Meeting, San Francisco, CA, Dec. 10-15, 1989. New York, American Society of Mechanical Engineers, 1989, p. 83-88. refs

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The development of inchworm-type piezoelectric actuators (PLAs) which are driven by piezoelectric devices, is presented. The newly developed PLAs feature not only precision positioning but also long stroke drive. Therefore, adaptive truss structures utilizing the PLAs by themselves can be stowed, deployed and precisely shaped. Functional tests and plane truss deployment/retraction tests were carried out; the PLA was assembled in a diagonal member of a deployable plane truss based upon the shear concept as a telescopic actuator. This plane truss is one of the basic elements for adaptive truss structures. Author

A91-41501

METALLURGICAL COATINGS 1989; PROCEEDINGS OF THE 16TH INTERNATIONAL CONFERENCE, SAN DIEGO, CA, APR. 17-21, 1989. VOLS. 1 & 2

BRUCE D. SARTWELL, ED. (U.S. Navy, Naval Research Laboratory, Washington, DC) Conference sponsored by American Vacuum Society and Vacuum Society of Japan. London and New York, Elsevier Applied Science, 1989, p. Vol. 1, 761 p.; vol. 2, 633 p. For individual items see A91-41502 to A91-41533.

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Topics discussed include coatings for use at high temperatures, hard coatings, and industrial equipment and applications. Consideration is given to coatings to resist high-temperature corrosion, coatings to resist wear at high temperature, thermal barrier coatings, superhard coatings and emerging technologies, fundamentals of hard coatings, hard coating properties, applications of hard coatings, and hard coating processes. Also discussed are the economics of coating materials and applications, industrial coating equipment and decorative and foil coating systems, surface modification techniques and coating enhancements, and coatings for corrosive aqueous environments. Particular attention is given to coatings for space applications. I.S.

A91-41515* Boeing Aerospace and Electronics Co., Seattle, WA.

MECHANISMS OF ATOMIC OXYGEN INDUCED MATERIALS DEGRADATION

H. G. PIPPIN (Boeing Aerospace and Electronics, Seattle, WA) IN: Metallurgical coatings 1989; Proceedings of the 16th International Conference, San Diego, CA, Apr. 17-21, 1989. Vol. 1. London and New York, Elsevier Applied Science, 1989, p. 595-598. Research supported by NASA and Boeing Co. refs

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This paper includes discussions of mechanisms by which atomic oxygen may attack materials being flown in low earth orbit (LEO), suggestions for development of materials intrinsically resistant to the harsh LEO environment, and results of an Arrhenius fit to mass loss of Kapton under exposure to thermal atomic oxygen in a laboratory environment. Oxygen atoms are powerful oxidizing agents which can rapidly degrade many types of polymeric materials. The process details depend upon the specific material, its detailed bonding, the thermodynamic stability of potential products, temperature, and particle dynamics. With regard to spacecraft, many effects associated with atomic oxygen may be explained simply by ordinary thermal oxidation processes and by the fact that the oxygen has a preferred direction of impingement. Author

A91-41516* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

UNDERCUTTING OF DEFECTS IN THIN FILM PROTECTIVE COATINGS ON POLYMER SURFACES EXPOSED TO ATOMIC OXYGEN

SHARON K. RUTLEDGE (NASA, Lewis Research Center, Cleveland, OH) and JUDITH A. MIHELCIC (Cleveland State University, OH) IN: Metallurgical coatings 1989; Proceedings of the 16th International Conference, San Diego, CA, Apr. 17-21, 1989. Vol. 1. London and New York, Elsevier Applied Science, 1989, p. 607-615. refs

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Protection for polymeric surfaces is needed to make them durable in the low earth orbital environment. Thin film coatings of oxides such as SiO_2 are viable candidates to provide this protection, but concern has been voiced over the ability of these coatings to protect when defects are present in the coating due to surface anomalies. When a defected coating protecting a polymer substrate is exposed to atomic oxygen, the defect provides a pathway to the underlying polymer allowing oxidation and subsequent undercutting to occur. Defect undercutting was studied for sputter deposited coatings of SiO_2 on polyimide Kapton. Preliminary results indicate that undercutting may be limited as long as the coating remains intact with the substrate. Therefore, coatings may not need to be defect free to give protection to the underlying surface. Author

A91-41517

EVALUATION OF PLASMA-DEPOSITED PROTECTIVE COATINGS FOR MULTIPURPOSE SPACE APPLICATIONS

D. G. ZIMCIK (Canadian Space Agency, Ottawa, Canada), M. R. WERTHEIMER (Ecole Polytechnique, Montreal, Canada), K. G. BALMAIN, and R. C. TENNYSON (Toronto, University, Canada) IN: Metallurgical coatings 1989; Proceedings of the 16th International Conference, San Diego, CA, Apr. 17-21, 1989. Vol. 1. London and New York, Elsevier Applied Science, 1989, p. 617-626. Research supported by NSERC, Institute for Space and Terrestrial Science, and Ministere de l'Education du Quebec. refs

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This paper reports evaluations of protective thin films applied to important polymers used on spacecraft, Kapton polyimide and graphite-epoxy, that are attacked by atomic oxygen. These films, derived from volatile compounds through microwave glow discharge deposition, include amorphous silicon (a-Si:H) and inorganic silicon compounds (P-SiN and P-SiO2). These materials are shown to provide excellent protection against atomic oxygen attack, as evidenced by the reduction in mass loss compared to unprotected specimens of the same materials after exposure to an atomic oxygen beam source. Scanning electron microscope photomicrographs are presented to confirm the lack of apparent attack of the surface. Results from high-energy (20 keV) electron beam bombardment show that these coatings reduce charge build-up which might otherwise result in electrostatic discharge phenomena. Author

A91-41518* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.

ATOMIC OXYGEN RESISTANT PROTECTIVE COATINGS FOR THE HUBBLE SPACE TELESCOPE SOLAR ARRAY IN LOW EARTH ORBIT

H. D. BURNS, A. F. WHITAKER, and R. C. LINTON (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Metallurgical coatings 1989; Proceedings of the 16th International Conference, San Diego, CA, Apr. 17-21, 1989. Vol. 1. London and New York, Elsevier Applied Science, 1989, p. 627-636.

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The Hubble Space Telescope back-up solar array (BSFR-ATOX) was designed with atomic oxygen resistant materials to replace the original high efficiency cell (HEC) array. Pending qualification of the BSFR-ATOX array, protective coatings for application to the existing HEC array were evaluated. Three polysiloxane-type coating materials, SWS V-10, DC-100, and CV-1144 were evaluated with respect to atomic oxygen resistance, outgassing, contamination potential, stability under UV irradiation, electron-proton irradiation, thermal cycling, and long-term storage after application. Atomic oxygen testing included characterization of the atomic oxygen plasma using comparison of Kapton reaction to existing flight data, residual gas analysis, and temperature measurements. Results from these tests show DC-100 as a greater contamination concern if used in the vicinity of sensitive optical surfaces, i.e., solar cell cover glasses. The SWS V-10 and CV-1144 coatings met all acceptance criteria. Author

A91-42640#

ESTIMATES OF PHOTOCHEMICALLY DEPOSITED CONTAMINATION ON THE GPS SATELLITES

ALAN C. TRIBBLE and JAMES W. HAFFNER (Rockwell International Corp., Seal Beach, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Mar.-Apr. 1991, p. 222-228. refs

(Contract F04701-81-C-0031)

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After about three years on orbit (altitude about 20,000 km), it became apparent that the solar array output from the first block of Navstar GPS satellites was degrading faster than could be accounted for on the basis of radiation damage alone. There are at least two possible explanations. Either the Van Allen radiation environment was causing unexpected damage, or contamination, such as would result from outgassing by the spacecraft itself, was partially obscuring the solar panels. An extensive analysis is presented of the outgassing properties of the materials used on the GPS Block I vehicles, their masses, temperatures, locations, and possible outgassing paths. It is shown that if a small fraction of the matter impinging upon the solar panels is subject to a photochemical reaction initiated by the solar UV and sticks, a sufficient amount of matter will remain on the panels to account for the unexplained degradation. The calculation is repeated for the GPS Block II vehicles now being launched, and estimates for the expected lifetimes of these vehicles are presented. Author

A91-43276

THE EFFECTS OF THE SPACE ENVIRONMENT ON SPACECRAFT SURFACES

CHARLES E. VEST (Johns Hopkins University, Laurel, MD) Johns Hopkins APL Technical Digest (ISSN 0270-5214), vol. 12, Jan.-Mar. 1991, p. 46-54. refs

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Space environmental data for selecting construction materials appropriate for spacecraft are summarized with emphasis on the effects of atomic oxygen and thermal vacuum on those materials. The effects of atomic oxygen are found to be most destructive in the low earth orbit and to become less in the orbit higher than 500 to 600 km. At the higher altitudes, the orientation of the materials in relation to the ram direction is considered to be important and must be taken into account. Thermal vacuum effects are present at all altitudes, especially when the critical surface is operated at low temperatures. For operation at temperatures lower than -30 C, it is recommended that the degree to which the construction materials will be subjected to self-contamination of the instrument be predicted. O.G.

A91-43457#

MEASUREMENT OF THE THERMAL CONDUCTIVITIES OF SOME TYPES OF BERYLLIUM AND CARBON

HOWARD J. DEACON, JR. and FRITZ MAURITZ (Aerospace Corp., El Segundo, CA) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 5 p.

(AIAA PAPER 91-1394) Copyright

Well ordered crystals of pure materials have very high thermal conductivities at cryogenic temperatures. This characteristic can be very useful in design of spacecraft infrared sensors and radiators. The thermal conductivities of four types of commercially available beryllium and three types of carbon were measured between 100 and 300 K to evaluate their utility in spacecraft design. The experiments showed that the thermal conductivities of beryllium alloys were about half the expected values and appear dependent on the oxide content of the specimens. Bulk pyrolytic graphite and carbon-carbon composites had lower thermal conductivities than single crystal pyrolytic graphite and these conductivities decreased as temperatures decreased below 300 K. The thermal conductivity of highly oriented pyrolytic graphite was nearly equal to the expected single crystal value and could be extremely useful in spacecraft if it can be manufactured in sizes of about 100 square inches. Author

A91-44080#

ADVANCED COMPOSITE FIBER/METAL PRESSURE VESSELS FOR SPACE SYSTEMS APPLICATIONS

CRAIG BRAUN, ALECK PAPANICOLOPOULOS, and IAN DEVEY (Structural Composites Industries, Plant City Steel Div., Pomona, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p. refs

(AIAA PAPER 91-1976) Copyright

Advanced composite fiber wrapped metal-lined pressure vessels are being developed and being used in many Space system applications because of high pressure performance, light weight, high reliability, safe leak-before-burst failure mode, and competitive costs. Carbon wrapped pressure vessels are now used in many Space programs because of their very light weight, long life characteristics, high producibility, availability of reliable high performance fiber, and growing proven track record. Commercial seamless aluminum liner technology has been further developed to produce very thin walled liners which meet military and aerospace production program requirements. Design considerations, performance requirements and test results for recently developed state of the art carbon wrapped pressure vessels are presented. Extensive testing performed on these vessels is discussed including tests designed to prove compliance with the requirements of the MIL-STD-1522A leak-before-burst failure mode. Author

A91-44492*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

ATOMIC OXYGEN TESTING WITH THERMAL ATOM SYSTEMS - A CRITICAL EVALUATION

STEVEN L. KOONTZ, KEITH ALBYN, and LUBERT J. LEGER (NASA, Johnson Space Center, Houston, TX) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, May-June 1991, p. 315-323. refs

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The use of thermal atom (kinetic energy near 0.04 eV) test methods as a materials selection and screening technique for LEO spacecraft is critically evaluated in this paper. The physics and chemistry of the thermal atom environments are shown to produce specific mass loss rates (mg/sq cm per min) and reaction efficiencies (Re) radically different from those produced in the LEO environment. A response surface study shows that specific mass loss rates change rapidly with plasma-asher parameters and seldom agree with flight data. FEP Teflon is shown to react by a different mechanism than Kapton, polyethylene, or graphite. The Re (Re = volume of material removed/oxygen atom) of Kapton, polyethylene, Mylar, Tedlar, FEP Teflon, and graphite measured in a flowing afterglow apparatus are 0.001 to 0.0001 those measured with high-energy atoms (kinetic energy 1.5 eV or greater) in beam systems or in LEO. The effect of sample temperature and atom impact energy on Re is discussed. A simple kinetic model describing the reaction of atomic oxygen with polymer surfaces is developed. Guidelines and recommendations for thermal atom testing and interpretation of test results are presented. Author

A91-45430

MATERIALS FOR SPACE APPLICATION

J. DAUPHIN, B. D. DUNN, M. D. JUDD, and F. LEVADOU (ESTEC, Noordwijk, Netherlands) Metals and Materials (ISSN 0266-7185), vol. 7, July 1991, p. 422-430. refs

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The existing commercial materials used for space hardware are reviewed. Topics discussed include the main functions of different categories of materials, the general effects of space environment on materials, and design aspects. A great variety of materials commonly used in space applications encompasses metallic materials (aluminum-lithium alloys, beryllium, indium-lead alloys, metal matrix composites, Nitinol shape-memory metal, platinum group metals, titanium alloys IMI 829 and IMI 834, and titanium aluminides), nonmetallic materials (ceramic matrix composite materials), high cleanliness materials, and human friendly materials. O.G.

A91-45431

SATELLITE MATERIALS - MEETING THE CHALLENGE OF THE SPACE ENVIRONMENT

MARK WILLIAMSON Metals and Materials (ISSN 0266-7185), vol. 7, July 1991, p. 434-438. refs

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The article treats the problem of an informed choice of materials to meet the many design requirements for satellites, combining high structural strength and low weight with an ability to survive the harsh environmental extremes of space. Material selection for space applications is reviewed focusing on aluminum alloys, titanium, beryllium, the Nitinol shape memory metal, carbon fiber reinforced plastic, Fiberite and Kevlar composites, and carbon-carbon composites. O.G.

A91-48675

LDEF MISSION UPDATE. III - COMPOSITES SURVIVE SPACE EXPOSURE

GARY L. STECKEL and TUYEN D. LE (Aerospace Corp., Mechanics and Materials Technology Center, El Segundo, CA) Advanced Materials and Processes (ISSN 0882-7958), vol. 140, Aug. 1991, p. 35-38.

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Numerous specimens of both polymer and metal matrix composite materials are noted to remain in excellent condition after almost six years of LEO space environment exposure aboard NASA's Long Duration Exposure Facility. The samples range over graphite fiber-reinforced Mg and Al alloys, and graphite fiber-reinforced epoxy, polysulfone, and polyimide resins, with and without. The properties of major interest in this study were the coefficients of thermal expansion, solar emittance and absorptance, specific heat, and thermal conductivity. Attention was given to the effects of micrometeoroid impact craters and atomic oxygen. O.C.

A91-49142

TAILORING OF THE COEFFICIENT OF THERMAL EXPANSION OF TUBE STRUCTURES THROUGH CHEMICAL ETCHING OF ALUMINUM CLAD GRAPHITE/EPOXY TUBES

CHRISTOPHER BLAIR and JERRY ZAKRZEWSKI (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: International SAMPE Technical Conference, 22nd, Boston, MA, Nov. 6-8, 1990, Proceedings. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 932-942. refs

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A91-49143

POTENTIAL FOR ADVANCED THERMOPLASTIC COMPOSITES IN SPACE SYSTEMS

R. E. GARVEY (Oak Ridge National Laboratory, TN) IN: International SAMPE Technical Conference, 22nd, Boston, MA, Nov. 6-8, 1990, Proceedings. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 943-956. Previously announced in STAR as N91-11069. refs

(Contract DE-AC05-84OR-21400)

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This paper provides a rational for incorporating graphite/thermoplastic into future Strategic Defense Initiative space systems. Graphite/PEEK is compared with the best available graphite/epoxy materials, which today are graphite/1962 produced by Amoco and graphite/934 produced by Fiberite. A first-order comparison reveals similar performance between these classes of materials with respect to maximum stiffness, minimum gage, maximum damping and threat hardness. There are significant differences in the behavior of graphite/polyether ether ketone and graphite/epoxy with respect to the following characteristics: water absorption, condensible-volatile contents, space-environment effects, dimensional stability, weight-saving options, joining alternatives, and production costs. A comparison is also made between organic composites, such as graphite/PEEK, with other spacecraft structural materials, such as aluminum and beryllium (which are commonly used today). The differing requirements for each spacecraft component will determine which of these material options is best suited for the particular structural application. Author

A91-49154

IMPACT DAMAGE EVALUATION OF GRAPHITE/EPOXY COMPOSITE MATERIALS FOR SPACE APPLICATIONS

ASHOK K. MUNJAL (Aerospace Corp., Los Angeles, CA), ERIC W. RAHNENFUEHRER, DONALD F. SPENCER, BARRY E. PICKETT, and PAUL F. MALONEY (Kaman Aerospace Corp., Bloomfield, CT) IN: International SAMPE Technical Conference, 22nd, Boston, MA, Nov. 6-8, 1990, Proceedings. Covina, CA, Society for the Advancement of Material and Process Engineering, 1990, p. 1200-1207. refs

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Results are presented on evaluations of impact damage tolerance of various graphite/epoxy composite materials for space applications. The materials evaluated include different graphite fiber forms (braided preform, fabric, and tape) and resin forms (wet coating, prepreg, film adhesive interleaf, and resin transfer molding). Special attention is given to the effects of stacking sequence, fiber volume, resin content, and specimen thickness. I.S.

A91-49801* Universal Energy Systems, Inc., Dayton, OH.
MATERIALS DEGRADATION IN LOW EARTH ORBIT (LEO); PROCEEDINGS OF THE SYMPOSIUM, 119TH ANNUAL MEETING OF THE MINERALS, METALS, AND MATERIALS SOCIETY, ANAHEIM, CA, FEB. 17-22, 1990
V. SRINIVASAN, ED. (Universal Energy Systems, Inc., Dayton, OH) and BRUCE A. BANKS, ED. (NASA, Lewis Research Center, Cleveland, OH) Symposium sponsored by Minerals, Metals, and Materials Society and ASM International. Warrendale, PA, Minerals, Metals, and Materials Society, 1990, 229 p. For individual items see A91-49802 to A91-49816.
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The current understanding of the effect of space environment on materials and the development of protective coatings is examined in reviews and reports. Consideration is given to hyperthermal atomic oxygen reactions, the effect of atomic oxygen on altered and coated Kapton surfaces for spacecraft applications in LEO, silicon dioxide space coatings studied ellipsometrically, atomic oxygen effects on spacecraft materials, atomic oxygen beam source for erosion simulation, and atomic oxygen effects on refractory materials. Particular attention is given to ellipsometric analysis of materials degradation in space, studies of the interaction of 8 km/s oxygen atoms with selected materials, characterization and calibration of the EOIM-III flight mass spectrometer in a high velocity oxygen atom beam, the reaction efficiency of thermal energy oxygen atoms with polymeric materials, and effects of simulated space environments on the properties of selected materials. O.G.

A91-49802* Los Alamos National Lab., NM.
HYPERTHERMAL ATOMIC OXYGEN REACTIONS WITH KAPTON AND POLYETHYLENE
J. B. CROSS (Los Alamos National Laboratory, NM), S. L. KOONTZ (NASA, Johnson Space Center, Houston, TX), J. C. GREGORY, and M. J. EDGELL (Alabama, University, Huntsville) IN: Materials degradation in low earth orbit (LEO); Proceedings of the Symposium, 119th Annual Meeting of the Minerals, Metals, and Materials Society, Anaheim, CA, Feb. 17-22, 1990. Warrendale, PA, Minerals, Metals, and Materials Society, 1990, p. 1-14. refs
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Gas phase reaction products produced by the interaction of high kinetic energy (1-3 eV) 3p ground state atomic oxygen (AO) with polyethylene and kapton were found to be H2, H2O, CO, and CO2 with NO being a possible secondary product from kapton. Hydrogen abstraction at high AO kinetic energy is postulated to be the key reaction controlling the erosion rate of kapton and polyethylene. An Arrhenius-like expression having an activation barrier of 0.4 eV can be fit to the data, which suggests that the rate limiting step in the AO/kapton reaction mechanism can be overcome by translational energy. Author

A91-49803* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ATOMIC OXYGEN UNDERCUTTING OF DEFECTS ON SIO2 PROTECTED POLYIMIDE SOLAR ARRAY BLANKETS
BRUCE A. BANKS, SHARON K. RUTLEDGE, BRUCE M. AUER (NASA, Lewis Research Center, Cleveland, OH), and FRANK DIFILIPPO (Case Western Reserve University, Cleveland, OH) IN: Materials degradation in low earth orbit (LEO); Proceedings of the Symposium, 119th Annual Meeting of the Minerals, Metals, and Materials Society, Anaheim, CA, Feb. 17-22, 1990. Warrendale, PA, Minerals, Metals, and Materials Society, 1990, p. 15-33. refs
Copyright

Low Earth Orbital (LEO) atomic oxygen can oxidize SiO2-protected polyimide kapton solar array blanket material which is not totally protected as a result of pinholes or scratches in the SiO2 coatings. The probability of atomic oxygen reaction upon initial impact is low, thus inviting oxidation by secondary impacts. The secondary impacts can produce atomic oxygen undercutting which may lead to coating mechanical failure and ever increasing mass loss rates of kapton. Comparison of undercutting effects in isotropic plasma asher and directed beam tests are reported. These experimental results are compared with computational undercutting profiles based on Monte Carlo methods and their implication on LEO performance of protected polymers. Author

A91-49806
ATOMIC OXYGEN EFFECTS ON SPACECRAFT MATERIALS
R. C. TENNYSON and W. D. MORISON (Toronto, University, Downsview, Canada) IN: Materials degradation in low earth orbit (LEO); Proceedings of the Symposium, 119th Annual Meeting of the Minerals, Metals, and Materials Society, Anaheim, CA, Feb. 17-22, 1990. Warrendale, PA, Minerals, Metals, and Materials Society, 1990, p. 59-75. Research sponsored by Ontario Centre for Materials Research and SDIO. refs
(Contract N60921-86-C-A226)
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A variety of thin film materials have been studied to determine their mass loss rates, reaction efficiencies, and dielectric property changes. Particular attention is given to an atomic oxigen beam facility based on SURFATRON, a microwave powered device capable of producing an atomic oxygen beam energy of 3 eV, with flux levels as high as 10 to the 17th atoms/sq cm sec. This facility produces materials recession rates and surface morphology changes consistent with the limited space flight data available. Accelerated testing provides predictable mass loss values based on these recession rates. Synergistic effects of combined UV radiation and atomic oxygen on dielectric material erosion rates are found to substantially enhance the erosion of Teflon FEP, and the dielectric properties of Kapton and Mylar are observed to change. O.G.

A91-49808* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EXPERIMENTAL INVESTIGATIONS OF LOW-ENERGY (4-40 EV) COLLISIONS OF O-(2P) IONS AND O(3P) ATOMS WITH SURFACES
O. J. ORIENT, A. CHUTJIAN (JPL, Pasadena, CA), and E. MURAD (USAF, Geophysics Laboratory, Hanscom AFB, MA) IN: Materials degradation in low earth orbit (LEO); Proceedings of the Symposium, 119th Annual Meeting of the Minerals, Metals, and Materials Society, Anaheim, CA, Feb. 17-22, 1990. Warrendale, PA, Minerals, Metals, and Materials Society, 1990, p. 87-95. Research supported by USAF and DARPA. Previously announced in STAR as N90-25530. refs
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Using a newly-developed, magnetically confined source, low-energy, ground state oxygen negative ions and neutral atoms are generated. The energy range is variable, and atom and neutrals have been generated at energies varying from 2 eV to 40 eV and higher. It was found that the interaction of these low-energy species with a solid magnesium fluoride target leads to optical emissions in the (at least) visible and infrared regions of the spectrum. Researchers describe y details of the photodetachment source, and present spectra of the neutral and ion glows in the wavelength range 250 to 850 nm (for O/-/) and 600 to 850 nm (for O), and discuss the variability of the emissions for incident energies between 4 and 40 eV. Author

A91-49809* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ATOMIC OXYGEN EFFECTS ON REFRACTORY MATERIALS
DALE C. FERGUSON (NASA, Lewis Research Center, Cleveland, OH) IN: Materials degradation in low earth orbit (LEO); Proceedings of the Symposium, 119th Annual Meeting of the Minerals, Metals, and Materials Society, Anaheim, CA, Feb. 17-22, 1990. Warrendale, PA, Minerals, Metals, and Materials Society, 1990, p. 97-105. refs
Copyright

Atomic oxygen in LEO may have undesirable effects on exposed refractory materials, such as are proposed for nuclear reactors in orbit, high temperature radiators, solar dynamic collectors, etc. Time-resolved measurement of the volatile efflux from such materials at high temperatures is being done in an ultrahigh vacuum atomic oxygen ion beam facility. Results of measurements of the efflux of volatile oxides of molybdenum and niobium-1 percent zirconium at temperatures as high as 1550 K are presented, along with a discussion of the roles of adsorption, desorption, and diffusion in atomic oxygen reactions on surfaces at high temperatures. The dependence of reaction rates for certain materials on the energy of the incident atomic oxygen beam will be emphasized. Author

A91-49810* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE EFFECT OF THE NEAR EARTH MICROMETEOROID ENVIRONMENT ON A MIRROR SURFACE AFTER 20 YEARS IN SPACE
MICHAEL J. MIRTICH (NASA, Lewis Research Center, Cleveland, OH) and WILLIAM R. KERSLAKE (Sverdrup Technology, Inc., Brook Park, OH) IN: Materials degradation in low earth orbit (LEO); Proceedings of the Symposium, 119th Annual Meeting of the Minerals, Metals, and Materials Society, Anaheim, CA, Feb. 17-22, 1990. Warrendale, PA, Minerals, Metals, and Materials Society, 1990, p. 107-122. refs
Copyright
The effect of micrometeoroid impact on the optical properties of polished metals and thin film coatings has been simulated by accelerating micron-sized particles to hypervelocities in a shock tube. The degradation of these properties after exposure to simulated meteoroids was determined as a function of impacting kinetic energy/area of the particles. A calibrated sensor, 2000-A Al/stainless steel, was developed to detect the micrometeoroid environment and to evaluate the degradation of the optical properties of thin aluminum films in space. No changes in the optical properties of the highly reflective surface sensor on SERT II, launched in 1970, were measured during 19 years in space. These results are found to be in agreement with the 1969 Micrometeoroid Flux Model. It is concluded that a highly reflective surface should lose less than 1 percent of its specular reflectance in near-earth orbit during 19 years. O.G.

A91-49811* Nebraska Univ., Lincoln.
ELLIPSOMETRIC ANALYSIS OF MATERIALS DEGRADATION IN SPACE
JOHN A. WOOLLAM, PAUL G. SNYDER, and BHOLA N. DE (Nebraska, University, Lincoln) IN: Materials degradation in low earth orbit (LEO); Proceedings of the Symposium, 119th Annual Meeting of the Minerals, Metals, and Materials Society, Anaheim, CA, Feb. 17-22, 1990. Warrendale, PA, Minerals, Metals, and Materials Society, 1990, p. 123-131. refs
(Contract NAG3-95)
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The fundamentals of variable angle spectroscopic ellipsometry (VASE) are reviewed, and its usefulness in studying the effect of atomic oxygen on space coatings such as indium tin oxide (ITO), silicon dioxide, and aluminum oxide is discussed. Monolayer sensitive and nondestructive VASE is found to be an effective technique for monitoring the atomic oxygen diffusion through the aluminum oxide and silicon dioxide protective overcoatings on space reflectors. Ashing of ITO/silicon samples had the net effect of annealing the film inside the plasma. The annealing effect was supported both by structural changes as verified by X-ray diffraction measurements and by increased absorbance in the spectral range below 3 eV as measured by VASE. O.G.

A91-49812* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
VACUUM ULTRAVIOLET RADIATION AND THERMAL CYCLING EFFECTS ON ATOMIC OXYGEN PROTECTIVE PHOTOVOLTAIC ARRAY BLANKET MATERIALS
J. BRADY and B. BANKS (NASA, Lewis Research Center, Cleveland, OH) IN: Materials degradation in low earth orbit (LEO); Proceedings of the Symposium, 119th Annual Meeting of the Minerals, Metals, and Materials Society, Anaheim, CA, Feb. 17-22, 1990. Warrendale, PA, Minerals, Metals, and Materials Society, 1990, p. 133-143. refs
Copyright
The importance of synergistic environmental exposure is demonstrated through the evaluation of DuPont 93-1 in simulated LEO environment. Changes in optical properties, surface condition, and mass loss data are described. The qualitative results indicate the necessity for exposure of materials to a series of simulated LEO environments in order to properly determine synergistic effects and demonstrate the overall LEO durability of candidate materials. It is shown that synergistic effects may occur with vacuum thermal cycling combined with VUV radiation followed by atomic oxygen exposure. Testing the durability of candidate solar array blanket materials in a test sequence with necessary synergistic effects makes it possible to determine the appropriate material for providing structural support and maintaining the proper operating temperature for solar cells in the SSF Photovaltaic Power System. O.G.

A91-49814
REACTION EFFICIENCY OF 5 EV OXYGEN IONS ON CARBON
GARY W. SJOLANDER (Martin Marietta Corp., Denver, CO) IN: Materials degradation in low earth orbit (LEO); Proceedings of the Symposium, 119th Annual Meeting of the Minerals, Metals, and Materials Society, Anaheim, CA, Feb. 17-22, 1990. Warrendale, PA, Minerals, Metals, and Materials Society, 1990, p. 175-188. refs
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Laboratory results of 5 eV oxygen ion reaction chemistry on carbon and carbon composites are presented. Emphasis is placed on erosion effects that specifically address the atomic oxygen/carbon system. Results of the comparison of oxygen ion beam apparatus with oxygen plasma asher device chemistry reveal that the former has some advantages for atomic oxygen testing. They include the provision of clean controllable energy and uncomplicated test environment and, a 100-times greater intensity than can be currently provided by neutralizing the beam. Data provided by the ion beam at 5 Ev are found to be consistent with on-orbit results with similar material. O.G.

A91-49815* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
THE REACTION EFFICIENCY OF THERMAL ENERGY OXYGEN ATOMS WITH POLYMERIC MATERIALS
S. L. KOONTZ (NASA, Johnson Space Center, Houston, TX) and PAUL NORDINE IN: Materials degradation in low earth orbit (LEO); Proceedings of the Symposium, 119th Annual Meeting of the Minerals, Metals, and Materials Society, Anaheim, CA, Feb. 17-22, 1990. Warrendale, PA, Minerals, Metals, and Materials Society, 1990, p. 189-205. refs
Copyright
The reaction efficiency of several polymeric materials with thermal-energy (0.04 eV translational energy), ground-state (O3P) oxygen atoms was determined by exposing the materials to a room temperature gas containing a known concentration of atomic oxygen. The reaction efficiency measurements were conducted in two flowing afterglow systems of different configuration. Atomic oxygen concentration measurements, flow, transport and surface dose analysis is presented in this paper. The measured reaction efficiencies of Kapton, Mylar, polyethylene, D4-polyethylene and Tedlar are .001 to .0001 those determined with high-energy ground-state oxygen atoms in low earth orbit or in a high-velocity atom beam. D4-polyethylene exhibits a large kinetic isotope effect with atomic oxygen at thermal but not hyperthermal atom energies. Author

A91-49816
EFFECTS OF SIMULATED SPACE ENVIRONMENTS ON PROPERTIES OF SELECTED MATERIALS
H. W. DURSCH and H. G. PIPPIN (Boeing Defense and Space Group, Seattle, WA) IN: Materials degradation in low earth orbit

(LEO); Proceedings of the Symposium, 119th Annual Meeting of the Minerals, Metals, and Materials Society, Anaheim, CA, Feb. 17-22, 1990. Warrendale, PA, Minerals, Metals, and Materials Society, 1990, p. 207-218. refs
Copyright

Results of recent experiments on the effects of atomic oxygen (AO) and ultraviolet (UV) radiation on materials are presented. An UV source added to an existing chamber used for exposing materials to AO is described. Data obtained indicate that simultaneous exposure to AO and UV radiation increases the mass loss rate of Kapton and an epoxy/S-glass relative to exposure to just AO. Wear and friction measurements were performed on thin-film solid lubricants before and after exposure to AO. The mass loss of the thin-film lubricant coatings under exposure to AO was expected. The coated surfaces are found to increase the coefficients of friction after exposure. O.G.

A91-49975* California Univ., Berkeley.
EFFECTS OF VARYING SUBATMOSPHERIC PRESSURE ON STATIONARY PLASMA ARC WELDS
J. J. CHIN and B. RUBINSKY (California, University, Berkeley) Welding Journal, Research Supplement (ISSN 0043-2296), vol. 70, Sept. 1991, p. 235-S to 243-S. refs
(Contract NAS1-18686)
Copyright

An experimental study was performed examining the variation of penetration, fluid behavior, heat-affected zone and arc in plasma arc welding (PAW) with respect to subatmospheric ambient pressure. The results reveal nonlinear variation of keyhole size, time of penetration, and size of the heat-affected zone with pressure. In a restricted range of pressure, dynamic components of fluid flow directed out of the molten pool appear and have a profound effect on keyhole formation. The generated plasma arc is observed to decrease in intensity with decreasing pressure, resulting in a reduction of penetration at lower pressures. Author

A91-51167
FIBRE OPTICS '90; PROCEEDINGS OF THE MEETING, LONDON, ENGLAND, APR. 24-26, 1990
P. MCGEEHIN, ED. (Compton Consultants; Optical Sensors Collaborative Association, England) Meeting sponsored by Institute of Measurement and Control, Institute of Physics, SPIE, et al. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Vol. 1314), 1990, 373 p. For individual items see A91-51168 to A91-51177.
(SPIE-1314) Copyright

The present conference on fiber optics emphasizes the use of components, devices, and materials for hostile environments, and also encompasses applications of optoelectronics in sensors, communications, 'white light' interferometry, the properties of monomode optical fibers, and coherent optical systems. Specific issues addressed include erbium-doped fiber amplifiers in communications, the use of optical amplification in communication, optical fibers in the adverse space environment, the effects of temperature variations on loose-tube and tight-buffered optical fiber cables, and radiation effects in polarization-maintaining fibers. Also addressed are methods to test the effects of high-ionizing-radiation dose rates on optical fiber data links, sensors for meteorological data acquisition, sensor technology for smart structure development, radiative ignition by loose agglomerates of fine fibers, and a multipurpose evanescent mode-coupling-based device. C.C.S.

A91-51168* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTICAL FIBERS IN THE ADVERSE SPACE ENVIRONMENT - THE SPACE STATION
ROGER A. GREENWELL (Science and Engineering Associates, Inc., San Diego, CA), CHARLES E. BARNES (JPL, Pasadena, CA), DAVID M. SCOTT (Aerospace Corp., El Segundo, CA), and DIPAK R. BISWAS (Spectran Corp., Sturbridge, MA) IN: Fibre optics '90; Proceedings of the Meeting, London, England, Apr. 24-26, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 100-104. refs
Copyright

On the NASA Space Station, the requirement for high speed data transfer between the exterior experimental bays and the interior research facilities has generated the need for fiberoptics. The adverse vacuum effects in space, temperature extremes, and natural space radiation place extreme conditions on optical fiber interconnects. This report addresses the adverse space environmental effects of temperature and radiation on optical fibers. Author

A91-51556
EXPERIMENTAL AND NUMERICAL SIMULATION OF ATOMIC OXYGEN ATTACK ON SPACE VEHICLE SURFACE
MASAHIRO ISHII (Ishikawajima-Harima Heavy Industries Co., Ltd., Yokohama, Japan), TAKASHI ABE, and KYOICHI KURIKI (Institute of Space and Astronautical Sciences, Sagamihara, Japan) IN: Workshop on Space Fluid Dynamics and Related Problems, Kurashiki, Japan, Nov. 22, 23, 1989, Proceedings. Fukuoka, Japan, Kyushu University, 1990, p. 37-41. refs

An atomic oxygen flow accelerated test facility has been developed to ascertain spacecraft materials degradation in LEO, and numerical simulations have been conducted for oxygen-surfaces interactions in order to determine collision effects on the basis of the direct-simulation Monte Carlo method. Tests have been conducted on the experimental facility at a Knudsen number of about 0.1; calculation results indicate an atomic oxygen flux of 10 to the 17th atoms/sq cm-sec. Attention is given to the erosion rate in these conditions of the polyimide, Kapton. O.C.

A91-52347*# Case Western Reserve Univ., Cleveland, OH.
SURVIVING THE SPACE ENVIRONMENT - AN OVERVIEW OF ADVANCED MATERIALS AND STRUCTURES DEVELOPMENT AT THE CWRU CCDS
JOHN F. WALLACE (Case Western Reserve University, Cleveland, OH), EDWARD M. ZDANKIEWICZ, and ROBERT N. SCHMIDT (Orbital Research, Inc., Cleveland, OH) AIAA, NASA, and OAI, Conference on Advanced SEI Technologies, Cleveland, OH, Sept. 4-6, 1991. 11 p. refs
(Contract NAGW-1193)
(AIAA PAPER 91-3430) Copyright

The development of advanced materials and structures for long-term use in space is described with specific reference given to applications to the Space Station Freedom and the lunar base. A flight-testing program is described which incorporates experiments regarding the passive effects of space travel such as material degradation with active materials experiments such as the Materials Exposure Flight Experiment. Also described is a research and development program for materials such as organic coatings and polymeric composites, and a simulation laboratory is described which permits the analysis of materials in the laboratory. The methods of investigation indicate that the NASA Center for the Commercial Development of Space facilitates the understanding of material degradation in space. C.C.S.

A91-52348*# Virginia Univ., Charlottesville.
MATERIALS AND LIGHT THERMAL STRUCTURES RESEARCH FOR ADVANCED SPACE EXPLORATION
EARL A. THORNTON, EDGAR A. STARKE, JR., and CARL T. HERAKOVICH (Virginia, University, Charlottesville) AIAA, NASA, and OAI, Conference on Advanced SEI Technologies, Cleveland, OH, Sept. 4-6, 1991. 17 p. Research supported by University of Virginia. refs
(Contract N00014-91-J-1285; NAG1-8414; NAG1-745; NAG1-1013; NAG1-745)
(AIAA PAPER 91-3431) Copyright

The Light Thermal Structures Center at the University of Virginia sponsors educational and research programs focused on the development of reliable, lightweight structures to function in hostile thermal environments. Technology advances in materials and design methodology for light thermal structures will contribute to improved space vehicle design concepts with attendant weight savings. This paper highlights current research activities in three areas relevant to space exploration: low density, high temperature aluminum alloys, composite materials, and structures with thermal gradients. Advances in the development of new aluminum-lithium alloys and mechanically alloyed aluminum alloys are described. Material properties and design features of advanced composites are highlighted. Research studies in thermal structures with temperature gradients include inelastic panel buckling and thermally induced unstable oscillations. Current and future research is focused on the integration of new materials with applications to structural components with thermal gradients. Author

A91-52349*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

ELECTRICALLY CONDUCTING POLYMERS FOR AEROSPACE APPLICATIONS

MARY ANN B. MEADOR, JAMES R. GAIER, BRIAN S. GOOD, G. R. SHARP, and MICHAEL A. MEADOR (NASA, Lewis Research Center, Cleveland, OH) AIAA, NASA, and OAI, Conference on Advanced SEI Technologies, Cleveland, OH, Sept. 4-6, 1991. 12 p. refs

(AIAA PAPER 91-3432) Copyright

Current research on electrically conducting polymers from 1974 to the present is reviewed focusing on the development of materials for aeronautic and space applications. Problems discussed include extended pi-systems, pyrolytic polymers, charge-transfer systems, conductive matrix resins for composite materials, and prospects for the use of conducting polymers in space photovoltaics. O.G.

A91-53157

DEVELOPMENT OF LOW PIM, ZERO CTE MESH FOR DEPLOYABLE COMMUNICATIONS ANTENNAS

WILLIAM D. WADE (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: MILCOM '90 - IEEE Military Communications Conference, Monterey, CA, Sept. 30-Oct. 3, 1990, Conference Record. Vol. 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1175-1178.

Copyright

The requirements that led to the development of the radio-frequency reflective fabric (RF 2) for use on wrap-rib mesh-type reflectors are discussed. The advantages of this mesh include low passive intermodulation (PIM) and a near-zero coefficient of thermal expansion (CTE). The composite mesh is composed of Kevlar and beryllium copper and accommodates all mesh requirements. Measured data for the mesh are presented. I.E.

A91-54976

OPTICAL SYSTEM CONTAMINATION: EFFECTS, MEASUREMENT, CONTROL II; PROCEEDINGS OF THE MEETING, SAN DIEGO, CA, JULY 10-12, 1990

A. P. GLASSFORD, ED. (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Meeting sponsored by SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Vol. 1329), 1990, 392 p. For individual items see A91-54977 to A91-55007.

(SPIE-1329) Copyright

The present conference on the effects, measurement, and control of optical system contamination encompasses contamination effects on spaceborne optical instruments, noncontact techniques for cleaning optical surfaces, contamination measurement techniques, the characterization of contaminants, and contamination transport and interactions with space systems. Specific issues addressed include contamination requirements for the Cosmic Background Explorer, contamination removal by CO2 jet spray, ultraviolet laser cleaning of mirrored surfaces, laser-mirror cleaning in a simulated space environment, a nonoptical real-time particle-fallout monitor, and a 200-MHz surface acoustic wave-mass microbalance. Also addressed are the optical effects of photochemically deposited contaminant films, a spacecraft contamination database, a BGK method to determine thruster-plume backscatter, the surface accommodation of molecular contaminants, and the role of low-energy neutral N2 beam-surface interaction leading to spacecraft glow. C.C.S.

A91-54992

TOTAL INTEGRATED SCATTER INSTRUMENT FOR IN-SPACE MONITORING OF SURFACE DEGRADATION

JOSEPH L. PEZZANITI, JAMES B. HADAWAY, RUSSELL A. CHIPMAN (Alabama, University, Huntsville), DON WILKES, LEE HUMMER (John M. Cockerham and Associates, Huntsville, AL), and JEAN BENNETT (U.S. Navy, Naval Weapons Center, China Lake, CA) IN: Optical system contamination: Effects, measurement, control II; Proceedings of the Meeting, San Diego, CA, July 10-12, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 200-210. refs

Copyright

A Total Integrated Scatter (TIS) system was built to test the viability of a TIS instrument to be used in space to monitor damage to optical and thermal control surfaces due to the low earth environment. The systems accuracy and repeatability in detecting changes in the surface quality of various space materials after exposure to atomic oxygen was tested. A method for distinguishing roughening of a surface from dust contamination is described. Author

A91-54999* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

NEW SCREENING METHODOLOGY TO SELECT LOW OUTGASSING MATERIALS FOR COLD, SPACEBORNE OPTICAL INSTRUMENTS

T. O'DONNELL, D. TAYOR, and J. BARENGOLTZ (JPL, Pasadena, CA) IN: Optical system contamination: Effects, measurement, control II; Proceedings of the Meeting, San Diego, CA, July 10-12, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 280-298. refs

Copyright

Standardized techniques for outgassing tests are developed and set forth for use in the screening of materials for aerospace instruments with cooled sensors, optics, and/or detectors. Materials for optical instruments are discussed in terms of molecular outgassing, and material-outgassing test results are presented which relate to several test conditions. The existing outgassing standard is found to be inadequate, and revised outgassing standards related to four application levels are given. The test protocols are designed for the development of materials for optical instruments that operate in environments with temperatures below 20 C. Consideration is also given to potential molecular contamination in the space environment and to outgas screening of instruments with a variety of sensor/optics/detector temperatures. The standards are designed for use with existing outgassing-test data as well as contamination analyses relating to the instrument being tested. C.C.S.

A91-55000

AMBIENT PRESSURE OFFGASSING APPARATUS FOR SCREENING MATERIALS UTILIZED IN ENVIRONMENTS SUPPORTING OPTICAL SPACEBORNE SYSTEMS

R. D. HEU, J. M. STEAKLEY, and E. J. PETROSKY (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Optical system contamination: Effects, measurement, control II; Proceedings of the Meeting, San Diego, CA, July 10-12, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 299-304. refs

Copyright

The method and setup developed to test optical support materials for the HST are presented in terms of general applications to the ambient offgassing of contamination-sensitive instruments. An ex situ vacuum UV spectrophotometer is employed to analyze optical witness samples for optical degradation related to offgassing contaminants that are condensed onto the samples. A table of the ambient offgassing-test results lists the weight loss, wavelengths, and presence of visible films on 15 materials. The offgassing initial requirement of less than 12 ppm and/or the requirement after testing of less than 0.1 ppm are not fulfilled in the cases of seven materials. The testing procedure is found to be an efficient method for screening nonmetallic materials that support spaceborne optical systems. The offgassing data can support standard outgassing data to screen candidate materials effectively. C.C.S.

A91-55001

SPACECRAFT CONTAMINATION DATA BASE

MARK M. THORTON and CLEVELAND C. GILBERT (Boeing Aerospace and Electronics, Seattle, WA) IN: Optical system contamination: Effects, measurement, control II; Proceedings of the Meeting, San Diego, CA, July 10-12, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 305-316.

(Contract F04611-86-C-0030)

Copyright

This paper discusses a computerized data base derived from 3053 selected data sources on the subject of spacecraft contamination. The paper focuses on a discussion of the data base and how it was assembled, a broad characterization of the data available, an assessment of areas where data are lacking or deficient, and brief conclusions and recommendations. Since completion of the contracted effort many publications have been released which address some of the most severe deficiencies. The most important recommendation is that a follow-up data base effort is required. Author

A91-55005

INFRARED EMISSION FROM THE REACTION OF ORBITAL VELOCITY ATOMIC OXYGEN WITH HYDROCARBON MATERIALS

K. W. HOLTZCLAW, M. E. FRASER, and A. GELB (Physical Sciences, Inc., Andover, MA) IN: Optical system contamination: Effects, measurement, control II; Proceedings of the Meeting, San Diego, CA, July 10-12, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 352-361. Research supported by SDIO. refs

(Contract DNA001-87-C-0114)

Copyright

A fast atomic-oxygen source has been used to bombard samples of the hydrocarbon materials graphite and polyethylene. IR fluorescence is readily observed above both surfaces that is consistent with the expected primary combustion products CO, CO2, and OH. Emitter production efficiencies (defined as the ratio of emitters to incident O-atoms) for both materials have been estimated from the observed radiation intensities. These are approximately 0.01 for CO and 0.001 for CO2 for both samples and about 0.01 for OH for polyethylene. Author

A91-55125* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

MICROMECHANICS ANALYSIS OF SPACE SIMULATED THERMAL STRESSES IN COMPOSITES. I - THEORY AND UNIDIRECTIONAL LAMINATES. II - MULTIDIRECTIONAL LAMINATES AND FAILURE PREDICTIONS

DAVID E. BOWLES (NASA, Langley Research Center, Hampton, VA) and O. H. GRIFFIN, JR. (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Reinforced Plastics and Composites (ISSN 0731-6844), vol. 10, Sept. 1991, p. 504-539. refs

Copyright

A micromechanics analysis is used to study the effects of constituent properties on thermally induced stresses in continuous fiber reinforced composites. A finite element formulation is described, and results are presented for unidirectional carbon/epoxy laminates. It is shown that significant stresses develop in composites exposed to thermal excursions typical of spacecraft operating environments and that the fiber thermoelastic properties have a minimal effect on the magnitude of these stresses. The finite element micromechanics analysis is then extended to the study of multidirectional laminates using a simple global/local formulation. Damage initiation predictions are compared with experimental data, and factors controlling the initiation of damage are identified. Ways of improving the durability of composites are discussed. V.L.

A91-55390

A MODEL OF THE RADIATION-INDUCED ELECTRIC CHARGING OF DIELECTRICS DURING THE SIMULATION OF PROTON EFFECTS IN SPACE [MODEL' RADIATSIONNOI ELEKTRIZATSII DIELEKTRIKOV PRI IMITATSII VOZDEISTVIIA PROTONOV V KOSMICHESKOM PROSTRANSTVE]

A. I. AKISHIN, N. M. DUNAEV, and IU. I. TIUTRIN Fizika i Khimiia Obrabotki Materialov (ISSN 0015-3214), July-Aug. 1991, p. 64-67. In Russian. refs

Copyright

The profile of the electric field excited in a dielectric under conditions of proton injection is calculated in the stationary case. The results are presented in dimensionless form for various dielectric parameters and proton fluxes. The conditions leading to an electric breakdown are determined for given material and particle flux parameters. V.L.

A91-55613* Vanderbilt Univ., Nashville, TN.

EVOLUTION OF OPTICAL COATINGS IN EARTH ORBIT

MARCUS H. MENDELHALL, ROBERT A. WELLER (Vanderbilt University, Nashville, TN), and ANN F. WHITAKER (NASA, Marshall Space Flight Center, Huntsville, AL) Optics Letters (ISSN 0146-9592), vol. 16, Oct. 1, 1991, p. 1466-1468. refs

Copyright

High-resolution medium-energy backscattering analyses have been performed on SiO and SiO2 optical coatings that were exposed to the space environment aboard the NASA long-duration experiment module flight. The data show an increase in areal density of 1 percent (resolved at the 10 sigma level) in the SiO film as a result of this exposure. It appears that this effect has been produced by the incorporation of atomic oxygen from the ambient environment. Data on the SiO2 film are less compelling but are consistent with some loss of material from the surface. These analyses set a new standard for profiling film thicknesses by ion backscattering. Author

A91-56411

OPTICAL SURFACES RESISTANT TO SEVERE ENVIRONMENTS; PROCEEDINGS OF THE MEETING, SAN DIEGO, CA, JULY 11, 12, 1990

SOLOMON MUSIKANT, ED. (TransCon Technologies, Inc., Paoli, PA) Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Vol. 1330), 1990, 194 p. For individual items see A91-56412 to A91-56424.

(SPIE-1330) Copyright

Current research on materials that are being developed for their damage-resistant qualities and the sensitivity of optical surfaces to damage is reported. Particular attention is given to pulsed electron-beam testing of optical surfaces; chemical-vapor-deposited silicon and silicon carbide optical substrates for severe environments; soft X-ray, optical, and thermal properties of hard carbon films; modifications of optical properties with ceramic coatings; the effect of the space environment on thermal control coatings; Space Station atomic-oxygen-resistant coatings; environments stressful to optical materials in low earth orbit; optical characteristics of Teflon AF fluoro-plastic materials; advanced infrared optically black baffle materials; and vacuum outgassing from diffuse-absorptive baffle materials. O.G.

A91-56419* General Electric Co., Philadelphia, PA.

ENVIRONMENTS STRESSFUL TO OPTICAL MATERIALS IN LOW EARTH ORBIT

S. MUSIKANT (TransCon Technologies, Inc., Paoli, PA) and W. J. MALLOY (General Electric Co., Astro-Space Div., Philadelphia, PA) IN: Optical surfaces resistant to severe environments; Proceedings of the Meeting, San Diego, CA, July 11, 12, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 119-130. refs

(Contract NAS5-32000)
Copyright

Spacecraft in low earth orbit experience a variety of environments which are potentially damaging to materials and to optical systems including electronic controls and components. The low earth orbit (typically 400 km) has a significantly different set of environments than higher orbits. The environments vary not only with altitude but also with inclination. This paper deals with the environment that the Space Station Freedom will experience and with some of the effects on the materials and electronic components that will comprise the optical systems on the station. Specific optical systems are not addressed but the information presented is general and does apply to optical systems. Author

A91-56420* McDonnell-Douglas Corp., Saint Louis, MO.
RADIATION EFFECTS ON VARIOUS OPTICAL COMPONENTS FOR THE MARS OBSERVER SPACECRAFT
JAY H. LOWRY and C. D. IFFRIG (McDonnell Douglas Corp., Saint Louis, MO) IN: Optical surfaces resistant to severe environments; Proceedings of the Meeting, San Diego, CA, July 11, 12, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 132-141. Research supported by NASA. refs
Copyright

The performance of selected optical parts of the Mars Observer Laser Altimeter (MOLA) is considered. Test results indicate that Schott RG-830, RG-850 filter glass, and the Rolyn Optics Neutral Density filters are essentially immune to levels of radiation an order of magnitude larger than that expected for the MOLA spacecraft. The Corion LG-840 filters are shown to be relatively safe for this application, but exposures to levels higher than 15 kilo-rads(Si) have a severe effect on this material. The BK-7 prism appears to be acceptable for the relatively benign environment required for MOLA. It is concluded that the optical performance of the components tested is not degraded by exposure to the whole life dose expected for the Mars Observer. O.G.

N91-21220 Kent Univ., Canterbury (England).
THE MICROMETEOROID IMPACT HAZARD IN SPACE: TECHNIQUES FOR DAMAGE SIMULATION BY PULSED LASERS AND ENVIRONMENTAL MODELLING
DAVID C. HILL 1990 331 p
Avail: Univ. Microfilms Order No. BRDX90409

Pulsed lasers, generating high irradiances (approximately 10(exp 16) W/sq m), offer an alternative means of simulating hypervelocity microparticle impacts for a wide range of impactor mass/velocity combinations, allowing a large database of damage parameters to be built up over a relatively short time. Applications of the simulation technique are outlined for the study of the operation of electrically-active spacecraft subsystems (e.g., solar arrays) and optical subsystems when exposed to the near-earth orbital debris environment. Emphasis is placed on the extension of this technique, by varying laser radiation wavelength to maximize surface absorption, to different materials for space use. The impact damage hazard for various environments is generally assessed and the laser simulation technique applied within the context of the impact damage expected for various spacecraft materials.
Dissert. Abstr.

N91-21286*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ATOMIC OXYGEN DEGRADATION OF INTELSAT 4-TYPE SOLAR ARRAY INTERCONNECTS: LABORATORY INVESTIGATIONS
S. L. KOONTZ, J. B. CROSS, M. A. HOFFBAUER, and T. D. KIRKENDAHL (Communications Satellite Corp., Clarksburg, MD.) Mar. 1991 25 p
(Contract RTOP 506-43-00)
(NASA-TM-102175; S-625; NAS 1.15:102175) Avail: CASI HC A03/MF A01 CSCL 11F

A Hughes 506 type communication satellite belonging to the Intelsat organization was marooned in low Earth orbit on March 14, 1990, following failure of the Titan third stage to separate properly. The satellite, Intelsat VI, was designed for service in geosynchronous orbit and contains several material configurations which are susceptible to attack by atomic oxygen. Analysis showed the silver foil interconnects in the satellite photovoltaic array to be the key materials issue because the silver is exposed directly to the atomic oxygen ram flux. The results are reported of atomic oxygen degradation testing of Intelsat VI type silver foil interconnects both as virgin material and in a configured solar cell element. Test results indicate that more than 80 pct. of the original thickness of silver in the Intelsat VI solar array interconnects should remain after completion of the proposed Space Shuttle rescue and/or reboost mission. Author

N91-22169*# Rockwell International Corp., Downey, CA. Space Transportation Systems Div.
UNUSUAL SPACECRAFT MATERIALS
JONATHAN V. POST *In* NASA. Lewis Research Center, Vision-21: Space Travel for the Next Millennium p 391-403 Apr. 1990
Avail: CASI HC A03/MF A06 CSCL 22B

For particularly innovative space exploration missions, unusual requirements are levied on the structural components of the spacecraft. In many cases, the preferred solution is the utilization of unusual materials. This trend is forecast to continue. Several hypothetic examples are discussed. Author

N91-22455# Lawrence Livermore National Lab., CA.
DEVELOPMENT OF LOW DENSITY SILICA AEROGEL AS A CAPTURE MEDIUM FOR HYPER-VELOCITY PARTICLES
L. W. HRUBESH and J. F. POCO 1 Dec. 1990 14 p
(Contract W-7405-ENG-48)
(DE91-008563; UCRL-CR-105858-SUMM) Avail: CASI HC A03/MF A01

The authors successfully demonstrated the production of monolithic bricks of transparent silica aerogel (2.5 x 4.5 x 16 cm) with densities as low as 0.003 g/cu cm. They have characterized the microstructure of these new ultra-low density aerogels, and determined that they are polymeric-like having crosslinked chains of silica as compared with the colloidal-like silica formed with the conventional sol-gel approach. They have determined that the new ultra-low density aerogels have a higher compressive modulus than would be expected from an extrapolation from the higher density aerogels, and they are typically 15 percent more transmissive than conventional aerogels for the wavelength range from 350 to 800 nm. The authors have developed a new method of casting regular shaped aerogels using silicone rubber molds. This new method eliminates irregular surfaces, for example the raised surface caused by a meniscus, in prior methods. Flat, and nearly parallel sides are obtained with the new method. They delivered 26 tiles of aerogels for the EURECA experiment. The nominal density of each tile was about 0.06 g/cu cm. Twenty of the tiles had dimensions of approximately 1.8 x 1.8 x 0.2 in., with flat sides. The remaining six tiles had dimensions of approximately 1.8 x 3.5 x 0.2 in. All tiles were shipped from LLNL to the University of Washington before September 30, 1990. DOE

N91-22577*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.
THE INFLUENCE OF TIME-DEPENDENT MATERIAL BEHAVIOR ON THE RESPONSE OF SANDWICH BEAMS
Interim Report No. 83, Sep. 1988 - Dec. 1990
LYNDA LEE SENSMEIER-OLEKSUK, MICHAEL W. HYER, and DAVID E. BOWLES (National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.) Feb. 1991 185 p
(Contract NAG1-343)
(NASA-CR-188029; NAS 1.26:188029; CCMS-91-05; VPI-E-91-02)
Avail: CASI HC A09/MF A02 CSCL 20K

Simple sandwich beam models are developed in order to study the influence of the time-dependent behavior of various materials being considered for use in orbiting precision segmented reflectors. The beam models included layers representing face sheets, core, and adhesive. The issue of time-dependency is essential because the expected life of a reflector is on the order of 20 years. Using the principle of stationary potential energy, the elastic response of three-layer and five-layer sandwich beams to mechanical and thermally-induced loads is studied. The sensitivity of the three-layer and five-layer sandwich beams to reductions of the material properties are used to demonstrate the application of the correspondence principle and evaluate the time-dependent response of the reflector. To verify the viscoelastic models and obtain a better idea of the amount of time-dependency to expect from the materials, simple time-dependent experiments on candidate materials were performed. Candidate materials include a quartz-epoxy face sheet material, and a glass-imide honeycomb core material. The percent increase in strain for a constant stress for the quartz-epoxy in tension and the honeycomb in shear were measured. For both, a four-parameter fluid model captured the essential characteristics of their behavior. These four-parameter fluid models were then used in the three-layer sandwich beam model to predict the time-dependent response of the beam to three-point bending. This prediction response was compared to experimental results of a sandwich beam subjected to three-point bending. Author

N91-23261# Aerospatiale Aquitaine, Saint-Medard en Jalles (France). Strategic and Space Div.
STRUCTURAL MATERIALS FOR SPACE MIRRORS
C. CAPITANIO 1991 6 p
(REPT-911-430-128; ETN-91-99300) Avail: CASI HC A02/MF A01

Results of evaluation of potential materials for the XMM telescope mirrors are presented. Tested substrates include SiC plane plates for XMM telescope and XMM reflection gratings and SiC shells for XMM telescope. Other materials described are carbon/resin, carbon/carbon, and glass matrix ceramics reinforced with fibers (SiC, carbon). The existence of new potentialities is shown but applications must be thoroughly studied before development decisions can be made. ESA

N91-23757# Aerospatiale Aquitaine, Saint-Medard en Jalles (France).
ACLICO: A COMPUTER AIDED DESIGN SYSTEM FOR BONDED JOINTS [ACLICO: UN SYSTEME D'AIDE A LA CONCEPTION DES LIAISONS COLLEES]
LABORIE 1991 16 p In FRENCH; ENGLISH summay
(REPT-911-430-101; ETN-91-99273) Avail: CASI HC A03/MF A01

The system is an expert system designed for the selection of adhesive bonding configurations of composites or other materials in space structures. It is shown that the increasing use of composite materials in space structures makes it necessary to acquire a perfect knowledge of adhesive bonding technique. Computer aided selection is required for the five thousand adhesives which are currently used. The joint type is to be classified, stress distribution is to be optimized, polymerization and the thermomechanical behavior of the joint are to be examined. The fabrication technology is investigated. The program architecture is described. A data base for adhesives was created. ESA

N91-24063*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A CONFORMAL OXIDATION-RESISTANT, PLASMA-POLYMERIZED COATING
MORTON A. GOLUB, THEODORE WYDEVEN, and NARCINDA R. LERNER *In* NASA, Washington, Technology 2000, Volume 2 p 185-191 1991
Avail: CASI HC A02/MF A03 CSCL 11C

A comparative study was made of the surface recession (etching) of thin films of plasma polymerized tetrafluoro ethylene (PPTFE), polytetrafluoro ethylene (PTFE), and ion-beam sputter deposited polytetrafluoro ethylene (SPTFE) exposed to ground-state atomic oxygen downstream from a nonequilibrium radio-frequency O2 plasma. At 22 C, the etch rates for PTFE, SPTFE, and PPTFE were in the ratio of 8.7:1.8:1.0. A thin, conformal coating of PPTFE (etch rate of 0.3 nm/h at 22 C) was found to protect an underlying cast film of a reactive polymer, cis-1,4 polybutadiene, against ground-state atomic oxygen attack for the time required to fully etch away the PPTFE coating. From ESCA analysis, PTFE exhibited only minor surface oxidation (uptake of 0.5 atom percent O) upon etching, its F/C ratio decreasing slightly from 2.00 to 1.97; PPTFE exhibited considerable surface oxidation (uptake of 5.9 atom percent O) intermediate between those of PTFE and PPTFE, with a decrease in F/C ratio from 1.73 to 1.67. A plasma-polymerized fluorocarbon coating such as PPTFE might be useful for space applications to protect polymers that are vulnerable to oxidation or degradation by oxygen atoms. Author

N91-27444*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ELECTRICAL CHARACTERIZATION OF GLASS, TEFLON, AND TANTALUM CAPACITORS AT HIGH TEMPERATURES
A. N. HAMMOUD (Sverdrup Technology, Inc., Brook Park, OH.), E. D. BAUMANN, I. T. MYERS, and E. OVERTON 1991 8 p
Presented at the 1991 Conference on Electrical Insulation and Dielectric Phenomena, Knoxville, TN, 20-24 Oct. 1991; sponsored by IEEE
(Contract RTOP 506-41-41)
(NASA-TM-104517; E-6387; NAS 1.15:104517) Avail: CASI HC A02/MF A01 CSCL 09C

Dielectric materials and electrical components and devices employed in radiation fields and the space environment are often exposed to elevated temperatures among other things. Therefore, these systems must withstand the high temperature exposure while still providing good electrical and other functional properties. Experiments were carried out to evaluate glass, teflon, and tantalum capacitors for potential use in high temperature applications. The capacitors were characterized in terms of their capacitance and dielectric loss as a function of temperature up to 200 C. At a given temperature, these properties were obtained in a frequency range of 50 Hz to 100 kHz. The DC leakage current measurements were also performed in a temperature range from 20 to 200 C. The obtained results are discussed and conclusions are made concerning the suitability of the capacitors investigated for high temperature applications. Author

N91-29297*# University of Eastern Kentucky, Richmond. Dept. of Physics and Astronomy.
STUDY OF ACTIVATION OF METAL SAMPLES FROM LDEF-1 AND SPACELAB-2 Final Report
C. E. LAIRD Jul. 1991 62 p
(Contract NAS8-36649)
(NASA-CR-184171; NAS 1.26:184171) Avail: CASI HC A04/MF A01 CSCL 11F

The activation of metal samples and other material orbited onboard the Long Duration Exposure Facility (LDEF) and Spacelab-2 were studied. Measurements of the radioactivities of spacecraft materials were made, and corrections for self-absorption and efficiency were calculated. Activation cross sections for specific metal samples were updated while cross sections for other materials were tabulated from the scientific literature. Activation cross sections for 200 MeV neutrons were experimentally determined. Linear absorption coefficients, half lives, branching ratios and other pertinent technical data needed for LDEF sample analyses were tabulated. The status of the sample counting at low background facilities at national laboratories is reported. Author

N91-29629*# Texas Univ., San Antonio. Engineering Div.
PROBABILISTIC LIFETIME STRENGTH OF AEROSPACE MATERIALS VIA COMPUTATIONAL SIMULATION Final Report, Jan. - Dec. 1989
LOLA BOYCE, JEROME P. KEATING, THOMAS B. LOVELACE, and CALLIE C. BAST Aug. 1991 280 p
(Contract NAG3-867; RTOP 505-63-5B)
(NASA-CR-187178; NAS 1.26:187178) Avail: CASI HC A13/MF A03 CSCL 20K

The results of a second year effort of a research program are presented. The research included development of methodology that provides probabilistic lifetime strength of aerospace materials via computational simulation. A probabilistic phenomenological constitutive relationship, in the form of a randomized multifactor interaction equation, is postulated for strength degradation of structural components of aerospace propulsion systems subjected to a number of effects of primitive variables. These primitive variables often originate in the environment and may include stress from loading, temperature, chemical, or radiation attack. This multifactor interaction constitutive equation is included in the computer program, PROMISS. Also included in the research is the development of methodology to calibrate the constitutive equation using actual experimental materials data together with the multiple linear regression of that data. Author

N91-29660# Institute for Defense Analyses, Alexandria, VA.
IDA STUDIES ON NATURAL SPACE ENVIRONMENTAL EFFECTS ON MATERIALS FOR SDIO Final Report, Nov. 1987 - Dec. 1990
JANET M. SATER, CHARLES F. BERSCH, and WILLIAM S. HONG Dec. 1990 109 p
(Contract MDA903-89-C-0003)
(AD-A237974; IDA-P-2432; IDA/HQ-90-35736; AD-E501404)
Avail: CASI HC A06/MF A02 CSCL 15C

The background is provided of IDA's role in the area of space environmental effects (SEE) for Strategic Defense Initiative Organization (SDIO), particularly the Materials and Structures program. Included in these efforts are establishing and co-chairing the NASA/SDIO Workshop on Space Environmental Effects on Materials (June 1988). This workshop, in part, led to the recovery of the NASA Long Duration Exposure Facility (LDEF) after more than 5 years in space as well as to the appointment of the M and S Office as the SDIO focal point for SEE. A technical assessment of the utility of various LDEF experiments to SDI is highlighted. Results of the assessment were presented at an SDIO Workshop in August 1989 and copies were provided to appropriate, interested groups. The study provided the basis for preparation of detailed SDIO sample/analysis information packages for the NASA-LDEF Office. Continuing involvement in LDEF post-retrieval activities is noted as well. GRA

N91-30237*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LEO MICROMETEORITE/DEBRIS IMPACT DAMAGE
PAUL M. STELLA *In* NASA. Lewis Research Center, Space Photovoltaic Research and Technology Conference 7 p Aug. 1991
Avail: CASI HC A02/MF A04 CSCL 22B

The school bus sized Long Duration Exposure Facility (LDEF) was retrieved in 1990, after nearly six years of 250 nautical mile altitude low earth orbit environmental exposure. The recovery of LDEF experiments has provided extensive information on space interactions, including micrometeorite, debris, atomic oxygen, ultraviolet, and particulate radiation. The Jet Propulsion Laboratory provided a test plate as part of Solar-Array-Materials Passive LDEF (SAMPLE) Experiment. The test plate contained thirty thin silicon solar cell/cover assemblies. The cover samples included a variety of materials such as Teflon and RTV silicones, in addition to conventional microsheet. The nature of the approximately 150 micrometeorite/debris impacts on the cell/cover samples, cell interconnects, and aluminum test plate is discussed. Author

N91-30251*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
WORKSHOP SUMMARY: SPACE ENVIRONMENTAL EFFECTS
A. MEULENBERG (Communications Satellite Corp., Clarksburg, MD.) and B. E. ANSPAUGH *In* NASA. Lewis Research Center, Space Photovoltaic Research and Technology Conference 21 p Aug. 1991
Avail: CASI HC A03/MF A04 CSCL 10B

The workshop on Space Environmental Effects is summarized. The underlying concern of the group was related to the question of how well laboratory tests correlate with actual experience in space. The discussion ranged over topics pertaining to tests involving radiation, atomic oxygen, high voltage plasmas, contamination in low earth orbit, and new environmental effects that may have to be considered on arrays used for planetary surface power systems. Author

N91-31024*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CRYO-MECHANICAL TESTS OF AMES 24E2 IR-BLACK COATING
SHELDON M. SMITH Jun. 1991 15 p Presented at the SPIE International Symposium, San Diego, CA, 8-13 Jul. 1990
(Contract RTOP 188-78-44)
(NASA-TM-102863; A-90279; NAS 1.15:102863) Avail: CASI HC A03/MF A01 CSCL 07C

In addition to the ambient condition tape test, five mechanical tests of the IR-black coating, Ames 24E2, were performed at either liquid helium or liquid nitrogen temperatures. Tensile strain in the coating at liquid nitrogen temperature was measured up to values of 4E-3, both before and after the coating was cycled down to liquid helium temperature. When applied to an aluminum substrate which was then bent in liquid nitrogen, the aluminum substrate always failed (permanently deformed) well before the coating failed. Sinusoidal accelerations up to 45 Gs in liquid nitrogen and 25 Gs in liquid helium did not crack or otherwise visibly damage the coating. Both sinusoidal and random acceleration at about 90 K of a representative baffle vane structure, at frequencies from 10 to 2000 Hz and up to 15 Gs, did not damage the coating, even at the intersection of a baffle with the telescope tube. Thus on a macroscopic level, cryogenic cooling and various levels of acceleration and strain did not affect this coating. However, on a microscopic scale, some loose particles were found associated with several tests. Outgassing data are also given. Author

N91-32170 Cranfield Inst. of Tech., Bedford (England).
COMPOSITE-FACED SANDWICH CONSTRUCTION FOR PRIMARY SPACECRAFT STRUCTURES Ph.D. Thesis
R. SLADE 1989 453 p
Avail: Univ. Microfilms Order No. BRDX90899

The application of fiber reinforced composite materials to spacecraft sandwich structures was studied. In particular, aspects of the manufacture, analysis, and design optimization of components fabricated using the co-cure process were studied. The manufacturing process was developed to ultimately enable a full size thrust tube structure to be built using a single step cure, the design of which was verified by a modal survey test. Techniques for the analysis of stiffness, strength, vibration frequencies, and local instability were established and found to correlate well with tests on co-cured sandwich specimens. The current wrinkling theory for composite faced sandwich was extended to the more general case to allow facesheet constitutive matrix coupling and multiaxial loading to be accommodated. The analytical methods were incorporated within simple optimization schemes, willing to be used at the preliminary design stage, to allow alternative feasible designs for panel and thrust tube structures to be generated. These illustrated the benefits of the use of composite materials and the co-cure manufacturing technique for spacecraft sandwich components. Dissert. Abstr.

N91-32234# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Structures and Mechanisms Div.
ADHESIVE BONDING HANDBOOK FOR ADVANCED STRUCTURAL MATERIALS
Feb. 1990 225 p
(ISSN 0379-4059)
(ESA-PSS-03-210-ISSUE-1; ETN-91-90071) Copyright Avail: CASI HC A10/MF A03

Adhesive bonding is a viable method of joining advanced composite materials and certain metals which are used in the aerospace industries. When desiging a joint, a whole range of factors which have a direct influence on the materials selection, manufacture and inspection activities, need to be considered. It is therefore necessary to follow a fully integrated program to ensure joint integrity. The aim of this handbook is to highlight what needs to be known, and identify what and where relevant information is available for the existing range of adhesives and the materials most commonly used in spacecraft structures. The state of technology for the merging materials which have potential for use in future European space projects is reviewed. ESA

06

STRUCTURAL MEMBERS & MECHANISMS

Design, analysis and description of structures. Includes their manufacture, arrangement, testing, weight analysis and fatigue. Also includes the design of joints, control mechanisms, springs, latches, or docking hardware.

A91-33391*# *Science Applications International Corp., Huntsville, AL.*
SPACECRAFT PROTECTIVE STRUCTURES DESIGN OPTIMIZATION
ROBERT A. MOG (Science Applications International Corp., Huntsville, AL) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Jan.-Feb. 1991, p. 109-117. Previously cited in issue 06, p. 777, Accession no. A90-19680. refs
(Contract NAS8-37378)
Copyright

A91-34457
MODELING OF A SHAPE MEMORY INTEGRATED ACTUATOR FOR VIBRATION CONTROL OF LARGE SPACE STRUCTURES
B. J. MACLEAN, G. J. PATTERSON, and M. S. MISRA (Martin Marietta Space Systems, Denver, CO) Journal of Intelligent Material Systems and Structures (ISSN 1045-389X), vol. 2, Jan. 1991, p. 72-94. refs
(Contract F04611-88-C-0063)
Copyright

A shape-memory alloy (SMA) actuator for large adaptive space structures is studied. To accomodate the multiple quadrant (tensile and compressive) hysteretic behavior of SMAs, the theory of nonequilibrium thermostatics was changed. The spatial mapping of alloy compositions and proportions was established by experimental outcome. Mapping included: austenite to martensite and martensite to austenite phase transformation boundaries and the relative locations of 100 percent austenite and 100 percent aligned martensite saturation surfaces. All are shown in the three-dimensional force-length-temperature material behavior domain. A simplified finite-element model (based on the SCOLE) underwent dynamic analysis using a FORTRAN subroutine. A slewing maneuver was employed to study the effects of a biasing force, and during and after the maneuver temperature was used to demonstrate active vibration control. Important passive damping and active control through pulsed actuator temperature are observed. The analysis provides information for the design of adaptive SMA space truss tubes and actuators for vibration and shape control. C.C.S.

A91-34575
TECHNICAL ASPECTS OF VSOP
NORIYUKI KAWAGUCHI (Nobeyama Radio Observatory, Minamimaki, Japan) and TOSHIMITSU NISHIMURA (Institute of Space and Astronautical Science, Sagamihara, Japan) (Infrared and radio astronomy, and astrometry; Proceedings of Symposia 7, 8, and Topical Meeting of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A91-34526 14-89) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 2, 1991, p. 381-386.
Copyright

A prototypical model for the Japanese VLBI Space Observatory Program (VSOP), and a tentative mission plan, are technically described. Specifications of the MUSES-B satellite, its tension truss antenna, receiver system, two-channel sampler and data link, two-way phase-transfer link, ground tracking station, and correlation processing center are described in detail. Its proposed orbit and the M-V rocket launching vehicle are also set forth. The deployable antenna, low-noise receivers, and data-acquisition system are shown to have satisfactory production possibilities. Potential for error in the Ku-band phase-transfer link is demonstrated as being low enough to maintain coherence in detecting fringes in high quality. Ground support facilities are being developed jointly by ISAS and the National Astronomical Observatory. Utilization is anticipated for 1995. C.C.S.

A91-34947#
SPACE BASED RADAR - TEST OF LARGE SPACE STRUCTURES
W. G. SINCARSIN, D. J. MCTAVISH, G. B. SINCARSIN (Dynacon Enterprises, Ltd., Downsview, Canada), and Y. SOUCY (CDC, Communications Research Centre, Ottawa, Canada) IN: CASI Conference on Astronautics, 6th, Ottawa, Canada, Nov. 19-21, 1990, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1990, 13 p. DND-supported research. refs

An evaluation is made of mechanical testing options available for the Space-Based Radar (SBR) satellite program which has been initiated by the Canadian Department of National Defense. When the mass constraints typical of current launch vehicles are factored into the SRB spacecraft's design, structural flexibility becomes a major concern; thermal loading-induced structural deformations will also tend to reduce beam quality and fatigue structural components through thermal cycling. Three generic spacecraft configurations proposed for the SBR are discussed with a view to the characteristics of tests required for validation of structural performance in stowage, deployment, static behavior, dynamic behavior, controlled system-structural interaction, and thermal behavior. O.C.

A91-36651
ADVANCES IN OPTICAL STRUCTURE SYSTEMS; PROCEEDINGS OF THE MEETING, ORLANDO, FL, APR. 16-19, 1990
JOHN BREAKWELL, ED. (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA), VICTOR L. GENBERG, ED. (Eastman Kodak Co., Rochester, NY), and GARY C. KRUMWEIDE, ED. (Composite Optics, Inc., San Diego, CA) Meeting sponsored by SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Vol. 1303), 1990, 572 p. For individual items see A91-36652 to A91-36693.
(SPIE-1303) Copyright

Various papers on advances in optical structure systems are presented. Individual topics addressed include: beam pathlength optimization, thermal stress in glass/metal bond with PR 1578 adhesive, structural and optical properties for typical solid mirror shapes, parametric study of spinning polygon mirror deformations, simulation of small structures-optics-controls system, spatial PSDs of optical structures due to random vibration, mountings for a four-meter glass mirror, fast-steering mirrors in optical control systems, adaptive state estimation for control of flexible structures, surface control techniques for large segmented mirrors, two-time-scale control designs for large flexible structures, closed-loop dynamic shape control of a flexible beam. Also discussed are: inertially referenced pointing for body-fixed payloads, sensor blending line-of-sight stabilization, controls/optics/structures simulation development, transfer functions for piezoelectric control of a flexible beam, active control experiments for large-optics vibration alleviation, composite structures for a large-optical test bed, graphite/epoxy composite mirror for beam-steering applications, composite structures for optical-mirror applications, thin carbon-fiber prepregs for dimensionally critical structures. C.D.

A91-36678
TRANSFER FUNCTIONS FOR PIEZOELECTRIC CONTROL OF A FLEXIBLE BEAM
THOMAS E. ALBERTS and JOSEPH A. COLVIN (Old Dominion University, Norfolk, VA) IN: Advances in optical structure systems;

Proceedings of the Meeting, Orlando, FL, Apr. 16-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 381-391. refs
(Contract NSF ENG-88-11633)
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Basic relationships for beams which employ piezoelectric film actuators and sensors are considered with reference to the design of lightweight flexible space structures. Laplace domain transfer function models are developed for the cantilever beam system (with piezoelectric film bonded to two sides) by employing the differential equation of motion of the system. The transfer functions, considered Laplace domain representations of the system equations of motion, are transformed into the closed rational form by employing Maclaurin series expansions for a number of modes, thus facilitating a conventional control analysis. The transfer functions which relate actuating layer voltage to sensing layer voltage and relating actuating layer voltage to tip position are found for spatially invariant PVDF film bonded to the beam. The latter function is shown to be an accurate model based on experimental verification. This function encounters instability problems due to the actuator signal incompatibility with the sensor signal. C.C.S.

A91-37019
LAMINATE PLATE THEORY FOR SPATIALLY DISTRIBUTED INDUCED STRAIN ACTUATORS
BOR-TSUEN WANG and CRAIG A. ROGERS (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Composite Materials (ISSN 0021-9983), vol. 25, April 1991, p. 433-452. refs
(Contract N0014-88-K-0566; N0014-88-K-0721)
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Classical laminated plate theory (CLPT) is applied to a laminate plate with induced strain actuators, such as piezoceramic patch, bonded to its surface or embedded within the laminate to develop an induced strain actuation theory that allows for the actuator patch to be spatially distributed. When piezoceramic patches are subjected to voltage fields, the equivalent external forces induced by piezoceramic patches can be determined upon the assumption of free constraint for the expansion or contraction of piezoceramic patches. This assumption is generally done in thermal expansion problem. Several examples, including pure bending and pure extension, are illustrated. For the case of pure bending, a comparison between the current work and that of Dimitriadis et al. (1989) is given. In addition, an orthotropic angle-ply laminate with an embedded piezoceramic patch is presented to show the coupling of bending and extension. Author

A91-38042
SPICE SIMULATION OF THE SPACE STATION SOLAR ALPHA ROTARY JOINT
FRANCIS D. RODRIGUEZ (Lockheed Missiles and Space Co., Inc., Space Systems Div., Sunnyvale, CA) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 2. New York, American Institute of Chemical Engineers, 1990, p. 115-120. refs
Copyright

The author describes the development of a dynamic load model for the Space Station solar alpha rotary joint (SARJ) servomechanism. He discusses the various components of the SARJ load insofar as they influence the rotational motion system. Formulation of the equations governing the motion of the structure leads to a mathematical model of the mechanical system. From the model equations, an electrical circuit analog is derived. The torsional modes associated with the rotational system are identified using frequency-domain analysis of the equivalent circuit. This is followed by brief descriptions of the SARJ velocity servo and of circuit implementation of the friction torques. Time-domain analysis is used to examine the nonlinear effects resulting from both static and Coulomb friction torques. Several torsional modes are identified as a result of this investigation. With the rotational system in the phase I electrical power system (EPS) configuration, torsional resonances were found at 0.1, 2.2, and 83 Hz, corresponding to the solar array cantilever mode, the interaction of the solar array with the structure, and the drive-shaft compliance, respectively. I.E.

A91-39487 Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PRECISION SEGMENTED REFLECTORS FOR SPACE APPLICATIONS
DAVID H. LEHMAN, EUGENE V. PAWLIK, ADEN B. MEINEL (JPL, Pasadena, CA), and W. B. FICHTER (NASA, Langley Research Center, Hampton, VA) IN: Adaptive optics and optical structures; Proceedings of the Meeting, European Congress on Optics, 3rd, The Hague, Netherlands, Mar. 12-14, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 191-203. refs
Copyright

A project to develop precision segmented reflectors (PSRs) which operate at submillimeter wavelengths is described. The development of a light efficient means for the construction of large-aperture segmented reflecting space-based telescopes is the primary aim of the project. The 20-m Large Deployable Reflector (LDR) telescope is being developed for a survey mission, and it will make use of the reflector panels and materials, structures, and figure control being elaborated for the PSR. The surface accuracy of a 0.9-m PSR panel is shown to be 1.74-micron RMS, the goal of 100-micron RMS positioning accuracy has been achieved for a 4-m erectable structure. A voice-coil actuator for the figure control system architecture demonstrated 1-micron panel control accuracy in a 3-axis evaluation. The PSR technology is demonstrated to be of value for several NASA projects involving optical communications and interferometers as well as missions which make use of large-diameter segmented reflectors. C.C.S.

A91-41752#
DELTA II-LAUNCHED MARS AEROBRAKE MISSIONS
EDWARD BAROCELA, DARRELL WEBER, and JOHN GARVEY (McDonnell Douglas Corp., Saint Louis, MO) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. refs
(AIAA PAPER 91-2329) Copyright

The trajectory analysis and preliminary design of a vehicle that can deliver a payload to Mars orbit using the aerocapture technique are presented. The mass of the aeroshell is considerably less than the mass of the fuel that would be needed for a purely propulsive capture. This mass savings makes it possible to use a medium lift launch vehicle such as the Delta II, and the vehicle was designed for a dedicated Delta II launch. The biconic aeroshell is a modification of a shape that is now under study for the MR/SR mission. The baseline trajectory chosen for this analysis is also taken from MR/SR studies, and would place the spacecraft into a 500 km orbit around the planet. The aerothermal and aerodynamic environment are not as severe as an Earth reentry, which allows the use of proven Space Shuttle materials for the thermal protection system. The aeroshell represents about 22 percent of the total spacecraft mass. Author

A91-42644*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DESIGN AND FABRICATION OF AN ERECTABLE TRUSS FOR PRECISION SEGMENTED REFLECTOR APPLICATION
HAROLD G. BUSH, CATHERINE L. HERSTROM, WALTER L. HEARD, JR., TIMOTHY J. COLLINS, W. B. FICHTER (NASA, Langley Research Center, Hampton, VA) et al. Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Mar.-Apr. 1991, p. 251-257. Previously cited in issue 11, p. 1693, Accession no. A90-29271. refs
Copyright

A91-43275
DETRANS - EFFICIENT ALGORITHM FOR STATIC ANALYSIS OF DETERMINATE TRUSSES
S. UTKU (Duke University, Durham, NC), A. V. RAMESH, and L.

Y. LU Journal of Aerospace Engineering (ISSN 0893-1321), vol. 4, July 1991, p. 274-285.
Copyright

A fast and storage-efficient algorithm for the computation of the static response of determinate trusses to nodal loading is proposed. In terms of the number of bars in the truss, M, the algorithm is of computational complexity O(M squared) and requires only O(M) primary storage, for M linearly independent loadings. The motivation to develop a fast algorithm stems from the need for such an algorithm in the fast and efficient control of adaptive space cranes. The algorithm is based on the well-known method of joints. The algorithm includes the extension for the compound and complex determinate trusses by generalizing the Henneberg method. It has been coded in FORTRAN77 into a computer program called DETRANS (Determinate Truss Analysis System).
Author

A91-43289#
INFLUENCES OF UNCERTAINTIES ON MECHANICAL BEHAVIOR OF A DOUBLE-LAYER SPACE TRUSS
AKIRA WADA (Tokyo Institute of Technology, Yokohama, Japan) and ZHU WANG Research Laboratory of Engineering Materials, Report (ISSN 0385-3799), no. 16, 1991, p. 281-297. refs

The estimation of the effects of undetermined quantities such as external loads and inherent structural resistances is considered in an investigation of the mechanical behavior of trusses. Observations are made on a model double-layer space truss with a 6 x 6 square plan which is based on the minimum-weight design concept. The Monte Carlo simulation method is employed to examine stochastic variation of the space truss including both nonlinear member buckling and automatic adjustments of the displacement increment. Uncertainties in the assembly process are compared to component-specific uncertainties such as variation of member strength and initial imperfection of member length. The mean value of member strengths influences the overall strength more than member strength variation, and strength deterioration tends to increase when members with initial length imperfections are tightened. Human errors have a significant impact on the mechanical behavior, and assembly errors increase the chance of collapse greatly.
C.C.S.

A91-43413*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
AEROBRAKE DESIGN STUDIES FOR MANNED MARS MISSIONS
M. TAUBER, M. CHARGIN, W. HENLINE, K. R. HAMM, JR., H. MIURA (NASA, Ames Research Center, Moffett Field, CA), A. CHIU, and L. YANG (Sterling Software, Inc., Palo Alto, CA) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 15 p. refs
(AIAA PAPER 91-1344) Copyright

The dimensions of aerobrakes and associated heat shields are calculated as a fraction of the vehicle mass required for a high-velocity manned Mars entry. The entry speed and deceleration limit are assumed to be 8.6 km/sec and 5 earth g, respectively, to consider vehicles with low lift-drag ratio (L/D) and ballistic coefficients of 100 and 200 kg/sq m, as well as a vehicle with a medium L/D and a ballistic coefficient of 375 kg/sq m. The aerobrake mass plus the heat shield divided by an optimized, blunt-shaped vehicle's total mass is 15 and 13 percent for ballistic coefficients of 100 and 200 kg/sq m, respectively. For a winged vehicle the mass fraction is 17 percent because the higher ballistic coefficient requires more thermal protection to account for the greater temperatures generated. It is concluded that aerobraking is more efficient than propulsive braking because the mass fraction for a propulsive system would be 4 or 5 times greater than those calculated for aerobraking.
C.C.S.

A91-44155#
INTEGRATING HEALTH MONITORING AND NONDESTRUCTIVE EVALUATION FOR SPACE TRANSPORTATION VEHICLES AND SPACE STATIONS
MIKE FOLEY and RON L. PUENING (Martin Marietta Astronautics Group, Denver, CO) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 17 p. refs
(AIAA PAPER 91-2207) Copyright

The role of nondestructive evaluation (NDE) measurements as an integrated complement to health monitoring (HM) in the long duration missions of the Space Station is discussed. External NDE inspection data fused with HM embedded sensor data should contribute to understanding the life cycle durability of many space based structures and systems. The aerobrake is considered to be a promising testbed for the NDE and HM data fusion concept. NDE and HM technologies including ultrasonics, thermography, optical property measurements, acoustic emission inspection of pressurized structures, imbedded smart sensors, and back bias inspection of solar cells are considered in terms of their applicability to some of the externally accessible components of space stations and space transfer vehicles.
O.G.

A91-44494#
NEW DEPLOYABLE TRUSS CONCEPTS FOR LARGE ANTENNA STRUCTURES OR SOLAR CONCENTRATORS
K. A. TAKAMATSU (Fuji Heavy Industries, Ltd., Tochigi, Japan) and J. ONODA (Institute of Space and Astronautical Science, Kanagawa, Japan) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, May-June 1991, p. 330-338. Previously cited in issue 12, p. 1797, Accession no. A89-30821. refs
Copyright

A91-46593#
STRUCTURAL CONCEPTS IN SPACE
KORYO MIURA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 38, no. 436, 1990, p. 221-229. In Japanese. refs

Principles behind the design of deployable space structures are presented. Particular attention is given to structural concepts of two-dimensional deployable truss structures. In particular, a next-generation space crane is discussed which would use local sensors and actuators under programmed master control to take any desired configuration.
B.J.

A91-48557
THE USE OF INFLATABLE STRUCTURES FOR RE-ENTRY OF ORBITING VEHICLES
ROBERT T. KENDALL (Aerospace Recovery Systems, Inc., Grants Pass, OR) and ARTHUR R. MADDOX (Northrop University, Inglewood, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 1-4, 1990. 11 p. refs
(SAE PAPER 901835) Copyright

Inflatable recovery systems offer the unique advantage that a large high-drag shape can be stored initially in a relatively small package. The resulting shapes decelerate rapidly with lower heating inputs than other types of re-entry vehicles. Recent developments have led to some light-weight materials, with little thermal protection, can withstand the heating inputs to such vehicles. As a result, inflatable recovery vehicles offer a simple, reliable and economical way to return various vehicles from orbit. This paper examines the application of this concept to a large and a small vehicle with the accompanying dynamics that might be expected. More complex systems could extend the concept to emergency personnel escape systems, payload abort and satellite recovery systems.
Author

A91-48844* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PRELIMINARY DESIGN CONSIDERATIONS FOR 10-40 METER-DIAMETER PRECISION TRUSS REFLECTORS
MARTIN M. MIKULAS, JR., TIMOTHY J. COLLINS (NASA, Langley Research Center, Hampton, VA), and JOHN M. HEDGEPETH Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, July-Aug. 1991, p. 439-447. Previously cited in issue 11, p. 1694, Accession no. A90-29272. refs
Copyright

A91-50325* Alabama Univ., Huntsville.
HYPERVELOCITY IMPACT RESPONSE OF ALUMINUM MULTI-WALL STRUCTURES
WILLIAM P. SCHONBERG (Alabama, University, Huntsville) and ALAN J. BEAN (NASA, Marshall Space Flight Center, Huntsville, AL) Acta Astronautica (ISSN 0094-5765), vol. 25, July 1991, p. 363-373. refs
(Contract NAS8-36955)
Copyright

The results of an investigation in which the perforation resistance of aluminum multiwall structures is analyzed under a variety of hypervelocity impact loading conditions are presented. A comparative analysis of the impact damage in structural systems with two or more bumpers and the damage in single-bumper systems of similar weight is performed to determine the advantages and disadvantages of employing more than one bumper in structural wall systems for long-duration spacecraft. A significant increase in protection against perforation by hypervelocity projectiles can be achieved if a single bumper is replaced by two bumpers of similar weight while the total wall spacing is kept constant. It is found that increasing the number of bumpers beyond two while keeping the total stand-off distance constant does not result in a substantial increase in protection over that offered by two bumpers of similar weight. P.D.

A91-52378*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DESIGN OF AN INFLATABLE, OPTICALLY CONTROLLED AND FED, PHASED ARRAY ANTENNA
RICHARD R. KUNATH and G. R. SHARP (NASA, Lewis Research Center, Cleveland, OH) AIAA, NASA, and OAI, Conference on Advanced SEI Technologies, Cleveland, OH, Sept. 4-6, 1991. 8 p. refs
(AIAA PAPER 91-3470) Copyright

Initial studies on the antenna requirements of the Space Exploration Initiative (SEI) system architecture have indicated the need for large, lightweight antennas. This paper discusses the design of a modular, inflatable, optically controlled and fed phased array antenna suitable for SEI aplications. When high gain antennas are required for space applications, large aperture mesh or collapsible solid antenna reflectors are considered. However, these designs are generally not lightweight, and have complicated deployment mechanisms. Alternatively, the modular, inflatable antenna design discussed here is a lightweight, modular design that incorporates a simple deployment scheme, and after deployment, can be rigidized to enhance its structural integrity. Further, the design features the fiberoptic distribution of both RF and control signals to individual microwave integrated circuit/reflector modules in each of the inflatable, phased array antenna cells. The result of combining these two technologies is a modular, phased array antenna design that is both mechanically and electrically agile and robust. Author

A91-53274
EARTHBOUND CIVIL ENGINEERING EXPERIENCE FOR SPACE APPLICATIONS
RAMESH B. MALLA (Connecticut, University, Storrs) Journal of Aerospace Engineering (ISSN 0893-1321), vol. 4, Oct. 1991, p. 330-346. refs
Copyright

Consideration is given to potential applications of various earth-based civil engineering fields to the engineering, construction, and operation of facilities on space stations in earth orbit, bases on the moon and Mars, and the exploration of other extraterrestrial bodies. It is concluded that earth-based knowledge and experience of civil engineers can be applied to create a suitable infrastructure in space for satisfying human needs. O.G.

A91-55813
HYPERBOLOIDAL DEPLOYABLE SPACE ANTENNA
MICHAEL T. WATERS (Douglas Aircraft Co., Long Beach, CA) and TERRANCE J. WATERS IN: Space utilization and applications in the Pacific; Proceedings of the 3rd Pacific Basin International Symposium on Advances in Space Science Technology and its Applications, Los Angeles, CA, Nov. 6-8, 1989. San Diego, CA, Univelt, Inc., 1990, p. 127-134.
(AAS PAPER 89-614) Copyright

Hyperboloidal geometry was used to make possible the deployment of large space antennas for transmitting and receiving electromagnetic radiation. Advantages of the hyperboloidal antenna are described. In particular, it is noted that large-size antenna (up to 100 m in diameter) having very light weight (up to 90 percent less than in normal shapes and design practices) can be contained in a small-diameter tube or container for trans-orbital insertion. It is rapidly self-deployable and can be folded back up and stored in the small-diameter container. It is extraordinarily strong and stiff, and when opened or closed it can withstand high G forces. The antenna structure is capable of withstanding extensive damage and remain operational due to its high geometric and structural redundancy. O.G.

N91-21214*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PRE-INTEGRATED STRUCTURES FOR SPACE STATION FREEDOM
JONATHAN N. CRUZ, DONALD W. MONELL, PHILIP MUTTON (Lockheed Engineering and Sciences Co., Hampton, VA.), and PATRICK A. TROUTMAN Feb. 1991 268 p
(Contract RTOP 476-14-15-01)
(NASA-TM-102780; NAS 1.15:102780) Avail: CASI HC A12/MF A03 CSCL 22B

An in-space construction (erectable) approach to assembling Freedom is planned but the increasing complexity of the station design along with a decrease in shuttle capability over the past several years has led to an assembly sequence that requires more resources (EVA, lift, volume) than the shuttle can provide given a fixed number of flights. One way to address these issues is to adopt a pre-integrated approach to assembling Freedom. A pre-integrated approach combines station primary structure and distributed systems into discrete sections that are assembled and checked out on the ground. The section is then launched as a single structural entity on the shuttle and attached to the orbiting station is then launched as a single structural entity on the shuttle and attached to the orbiting station with a minimum of EVA. The feasibility of a pre-integrated approach to assembling Freedon is discussed. The structural configuration, packaging, and shuttle integration of discrete pre-integrated elements for Freedom assembly are discussed. It is shown that the pre-integrated approach to assembly reduces EVA and increases shuttle margin with respect to mass, volume, and center of gravity limits when compared to the baseline Freedom assembly sequence. Author

N91-21221* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
OVERCENTER COLLET SPACE STATION TRUSS FASTENER Patent
PHILIP L. SHERIDAN, inventor (to NASA) 12 Mar. 1991 10 p
Filed 30 Apr. 1990 Supersedes N90-26859 (28 - 21, p 2966)
(NASA-CASE-MSC-21504-1; US-PATENT-4,998,842; US-PATENT-APPL-SN-516856; US-PATENT-CLASS-403-252; US-PATENT-CLASS-403-171; US-PATENT-CLASS-403-176; US-PATENT-CLASS-52-646; INT-PATENT-CLASS-B25G-3/00)
Avail: US Patent and Trademark Office CSCL 22B

A quick-connect fastener is arranged with a tubular body that is arranged to be engaged against the exterior surface of a hollow attachment fitting and coincidentally aligned with an opening in the fitting. A collet having normally-contracted fingers with outwardly-enlarged ends is operatively arranged in the body to be moved forwardly by an expander member mounted in the tubular body for advancing the collet fingers through the opening in the attachment fitting. Biasing means are arranged between the expander member and a toggle linkage in the tubular body which is selectively operated to urge the expander member forwardly into engagement with the collet fingers with an initial biasing force to advance their forward portions through the body opening and then expand them outwardly. The biasing means also provide a subsequent biasing force for retaining the collet members in their expanded positions once their enlarged forward end portions are on the opposite side of the body.

Official Gazette of the U.S. Patent and Trademark Office

N91-21222* *National Aeronautics and Space Administration.* Lyndon B. Johnson Space Center, Houston, TX.

ORBITAL DEBRIS SWEEPER AND METHOD Patent

ANDREW J. PETRO, inventor (to NASA) 12 Feb. 1991 7 p Filed 16 Feb. 1990 Supersedes N90-26860 (28 - 21, p 2966) (NASA-CASE-MSC-21534-1; US-PATENT-4,991,788; US-PATENT-APPL-SN-480985; US-PATENT-CLASS-244-158R; US-PATENT-CLASS-244-14; INT-PATENT-CLASS-B24G-1/00) Avail: US Patent and Trademark Office CSCL 22B

An orbital debris sweeper is provided for removing particles from orbit which otherwise may impact and damage an orbiting spacecraft. The debris sweeper includes a central sweeper core which carries a debris monitoring unit, and a plurality of large area impact panels rotatable about a central sweeper rotational axis. In response to information from the debris monitoring unit, a computer determines whether individual monitored particles preferably impact one of the rotating panels or pass between the rotating panels. A control unit extends or retracts one or more booms which interconnect the sweeper core and the panels to change the moment of inertia of the sweeper and thereby the rotational velocity of the rotating panels. According to the method of the present invention, the change in panel rotational velocity increases the frequency of particles which desirably impact one of the panels and are thereby removed from orbit, while large particles which may damage the impact panels pass between the trailing edge of one panel and the leading edge of the rotationally succeeding panel.

Official Gazette of the U.S. Patent and Trademark Office

N91-21556*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

DETERMINATION OF THE FLIGHT HARDWARE CONFIGURATION OF AN ENERGY ABSORBING ATTENUATOR FOR THE PROPOSED SPACE STATION CREW AND EQUIPMENT TRANSLATION AID CART

EDWIN L. FASANELLA, KAREN E. JACKSON (Army Aviation Research and Development Command, Hampton, VA.), LISA E. JONES, and JOHN E. TETER, JR. 1991 58 p

(Contract RTOP 505-63-01-11)

(NASA-TP-3084; L-16852; NAS 1.60:3084; AD-A235901) Avail: CASI HC A04/MF A01 CSCL 20K

A device incorporating a crushable honeycomb column as the energy dissipating mechanism was designed as an emergency stopping device for the crew and equipment translation aid (CETA) cart. The CETA cart is designed to transport astronauts along a monorail on the space station. Impact tests were performed to determine which honeycomb design provided a stopping force of 100 lbs and energy dissipation of at least 1650 in-lbs for 16.5 inches of stroke. A typical honeycomb column consisted of four 5 7/8 inch long segments of 75 psi honeycomb, separated by 1.5 inch diameter washers. The impact load was provided by a mass which was dropped from a sufficient height to provide 1/2 the equivalent energy of one astronaut plus equipment (500 lbs total) moving at 6 ft/sec. Specimen configurations having aluminum, polyethylene, and teflon washers were tested. Based on the results of impact tests, a honeycomb energy absorbing column with standard core, foil wrapping, and teflon washers was chosen for the CETA flight experiment. Author

N91-21579*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ON-ORBIT DAMAGE DETECTION AND HEALTH MONITORING OF LARGE SPACE TRUSSES: STATUS AND CRITICAL ISSUES

THOMAS A. L. KASHANGAKI Mar. 1991 14 p Presented at the 32nd Structures, Structural Dynamics and Materials Conference, Baltimore, MD, 8-10 Apr. 1991

(Contract RTOP 590-14-31-01)

(NASA-TM-104045; NAS 1.15:104045) Avail: CASI HC A03/MF A01 CSCL 20K

The long lifetimes, delicate nature and stringent pointing requirements of large space structures such as Space Station Freedom and geostationary Earth sciences platforms might require that these spacecraft be monitored periodically for possible damage to the load carrying structures. A review of the literature in damage detection and health monitoring of such structures is presented, along with a candidate structure to be used as a testbed for future work in this field. A unified notation and terminology is also proposed to facilitate comparisons between candidate methods. Author

N91-22018# Bell Telephone Labs., Inc., Holmdel, NJ.

LDR: A SUBMILLIMETER GREAT OBSERVATORY

ROBERT WILSON *In* ESA, From Ground-Based to Space-Borne Sub-mm Astronomy p 215-219 Dec. 1990

Copyright Avail: CASI HC A01/MF A03; EPD, ESTEC, Noordwijk, Netherlands, HC 80 Dutch guilders

The Large Deployable Reflector (LDR), a high Earth orbit free flying 10 to 20 m diameter deployable telescope, is described. The LDR is intended for use throughout the submillimeter band, using imaging receivers with unprecedented sensitivity and angular resolution. Its mission is to produce pictures of line emission regions in the solar neighborhood, in nearby galaxies and in objects at the edge of the known galaxy distribution. It is predicted to be an ideal instrument for exploring the first galaxies and protogalaxies as the submillimeter cooling lines should light up as soon as metals form. ESA

N91-22153*# Boeing Aerospace Co., Seattle, WA.

USE OF MAGNETIC SAILS FOR ADVANCED EXPLORATION MISSIONS

DANA G. ANDREWS and ROBERT M. ZUBRIN (Martin Marietta Aerospace, Denver, CO.) *In* NASA. Lewis Research Center, Vision-21: Space Travel for the Next Millennium p 202-210 Apr. 1990

Avail: CASI HC A02/MF A06 CSCL 22A

The magnetic sail, or magsail, is a field effect device which interacts with the ambient solar wind or interstellar medium over a considerable volume of space to generate drag and lift forces. Two theories describing the method of thrust generation are analyzed and data results are presented. The techniques for maintaining superconductor temperatures in interplanetary space are analyzed and low risk options presented. Comparisons are presented showing mission performance differences between currently proposed spacecraft using chemical and electric propulsion systems, and a Magsail propelled spacecraft capable of generating an average thrust of 250 Newtons at a radius of one A.U. The magsail also provides unique capabilities for interstellar missions, in that at relativistic speeds the magnetic field would ionize and deflect the interstellar medium producing a large drag force. This would make it an ideal brake for decelerating a spacecraft from relativistic speeds and then maneuvering within the target star system. Author

N91-22164*# General Atomic Co., San Diego, CA.

EXPLORATION OF PLANETESIMALS BY A TRIPARTITE TETHERED SPACECRAFT

RICHARD B. STEPHENS *In* NASA. Lewis Research Center, Vision-21: Space Travel for the Next Millennium p 341-345 Apr. 1990

Avail: CASI HC A01/MF A06 CSCL 22A

Asteroids and comets exert such a small gravitational force that it is not practical to survey them from orbit. One must instead continuously accelerate using maneuvering rockets to move around the surface. A space exploration craft in three parts connected by lightweight cables can survey asteroids and comets, and deploy landers, without requiring the large thrusters and the continuous depletion of fuel required by a single craft. The spacecraft is deployed by spinning up from a compact configuration using low thrust jets, and then maintain surveying orbit without any major *expenditure of energy. The triangular tether arrangement is stable,* but care must be taken in changing orbits and with deploying and recovering samples, as can be demonstrated with a simple simulation. Even 100 km long tethers occupy a low payload fraction. Author

N91-22165*# Hawaii Univ., Manoa. Dept. of Mechanical Engineering.
ON SPACE-BASED SETI
WILLEM STUIVER *In* NASA. Lewis Research Center, Vision-21: Space Travel for the Next Millennium p 346-350 Apr. 1990
Avail: CASI HC A01/MF A06 CSCL 22A

Space-based antenna systems for the search of signals from extra-terrestrial intelligence are discussed. Independent studies of the ecliptic solar-sailing transfer problem from the geosynchronous departure orbit to Sun-Earth collinear transterrestrial liberation point were conducted. They were based on a relatively simple mathematical model describing attitude-controlled spacecraft motion in the ecliptic plane as governed by solar and terrestrial gravitational attraction together with the solar radiation pressure. The resulting equations of motion were integrated numerically for a relevant range of values of spacecraft area-to-mass ratio and for an appropriate spacecraft attitude-control law known to lead to Earth escape. Experimentation with varying initial conditions in the departure orbit, and with attitude-control law modification after having achieved Earth escape, established the feasibility of component deployment by means of solar sailing. Details are presented. Author

N91-22309*# Temple Univ., Philadelphia, PA. Dept. of Electrical Engineering.
STABILIZATION OF LARGE SPACE STRUCTURES BY LINEAR RELUCTANCE ACTUATORS
SAROJ K. BISWAS and HENRY M. SENDAULA *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 1 p 15-21 Mar. 1991
Avail: CASI HC A02/MF A04 CSCL 22B

Application of magnetic forces are considered for stabilization of vibrations of flexible space structures. Three electromagnetic phenomena are studied, such as: (1) magnetic body force; (2) reluctance torque; and (3) magnetostriction, and their application is analyzed for stabilization of a beam. The magnetic body force actuator uses the force that exists between poles of magnets. The reluctance actuator is configured in such a way that the reluctance of the magnetic circuit will be minimum when the beam is straight. Any bending of the beam increases the reluctance and hence generates a restoring torque that reduces bending. The gain of the actuator is controlled by varying the magnetizing current. Since the energy density of a magnetic device is much higher compared to piezoelectric or thermal actuators, it is expected that the reluctance actuator will be more effective in controlling the structural vibrations. Author

N91-22363*# Alabama Univ., Tuscaloosa. Dept. of Engineering Mechanics.
MLIBLAST: A PROGRAM TO EMPIRICALLY PREDICT HYPERVELOCITY IMPACT DAMAGE TO THE SPACE STATION Final Report
WILLIAM K. RULE May 1991 191 p
(Contract NAG8-123)
(NASA-CR-184153; NAS 1.26:184153) Avail: CASI HC A09/MF A02 CSCL 22B

MLIBlast is described, which consists of a number of DOC PC based MIcrosoft BASIC program modules written to provide spacecraft designers with empirical predictions of space debris damage to orbiting spacecraft. The Spacecraft wall configuration is assumed to consist of multilayer insulation (MLI) placed between a Whipple style bumper and a pressure wall. Predictions are based on data sets of experimental results obtained from simulating debris impact on spacecraft. One module of MLIBlast facilitates creation of the data base of experimental results that is used by the damage *prediction modules of the code. The user has a choice of three* different prediction modules to predict damage to the bumper, the MLI, and the pressure wall. Author

N91-23289# TiNi Alloy Co., Oakland, CA.
SHAPE-MEMORY ALLOY TACTICAL FEEDBACK ACTUATOR, PHASE 1 Final Report, 1 Feb. - 1 Aug. 1989
A. D. JOHNSON Aug. 1990 36 p
(Contract F33615-88-C-0541)
(AD-A231389; AAMRL-TR-90-039-PHASE-1) Avail: CASI HC A03/MF A01 CSCL 06D

The hardware developed to realize a shape memory alloy (SMA) tactile stimulator is described. A 5x6 30 element array was developed to provide tactile stimulation to the human operator of a remotely controlled robotic system. It is verified that a tactile *stimulator can be packaged in finger-pad size arrays and that* computer control is feasible. Actuation profiles and design techniques are discussed. GRA

N91-24612*# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.).
DEVELOPMENT OF A RELATCHABLE COVER MECHANISM FOR A CRYOGENIC IR-SENSOR
R. BIRNER, G. LANGE, M. ROTH, and A. VOIT *In* JPL, The 25th Aerospace Mechanisms Symposium p 125-134 May 1991
Avail: CASI HC A02/MF A03 CSCL 13I

A cover mechanism for use on the Infrared Background Signature Survey (IBSS) cryostat was developed. The IBSS IR-instrument is scheduled for STS launch in early 1991 as a payload of the Shuttle Payload Satellite (SPS) 2. The cover is *hinged, with a motorized rope drive. During ground processing,* launch, entry, and landing, the cryostat, which houses the IR-instrument, is required to be a sealed vacuum tight container for cooling purposes and contamination prevention. When on orbit, the cover is opened to provide an unobstructed field of view for the IR-instrument. A positive seal is accomplished through the use of latch mechanism. The cover and the latch are driven by a common redundant actuator consisting of dc motors, spur gears, and a differential gear. Hall probe limit switches and position sensors (rotary variable transformer) are used to determine the position of the cover and the latch. The cover mechanism was successfully qualified for thermal vacuum (-25 to 35 C), acoustic noise, vibration (6 Gs sine, 9.7 G RMS) and life cycles. Constricting requirements, mechanical and electronic control design, specific design details, test results of functional performance, and environmental and life tests are described. Author

N91-24618*# Honeywell, Inc., Glendale, AZ. Satellites Systems Operations.
TOPEX HIGH-GAIN ANTENNA SYSTEM DEPLOYMENT ACTUATOR MECHANISM
STEPHEN R. JONES *In* JPL, The 25th Aerospace Mechanisms Symposium p 205-220 May 1991
Avail: CASI HC A03/MF A03 CSCL 13I

A deployment actuator mechanism was developed to drive a two-axis gimbal assembly and a high-gain antenna to a deployed and locked position on the Jet Propulsion Laboratory Ocean Topography Experiment (TOPEX) satellite. The Deployment Actuator Mechanism requirements, design, test, and associated problems and their solutions are discussed. Author

N91-24619*# Starsys Research Corp., Boulder, CO.
RESETTABLE BINARY LATCH MECHANISM FOR USE WITH PARAFFIN LINEAR MOTORS
DARYL MAUS and SCOTT TIBBITTS *In* JPL, The 25th Aerospace Mechanisms Symposium p 221-236 May 1991
Avail: CASI HC A03/MF A03 CSCL 13I

A new resettable Binary Latch Mechanism was developed utilizing a paraffin actuator as the motor. This linear actuator alternately latches between extended and retracted positions, maintaining either position with zero power consumption. The design evolution and kinematics of the latch mechanism are presented, as well as the development problems and lessons that were learned. Author

N91-24622*# Contraves Italiana, Rome.
SMA APPLICATIONS IN AN INNOVATIVE MULTISHOT DEPLOYMENT MECHANISM
D. STELLA, G. PEDRAZZOLI, G. SECCI, and C. PORTELLI (Italian Space Agency, Rome.) *In* JPL, The 25th Aerospace Mechanisms Symposium p 275-290 May 1991
Avail: CASI HC A03/MF A03 CSCL 13I

An innovative Deployment and Retraction hinge Mechanism (DARM) in the frame of a technological program is examined. The mechanism includes two restraint/release devices, which enable it to be stable in its stowed or deployed position while sustaining all associated loads, and to carry its payload by remote command. The main characteristics of the DARM are as follows: deployment and retraction movements are spring actuated; the available amount of functional sequences is almost unlimited; and no use of electrical motors is made. These features were accomplished by: the application of a special kinematic scheme to the mechanical connection between the spring motor and the swivel head arm; and the use of shape memory alloys (SMA) actuators for both release and spring recharge functions. DARM is thus a mechanism which can find many applications in the general space scenario of in-orbit maintenance and servicing. In such a frame, the DARM typical concept, which has a design close to very simple one-shot deployment mechanisms, has a good chance to replace existing analog machines. Potential items that could be moved by DARM are: booms for satellite instruments; antenna reflector tips; entire antenna reflectors; and solar panels. Author

N91-25167*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
THERMALLY ISOLATED DEPLOYABLE SHIELD FOR SPACECRAFT Patent Application
JOHN W. REDMON, JR., inventor (to NASA), ANDRE E. MILLER, inventor (to NASA), BOBBY E. LAWSON, inventor (to NASA), and WILLIAM E. COBB, inventor (to NASA) 18 Apr. 1991 25 p
(NASA-CASE-MFS-28524-1; NAS 1.71:MFS-28524-1; US-PATENT-APPL-SN-691610) Avail: CASI HC A03/MF A01 CSCL 22B

A thermally isolated deployable shield for spacecraft is provided utilizing a plurality of lattice panels stowable generally against the craft and deployable to some fixed distance from the craft. The lattice panels are formed from replaceable shield panels affixed to lattice structures. The lattice panels generally encircle the craft providing 360 degree coverage therearound. Actuation means are provided from translating the shield radially outward from the craft and thermally isolating the shield from the craft. The lattice panels are relatively flexible, allowing the shield to deploy to variable diameters while retaining uniform curvature thereof. Restraining means are provided for holding the shield relatively tight in its stowed configuration. Close-out assemblies provide light sealing and protection of the annular spaces between the deployed shield and the crafts end structure. NASA

N91-27198*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPARISON OF STRUCTURAL PERFORMANCE OF ONE- AND TWO-BAY ROTARY JOINTS FOR TRUSS APPLICATIONS
J. DOUGLAS VAIL and MARK S. LAKE Washington Aug. 1991 25 p
(Contract RTOP 506-43-41-02)
(NASA-TM-4282; L-16904; NAS 1.15:4282) Avail: CASI HC A03/MF A01 CSCL 22B

The structural performance of one- and two-bay large-diameter discrete-bearing rotary joints was addressed for application to truss-beam structures such as the Space Station Freedom. Finite element analyses are performed to determine values for rotary joint parameters that give the same bending vibration frequency as the parent truss beam. The structural masses and maximum internal loads of these joints are compared to determine their relative structural efficiency. Results indicate that no significant difference exists in the masse of one- and two-bay rotary joints. This conclusion is reinforced with closed-form calculations of rotary joint structural efficiency in extension. Also, transition truss-member loads are higher in the one-bay rotary joint. However, because of the increased buckling strength of these members, the external load-carrying capability of the one-bay concept is higher than that of the two-bay concept. Author

N91-27199* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SYNCHRONOUSLY DEPLOYABLE DOUBLE FOLD BEAM AND PLANAR TRUSS STRUCTURE Patent
MARVIN D. RHODES, inventor (to NASA) and JOHN M. HEDGEPETH, inventor (to NASA) (Astro Research Corp., Carpinteria, CA.) 21 May 1991 14 p Filed 22 Aug. 1986
(NASA-CASE-LAR-13490-1; US-PATENT-5,016,418; US-PATENT-APPL-SN-899683; US-PATENT-CLASS-52-646; US-PATENT-CLASS-403-72; INT-PATENT-CLASS-E04H-12/18)
Avail: US Patent and Trademark Office CSCL 22B

A deployable structure that synchronously deploys in both length and width is disclosed which is suitable for use as a structural component for orbiting space stations or large satellites. The structure is designed with maximum packing efficiency so that large structures may be collapsed and transported in the cargo bay of the Space Shuttle. The synchronous deployment feature allows the structure to be easily deployed in space by two astronauts, without a complex deployment mechanism. The structure is made up of interconnected structural units, each generally in the shape of a parallelepiped. The structural units are constructed of structural members connected with hinged and fixed connections at connection nodes in each corner of the parallelepiped. Diagonal members along each face of the parallelepiped provide structural rigidity and are equipped with mid-length, self-locking hinges to allow the structure to collapse. The structure is designed so that all hinged connections may be made with simple clevis-type hinges requiring only a single degree of freedom, and each hinge pin is located along the centerline of its structural member for increased strength and stiffness.
Official Gazette of the U.S. Patent and Trademark Office

N91-27613*# Sverdrup Technology, Inc., Brook Park, OH.
DESIGN, OPTIMIZATION, AND ANALYSIS OF A SELF-DEPLOYING PV TENT ARRAY Final Report
ANTHONY J. COLLOZZA Jun. 1991 18 p Presented at the 26th Intersociety Energy Conversion Engineering Conferences, Boston, MA, 4-9 Aug. 1991; sponsored by ANS, SAE, ACS, AIAA, ASME, IEEE, and AIChE
(Contract NAS3-25266; RTOP 593-14-11)
(NASA-CR-187119; E-6252; NAS 1.26:187119) Avail: CASI HC A03/MF A01 CSCL 10B

A tent shaped PV array was designed and the design was optimized for maximum specific power. In order to minimize output power variation a tent angle of 60 deg was chosen. Based on the chosen tent angle an array structure was designed. The design considerations were minimal deployment time, high reliability, and small stowage volume. To meet these considerations the array was chosen to be self-deployable, form a compact storage configuration, using a passive pressurized gas deployment mechanism. Each structural component of the design was analyzed to determine the size necessary to withstand the various forces to which it would be subjected. Through this analysis the component weights were determined. An optimization was performed to determine the array dimensions and blanket geometry which produce the maximum specific power for a given PV blanket. This optimization was performed for both lunar and Martian environmental conditions. Other factors such as PV blanket types, structural material, and wind velocity (for Mars array), were varied to determine what influence they had on the design point. The performance specifications for the array at both locations and with each type of PV blanket were determined. These specifications were calculated using the Arimid fiber composite as the structural material. The four PV blanket types considered were silicon, GaAs/Ge, GaAsCLEFT, and amorphous silicon. The specifications used for each blanket represented either present day or near term technology. For both the Moon and Mars the amorphous silicon arrays produced the highest specific power. Author

N91-28109*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
END-EFFECTOR-JOINT CONJUGATES FOR ROBOTIC ASSEMBLY OF LARGE TRUSS STRUCTURES IN SPACE: A SECOND GENERATION
WILLIAM V. BREWER *In* Alabama A & M Univ., NASA-HBCU Space Science and Engineering Research Forum Proceedings p 336-342 1989 Prepared in cooperation with Jacksonville State Univ., AL
Avail: CASI HC A02/MF A04 CSCL 06K

Attachment of strut to node can be accomplished with a variety of mechanisms. All require extensive standoff elements (called scars) added to the nodes. These increase packaging volume for the nodes by as much as 300 percent. First generation designs also tend to be either heavy or expensive due to complex parts. Screws thread mechanisms are discussed simplest and most easily manufactured of alternatives. Torque and rotational motion must be transmitted across the strut to end-effector interface accomplishing the joining process and establishing a specific preload. Four drive mechanisms are considered: worm, helical, bevel, and differential gears. Author

N91-28190 Alabama Univ., Huntsville.
DISCRETE POSYNOMIAL PROGRAMMING WITH APPLICATIONS TO SPACECRAFT PROTECTIVE STRUCTURES DESIGN OPTIMIZATION Ph.D. Thesis
ROBERT ALAN MOG 1990 168 p
Avail: Univ. Microfilms Order No. DA9113971

The development of a discrete optimization technique for posynomial programs results in global nonlinear optimization under duality. The dual-to-primal variable transformation is eased under what is defined as posyserparable conditions. Additionally, partial invariance approaches may be successfully used under these conditions to reduce dual program degree of difficulty. Primal approaches using penalty function techniques supported by search methods result in less derivation and sufficiently fast convergence, but no guarantee of global optimality and little analytic information. Both dual and primal techniques have excellent application to discrete protective structures design optimization problems employing hypervelocity impact predictors. Dissert. Abstr.

N91-28580*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NONCIRCULAR ROLLING JOINTS FOR VIBRATIONAL REDUCTION IN SLEWING MANEUVERS Patent Application
MENG-SANG CHEW, inventor (to NASA) (Old Dominion Univ., Norfolk, VA.), JER-NAN JUANG, inventor (to NASA), and LI-FARN YANG, inventor (to NASA) 28 Mar. 1991 22 p
(NASA-CASE-LAR-14515-1-CU; NAS 1.71:LAR-14515-1-CU; US-PATENT-APPL-SN-678551) Avail: CASI HC A03/MF A01 CSCL 13K

A rolling joint is provided for obtaining slewing maneuvers for various apparatus including space structures, space vehicles, robotic manipulators and simulators. Two noncircular cylinders, namely a drive and a driven cylinder, are provided in driving contact with one another. This contact is maintained by two pairs of generally S-shaped bands, each pair forming a generally 8-shaped coupling tightly about the circumferential periphery of the noncircular drive and driven cylinders. A stationarily fixed arm extends between and is rotably journalled with a drive axle and a spindle axle respectively extending through selected rotational points of the drive cylinder and of the driven cylinder. The noncircular cylinders are profiled to obtain the desired varying gear ratio. The novelty of the present invention resides in using specifically profiled noncircular cylinders to obtain a desired varying gear ratio. NASA

N91-29213*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
WHIPPLE BUMPER SHIELD SIMULATIONS
E. S. HERTEL, L. C. CHHABILDAS (Sandia National Labs., Albuquerque, NM.), and S. A. HILL 1991 4 p Presented at the 1991 American Physical Society (APS) Conference on Shock Compression of Condensed Matter, Williamsburg, 17-20 Jul. 1991
(Contract DE-AC04-76DP-00789)
(NASA-TM-105089; NAS 1.15:105089; DE91-014896; SAND-91-1227C; CONF-9107105-45) Avail: CASI HC A01/MF A01 CSCL 22B

The Whipple bumper is a space shield designed to protect a space station from the most hazardous orbital space debris environment. A series of numerical simulations has been performed using the multi-dimensional hydrodynamics code CTH to estimate the effectiveness of the thin Whipple bumper design. These simulations are performed for impact velocities of (approximately)10 km/s which are now accessible by experiments using the Sandia hypervelocity launcher facility. For a (approximately)10 km/s impact by a 0.7 gm aluminum flier plate, the experimental results indicate that the debris cloud resulting upon impact of the bumper shield by the flier plate, completely penetrates the sub-structure. The CTH simulations also predict complete penetration by the subsequent debris cloud. DOE

N91-30193# Oklahoma Univ., Norman. Dept. of Mathematics.
ESTIMATION OF ELASTIC PARAMETERS IN LINEAR AND NONLINEAR DISTRIBUTED MODELS OF PLATES ARISING IN LARGE FLEXIBLE SPACE STRUCTURES Final Report, 30 Sep. 1987 - 29 Oct. 1990
LUTHER W. WHITE Oct. 1990 26 p
(Contract AF-AFOSR-0368-87)
(AD-A229527; AFOSR-90-1158TR) Avail: CASI HC A03/MF A01 CSCL 12A

During the period covered by the grant over 20 research articles were written. Titles include: Identification of Cauchy Data in Nonlinear First Order Hyperbolic Systems, Control of Certain Dynamic Models of Beams and Plates, Identification of Elastic Parameters in von Karman Plate Models, and Identification of a Coefficient of Conductivity from Potential Measurements. GRA

N91-30565*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
STRUCTURAL DESIGN CONCEPTS FOR A MULTI-MEGAWATT SOLAR ELECTRIC PROPULSION (SEP) SPACECRAFT
CHARLES LAWRENCE and J. MARK HICKMAN Aug. 1991 19 p
(NASA-TM-105148; NAS 1.15:105148) Avail: CASI HC A03/MF A01 CSCL 20K

As a part of the Space Exploratory Initiative (SEI), NASA-Lewis is studying Solar Electric Propulsion (SEP) spacecraft to be used as a cargo transport vehicle to Mars. Two preliminary structural design concepts are offered for SEP spacecraft: a split blanket array configuration, and a ring structure. The split blanket configuration is an expansion of the photovoltaic solar array design proposed for Space Station Freedom and consists of eight independent solar blankets stretched and supported from a central mast. The ring structural concept is a circular design with the solar blanket stretched inside a ring. This concept uses a central mast with guy wires to provide additional support to the ring. The two design concepts are presented, then compared by performing stability, normal modes, and forced response analyses for varying levels of blanket and guy wire preloads. The ring structure configuration is shown to be advantageous because it is much stiffer, more stable, and deflects less under loading than the split blanket concept. Author

N91-30751*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
EMPIRICAL PREDICTIONS OF HYPERVELOCITY IMPACT DAMAGE TO THE SPACE STATION
W. K. RULE (Alabama Univ., Tuscaloosa.) and K. B. HAYASHIDA

Jul. 1991 40 p
(NASA-TM-103550; NAS 1.15:103550) Avail: CASI HC A03/MF A01 CSCL 09B

A family of user-friendly, DOS PC based, Microsoft BASIC programs written to provide spacecraft designers with empirical predictions of space debris damage to orbiting spacecraft is described. The spacecraft wall configuration is assumed to consist of multilayer insulation (MLI) placed between a Whipple style bumper and the pressure wall. Predictions are based on data sets of experimental results obtained from simulating debris impacts on spacecraft using light gas guns on Earth. A module of the program facilitates the creation of the data base of experimental results that are used by the damage prediction modules of the code. The user has the choice of three different prediction modules to predict damage to the bumper, the MLI, and the pressure wall. One prediction module is based on fitting low order polynomials through subsets of the experimental data. Another prediction module fits functions based on nondimensional parameters through the data. The last prediction technique is a unique approach that is based on weighting the experimental data according to the distance from the design point. Author

N91-31204*# Science Applications International Corp., Huntsville, AL.
OPTIMIZATION TECHNIQUES APPLIED TO PASSIVE MEASURES FOR IN-ORBIT SPACECRAFT SURVIVABILITY Interim Report, period ending 30 Jun. 1991
ROBERT A. MOG and D. MARVIN PRICE Jun. 1991 192 p
(Contract NAS8-37378)
(NASA-CR-184198; NAS 1.26:184198) Avail: CASI HC A09/MF A02 CSCL 22B

Spacecraft designers have always been concerned about the effects of meteoroid impacts on mission safety. The engineering solution to this problem has generally been to erect a bumper or shield placed outboard from the spacecraft wall to disrupt/deflect the incoming projectiles. Spacecraft designers have a number of tools at their disposal to aid in the design process. These include hypervelocity impact testing, analytic impact predictors, and hydrodynamic codes. Analytic impact predictors generally provide the best quick-look estimate of design tradeoffs. The most complete way to determine the characteristics of an analytic impact predictor is through optimization of the protective structures design problem formulated with the predictor of interest. Space Station Freedom protective structures design insight is provided through the coupling of design/material requirements, hypervelocity impact phenomenology, meteoroid and space debris environment sensitivities, optimization techniques and operations research strategies, and mission scenarios. Major results are presented. Author

N91-31482 COM DEV Ltd., Cambridge (Ontario).
ANTENNA STUDY FOR 60 GHZ INTERSATELLITE LINK Final Report
SUBIR GHOSH 26 Apr. 1989 102 p
(Contract DREO-W7714-8-5734/01-ST)
(CD-RPT-ITL-5043-003; CTN-91-60178) Copyright Avail: CASI HC A06

This report describes a detailed study of the antenna design and operation for the 60 GHz intersatellite cross links to a geostationary relay satellite. Intersatellite links will be used extensively in the future to achieve global connectivity of satellite constellations. Scenarios for inter-orbital linkages were examined with respect to the following antenna characteristics: inter-orbital link parameters, pointing and tracking requirements, radio frequency (RF) design encompassing transmission and receiving links, tracking and anti-jamming measures, mechanical and thermal design, positioner mechanism, mounting and deployment, and signal routing. A comparative study of the options is given wherever appropriate, to highlight the key features. The key features of the proposed antenna system are: (1) a rotating reflector design to allow tracking with a fast moving satellite; (2) a beam waveguide arrangement which allows the transmitter and receiver equipment to be entirely located in a controlled environment; (3) a multi-function feed system (transmit receive, beacon) inside the antenna boom ensures a reliable and compact feed network; and (4) positional mechanisms for azimuth and elevation tracking that allow unconstrained RF signal routing through beam waveguides. Author (CISTI)

N91-32498* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
TWO FAULT TOLERANT TOGGLE-HOOK RELEASE Patent
THOMAS JOSEPH GRAVES, inventor (to NASA) and CHRISTOPHER WILLIAM BROWN, inventor (to NASA) 10 Sep. 1991 12 p Filed 25 Oct. 1990 Supersedes N91-13723 (29 - 5, p 670)
(NASA-CASE-MSC-21671-1; US-PATENT-5,046,395; US-PATENT-APPL-SN-603337; US-PATENT-CLASS-89-1.14; US-PATENT-CLASS-89-1.57; US-PATENT-CLASS-102-378; US-PATENT-CLASS-294-82.26; INT-PATENT-CLASS-B64D-1/12)
Avail: US Patent and Trademark Office CSCL 13I

A coupling device is disclosed which is mechanically two fault tolerant for release. The device comprises a fastener plate and fastener body, each of which is attachable to a different one of a pair of structures to be joined. The fastener plate and body are coupled by an elongate toggle mounted at one end in a socket on the fastener plate for universal pivotal movement thereon. The other end of the toggle is received in an opening in the fastener body and adapted for limited pivotal movement therein. The toggle is adapted to be restrained by three latch hooks arranged in symmetrical equiangular spacing about the axis of the toggle, each hook being mounted on the fastener body for pivotal movement between an unlatching non-contact position with respect to the toggle and a latching position in engagement with a latching surface of the toggle. The device includes releasable lock means for locking each latch hook in its latching position whereby the toggle couples the fastener plate to the fastener body and means for releasing the lock means to unlock each said latch hook from the latch position whereby the unlocking of at least one of the latch hooks from its latching position results in the decoupling of the fastener plate from the fastener body.
Official Gazette of the U.S. Patent and Trademark Office

07

VIBRATION & DYNAMIC CONTROLS

Design and analysis of structural dynamics. Includes descriptions of analytical techniques and computer codes, trade studies, requirements and descriptions of orbit maintenance systems, rigid and flexible body attitudesensing systems and controls.

A91-32955# Colorado Univ., Boulder.
DYNAMICS OF THREE-DIMENSIONAL SPACE CRANE - MOTION REQUIREMENTS AND COMPUTATIONAL CONSIDERATIONS
K. C. PARK, J. C. CHIOU, J. D. DOWNER, C. FARHAT (Colorado, University, Boulder), G. S. CHEN, and B. K. WADA (JPL, Pasadena, CA) ASME, Winter Annual Meeting, Dallas, TX, Nov. 25-30, 1990. 12 p. refs
(Contract NAG1-756)
(ASME PAPER 90-WA/AERO-7)

Preliminary design requirements for a space crane are surveyed and some theoretical and computational issues that need to be addressed in support of the design activities are identified. Computational experiments conducted so far on rigid space crane models indicate that the sizing of joint actuators and operational constraints can be assessed by quasi-static rigid crane maneuvering simulations. Limited numerical experiments on flexible crane models raise several difficulties in developing control strategies, maneuvering speeds, maximum torque sustainable, and modeling detailed flexibility effects on the tip positioning accuracy.

Computational algorithms development that will alleviate some of these difficulties are discussed and illustrated via example test runs. Author

A91-33201*# California Univ., Los Angeles.
MODELLING AND CONTROL OF LARGE SPACE STRUCTURES
A. V. BALAKRISHNAN (California, University, Los Angeles) International Federation for Information Processing, International Conference on Modeling the Innovation, Rome, Italy, Mar. 21-23, 1990, Paper. 10 p. refs
(Contract NCC2-374)
Currently NASA, USA, has under active study and development several large structures for deployment in space. These include for instance beam-like trusses to serve as antenna masts and/or basic building blocks for Space Station construction. An important design consideration is that of assuring adequate stability of the structure in the space environment and in addition in the case of antennas, meeting stringent pointing accuracy requirements. This paper addresses some of the basic design considerations involved such as: (1) modeling flexible multibody dynamics, including sensors and actuators, (2) identifying/monitoring model parameters in orbit, and (3) integrated controls-structures optimization with emphasis on novel concepts and techniques. Author

A91-33610
ATTITUDE DETERMINATION CONCEPTS FOR THE SPACE STATION FREEDOM
BILL JONES (Honeywell Space Systems Group, Clearwater, FL) IN: IEEE PLANS '90 - Position Location and Navigation Symposium, Las Vegas, NV, Mar. 20-23, 1990, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 94-101.
Copyright
The requirements, technical approach, and key features of the attitude determination system (ADS) being developed for the space station Freedom are described. Use of current technology provides new capabilities for all attitude autonomous operation and rapid determination of attitude in a debris-filled environment. The ADS is implemented using star trackers with fixed mosaic array detectors and inertial sensors based on current laser gyro technology. Star catalog characteristics, star identification techniques, the functional implementation of the ADS system, and the results of preliminary covariance performance analyses are presented. Covariance analysis indicates that the stringent accuracy requirements of the space station can be met with the baseline system. The automated ADS mechanization provides rapid attitude acquisition from any orientation where stars are visible; astronaut intervention is not required. The inertial sensors and the star trackers are on-orbit replaceable, are highly reliable, and promise long-life operation. I.E.

A91-33931* Harris Government Aerospace Systems Div., Melbourne, FL.
ROBUST DECENTRALIZED CONTROL LAWS FOR THE ACES STRUCTURE
EMMANUEL G. COLLINS, JR., DOUGLAS J. PHILLIPS, and DAVID C. HYLAND (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 11, April 1991, p. 62-70. refs
(Contract NAS1-18872)
Copyright
Control system design for the Active Control Technique Evaluation for Spacecraft (ACES) structure at NASA Marshall Space Flight Center is discussed. The primary objective of this experiment is to design controllers that provide substantial reduction of the line-of-sight pointing errors. Satisfaction of this objective requires the controllers to attenuate beam vibration significantly. The primary method chosen for control design is the optimal projection approach for uncertain systems (OPUS). The OPUS design process allows the simultaneous tradeoff of five fundamental issues in control design: actuator sizing, sensor accuracy, controller order, robustness, and system performance. A brief description of the basic ACES configuration is given. The development of the models used for control design and control design for eight system loops that were selected by analysis of test data collected from the structure are discussed. Experimental results showing that very significant performance improvement is achieved when all eight feedback loops are closed are presented. I.E.

A91-34146*# VMA Engineering, Goleta, CA.
CONTROL-AUGMENTED STRUCTURAL SYNTHESIS WITH DYNAMIC STABILITY CONSTRAINTS
H. L. THOMAS (VMA Engineering, Goleta, CA) and L. A. SCHMIT, JR. (California, University, Los Angeles) AIAA Journal (ISSN 0001-1452), vol. 29, April 1991, p. 619-626. Previously cited in issue 12, p. 1897, Accession no. A89-30704. refs
(Contract NSG-1490)
Copyright

A91-34148*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SYSTEM IDENTIFICATION TEST USING ACTIVE MEMBERS
JAY-CHUNG CHEN (Hong Kong University of Science and Technology, Kowloon) and JAMES L. FANSON (JPL, Pasadena, CA) AIAA Journal (ISSN 0001-1452), vol. 29, April 1991, p. 633-640. Previously cited in issue 12, p. 1796, Accession no. A89-30772. refs
Copyright

A91-34459
SHAPE CONTROL OF FLEXIBLE STRUCTURES
TOSHIO KASHIWASE, MASAKI TABATA, KAZUO TSUCHIYA (Mitsubishi Electric Corp., Amagasaki, Japan), and SADAO AKISHITA (Ritsumeikan University, Kyoto, Japan) Journal of Intelligent Material Systems and Structures (ISSN 1045-389X), vol. 2, Jan. 1991, p. 110-125. refs
Copyright
A shape control algorithm for a large flexible structure is proposed: (1) a reduced order model, which represents the precise shape of a structure; (2) a shape estimation filter, which reduces the estimation error caused not only by the white noises of sensor measurements but also by the variation of the D.C. offsets of sensors; (3) a simple and robust controller to regulate many state variables by using many sensors and actuators. The controller is realized by a zero proportional, integral, derivative controller (zero P-ID controller) with the concept of low authority control/high authority control (LAC/HAC). The proposed shape control algorithm is illustrated through applications to a numerical model of an experimental setup. Author

A91-34948#
TECHNOLOGY DEVELOPMENT FOR NON-CONTACT MEASUREMENT IN MODAL TESTING OF LARGE SPACE STRUCTURES
Y. SOUCY, W. B. GRAHAM (Canadian Space Agency, Ottawa, Canada), A. K. MITCHELL, and C. R. HAZELL (Nova Scotia, Technical University, Halifax, Canada) IN: CASI Conference on Astronautics, 6th, Ottawa, Canada, Nov. 19-21, 1990, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1990, 15 p. DND-supported research. refs
This paper describes the Canadian Space Agency's technology development project, in cooperation with the Defence Research Establishment Ottawa, to develop non-contact measurement systems for ground-based modal testing of Large Space Structures. The phases of the work are outlined, and the technical requirements and critical selection criteria for the systems are discussed. The two techniques of special interest which have emerged from the study to date are the projected grid and shadow Moire methods, and the application of a laser vibrometer. The Moire techniques are reviewed elsewhere. A description of the laser vibrometer is provided followed by a discussion of a new multichannel system to be developed using the laser vibrometer. Modal tests of a test article representative of a space structure are described and demonstrate the capabilities of the laser vibrometer system as well as the deficiencies of using accelerometers in testing lightweight structures. Author

A91-34963#
ON SOME KINEMATIC AND MASS CHARACTERISTICS OF FOLDABLE SOLAR ARRAYS
THOMAS SZIRTES (Spar Aerospace, Ltd., Weston, Canada) IN: CASI Conference on Astronautics, 6th, Ottawa, Canada, Nov. 19-21, 1990, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1990, p. 430-440.

The kinematic and mass characteristics of an unfolding solar array are analyzed. The deployment angle throughout the array is assumed to be constant. Other assumptions include identical lengths and negligible thickness and hinge dimensions. It is demonstrated that adjacent panels move in different ways: one will translate as the other rotates. Rotating panels are shown to have identical angular speed, while translating panels have variable velocities which equal the product of the tangential speed of the tip of the first panel and half of the panel number. The resultant moment of inertia and equivalent mass are defined and determined analytically. These inertial resistance quantities are shown to be independent of the array's deployment angle and thus time-invariant constants. They are also demonstrated to vary as the third power of the number of panels in an array. C.C.S.

A91-35476
INTERNATIONAL MODAL ANALYSIS CONFERENCE, 8TH, KISSIMMEE, FL, JAN. 29-FEB. 1, 1990, PROCEEDINGS. VOLS. 1 & 2
Conference sponsored by Union College and SEM. Bethel, CT, Society for Experimental Mechanics, Inc., 1990, p. Vol. 1, 759 p.; vol. 2, 785 p. For individual items see A91-35477 to A91-35538, A91-35540 to A91-35592.
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Various papers on modal analysis are presented. The general topics addressed include: experimental case histories, analytical methods, structural dynamics modification, linking analysis and test, processing modal data, modal test methods, system identification, modal techniques for rotating machinery, substructuring, noise/acoustics topics, experimental techniques, nonlinear structures, modeling structures, finite element analysis, seismic topics, space structures, vehicular topics, fundamentals of modal analysis, damping, excitation methods, design methods. C.D.

A91-35477* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
IDENTIFICATION CHALLENGES FOR LARGE SPACE STRUCTURES
RICHARD S. PAPPA (NASA, Langley Research Center, Hampton, VA) IN: International Modal Analysis Conference, 8th, Kissimmee, FL, Jan. 29-Feb. 1, 1990, Proceedings. Vol. 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1990, p. XV-XXIII. refs
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The paper examines the on-orbit modal identification of large space structures, stressing the importance of planning and experience, in preparation for the Space Station Structural Characterization Experiment (SSSCE) for the Space Station Freedom. The necessary information to foresee and overcome practical difficulties is considered in connection with seven key factors, including test objectives, dynamic complexity of the structure, data quality, extent of exploratory studies, availability and understanding of software tools, experience with similar problems, and pretest analytical conditions. These factors affect identification success in ground tests. Comparisons with similar ground tests of assembled systems are discussed, showing that the constraints of space tests make these factors more significant. The absence of data and experiences relating to on-orbit modal identification testing is shown to make identification a uniquely mathematical problem, although all spacecraft are constructed and verified by proven engineering methods. C.C.S.

A91-35479
EXPERIMENTAL AND THEORETICAL STUDY ON DAMPED JOINTS IN TRUSS STRUCTURE
HIDEHIKO MITSUMA, AKIO TSUJIHATA (NASDA, Tokyo, Japan), SHINYA SEKIMOTO, and FUMIHIRO KUWAO (Toshiba Corp., Kawasaki, Japan) IN: International Modal Analysis Conference, 8th, Kissimmee, FL, Jan. 29-Feb. 1, 1990, Proceedings. Vol. 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1990, p. 8-14.
Copyright

Damped joints which enhance the vibration controllability in truss structures have been developed and characterized. The damping and stiffness properties have been evaluated both experimentally and theoretically. Hysteresis loops between the load and displacement time histories obtained by the excitation test in the axial direction of the beam were analyzed to identify loss factors. Frequency response functions were also measured to identify modal characteristics of the damped joint. Parametric surveys were performed to examine the effects of thickness and length of the Viscoelastic materials and the constraint layers. Finite element models were evaluated using NASTRAN complex eigenvalue analysis. There was good agreement between experimental and theoretical results. The results shows that well-tuned damped joints can yield good damping effects to truss structures. The damped joints were applied to a large space structure. Author

A91-35483
MODEL IMPROVEMENT BY USING SUBSTRUCTURE MODAL TESTING RESULTS CASE STUDY
CONSTANTINOS MINAS and DANIEL J. INMAN (New York, State University, Buffalo) IN: International Modal Analysis Conference, 8th, Kissimmee, FL, Jan. 29-Feb. 1, 1990, Proceedings. Vol. 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1990, p. 62-66. refs
Copyright

Large flexible structures like space structures can be modeled by very large models divided into substructures which are low in dimension and which can be easily treated by model correction algorithms. In this paper, the application of model improvement to such subassemblies in order to obtain a full-order model which is in better agreement with experimentally obtained natural frequencies and mode shapes is discussed. A simple one-bay substructure is tested and its material properties and mass distribution along its lines and joints are determined. The necessary degrees of freedom and number of nodal points per bay are determined. These findings are used to model two structures: a two-dimensional one in the clamped-free configuration and a second one in the free-free boundary condition. The experimental boundary conditions are successfully identified, resulting in more accurate finite element models. C.D.

A91-35501
COMBINED MODAL SYNTHESIS TECHNIQUES AND RESIDUAL FLEXIBILITY FOR LARGE STRUCTURES
MOKHTAR ELNOMROSSY (Military Technical College, Cairo, Egypt) IN: International Modal Analysis Conference, 8th, Kissimmee, FL, Jan. 29-Feb. 1, 1990, Proceedings. Vol. 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1990, p. 255-262. refs
Copyright

The residual flexibility concept related to modal synthesis techniques is used to counterbalance the effect of omitted higher modes and to make computed eigenvalues more accurate. The work introduces an assumed link of flexibility, connected in series to the physical link in traditional stiffness coupling methods. The fictive link equals the sum of residual flexibilities of both components at the interface degree of freedom. The method is tested on a framed structure for verification. Errors in the first seven natural frequencies did not exceed 10 percent for the finite-element model, although the coupling equations had fewer degrees of freedom than the actual practical structure considered. The efficacy of residual flexibility to improve the accuracy of calculated natural frequencies varies directly with the stiffness of the coupling. The techniques present an efficient process applicable to large realistic structures using limited-capacity computers. C.C.S.

A91-35504
MODAL TEST OF A LARGE SPACECRAFT USING A MASS LOADED INTERFACE
J. M. HAUGHTON (Kinetic Research Corp., Madison, WI), J. A. HAUSER, and L. M. TURNER (U.S. Navy, Naval Research Laboratory, Washington, DC) IN: International Modal Analysis Conference, 8th, Kissimmee, FL, Jan. 29-Feb. 1, 1990, Proceedings. Vol. 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1990, p. 322-328.
Copyright

A modal test was performed on a large spacecraft structure for the purpose of checking the validity of a structural Nastran model. The test was unique in that an inertial mass base plate was used to load the system interface. The system, comprised of the spacecraft, adapter and inertial interface mass, was supported by a low frequency isolation system which provided free-free boundary conditions. Modal parameters and displacement vectors were calculated and used to refine and verify the mathematical Nastran model of the structure. Author

A91-35525
IDENTIFICATION AND CORRECTION OF ERRORS IN ANALYTICAL MODELS USING TEST DATA - THEORETICAL AND PRACTICAL BOUNDS
MICHAEL LINK (Kassel, Gesamthochschule, Federal Republic of Germany) IN: International Modal Analysis Conference, 8th, Kissimmee, FL, Jan. 29-Feb. 1, 1990, Proceedings. Vol. 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1990, p. 570-578. refs
Copyright

A classification of possible error sources in an analytical model is presented, and their influence is discussed with reference to the mass and stiffness matrices, the modal data, and especially the error indicators used in the different localization procedures. Bounds for error localization are presented. In order to derive practical bounds, the influence of a typical measurement environment, as given by incomplete and noisy test data on the error indicators is investigated. Using a simple academic bar example, it is shown how modeling and measurement errors are superimposed. The limits for successfull error localization and subsequent model updating in presence of realistic test data are discussed. Author

A91-35532* Old Dominion Univ., Norfolk, VA.
EIGENSENSITIVITY ANALYSIS FOR SPACE STRUCTURES
JEAN W. HOU and SEAN P. KENNY (Old Dominion University, Norfolk, VA) IN: International Modal Analysis Conference, 8th, Kissimmee, FL, Jan. 29-Feb. 1, 1990, Proceedings. Vol. 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1990, p. 622-628. refs
(Contract NAS1-18485)
Copyright

The main thrust of this paper is to study eigensensitivity analysis techniques and their applications to design optimization of space structures. It is found that in general, space structures show four types of eigenvalue problems most of which are related to repeated eigenvalues. This paper first gives a detailed derivation of eigensensitivity equations. Later, numerical examples are provided to verify the derived sensitivity equations as well as to demonstrate the applicability of those sensitivity equations in an iterative design environment. Author

A91-35540* State Univ. of New York, Buffalo.
MODELING AND TACHOMETER FEEDBACK IN THE CONTROL OF AN EXPERIMENTAL SINGLE LINK FLEXIBLE STRUCTURE
EPHRAHIM GARCIA and DANIEL J. INMAN (New York, State University, Buffalo) IN: International Modal Analysis Conference, 8th, Kissimmee, FL, Jan. 29-Feb. 1, 1990, Proceedings. Vol. 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1990, p. 735-740. refs
(Contract F49620-86-C-0011; NGT-33-183-804)
Copyright

In this work a formulation for the modeling of a single link flexible structure will be introduced that includes the effects of dynamic interaction between the actuator and structure. These effects are the rotational modal participation factors for the structure's vibratory motion that occurs at the slewing axis. It will be shown, both theoretically and experimentally, that this dynamic interaction can be advantageous for vibration suppression of the flexible modes of the system during slewing positioning maneuvers. Author

A91-35547
FREE BODY STRUCTURAL SYSTEM IDENTIFICATION USING CONSTRAINED TEST DATA
ALEX BERMAN (Kaman Aerospace Corp., Bloomfield, CT) IN: International Modal Analysis Conference, 8th, Kissimmee, FL, Jan. 29-Feb. 1, 1990, Proceedings. Vol. 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1990, p. 788-791. refs
Copyright

A method is described which has the capability to improve the dynamic equations of a free body using data obtained from an elastically constrained dynamic test. The method uses: an analytically derived approximation to the free system equations; measured normal modes and frequencies; and the assumed known characteristics of the test supports. The procedure is an extension of previous methods which find the minimum necessary changes in the mass and stiffness matrices. The resulting equations are consistent with the rigid body modes, preserve all free rigid body mass and stiffness characteristics, and exactly predict all the test results when the support parameters are added to the resulting free body equations. The procedure is expected to be especially useful in applications to large and very flexible space structures which cannot be tested on the ground without supports which produce large changes in dynamic characteristics. Author

A91-35556* SDRC, Inc., San Diego, CA.
SIMULATION OF ON-ORBIT MODAL TESTS OF LARGE SPACE STRUCTURES
PAUL BLELLOCH, CHARLIE ENGELHARDT, and DAVID L. HUNT (SDRC, Inc., Engineering Services Div., San Diego, CA) IN: International Modal Analysis Conference, 8th, Kissimmee, FL, Jan. 29-Feb. 1, 1990, Proceedings. Vol. 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1990, p. 926-932. NASA-sponsored research. refs
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This paper describes a procedure to analytically simulate a modal test of an on-orbit large space structure (LSS), extract the modal properties, and evaluate the success of the modal test. This procedure addresses some of the major challenges to performing an on-orbit modal test of an LSS including high modal density, low frequency modes, and limitations in excitation capabilities. A finite element model of the orbiting structure is used to predict acceleration responses due to thruster excitations, time-domain modal extraction methods are used to estimate the modal properties, and comparison of frequencies and cross-orthogonality values is used to evaluate the success of the modal test. Several alternative excitation patterns and sensor arrangements were evaluated using a space station model as an example. Results of the simulations indicate that the choice of excitation functions is critical to the success of the test. Author

A91-35557
COMBINED HIGH LEVEL ACOUSTIC AND MECHANICAL VIBRATION TESTING AND ANALYSIS
AARON SALZBERG (U.S. Navy, Naval Research Laboratory, Washington, DC) and JAMES HOUGHTON (Kinetic Research Corp., Annapolis, MD) IN: International Modal Analysis Conference, 8th, Kissimmee, FL, Jan. 29-Feb. 1, 1990, Proceedings. Vol. 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1990, p. 933-939. SDIO-supported research.
Copyright

The application of test data from a combined random vibration/high level acoustic (vibroacoustic) test of the Low powered Altitude Compensation Experiment to evaluate preliminary component random vibration specifications is discussed. It is shown that the combined vertical random vibroacoustic test is a viable, realistic test to accurately reproduce the launch environment. It also presents the random acoustic and vibration loads acting on the structure and allows for energy input throughout the entire spectrum. R.E.P.

A91-35574* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

AN ENHANCED SINE DWELL METHOD AS APPLIED TO THE GALILEO CORE STRUCTURE MODAL SURVEY

KENNETH S. SMITH and MARC TRUBERT (JPL, Pasadena, CA) IN: International Modal Analysis Conference, 8th, Kissimmee, FL, Jan. 29-Feb. 1, 1990, Proceedings. Vol. 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1990, p. 1214-1220. refs

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An incremental modal survey performed in 1988 on the core structure of the Galileo spacecraft with its adapters with the purpose of assessing the dynamics of the new portions of the structure is considered. Emphasis is placed on the enhancements of the sine dwell method employed in the test. For each mode, response data is acquired at 32 frequencies in a narrow band enclosing the resonance, utilizing the SWIFT technique. It is pointed out that due to the simplicity of the data processing involved, the diagnostic and modal-parameter data is available within several minutes after data acquisition; however, compared with straight curve-fitting approaches, the method requires more time for data acquisition. V.T.

A91-36657

SPATIAL PSDS OF OPTICAL STRUCTURES DUE TO RANDOM VIBRATION

SIMON C. F. SHENG (Hughes Danbury Optical Systems, Inc., CT) IN: Advances in optical structure systems; Proceedings of the Meeting, Orlando, FL, Apr. 16-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 121-128.

Copyright

The paper presents two methods for connecting the standard random vibration output - numerous pointwise temporal power spectral densities (PSDs) - to spatial PSDs, as a means for eliminating ground vibration effects. Spatial PSDs are measured with interferometers. Method 1 employs direct integration beginning with the mathematical definition of a function's PSD. Method 2 utilizes the connection between temporal PSD and two-dimensional spatial PSD found in atmospheric disturbance. A structural model is used for both methods to simulate the response of a large parabolic mirror from the AXAF project. Presented graphically, meridian responses from horizontal and vertical PSDs show peaks that are related to the natural frequencies of the structure when subjected to the input excitations. The two methods are shown to agree analytically and experimentally. Temporal PSD responses may be transformed into spatial PSD responses to verify interferometer measurements, thereby permitting the analysis of ground vibration effects. C.C.S.

A91-36665* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

MEASUREMENT OF STRUCTURE MOTION BY MEANS OF A MOVING LIGHT SHEET

PING TCHENG, THOMAS JORDAN, JOHN FRANKE, and KENNETH CATE (NASA, Langley Research Center, Hampton, VA) IN: Advances in optical structure systems; Proceedings of the Meeting, Orlando, FL, Apr. 16-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 218-229.

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The elaboration of an optical system which measures the displacement and velocity of large flexible space structures is reviewed. The motion-measuring system, comprised of a laser, optics, motorized mirror, two photodiodes and electronics, is designed to allow feedback for configuration control of flexible structures. A motor or scanner is employed to sweep the light sheet. The range of motion was shown to be 2 inches, and information was received at a rate of 30 Hz. The uncertainty in displacement measurement was better than +0.01 inch from a distance of 16 feet. The results are considered to be very good for two scanning light sheet systems. Higher sample rates and a more constant speed would improve the rotating mirror option, and the accuracy and range of the scanning mirror option could be upgraded as well. Both setups are shown to be viable noncontact measuring methods for the displacement and velocity of large space structures. C.C.S.

A91-36666

FAST STEERING MIRRORS IN OPTICAL CONTROL SYSTEMS

REYNOLD W. COCHRAN and RICHARD H. VASSAR (Lockheed Research Laboratories, Palo Alto, CA) IN: Advances in optical structure systems; Proceedings of the Meeting, Orlando, FL, Apr. 16-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 245-251. Research supported by Lockheed Missiles and Space Co.

Copyright

This paper contains a discussion of the functions of fast steering mirrors (FSMs) in optical systems which include target tracking, attenuation of disturbances including jitter, alignment beam and image stabilization, and extending optical sensor linear range. Dynamic and control modeling of the FSM mechanism, actuators, position sensors, and controllers are described in terms of mass and inertia properties, dynamic range, and bandwidth. Illustrative examples of the use of FSMs in optical systems and a simulation of a representative optical system using an FSM and corresponding results are shown. The use of software tools in performing control systems simulations is discussed. Author

A91-36667* Old Dominion Univ., Norfolk, VA.

ADAPTIVE STATE ESTIMATION FOR CONTROL OF FLEXIBLE STRUCTURES

CHUNG-WEN CHEN and JEN-KUANG HUANG (Old Dominion University, Norfolk, VA) IN: Advances in optical structure systems; Proceedings of the Meeting, Orlando, FL, Apr. 16-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 252-262. refs

(Contract NAG1-830)

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This paper proposes a new approach of obtaining adaptive state estimation of a system in the presence of unknown system disturbances and measurement noise. In the beginning, a non-optimal Kalman filter with arbitrary initial guess for the process and measurement noises is implemented. At the same time, an adaptive transversal predictor (ATP) based on the recursive least-squares (RLS) algorithm is used to yield optimal one- to p-step-ahead output predictions using the previous input/output data. Referring to these optimal predictions the Kalman filter gain is updated and the performance of the state estimation is thus improved. If forgetting factor is implemented in the recursive least-squares algorithm, this method is also capable of dealing with the situation when the noise statistics are slowly time-varying. This feature makes this new approach especially suitable for the control of flexible structures. A numerical example demonstrates the feasibility of this real time adaptive state estimation method. Author

A91-36670

SURFACE CONTROL TECHNIQUES FOR LARGE SEGMENTED MIRRORS

ANTHONY D. GLECKLER, BOBBY L. ULICH, CHRIS SHEPPARD (Kaman Aerospace Corp., Tucson, AZ), and EDWARD K. CONKLIN (Forth, Inc., Manhattan Beach, CA) IN: Advances in optical structure systems; Proceedings of the Meeting, Orlando, FL, Apr. 16-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 288-299. Research supported by Kaman Aerospace Corp.

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Techniques are demonstrated which, at high temporal bandwidths, can control a segmented reflector with many segments.

Phased Array Mirror, Extendible Large Aperture (PAMELA) technology is applied, where small hexagonal mirror segments are about equal to the atmospheric coherence length, to allow diffraction-limited visible imaging. Attention is first given to an adaptive optics technique which corrects the wavefront for atmospheric distortion in the isoplanatic patch of the observed object. Wavefront sensing control methods are presented for adjusting the mirror segments. The second technique considered is active optics, whereby a control system employing local figure sensing allows the utilization of the telescope as a traditional telescope. The latter technique is shown to work for objects that are not adequately bright. The incompatibilities of local and global iterative control methods are analyzed, as are hierarchical techniques which cluster the segments. The methods, in conjunction with the reduced stiffness and therefore low mass of a large segmented mirror, present high bandwidth wavefront correction capability in a system which can be used on earth and in space. C.C.S.

A91-36671

TWO-TIME-SCALE CONTROL DESIGNS FOR LARGE FLEXIBLE STRUCTURES

LI-FARN YANG and JEN-KUANG HUANG (Old Dominion University, Norfolk, VA) IN: Advances in optical structure systems; Proceedings of the Meeting, Orlando, FL, Apr. 16-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 300-311. refs

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Unification of the singular perturbation method and the Liapunov-based nonlinear control design is proposed as a method for effecting rapid maneuvers of large flexible structures. The flexural vibration of such structures is separated via the singular perturbation technique into fast- and slow-model subsystems with unique time scales. High-frequency modes decay in the fast time scale after brief initial activity, whereafter the slow-model states of low frequency modes are dominant. The slow-model subsystem shows that linear control theory can provide a linear output feedback gain, whereas the fast model control is Liapunov-based. A mathematically expressed complex slewing maneuver with rotational, translational and vibrational motions is used to demonstrate the control designs. A stable feedback control design for nonlinear two-time-scale flexible structures results from the two models. Even when the nonlinear behavior of a structural system is significant, the control design allows a stable closed-loop system in the Liapunov sense. C.C.S.

A91-36674

ATTITUDE DETERMINATION FOR HIGH-ACCURACY SUBMICRORADIAN JITTER POINTING ON SPACE-BASED PLATFORMS

AVANINDRA A. GUPTA, CHARLES N. VAN HOUTEN, and LAWRENCE M. GERMANN (Ball Aerospace Systems Group, Boulder, CO) IN: Advances in optical structure systems; Proceedings of the Meeting, Orlando, FL, Apr. 16-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 336-349.

Copyright

A description of the requirement definition process is given for a new wideband attitude determination subsystem (ADS) for image motion compensation (IMC) systems. The subsystem consists of either lateral accelerometers functioning in differential pairs or gas-bearing gyros for high-frequency sensors using CCD-based star trackers for low-frequency sensors. To minimize error the sensor signals are combined so that the mixing filter does not allow phase distortion. The two ADS models are introduced in an IMC simulation to predict measurement error, correction capability, and residual image jitter for a variety of system parameters. The IMC three-axis testbed is utilized to simulate an incoming beam in inertial space. Results demonstrate that both mechanical and electronic IMC meet the requirements of image stabilization for space-based observation at submicroradian-jitter levels. Currently available technology may be employed to implement IMC systems. C.C.S.

A91-36675

LINE OF SIGHT STABILIZATION - SENSOR BLENDING

CHRISTOPHER PETTIT and JIM HARRER (Martin Marietta Space Systems, Denver, CO) IN: Advances in optical structure systems; Proceedings of the Meeting, Orlando, FL, Apr. 16-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 350-359.

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The optical line-of-sight (LOS) system on a two-body space platform must be stabilized to sub-microradian levels in the presence of base disturbances to obtain blur-free images. An example of a two-body spacecraft has a telescope (or beam expander) as the fore body and a sensor suite which can include an active tracking system on the aft body. An isolation system between the two bodies will keep the disturbances generated in each from effecting the other. Such a system could be used for satellite communications, weather tracking systems, etc. The need for accurate control of angular motion is accomplished with stabilization and isolation platforms and active control of structures and optics. This paper will discuss a method to isolate the LOS from the base motion of the space platform over a wide frequency range. This method includes a concept to blend inertial measuring sensors (IMS) that operate in different frequency ranges to produce an IMS sensor system that can measure base disturbances from DC to over 1000 Hz with minimum distortion. Experimental data from this blending technique will also be included in this report. Author

A91-36676

ACTIVE CONTROL OF PERSISTENT DISTURBANCES IN LARGE PRECISION AEROSPACE STRUCTURES

MARK J. BALAS (Colorado, University, Boulder) IN: Advances in optical structure systems; Proceedings of the Meeting, Orlando, FL, Apr. 16-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 360-370. refs

Copyright

A theoretical design for reduced-order model-based disturbance accommodating controllers (DAC) is presented for applications in precision structures. A linear FEM model is utilized to analyze persistent disturbances and exact disturbance cancellation with the DAC controller. A DAC for rapid on-line implementation based on a reduced-order model (ROM) is also analyzed. A residual mode filter (RMF) is used to compensate for stability loss due to spillover. The RMF is shown to be effective, and to permit the DAC to produce stable closed-loop control of the full aerospace structure. The DAC, based on a modal ROM of persistently disturbed large precision structures, is useful when three important constraints are met in the model. The RMF is shown to be easily implemented in situations where the model reduction compromises stability. C.C.S.

A91-36677

CONTROLS/OPTICS/STRUCTURES SIMULATION DEVELOPMENT

DAVID B. SCHAECHTER (Lockheed Research Laboratories, Palo Alto, CA) IN: Advances in optical structure systems; Proceedings of the Meeting, Orlando, FL, Apr. 16-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 371-380. Research supported by Lockheed Missiles and Space Co., Inc.

Copyright

This paper contains a presentation of the techniques needed to develop simulations for large scale systems which are composed of control systems, optics, and structures. A case study is presented which consists of a generic, controlled spacecraft whose purpose is to maintain a precise line-of-sight (LOS) in the presence of disturbances and structural deformations. The spacecraft model consists of a six degree-of-freedom (DOF) rigid body with superimposed small structural deformations obtained from a high-order finite element model. The optical system consists of a telescope with a controlled Fast Steering Mirror (FSM) for maintaining an accurate line-of-sight. Reaction wheels and an Inertial Measurement Unit (IMU) are used for spacecraft attitude control. Disturbances consist of onboard payload motions, sensor noises and reaction wheel imbalance. Results of the simulation are shown. Author

A91-36679
ACTIVE CONTROL EXPERIMENTS FOR LARGE OPTICS VIBRATION ALLEVIATION
D. C. HYLAND, D. J. PHILLIPS, and E. G. COLLINS, JR. (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: Advances in optical structure systems; Proceedings of the Meeting, Orlando, FL, Apr. 16-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 392-404. refs
Copyright

Three experiments which illustrate control of flexible structures are discussed. The Optimal Projection for Uncertain Systems (OPUS) method is used for primary control synthesis in the experimentation. In the pendulum experiment, a 5-m compound pendulum is employed as an end-to-end testbed for a linear proof mass actuator with supporting electronics. Two controllers created to accomplish 5 percent damping are tested in the first two pendulum modes, and experimental results are given. The more dynamically complex plate experiment involves a 4-ft square aluminum plate with the corners cut to achieve high modal density and many closely spaced modes. OPUS is used experimentally to show the design capabilities for broad-band vibration suppression. In one of the experiments, a large optical reflector structure typical of large spaceborne systems is tested. Finite element models are shown to be inaccurate tools for developing implementable controllers; identification tools, dynamic actuators and sensors, sampled-data issues, and efficient design environments are needed to develop active control for flexible structures. Low-order and decentralized controllers are shown to significantly improve the performance of these structures. C.C.S.

A91-37591* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONTROL LAW SYNTHESIS AND STABILITY ROBUSTNESS IMPROVEMENT USING CONSTRAINED OPTIMIZATION TECHNIQUES
VIVEKANANDA MUKHOPADHYAY (NASA, Langley Research Center, Hampton, VA) IN: Control and dynamic systems. Vol. 32 - Advances in aerospace systems dynamics and control systems. Pt. 2. San Diego, CA, Academic Press, Inc., 1990, p. 163-205. refs
(Contract NAG1-199; NAS1-18000)
Copyright

The present generic optimization procedure for a continuous or discrete control law (of arbitrary order), which will be applicable to a multiinput-multioutput system, is upon constraining used to satisfy conflicting design requirements on the mean-square responses and stability robustness at the plant input and output. The synthesis procedure is especially suitable for flexible airframes and large space structures modeled by a high-order state-space system of equations. Analytical expressions are obtained for the gradients of the cost function, together with design constraints on the mean-square response and minimum singular value. O.C.

A91-37601
A PERTURBATION APPROACH TO THE MANEUVERING AND CONTROL OF SPACE STRUCTURES
L. MEIROVITCH and Y. SHARONY (Virginia Polytechnic Institute and State University, Blacksburg) IN: Control and dynamic systems. Vol. 33 - Advances in aerospace systems dynamics and control systems. Pt. 3. San Diego, CA, Academic Press, Inc., 1990, p. 247-293. refs
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The problem of the simultaneous maneuvering and vibration control of a flexible space structure is studied. It is found that the equations of motion describing the slewing of a flexible space structure, following discretization in space and truncation, consist of a set of nonlinear ordinary differential equations that can be of relatively high order. A perturbation technique is adopted to avoid difficulties involved in solving the nonlinear two-point boundary-value problem which is encountered in a minimum-time problem. K.K.

A91-38252
OPTIMAL VIBRATION CONTROL OF FLEXIBLE SPACECRAFT DURING A MINIMUM-TIME MANEUVER
L. MEIROVITCH and Y. SHARONY (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Optimization Theory and Applications (ISSN 0022-3239), vol. 69, April 1991, p. 31-54. refs
(Contract F33615-86-C-3233)
Copyright

This paper is concerned with the simultaneous maneuver and vibration control of a flexible spacecraft. The problem is solved by means of a perturbation approach whereby the slewing of the spacecraft regarded as rigid represents the zero-order problem and the control of vibration, as well as of perturbations from the rigid-body maneuver, represents the first-order problem. The zero-order control is to be carried out in minimum time, which implies bang-bang control. On the other hand, the first-order control is a time-dependent linear quadratic regulator including integral feedback and prescribed convergence rate. Author

A91-38744
A SUBSTRUCTURE SYNTHESIS APPROACH TO THE CONTROL OF FLEXIBLE MULTI-BODY SYSTEMS
L. MEIROVITCH, M. K. KWAK, and T. STEMPLE (Virginia Polytechnic Institute and State University, Blacksburg) IN: Dynamics and control of multibody/robotic systems with space applications; Proceedings of the ASME Winter Annual Meeting, San Francisco, CA, Dec. 10-15, 1989. New York, American Society of Mechanical Engineers, 1989, p. 1-6. refs
(Contract F49620-89-C-0049)
Copyright

This paper is concerned with the dynamics and control of flexible multibody systems. The mathematical model consists of a flexible central substructure and a given number of retargeting flexible substructures. The equations of motions are derived by means of a Lagrangian approach in terms of quasi-coordinates in conjuntion with a substructure synthesis. The control design represents a substructure decentralized control scheme whereby the control gains are designed independently for each substructure. Assuming that the time-varying terms are relatively small, the control gains are computed in closed form by means of a perturbation technique. The actuator forces designed by substructure decentralized control are applied to the fully interacting structure. Author

A91-38826* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADAPTIVE STRUCTURES; PROCEEDINGS OF THE ASME WINTER ANNUAL MEETING, SAN FRANCISCO, CA, DEC. 10-15, 1989
BEN K. WADA, ED. (JPL, Pasadena, CA) Meeting sponsored by ASME. New York, American Society of Mechanical Engineers, 1989, 123 p. For individual items see A91-38827 to A91-38838.
Copyright

The present conference on adaptive structures discusses piezoelectric and electrostrictive sensors and actuators for adaptive structures and smart materials, real-time control for composite structures with embedded actuators and sensors, a laminated-shell theory incorporating embedded distributed actuators, traveling-wave power flow techniques, uncertainty modeling for the control of an active structure, and active vibration isolation in the presence of unmodeled structural dynamic response. Also discussed are the control of flexible beams via free-free active truss, truss structure control using member actuators with latch mechanism, neural processors for smart-structure control, the effect of imperfections on the static control of adaptive structures, adaptive structures for segmented optical systems, and the shape-control of flexible structures. O.C.

A91-38828
REAL-TIME CONTROL FOR COMPOSITE STRUCTURES WITH EMBEDDED ACTUATORS AND SENSORS
F. M. HAM, B. GROSSMAN, and M. THURSBY (Florida Institute of Technology, Melbourne) IN: Adaptive structures; Proceedings of the ASME Winter Annual Meeting, San Francisco, CA, Dec. 10-15, 1989. New York, American Society of Mechanical Engineers, 1989, p. 19-24. refs
Copyright
A decentralized control design methodology for structures with embedded actuators and sensors is presented. The structure is segmented into artificial segments, assuming at each segment colocated point actuation and sensing. A decentralized controller is designed for each segment. This approach makes it possible to dictate the density of the segmentation; i.e., a trade-off is performed assessing the system performance as a function of the density of the segmentation. O.G.

A91-38832* Virginia Polytechnic Inst. and State Univ., Blacksburg.
CONTROL OF FLEXIBLE BEAMS USING A FREE-FREE ACTIVE TRUSS
W. W. CLARK, B. KIMIAVI, and H. H. ROBERTSHAW (Virginia Polytechnic Institute and State University, Blacksburg) IN: Adaptive structures; Proceedings of the ASME Winter Annual Meeting, San Francisco, CA, Dec. 10-15, 1989. New York, American Society of Mechanical Engineers, 1989, p. 61-68. refs
(Contract NAG1-933)
Copyright
An analytical and experimental study involving controlling flexible beams using a free-free active truss is presented. This work extends previous work in controlling flexible continua with active trusses which were configured with fixed-free boundary conditions. The following describes the Lagrangian approach used to derive the equations of motion for the active truss and the beams attached to it. A partial-state feedback control law is derived for this system based on a full-state feedback Linear Quadratic Regulator method. The analytical model is examined via numerical simulations and the results are compared to a similar experimental apparatus described herein. The results show that control of a flexible continua is possible with a free-free active truss. Author

A91-38833
CONTROL OF TRUSS STRUCTURES USING MEMBER ACTUATORS WITH LATCH MECHANISM
M. NATORI (Institute of Space and Astronautical Science, Sagamihara, Japan), S. MUROHASHI (Tokyo, University, Japan), K. TAKAHARA, and F. KUWAO (Toshiba Corp., Kawasaki, Japan) IN: Adaptive structures; Proceedings of the ASME Winter Annual Meeting, San Francisco, CA, Dec. 10-15, 1989. New York, American Society of Mechanical Engineers, 1989, p. 69-75.
Copyright
A basic concept of stiffness and damping control for truss structures by the use of axial member actuators with latch mechanism is investigated. When the structure is subjected to disturbance forces, the axial member actuator can drastically change its original stiffness to a very low stiffness by releasing the latch mechanism, and this low stiffness is effectively used for structural control. After controlled, the structure recovers its stiffness through the latch of member actuators. The basic aspects of this control idea are clarified through the numerical simulation of a hypothetical two-dimensional truss beam and the experiment of a model truss beam structure. Author

A91-38836
STUDIES OF INTELLIGENT ADAPTIVE STRUCTURES
K. MIURA (Institute of Space and Astronautical Science, Sagamihara, Japan) IN: Adaptive structures; Proceedings of the ASME Winter Annual Meeting, San Francisco, CA, Dec. 10-15, 1989. New York, American Society of Mechanical Engineers, 1989, p. 89-94. refs
Copyright
The paper introduce seven years of activity on intelligent/adaptive structures carried out the author's laboratory, which certainly reflects the trend in advancement and change of structural concepts occurred during the period. The study includes two categories of adaptation; the global change in configuration, and the shape control of a precision reflector. The subjects discussed are the definition of intelligent/adaptive structures, the variable geometry truss, construction of a large space structure by intelligent structures, stabilization and shape control of the tension truss antenna. Author

A91-38837* Duke Univ., Durham, NC.
EFFECT OF IMPERFECTIONS ON STATIC CONTROL OF ADAPTIVE STRUCTURES AS A SPACE CRANE
A. V. RAMESH, S. UTKU (Duke University, Durham, NC), B. K. WADA, and G. S. CHEN (JPL, Pasadena, CA) IN: Adaptive structures; Proceedings of the ASME Winter Annual Meeting, San Francisco, CA, Dec. 10-15, 1989. New York, American Society of Mechanical Engineers, 1989, p. 95-101. refs
(Contract NAS7-100)
Copyright
Effect of imperfections in the joints of an adaptive structure on its slow (no inertia forces) motion along a prescribed trajectory as a space crane is studied. Two mathematical models to predict the effect of joint imperfections are proposed. The two models are used to obtain estimates of the deviations of the node of the space crane to which the end-effector is attached, from its prescribed trajectory. An application of the models to a two-section space crane is given. Author

A91-38838* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADAPTIVE STRUCTURES FOR PRECISION SEGMENTED OPTICAL SYSTEMS
G.-S. CHEN, C.-P. KUO, and B. K. WADA (JPL, Pasadena, CA) IN: Adaptive structures; Proceedings of the ASME Winter Annual Meeting, San Francisco, CA, Dec. 10-15, 1989. New York, American Society of Mechanical Engineers, 1989, p. 103-111. refs
(Contract NAS7-100)
Copyright
An adaptive structures approach for a large segmented optical system with a 20-meter primary reflector made of lightweight hexagonal composite panels is considered. This approach makes it possible to vary the static and dynamic characteristics of a structural system through actuators and sensors integrated within the structure. Topics discussed include quasi-static shape adjustment and active damping augmentation of the primary backup truss structure, deformable panels for long spatial wavelength quasi-static figure correction, and an on-orbit identification system for large segmented optical systems. O.G.

A91-39132
MATHEMATICAL MODELING OF THE ATTITUDE MAINTENANCE OF THE MIR ORBITAL STATION BY MEANS OF GYRODYNES [MATEMATICHESKOE MODELIROVANIE PROTSESSOV PODDERZHANIIA ORIENTATSII ORBITAL'NOI STANTSII 'MIR' S POMOSHCH'IU GIRODINOV]
V. A. SARYCHEV, M. IU. BELIAEV, S. G. ZYKOV, V. V. SAZONOV, and V. P. TESLENKO Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, Mar.-Apr. 1991, p. 212-220. In Russian.
Copyright
Mathematical models are developed for simulating the process of attitude stabilization of the Mir space station in either the inertial or the orbital coordinate systems, by means of gyrodynes. These models, developed for calculating the optimal times for activating the station's microjets, are used for planning scientific on-board experiments. I.S.

A91-39402*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
MULTISTAGE DESIGN OF AN OPTIMAL MOMENTUM MANAGEMENT CONTROLLER FOR THE SPACE STATION
J. W. SUNKEL (NASA, Johnson Space Center, Houston, TX) and L. S. SHIEH (Houston, University, TX) Journal of Guidance,

Control, and Dynamics (ISSN 0731-5090), vol. 14, May-June 1991, p. 492-502. Previously cited in issue 21, p. 3329, Accession no. A90-47578. refs
(Contract DAAL03-87-K-0001; NAG9-380; NAG9-385)
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A91-39404#
H(INFINITY) ROBUST CONTROL SYNTHESIS FOR A LARGE SPACE STRUCTURE
MICHAEL G. SAFONOV, RICHARD Y. CHIANG, and HENRYK FLASHNER (Southern California, University, Los Angeles, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, May-June 1991, p. 513-520. TRW, Inc.-supported research. refs
(Contract AF-AFOSR-85-0256; AF-AFOSR-88-0282)
Copyright

In a design study involving the use of H(infinity) optimal control theory, a six-state control law is generated for a 116-state model of a large flexible space structure. A combination of collocated rate feedback and balanced-stochastic-truncation model reduction techniques is found to lead to a vastly simplified four-state model of the structure. Using a singular-value robustness criterion, the four-state model is proved to be satisfactory for the design of a controller whose bandwidth exceeds the natural frequencies of all of the modes of the original 116-state model. Specifications regarding disturbance attenuation, bandwidth, and stability robustness are quantitatively expressed as weighting functions in a mixed-sensitivity H(infinity) optimal control synthesis problem, the solution to which is computed by using the PRO-MATLAB Robust-Control Toolbox. Author

A91-39407#
ATTITUDE ACQUISITION SYSTEM FOR COMMUNICATION SPACECRAFT
M. SCHWARZSCHILD and S. RAJARAM (General Electric Co., Astro Space Div., Princeton, NJ) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, May-June 1991, p. 543-547. Previously cited in issue 23, p. 3631, Accession no. A89-52683. refs
Copyright

A91-39423#
MODELING ERROR BOUNDS FOR FLEXIBLE STRUCTURES WITH APPLICATION TO ROBUST CONTROL
YOSSI CHAIT (Massachusetts, University, Amherst) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, May-June 1991, p. 665-667. refs
Copyright

General formulas for computing useful error bounds for the approximations of large space structures are presented. The approximation error bounds are developed for systems whose dynamics can be represented by a series solution where each term in the series arises from a second-order ordinary differential equation. Uniform, frequency-dependent, and overall bounds are considered, and numerical computation aspects as well as a graphical interpretation are discussed. It is observed that the bounds developed in the study can be used to specify the order of the initial (open-loop) approximate model and the minimum number of modes necessary for (closed-loop) control synthesis. V.T.

A91-39427*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
GENERALIZED PROPORTIONAL-PLUS-DERIVATIVE COMPENSATORS FOR A CLASS OF UNCERTAIN PLANTS
SURESH M. JOSHI (NASA, Langley Research Center, Hampton, VA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, May-June 1991, p. 677-680.
Copyright

Controller design for a class of systems consisting of a positive-real transfer function P(s) followed by an integrator is considered. A generalized proportional-plus-derivative compensator is proposed for robustly stabilizing a class of uncertain plants represented by a positive-real transfer function followed by an integrator. The novel feature of the proposed compensator is that the proportional and rate gains used are transfer functions rather than constants, which allows more design freedom and offers the potential for better performance with guaranteed robust stability. The results obtained are for single-input/single-output systems. If the results are extended to the multivariable case, they will then be applicable to realistic flexible spacecraft. P.D.

A91-39430#
EXPERIMENTAL MODAL ANALYSIS FOR DYNAMIC MODELS OF SPACECRAFT
KEIJI KOMATSU, MASAAKI SANO, TAKASHI KAI (National Aerospace Laboratory, Tokyo, Japan), AKIO TSUJIHATA, and HIDEHIKO MITSUMA (NASDA, Tokyo, Japan) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, May-June 1991, p. 686-688.
Copyright

An unconstrained component-mode synthesis technique based on measured modal data for testing solar-array-type structures is presented. A polynomial approximation for the measured modes is introduced to overcome the difficulty involved in synthesizing such a platelike structure; namely, that rotational displacements cannot be measured in the usual modal test. The examples that are adduced demonstrate that this method has potential as an alternative for modal tests of a complete structure. P.D.

A91-39432*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MODEL REDUCTION FOR FLEXIBLE STRUCTURES - TEST DATA APPROACH
WODEK GAWRONSKI (JPL, Pasadena, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, May-June 1991, p. 692-694. Previously cited in issue 23, p. 3630, Accession no. A89-52652. refs
Copyright

A91-39435#
LOW-AUTHORITY EIGENVALUE PLACEMENT FOR SECOND-ORDER STRUCTURAL SYSTEMS
NELSON G. CREAMER (Swales and Associates, Inc., Beltsville, MD) and JOHN L. JUNKINS (Texas A & M University, College Station) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, May-June 1991, p. 698-701. refs
Copyright

The concepts of low-authority control (i.e., 10-20 percent damping) and linear feedback control of very large highly flexible space structures are combined with optimal linear programming to provide a systematic approach to optimize symmetric displacement and velocity feedback gain matrices utilizing the properties of second-order structural systems. The feedback gains are designed to minimize a modal energy dissipation criterion subject to constraints on selected eigenvalues and actuator saturation limits. The method takes advantage of the symmetry and modal orthonormality properties of second-order structural systems. The gain design algorithm is conveniently formulated in a standard linear programming format. P.D.

A91-39486* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
WAVEFRONT CONTROL OF LARGE OPTICAL SYSTEMS
ADEN B. MEINEL, MARJORIE P. MEINEL, and J. B. BRECKINRIDGE (JPL, Pasadena, CA) IN: Adaptive optics and optical structures; Proceedings of the Meeting, European Congress on Optics, 3rd, The Hague, Netherlands, Mar. 12-14, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 180-190. refs
Copyright

Several levels of wavefront control are necessary for the optimum performance of very large telescopes, especially segmented ones like the Large Deployable Reflector. In general, the major contributors to wavefront error are the segments of the large primary mirror. Wavefront control at the largest optical surface may not be the optimum choice because of the mass and inaccessibility of the elements of this surface that require upgrading. The concept of two-stage optics was developed to permit a poor wavefront from the large optics to be upgraded by means of a wavefront corrector at a small exit pupil of the system. Author

A91-39836* California Univ., Los Angeles.
NASA-UCLA WORKSHOP ON COMPUTATIONAL TECHNIQUES IN IDENTIFICATION AND CONTROL OF FLEXIBLE FLIGHT STRUCTURES, LAKE ARROWHEAD, CA, NOV. 2-4, 1989, PROCEEDINGS
A. V. BALAKRISHNAN, ED. (California, University, Los Angeles) Workshop sponsored by NASA, University of California, and ComCon Conference Board. Los Angeles, CA, Optimization Software, Inc., 1990, 303 p. For individual items see A91-39837 to A91-39850.
Copyright
The present conference on the identification and control of flexible flight structures with computational techniques encompasses existing and planned testbeds, modeling techniques, adaptive control, and numerical computation and simulation. Specific issues addressed include the NASA/MFSC ground test facility, an active control test on the NASA Minimast, the Astrex testbed for large precision space structures, the dynamic analysis of truss-beam modeling, combined structure-controls-integrated optimization, distributed parameter modeling applicable to the control of flexible flight structures, and approaches to nonclassically damped dynamic systems. Also addressed are adaptive control concepts, techniques for vibration and decentralized slew maneuver control, the discretization of second-order-in-time differential equations which are applicable to nonlinear wave problems, the finite-dimensional approximations of Riccati equations, and numerical simulations of actively controlled space structures. C.C.S.

A91-39840* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADAPTIVE STRUCTURES - TEST HARDWARE AND EXPERIMENTAL RESULTS
BEN K. WADA, JAMES L. FANSON, GUN-SHING CHEN, and CHIN-PO KUO (JPL, Pasadena, CA) IN: NASA-UCLA Workshop on Computational Techniques in Identification and Control of Flexible Flight Structures, Lake Arrowhead, CA, Nov. 2-4, 1989, Proceedings. Los Angeles, CA, Optimization Software, Inc., 1990, p. 38-60. refs
Copyright
The facilities and procedures used at JPL to test adaptive structures such as the large deployable reflector (LDR) are described and preliminary results are reported. The applications of adaptive structures in future NASA missions are outlined, and the techniques which are employed to modify damping, stiffness, and isolation characteristics, as well as geometric changes, are listed. The development of adaptive structures is shown to be effective as a result of new actuators and sensors, and examples are listed for categories such as fiber optics, shape-memory materials, piezoelectrics, and electrorheological fluids. Some ground test results are described for laboratory truss structures and truss test beds, which are shown to be efficient and easy to assemble in space. Adaptive structures are shown to be important for precision space structures such as the LDR, and can alleviate ground test requirements. C.C.S.

A91-39843* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DISTRIBUTED PARAMETER MODELING FOR THE CONTROL OF FLEXIBLE SPACECRAFT
LAWRENCE W. TAYLOR, JR. (NASA, Langley Research Center, Hampton, VA) IN: NASA-UCLA Workshop on Computational Techniques in Identification and Control of Flexible Flight Structures, Lake Arrowhead, CA, Nov. 2-4, 1989, Proceedings. Los Angeles, CA, Optimization Software, Inc., 1990, p. 87-114. refs
Copyright
The use of FEMs of spacecraft structural dynamics is a common practice, but it has a number of shortcomings. Distributed-parameter models offer an alternative, but present both advantages and difficulties. First, the model order does not have to be reduced prior to the inclusion of control system dynamics. This advantage eliminates the risk involved with model 'order reduction'. Second, distributed parameter models inherently involve fewer parameters, thereby enabling more accurate parameter estimation using experimental data. Third, it is possible to include the damping in the basic model, thereby increasing the accuracy of the structural damping. The difficulty in generating distributed parameter models of complex spacecraft configurations has been greatly alleviated by the use of PDEMOD, BUNVIS-RG, or DISTEL. PDEMOD is being developed for simultaneously modeling structural dynamics and control system dynamics. Author

A91-39846
DECENTRALIZED SLEW MANEUVER CONTROL AND VIBRATION SUPPRESSION OF LARGE FLEXIBLE SPACECRAFTS
Y. P. KAKAD (North Carolina, University, Charlotte) IN: NASA-UCLA Workshop on Computational Techniques in Identification and Control of Flexible Flight Structures, Lake Arrowhead, CA, Nov. 2-4, 1989, Proceedings. Los Angeles, CA, Optimization Software, Inc., 1990, p. 159-175. refs
Copyright
A decentralized control scheme is employed to describe arbitrary large-angle nonlinear slew maneuver control in a large flexible spacecraft, with specific attention given to the NASA space control experiment (SCOLE). Two dynamical subsystems - the rigid-body slewing of the spacecraft as a whole and the flexible appendage's vibrations - are considered to formulate the problem. A two-point boundary-value problem based on the nonlinear and coupled equations of the entire system is used to express the control problem of each subsystem. The coupling variables between the subsystems are utilized in connection with a state regulator formulation; this allows a closed-loop optimal control law to be described in terms of a state-trajectory optimization problem for each subsystem. C.C.S.

A91-39850* Colorado Univ., Boulder.
NUMERICAL SIMULATION OF ACTIVELY CONTROLLED SPACE STRUCTURES
RALPH QUAN and MARK BALAS (Colorado, University, Boulder) IN: NASA-UCLA Workshop on Computational Techniques in Identification and Control of Flexible Flight Structures, Lake Arrowhead, CA, Nov. 2-4, 1989, Proceedings. Los Angeles, CA, Optimization Software, Inc., 1990, p. 270-295. NASA-supported research. refs
Copyright
The numerical simulation of large, actively controlled space structures is a problem that has received considerable attention. A new computational method is presented in this paper, which simulates the vibration suppression of a large space structure by a linear compensator. The structure is assumed to be modeled by a large linear finite element model. Nested circularly linked lists and the trapezoidal rule are key aspects of this algorithm. There is an emphasis on generality, while establishing an equivalence between numerical stability and system stability. Author

A91-40134#
DIRECT OUTPUT FEEDBACK CONTROL OF FLEXIBLE SPACECRAFTS DURING A LARGE-ANGLE MANEUVER
WENLING ZENG, WEIBING GAO, and MIAN CHEN (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 12, Jan. 1991, p. A54-A62. In Chinese, with abstract in English. refs
The control problem of a flexible spacecraft during a large-angle maneuver is studied and a direct output feedback control method is proposed. It is shown that a linear output feedback is effective for asymptotic stability of a flexible spacecraft with a few control

devices. The number of the required control devices and their location have been given. Optimal index of the direct output feedback control is also given. In this way, it is shown that the large-dimension nonlinear system is controlled by using a few control devices. Author

A91-42068

OPTIMAL LARGE ANGLE MANEUVERS OF A FLEXIBLE SPACECRAFT

PETER M. BAINUM and FEIYUE LI (Howard University, Washington, DC) Acta Astronautica (ISSN 0094-5765), vol. 25, March 1991, p. 141-148. refs

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The optimal control of three-dimensional large-angle rapid maneuvers and vibrations of a Shuttle-mast-reflector system is considered. The nonliear equations of motion are formulated by using Lagrange's formula, with the mast modeled as a continuous beam subject to three-dimensional deformations. The nonlinear terms in the equations come from the coupling between the angular velocities, the modal coordinates, and the modal rates. Pontriagin's Maximum Principle is applied to the slewing problem, to derive the necessary conditions for the optimal controls, which are bounded by given saturation levels. The resulting two-point boundary-value problem is then solved by using the quasi-linearization algorithm and the method of particular solutions. The numerical results for the flexible nonlinear system, the flexible linearized system, and the rigidized nonlinear system are presented to compare the differences in their time responses. Author

A91-42070

SIMULATION OF SOLAR ARRAY SLEWING OF INDIAN REMOTE SENSING SATELLITE

P. K. MAHARANA and P. S. GOEL (ISRO, Satellite Centre, Bangalore, India) Acta Astronautica (ISSN 0094-5765), vol. 25, March 1991, p. 157-164.

Copyright

The effect of flexible arrays on sun tracking for the IRS satellite is studied. Equations of motion of satellites carrying a rotating flexible appendage are developed following the Newton-Euler approach and utilizing the constrained modes of the appendage. The drive torque, detent torque and friction torque in the SADA are included in the model. Extensive simulations of the slewing motion are carried out. The phenomena of back-stepping, step-missing, step-slipping and the influences of array flexibility in the acquisition mode are observed for certain combinations of parameters. Author

A91-42293*# Duke Univ., Durham, NC.

CONTROL OF A SLOW-MOVING SPACE CRANE AS AN ADAPTIVE STRUCTURE

S. UTKU, S. K. DAS (Duke University, Durham, NC), B. K. WADA, G. S. CHEN (JPL, Pasadena, CA), and A. V. RAMESH AIAA Journal (ISSN 0001-1452), vol. 29, June 1991, p. 961-967. Previously cited in issue 12, p. 1796, Accession no. A89-30768. refs

(Contract NAS7-100)

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A91-42295#

VIBRATION SUPPRESSION BY VARIABLE-STIFFNESS MEMBERS

JUNJIRO ONODA, NAOYUKI WATANABE (Institute of Space and Astronautical Science, Kanagawa, Japan), TAKAO ENDO, and HIDEHIKO TAMAOKI (Nissan Motor Co., Ltd., Tokyo, Japan) AIAA Journal (ISSN 0001-1452), vol. 29, June 1991, p. 977-983. Previously cited in issue 11, p. 1631, Accession no. A90-29457. refs

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A91-42643#

DEVELOPMENT OF TEST-ANALYSIS MODELS FOR LARGE SPACE STRUCTURES USING SUBSTRUCTURE REPRESENTATIONS

DANIEL C. KAMMER (Wisconsin, University, Madison) and CHRISTOPHER C. FLANIGAN (SDRC, Inc., San Diego, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Mar.-Apr. 1991, p. 244-250. refs

Copyright

A method is presented for reducing a substructured finite element model to a test-analysis-model representation for use in test-analysis correlation. The method requires sensor locations within each substructure to be selected such that they are capable of spatially differentiating between the component mode shapes of the substructures rather than an analogous requirement of an earlier method pertaining to the system mode shapes. This is an important development for FEM representations of large space structures that are often formed of extremely detailed substructures with weak coupling. The new method was applied to a simple but representative example of a model containing three substructures. A straightforward application of the earlier method of model reduction resulted in the inability to spatially differentiate between the system mode shapes at the substructure level. The new reduction method for substructured models resulted in a test-analysis model that exactly predicted the finite element model frequencies and mode shapes to within numerical accuracy. Author

A91-42715

ROBUSTNESS MEASURES FOR INTEGRATED STRUCTURAL/CONTROL SYSTEMS

I. U. HAQ, R. V. GRANDHI (Wright State University, Dayton, OH), and R. K. YEDAVALLI (Ohio State University, Columbus) (Computational technology for flight vehicles; Proceedings of the Symposium on Computational Technology on Flight Vehicles, Washington, DC, Nov. 5-7, 1990. A91-42703 18-59) Computing Systems in Engineering (ISSN 0956-0521), vol. 1, no. 2-4, 1990, p. 285-292. refs

(Contract F33615-88-C-3204) .

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Several stability robustness methods are compared in an effort to employ an appropriate approach in the integrated design of space structures and control systems. The motivation of this work is to identify a method which gives a realistic stability bound on the parameter uncertainties of the physical model in designing a control system for aerospace structures. Four different methods are compared for structured and unstructured perturbation matrices. A suitable method is suggested based on the results obtained for a two-bar truss, a five-bar truss, and ACOSS-four structures. Author

A91-42737* Duke Univ., Durham, NC.

USE OF REDUCED BASIS TECHNIQUE IN THE INVERSE DYNAMICS OF LARGE SPACE CRANES

S. K. DAS, S. UTKU (Duke University, Durham, NC), and B. K. WADA (JPL, Pasadena, CA) (Computational technology for flight vehicles; Proceedings of the Symposium on Computational Technology on Flight Vehicles, Washington, DC, Nov. 5-7, 1990. A91-42703 18-59) Computing Systems in Engineering (ISSN 0956-0521), vol. 1, no. 2-4, 1990, p. 577-589. refs

(Contract NAS7-100)

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The inverse dynamics of adaptive structures used as space cranes can prove computationally expensive in the case of large structures, due to the large number of degrees of freedom involved. Consequently, reduced basis techniques (reduction techniques) are frequently used to reduce the problem size to a time manageable level (for possible use in real time control). A reduced basis technique is proposed which is different from, but related to, the path-derivatives reduction technique. A linearly independent set of deflection n-tuples is used, chosen at the beginning of the time range in which it is wished to reduce the equations, in whose subspace it is assumed that the deflection vectors of the unreduced problem will lie (approximately). Author

A91-42739
EFFECTS OF STRUCTURAL IMPERFECTIONS ON CONSTANT-FEEDBACK-GAIN CONTROL OF A SPATIAL STRUCTURE
B. H. AUBERT, J. F. ABEL, J. LU, and J. S. THORP (Cornell University, Ithaca, NY) (Computational technology for flight vehicles; Proceedings of the Symposium on Computational Technology on Flight Vehicles, Washington, DC, Nov. 5-7, 1990. A91-42703 18-59) Computing Systems in Engineering (ISSN 0956-0521), vol. 1, no. 2-4, 1990, p. 601-606. refs
(Contract F49620-87-C-0011)
Copyright
The numercial sensitivity of a constant-feedback-gains controller to random structural imperfections is examined using the results of a series of finite element analyses. The basic finite element model, which uses linear beam-column elements, is a two-dimensional simplifications of a large (10 m long) three-dimensional frame currently undergoing testing at Cornell University. The cross-sectional properties, nodal coordinates, and masses of the models were randomly varied within four different ranges of maximum imperfection. Twenty transient dynamic analyses were run for each range of structural perturbation. Each analysis used a different random distribution of imperfections. The results of the finite element analyses show that the optimal control configuration, found by dynamic programming, exhibited unacceptable sensitivity to small perturbations of the structural model. A second, nearly optimal, control configuration was found to be more robust with respect to structural imperfections.
Author

A91-43108
FREQUENCY RESPONSE OF NON-LINEARLY DAMPED FLEXIBLE STRUCTURES
WEIJIAN ZHANG (California, University, Los Angeles) International Journal of Control (ISSN 0020-7179), vol. 54, July 1991, p. 135-155. refs
(Contract AF-AFOSR-83-0318)
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NASA experiments have indicated the need for nonlinear damping models to describe the motion of large flexible space structures. In this work, energy type nonlinear damping models in an infinite dimensional setting are studied. According to the geometry of the structures considered, energy type nonlinear damping models are divided into two types. Their frequency response is found and compared with that given by linear models and nonlinear stiffness models. It is concluded that nonlinear damping models do not produce peculiar behaviors such as internal resonance, jump phenomenon or chaotic behavior. Author

A91-43927* California Univ., Los Angeles.
NOVEL ARRAY-FEED DISTORTION COMPENSATION TECHNIQUES FOR REFLECTOR ANTENNAS
YAHYA RAHMAT-SAMII (California, University, Los Angeles) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 6, June 1991, p. 12-17. JPL-supported research. refs
Copyright
Degradation of antenna performance by reflector surface distortion, which lowers gain and increases sidelobe levels, is addressed. Distortion compensation concepts based on the applications of properly matched array feeds are presented. Results of conceptual developments, numerical simulations, and measurement verifications are presented in support of this approach, with particular attention to the measurement technique. It is shown that the concept is most useful for overcoming the deterioration effects of slowly varying surface distortions, which would make the method very useful for future large space and ground antennas. It is further shown that for a typical, slowly varying thermal or gravitational surface distortion, a 19-element array feed can improve the reflector performance considerably.
I.E.

A91-44782
ACTIVE VIBRATION CONTROL OF A THREE-DIMENSIONAL FLEXIBLE FRAME STRUCTURE - SPILLOVER COMPLETELY ELIMINATED RESPONSE ANALYSIS
MASAHIKO UTSUMI (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) JSME International Journal, Series III (ISSN 0914-8825), vol. 34, June 1991, p. 176-185. refs
Copyright
A modal analysis is presented for the response of a frame structure controlled by a small number of sensors and actuators with high accuracy, with short computation time, and without causing any observation or control spillover. The time response is determined by solving integral equations with respect to only the member joint displacements. The integral equations can be solved by transforming them into ordinary differential equations and by introducing additional mass corresponding to the inertial force due to the rigid-body axial translation and rotation of members. Detailed explanation is given on the complete elimination of the spillover by the present analysis. Numerical examples deal with the control of the position, attitude and elastic deformation of a space structure and a manipulator arm, a vehicle frame supported by nonlinear springs and a frame with a dynamic absorber used for economizing the energy consumed for the active control. Author

A91-45087
STEADY-STATE MOTIONS AND STABILITY OF FLEXIBLE SATELLITES [STATSIONARNYE DVIZHENIIA I USTOICHIVOST' UPRUGIKH SPUTNIKOV]
MANSUR K. NABIULLIN Novosibirsk, Izdatel'stvo Nauka, 1990, 217 p. In Russian. refs
Copyright
Problems in the simulation of the rotational motion of flexible satellites are examined, and a method involving nonlinear integrodifferential equations with ordinary and partial derivatives is described. Attention is given to a general approach to the nonlinear analysis of steady state motions of flexible satellites in the orbital coordinate system. The direct Liapunov method, extended to distributed-parameter systems, is used to study the stability of the steady-state motions of satellites containing various deformable structural elements, antennas, solar arrays in the form of elastic plates, etc. L.M.

A91-45127*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
DIGITAL REDESIGN OF AN OPTIMAL MOMENTUM MANAGEMENT CONTROLLER FOR THE SPACE STATION
J. W. SUNKEL (NASA, Johnson Space Center, Houston, TX), L. S. SHIEH, and J. L. ZHANG (Houston, University, TX) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, July-Aug. 1991, p. 712-723. Previously cited in issue 23, p. 3629, Accession no. A89-52567. refs
(Contract DAAL03-91-G-0106; NAG9-380; NAG9-385)
Copyright

A91-45130*# State Univ. of New York, Buffalo.
MODELING OF THE SLEWING CONTROL OF A FLEXIBLE STRUCTURE
EPHRAHIM GARCIA and DANIEL J. INMAN (New York, State University, Buffalo) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, July-Aug. 1991, p. 736-742. refs
(Contract NGT-33-183-804; F49620-88-C-0018)
Copyright
This paper presents a formulation for the modeling of a single-link flexible beam that is undergoing slewing motion at an actively controlled pinned end, where the other end of the beam is free. This pinned end, or slewing axis, is of fixed orientation such that the beam rotates in the horizontal plane. A geared dc electric motor is connected to the beam at the slewing axis. A position and a velocity sensor are placed at this hinged location, and their proportional feedback provides a position control system about the slewing axis. The motor characteristics, gear ratio, and the position feedback constant determine an equivalent rotational spring constant, often called the servo stiffness. This paper

generalizes the structure's boundary conditions at the slewing axis to include the effects of the servo system. It is shown that the clamped-free beam assumption for the dynamics of the structure is a valid assumption if the ratio of the servo stiffness to beam flexibility is high. However, for moderate or low values of this ratio, the clamped-free beam leads to erroneous system models so that it becomes necessary to consider the effects of the driving servo on the dynamics of the flexible beam. Author

A91-45131#
IDENTIFICATION OF A TENDON CONTROL SYSTEM FOR FLEXIBLE SPACE STRUCTURES
YOSHISADA MUROTSU, HIROSHI OKUBO, and KEI SENDA (Osaka Prefecture, University, Sakai, Japan) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, July-Aug. 1991, p. 743-750. MOESC-supported research. Previously cited in issue 23, p. 3630, Accession no. A89-52651. refs
Copyright

A91-45132#
STABILITY OF AN ASYMMETRIC DUAL-SPIN SPACECRAFT WITH FLEXIBLE PLATFORM
Z. VIDERMAN (Rafael Armament Development Authority, Haifa, Israel), F. P. J. RIMROTT, and W. L. CLEGHORN (Toronto, University, Canada) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, July-Aug. 1991, p. 751-760. refs
Copyright

This paper investigates the variational stability of a general dual-spin spacecraft consisting of an asymmetric rigid rotor and a flexible platform. Two cases of rotors are considered: constant spin-rate rotors and axially torque-free rotors. The full equations of motion are derived and conditions for the existence of a pure spin motion, referred to as the desired solution, are obtained. A linearization about this solution yields equations with periodic coefficients. A special class of spacecraft is observed, in which the linearized equations are the same for both cases of rotors. Two stability-analysis methods are developed and used for stability analysis of the linearized system under consideration: a numerical scheme based on the Floquet theory and Hsu's single-pass method, and a perturbation method based on the multiple-scales method. A numerical example is presented of a platform consisting of a rigid core and a beam-like antenna extended along the spin axis of the rotor. The effects of the rotor and platform asymmetry, rotor location, and platform damping are demonstrated and explained. Author

A91-45135*# Arizona State Univ., Tempe.
CLASSICAL CONTROL SYSTEM DESIGN AND EXPERIMENT FOR THE MINI-MAST TRUSS STRUCTURE
BONG WIE (Arizona State University, Tempe), LUCAS HORTA, and JEFF SULLA (NASA, Langley Research Center, Hampton, VA) (1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2, p. 1428-1434) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, July-Aug. 1991, p. 778-784. Previously cited in issue 11, p. 1717, Accession no. A91-30125. refs
Copyright

A91-45136*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
MODAL TRUNCATION, RITZ VECTORS, AND DERIVATIVES OF CLOSED-LOOP DAMPING RATIOS
CHRIS A. SANDRIDGE and RAPHAEL T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, July-Aug. 1991, p. 785-790. refs
(Contract NAG1-603)

The effect of modal truncation on the damping ratio and their derivatives with respect to an added mass is investigated for a simply supported, multispan beam with a linear quadratic Gaussian control system. It is found that both the damping ratios and derivatives converge slowly, but the derivatives converge more slowly than the damping ratios. However, it is shown that when Ritz vectors corresponding to static displacements due to actuator forces are added to the reduced model, the convergence of both the damping ratios and their derivatives is accelerated. It is also shown that the accuracy of the damping ratio predicted by a reduced-model control design can be improved significantly if the Ritz vectors are included in the design of the control system. Thus, it appears that Ritz vectors added to the reduced model of flexible structures can improve greatly the accuracy of both the design and analysis of the control system. Author

A91-45145#
GRAVITY GRADIENT STABILITY OF SATELLITES WITH GUY-WIRE CONSTRAINED APPENDAGES
A. L. SCHLACK (Wisconsin, University, Madison) and ANDRE P. MAZZOLENI Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, July-Aug. 1991, p. 855-857. refs
Copyright

The effect of torsional vibrations of elastically supported solar panels on the attitude stability of earth-pointing gravity-stabilized satellites is investigated. A set of sufficient conditions for stability, involving the moments of inertia of the satellite, orbital speed, and torsional stiffness of supporting shafts are obtained by using Liapunov's direct method. It is pointed out that the torsional stiffness plays a significant role as the magnitude of the gravity gradient torque vector approaches zero, and that the use of guy wires for restricting vibrations to purely torsional modes can improve attitude stability. V.T.

A91-45146#
RESULTS IN IDENTIFICATION OF A FLEXIBLE STRUCTURE USING LATTICE FILTERS
M. D. ROESLER (TRW, Inc., Space and Defense Sector, Redondo Beach, CA) and F. JABBARI (California, University, Irvine) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, July-Aug. 1991, p. 857-860. refs
Copyright

Attention is given to an experimental truss structure, which is a flexible MIMO system. To identify the truss experiment's modal frequencies and damping ratios for two important cases, i.e., a time-varying system with order change and a multiinput system configuration, the vector-channel lattice filter was used. The time-varying test showed a significant as well as sudden variation in parameters, but more importantly, it showed a change in the effective order of the system. The lattice filter promptly adapted to parameter changes and showed the detection of order changes in the system. For the system damping ratios, the multiinput data was found to give a better picture of the system dynamics than single-input data. These results suggest that the vector-channel lattice filter is an efficient on-line identification tool with applications in adaptive identification and control. V.I.

A91-45735#
USE OF ROBUSTNESS CONSTRAINTS IN THE OPTIMUM DESIGN OF SPACE STRUCTURES
N. S. KHOT and D. E. VELEY (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) Journal of Intelligent Material Systems and Structures (ISSN 1045-389X), vol. 2, April 1991, p. 161-176. refs

This paper describes an optimization procedure to design a minimum weight structure and optimum control system with constraints on the eigenvalues and robustness parameter for structured uncertainties in the closed-loop plant matrix. The design variables are the cross-sectional areas of the members and the elements of the state and control weighting matrices. The optimization problem was solved by using a nonlinear mathematical optimization technique based on the interior penalty functions. The numerical results are presented for the ACOSS-FOUR structure. This example illustrates how the use of optimization techniques can reduce the weight of the nominal structure, make the control system more robust and improve the response due to the external disturbance. Author

A91-46190#
SHAPE SENSITIVITY ANALYSIS OF PIEZOELECTRIC STRUCTURES BY THE ADJOINT VARIABLE METHOD
R. A. MERIC (Istanbul Technical University, Turkey) and SUNIL SAIGAL (Carnegie-Mellon University, Pittsburgh, PA) AIAA Journal (ISSN 0001-1452), vol. 29, Aug. 1991, p. 1313-1318. Previously cited in issue 11, p. 1751, Accession no. A90-29265. refs
Copyright

A91-46192*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTIMAL PLACEMENT OF ACTIVE/PASSIVE MEMBERS IN TRUSS STRUCTURES USING SIMULATED ANNEALING
GUN-SHING CHEN, ROBIN J. BRUNO, and MOKTAR SALAMA (JPL, Pasadena, CA) AIAA Journal (ISSN 0001-1452), vol. 29, Aug. 1991, p. 1327-1334. Previously cited in issue 12, p. 1854, Accession no. A89-30769. refs
Copyright

A91-46386
SHAPE OPTIMAL DESIGN OF VIBRATING STRUCTURES USING BOUNDARY ELEMENTS
P. FEDELINSKI and T. BURCZYNSKI (Silesian Technical University, Gliwice, Poland) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 71, no. 6, 1991, p. T726-T728. refs
Copyright

An attempt is made to perform a shape optimization for vibrating structures using boundary elements while avoiding resonance by maximizing the difference between the forcing frequency and the natural frequency. The first variation of the simple frequencies is explicitly expressed as a boundary integral. The BEM is applied to find the natural frequencies and corresponding mode shapes. The BEM is found to provide satisfactory results for the calculation of the boundary integral. C.D.

A91-46387
FORMULATION OF EIGENFREQUENCY SECONDARY CONDITIONS FOR STRUCTURAL OPTIMIZATION PROBLEMS [ZUR FORMULIERUNG VON EIGENFREQUENZ-NEBENBEDINGUNGEN IN STRUKTUROPTIMIERUNGSPROBLEMEN]
F. PFEIFFER and C. ROSS (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) Zeitschrift fuer angewandte Mathematik und Mechanik (ISSN 0044-2267), vol. 71, no. 6, 1991, p. T729-T731. In German.
Copyright

Various secondary conditions for eigenfrequencies are formulated. It is shown how it is possible to reduce individual or multiple eigenfrequencies or to reduce eigenfrequencies of particular form. It is demonstrated that derivations occurring during optimization remain constant during the usual eigenfrequency reductions. C.D.

A91-47212*# Wisconsin Univ., Madison.
A HYBRID APPROACH TO TEST-ANALYSIS-MODEL DEVELOPMENT FOR LARGE SPACE STRUCTURES
D. C. KAMMER (Wisconsin, University, Madison) ASME, Transactions, Journal of Vibration and Acoustics (ISSN 0739-3717), vol. 113, July 1991, p. 325-332. Research supported by NASA and Structural Dynamics Research Corp. refs
Copyright

The present FEM reduction method for the generation of test-analysis-models (TAMs) in test-analysis correlation addresses contentions that the current modal TAM is hypersensitive to differences between test model shapes and analysis mode shapes, thereby generating large off-diagonal terms within the orthogonality and cross-orthogonality matrices employed in test-analysis mode-shape correlation. A hybrid TAM methodology is accordingly developed which combines the exact representation of the FEM target modes from the modal TAM with the more accurate TAM representation of the residual modes; the superior residual dynamics representation of the hybrid TAM is demonstrated for a detailed representation of a large space structure. O.C.

A91-47214# Florida Univ., Gainesville.
VIBRATION SUPPRESSION USING A CONSTRAINED RATE-FEEDBACK-THRESHOLD CONTROL STRATEGY
D. C. ZIMMERMAN (Florida, University, Gainesville), D. J. INMAN (New York, State University, Buffalo), and J.-N. JUANG (NASA, Langley Research Center, Hampton, VA) ASME, Transactions, Journal of Vibration and Acoustics (ISSN 0739-3717), vol. 113, July 1991, p. 345-353. refs
(Contract NGT-33-183-801; NSF MEA-83-51807; AF-AFOSR-85-0220)
Copyright

A finite time, minimum force rate-feedback-threshold controller is developed to bring a system with or without known external disturbances back into an 'allowable' state bound in finite time. The disturbances are assumed to be expandable in terms of Fourier series. The optimal control is defined by a two-point boundary value problem coupled to a set of definite integral constraints. Quasi-closed form solutions are derived which replace the solution of the two-point boundary value problem and definite integral constraints with the solution of algebraic equations and the calculation of matrix exponentials. Examples are provided which demonstrate the threshold control technique and compare the quasi-closed form solutions with numerical and MACSYMA generated exact solutions. Author

A91-47884
ON THE FINITE SETTLING TIME AND RESIDUAL VIBRATION CONTROL OF FLEXIBLE STRUCTURES
S. JAYASURIYA and S. CHOURA (Texas A & M University, College Station) Journal of Sound and Vibration (ISSN 0022-460X), vol. 148, July 8, 1991, p. 117-136. Research supported by Texas Advanced Research Program. refs
Copyright

Rapid end-point positioning of a structure with minimal residual vibration under a single bounded control input is considered. The structure between the actuator and the end point is assumed to be flexible, and is the main cause of positioning error from residual vibration. An appropriately shaped input function based on minimum energy and bounded control for such end-point positioning systems totally eliminates the residual vibration while making the response time small. The proposed forcing input has two discontinuities at most and therefore does not suffer from the undesirable intermediate discontinuities present in the bang-bang control. This novel control force compares favorably with the bang-bang solution with respect to response time. Author

A91-48531
OPTIMAL VIBRATION REDUCTION FOR LARGE SPACE STRUCTURES
YUNG-TSENG CHUNG and JOHN P. LEUER (McDonnell Douglas Space Systems Co., Space Station Div., Huntington Beach, CA) SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 1-4, 1990. 8 p. refs
(SAE PAPER 901791) Copyright

Vibration reduction of the large space structure to meet its operational requirements was achieved by using the modal contribution indicator, which is defined as the percent contribution of each mode to the total response. The modal contribution indicator is related to the modal force participation factor and may be thought of as a measure of the extent to which the normal mode participates in synthesizing the load on the structure. Furthermore, a cross modal contribution indicator was defined to optimally reduce the vibration levels for a structure subject to multiple excitations. Examples were given to demonstrate the application and the efficiency of using the modal contribution indicator to reduce the undesired structural responses. Author

A91-49578
AIAA GUIDANCE, NAVIGATION AND CONTROL CONFERENCE, NEW ORLEANS, LA, AUG. 12-14, 1991, TECHNICAL PAPERS. VOLS. 1, 2, & 3
Conference sponsored by AIAA. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. Vol. 1, 707 p.; vol. 2, 646 p.; vol. 3, 705 p. For individual items see A91-49579 to A91-49776.
Copyright

Topics discussed include control design using parameter optimization; the theory and design for flexible structure control; the missile flight control; the aerospace guidance, navigation, and tracking; optimal control and optimization; the attitude control of flexible structures; the German approach to flight design; and the Space Station attitude. Some of the other topics are on H-infinity control and estimation; experiments in flexible structure control; the spacecraft attitude determination and control; nonlinear and optimal aircraft control; artificial intelligence applications; loop transfer recovery; the modeling and identification of flexible structures; and the optimal launch vehicle control. Attention is also given to the rotorcraft guidance and control; the pilot's associate; guidance, navigation, and control components and avionics; the robustness analysis and design; robotics for aerospace applications; integrated/multidisciplinary flight control; fuzzy logic applications; digital control and estimation; space transportation guidance and control; and control of large scale/multibody systems. I.S.

A91-49583*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SENSOR-ACTUATOR PLACEMENT FOR FLEXIBLE STRUCTURES WITH ACTUATOR DYNAMICS
P. G. MAGHAMI and S. M. JOSHI (NASA, Langley Research Center, Hampton, VA) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 46-55. refs
(AIAA PAPER 91-2606) Copyright

A novel approach for placement of sensors and actuators in control of flexible space structures is developed. Using an approximation of the control forces and output measurements by spatially continuous functions, the approach follows a nonlinear programming technique to determine optimal locations for sensors and actuators. Two different criteria are considered for the placement of sensors and actuators. The first criterion optimizes the location of the sensors and actuators in order to move the transmission zeros of the system farther to the left of the imaginary axis. The second criterion, however, places the sensors and actuators to optimize a function of the singular values of the Hankel matrix, which includes both measures of controllability and observability. Moreover, the effect of actuator dynamics in the placement of sensors and actuators is investigated. Author

A91-49584#
A CONTROL FORMULATION FOR THE DAMPING OF STRUCTURES BY VIBRATION ABSORBERS
THOMAS A. POSBERGH (Minnesota, University, Minneapolis) and SCOTT DAHL IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 56-60. Research supported by USAF. refs
(AIAA PAPER 91-2607) Copyright

The problem of passive damping of large flexible space structures is addressed by reformulating the classical Den Hartog vibration absorber theory as a feedback control problem. With this reformulation recently developed algorithms which solve the H-infinity feedback control problem can be used to determine the optimal tuning of the vibration absorber. These results are then extended to multiple-degree-of-freedom systems with several vibration absorbers. Author

A91-49586#
DERIVATION OF REDUCED ORDER MODELS FOR LARGE FLEXIBLE STRUCTURES
VITTAL RAO, K. NGO (Missouri-Rolla, University, Rolla), JOEL BERG, and ALOK DAS (USAF, Phillips Laboratory, Edwards AFB, CA) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 72-82. Research supported by USAF. refs
(AIAA PAPER 91-2609)

In this paper, balance-truncation, eigenvalue truncation/aggregation, and optimal projection techniques have been applied for deriving reduced-order models for a large space structure. A new procedure is developed for determining projection parameters associated with balance-truncation and aggregation methods. These parameters play an important role in the design of robust controllers. The Advanced Space Structure Technology Research Experiments (ASTREX) facility was developed as a test bed for validation and integration of control-structures technologies. A detailed finite element model is developed to allow incorporation of the actuators and sensors with the test article. The reduced order models are derived for this structure, and a critical comparison has been provided. Author

A91-49621*# Arizona State Univ., Tempe.
ROBUSTIFIED TIME-OPTIMAL CONTROL OF UNCERTAIN STRUCTURAL DYNAMIC SYSTEMS
QIANG LIU and BONG WIE (Arizona State University, Tempe) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 443-452. Research supported by NASA. refs
(AIAA PAPER 91-2646) Copyright

A new approach for computing open-loop time-optimal control inputs for uncertain linear dynamical systems is developed. In particular, the single-axis, rest-to-rest maneuvering problem of flexible spacecraft in the presence of uncertainty in model parameters is considered. Robustified time-optimal control inputs are obtained by solving a parameter optimization problem subject to robustness constraints. A simple dynamical system with a rigid-body mode and one flexible mode is used to illustrate the concept. Author

A91-49623#
VIBRATION SUPPRESSION FOR A LARGE SPACE STRUCTURE USING H-INFINITY CONTROL
R. M. STOUGHTON and CHRISTOPHER T. VOTH (Martin Marietta Corp., Denver, CO) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 458-466. refs
(Contract F33615-82-C-3222)
(AIAA PAPER 91-2649) Copyright

An application of an H-infinity design technique to the active control of the Dynamic Test Article (DTA) is presented, which is a ground-based test structure designed and built under the Passive and Active Control Space Structures Program. The control problem was to reduce the X and Y line-of-sight pointing errors caused by deformation of the structure due to vibration. Active suppression of the structural modes is accomplished using 10 proof-mass actuators located on the structure, in conjunction with 23 sensors. Explicit modeling of uncertainties within the nominal plant model was found to be important in achieving a closed-loop system insensitive to plant variations typical of flight hardware. Implementation of the resulting controller on the DTA structure provided experimental verification of the performance of the closed-loop system, and the stability of the closed-loop design in the presence of model errors typical of test verified structures possessing high modal density. Author

A91-49624*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

DYNAMIC DISSIPATIVE COMPENSATOR DESIGN FOR LARGE SPACE STRUCTURES

S. M. JOSHI, P. G. MAGHAMI, and A. G. KELKAR (NASA, Langley Research Center, Hampton, VA) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 467-477. refs

(AIAA PAPER 91-2650) Copyright

Control system design is considered for attitude control and vibration suppression of flexible space structures. The problem addressed is that of controlling both the zero-frequency rigid-body modes and the elastic modes. Model-based compensators, which employ observers tuned to the plant parameters, are first investigated. Such compensators are shown to generally exhibit high sensitivity to the knowledge of the parameters, especially the elastic mode frequencies. To overcome this problem a class of dynamic dissipative compensators is next proposed, which robustly stabilize the plant in the presence of unmodeled dynamics and parametric uncertainties. An analytical proof of robust stability is given, and a method of implementing the controller as a strictly proper compensator is given. Methods of designing such controllers to obtain optimal performance and robust stability are presented. Numerical and experimental results of application of the methods are presented, which indicate that dynamic dissipative controllers can simultaneously provide excellent performance and robustness. Author

A91-49625#

ATTITUDE CONTROL OF FLEXIBLE COMMUNICATIONS SATELLITES

BRIJ N. AGRAWAL (U.S. Naval Postgraduate School, Monterey, CA) and RICHARD GRAN (Grumman Aerospace Corp., Bethpage, NY) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 478-487. refs

(AIAA PAPER 91-2651) Copyright

This paper investigates alternate control techniques for the attitude control of a three-axis stabilized flexible communications satellite consisting of a large reflector and a solar array. The control configurations consisted of three classes: Class 1 - sensors and actuators co-located on the central body, Class 2 - actuator on the central body and sensors distributed, and Class 3 - actuators and sensors distributed. Criteria are developed for modal truncation. The results indicate that Class 2 can cause instability and is not generally a desirable design approach. An experimental setup to study the effects of flexibility on attitude control performance during slew maneuvers and wheel desaturation is also discussed. Author

A91-49627#

ADAPTIVE CONTROL STRATEGIES FOR VIBRATION SUPPRESSION IN FLEXIBLE STRUCTURES

A. M. ANNASWAMY (Boston University, MA) and D. J. CLANCY (Raytheon Co., Missile Systems Div., Tewksbury, MA) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 501-511. refs

(Contract NSF ECS-89-15276)

(AIAA PAPER 91-2653) Copyright

Flexible structural systems are high dimensional and lightly damped, and invariably contain significant uncertainties in their dynamic behavior. Adaptive controllers, which are capable of overcoming such uncertainties and delivering high performance by providing a time-varying compensation on-line, are therefore desirable for such systems. A new adaptive controller which can globally stabilize a class of flexible structures is presented. This controller is applicable whether position measurements, rate measurements, or combinations thereof are available, as well as for colocated and noncolocated actuator-sensor pairs. The superior performance generated using such controllers is demonstrated using two practical structural systems. Author

A91-49633#

SPACE STATION RCS ATTITUDE CONTROL SYSTEM

STEVEN W. LEE, REINHOLD MATULENKO, and J. B. CALDWELL (Honeywell, Inc., Clearwater, FL) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 554-564.

(AIAA PAPER 91-2661) Copyright

This paper provides an overview of the preliminary design of the Space Station Reaction Control System (RCS) Controller portion of the Attitude Control System. The RCS controller is used for reboost operations and large-angle attitude maneuvers; it also serves as a backup means of attitude control. It accommodates the numerous Space Station assembly configurations and operational modes with one general set of design algorithms. The RCS Controller includes such features as a rigid-body state estimator which attenuates flexible body effects while accounting for desired high-frequency events such as RCS jet firings, a fuel-optimal jet select logic, and a torque equilibrium attitude (TEA) seeker which acquires and tracks the TEA without the need for an explicit TEA estimator. The RCS Controller, its configuration, functions, capabilities, operational modes, and performance are described. Author

A91-49634#

APPLICATION OF MICRO-SYNTHESIS TECHNIQUES TO MOMENTUM MANAGEMENT AND ATTITUDE CONTROL OF THE SPACE STATION

GARY J. BALAS (Minnesota, University, Minneapolis), ANDY K. PACKARD (California, University, Berkeley), and JOHN T. HARDUVEL (McDonnell Douglas Corp., Huntington Beach, CA) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 565-575. refs

(AIAA PAPER 91-2662) Copyright

The paper discusses application of microsynthesis techniques to the design of full-state feedback controllers for momentum management and attitude control of the Space Station. The primary objective is to maximize the robustness of the controller to variations in the moment of inertias of the Space Station. The performance objective is to restrict the closed-loop poles of the nominal system to be within a semicircle in the left-half plane. A number of controllers are designed which achieve different levels of robustness and performance when implemented on the nominal system. These designs have significant robustness to variations in moment of inertias and are able to meet a majority of the performance specifications. There are large increases in the robustness of the designs as the specifications on the placement of the closed-loop poles is relaxed. It appears that there is a tradeoff between the closed-loop pole locations and the robustness of controllers. Author

A91-49635#

INVERTIBILITY OF MAP, ZERO DYNAMICS AND NONLINEAR CONTROL OF SPACE STATION

THEODORE C. BOSSART and SAHJENDRA N. SINGH (Nevada, University, Las Vegas) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 576-584. refs

(Contract DAAL03-87-G-0004)

(AIAA PAPER 91-2663) Copyright

The use of control-moment gyros in the attitude control of the Space Station is reconsidered by introducing an approach based on feedback linearization. The input-output map is linear in the closed-loop system of the attitude-control law, and the control of each output variables is effected individually. The origin of the zero dynamics is found to be asymptotically stable for given Space

Station parameters, and attitude angles and control-moment-gyro momenta asymptotically converge to the origin in the closed-loop system. The closed-loop system can be used to control angular momenta, yaw, roll, and large pitch angles. C.C.S.

A91-49636*# Analytical Mechanics Associates, Inc., Hampton, VA.

SENSITIVITY OF SPACE STATION ALPHA JOINT ROBUST CONTROLLER TO STRUCTURAL MODAL PARAMETER VARIATIONS

RENJITH R. KUMAR (Analytical Mechanics Associates, Inc., Hampton, VA), PAUL A. COOPER (NASA, Langley Research Center, Hampton, VA), and TAE W. LIM (Lockheed Engineering and Sciences Co., Hampton, VA) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 585-594. refs

(AIAA PAPER 91-2665) Copyright

The baseline design of the photovoltaic-array sun-tracking control system is presented with special attention given to the optimization of design variables related to stability and performance. The procedures utilized to attenuate control/structure interaction are described, and controller sensitivity to variations in structural modal parameters is examined. Constrained optimization techniques determine the stability margin and tracking capability, which are then tested for sensitivity to variations in natural frequency, mode-shape amplitudes, and modal-damping ratios. The effect of variations in the modal parameters of the dominant modes on performance indicators is also examined to optimize tracking-performance responsiveness and satisfy the design requirements. It is concluded that accurate on-orbit modal data are necessary to make the reoptimization procedure effective in improving the performance of the control system. C.C.S.

A91-49656*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

EXPERIMENTAL STUDY OF ADAPTIVE POINTING AND TRACKING FOR LARGE FLEXIBLE SPACE STRUCTURES

D. BOUSSALIS, D. S. BAYARD, C. IH, S. J. WANG, and A. AHMED (JPL, Pasadena, CA) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 769-778. Research supported by USAF. refs

(AIAA PAPER 91-2691) Copyright

This paper describes an experimental study of adaptive pointing and tracking control for flexible spacecraft conducted on a complex ground experiment facility. The algorithm used in this study is based on a multivariable direct model reference adaptive control law. Several experimental validation studies were performed earlier using this algorithm for vibration damping and robust regulation, with excellent results. The current work extends previous studies by addressing the pointing and tracking problem. As is consistent with an adaptive control framework, the plant is assumed to be poorly known to the extent that only system level knowledge of its dynamics is available. Explicit bounds on the steady-state pointing error are derived as functions of the adaptive controller design parameters. It is shown that good tracking performance can be achieved in an experimental setting by adjusting adaptive controller design weightings according to the guidelines indicated by the analytical expressions for the error. Author

A91-49657*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

EXPERIMENTAL RESULTS OF ACTIVE CONTROL ON A LARGE STRUCTURE TO SUPPRESS VIBRATION

H. J. DUNN (NASA, Langley Research Center, Hampton, VA) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 779-791. refs

(AIAA PAPER 91-2692) Copyright

Three design methods, Linear Quadratic Gaussian with Loop Transfer Recovery (LQG/LTR), H-infinity, and mu-synthesis, are used to obtain compensators for suppressing the vibrations of a 10-bay vertical truss structure, a component typical of what may be used to build a large space structure. For the design process the plant dynamic characteristics of the structure were determined experimentally using an identification method. The resulting compensators were implemented on a digital computer and tested for their ability to suppress the first bending mode response of the 10-bay vertical truss. Time histories of the measured motion are presented, and modal damping obtained during the experiments are compared with analytical predictions. The advantages and disadvantages of using the various design methods are discussed. Author

A91-49659#

H-INFINITY CONTROL DESIGN FOR THE ASCIE SEGMENTED OPTICS TEST BED - ANALYSIS, SYNTHESIS AND EXPERIMENT

ALAIN CARRIER, JEAN-NOEL AUBRUN, KENNETH LORELL (Lockheed Research Laboratories, Palo Alto, CA), and ARTHUR E. BRYSON, JR. (Stanford University, CA) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 807-817. refs

(AIAA PAPER 91-2695) Copyright

Applications of worst-case-control design methods (H-infinity) to the Advanced Structures/Controls Integrated Experiment (ASCIE) are examined. A segment alignment bandwidth series of tests are conducted in which the mode shape of some of the modes from the FEM is extracted and square waves are forced through each of them into the actuators. The tests show how well the control system rejects input step disturbances and provide valuable information on the control bandwidth. P.D.

A91-49660*# Arizona State Univ., Tempe.

EXPERIMENTAL DEMONSTRATION OF A CLASSICAL APPROACH FOR FLEXIBLE STRUCTURE CONTROL - THE ACES TESTBED

BONG WIE (Arizona State University, Tempe) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 818-826. Research supported by NASA. refs

(AIAA PAPER 91-2696) Copyright

This paper describes the results of an active structural control experiment performed for the Advanced Control Evaluation for Structures (ACES) testbed at NASA-Marshall as part of the NASA Control-Structure Interaction Guest Investigator Program. The experimental results successfully demonstrate the effectiveness of a 'dipole' concept for line-of-sight control of a pointing system mounted on a flexible structure. The simplicity and effectiveness of a classical 'single-loop-at-a-time' approach for the active structural control design for a complex structure, such as the ACES testbed, are demonstrated. Author

A91-49668#

FRACTAL INTERPOLATION OF STRANGE ATTRACTORS IN ADAPTIVE CONTROL OF ATTITUDE DYNAMICS

ANDREW J. KURDILA, LARRY KEALEY (Texas A & M University, College Station), and FRANCIS NARCOWICH IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 894-907. refs

(AIAA PAPER 91-2705) Copyright

Analytical and numerical evidence are provided to the effect that even simple adaptive control schemes applied to the forthcoming class of evolutionary large space structures may exhibit a pathological response in the form of chaotic motion. The approach taken employs a common stochastic gradient method to estimate abrupt changes of inertia about the pitch axis of a large space structure due to a docking spacecraft. A methodology is introduced for expressing the continuous dependence of the attractor of the Poincare map for inertial estimate versus pitch attitude. P.D.

A91-49677*# Texas A&M Univ., College Station.
PARAMETER ESTIMATION IN SPACE SYSTEMS USING RECURRENT NEURAL NETWORKS
ALEXANDER G. PARLOS, AMIR F. ATIYA (Texas A & M University, College Station), and JOHN W. SUNKEL (NASA, Johnson Space Center, Houston, TX) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1010-1022. refs
(Contract NAG9-941)
(AIAA PAPER 91-2716) Copyright

The identification of time-varying parameters encountered in space systems is addressed, using artificial neural systems. A hybrid feedforward/feedback neural network, namely a recurrent multilayer perception, is used as the model structure in the nonlinear system identification. The feedforward portion of the network architecture provides its well-known interpolation property, while through recurrency and cross-talk, the local information feedback enables representation of temporal variations in the system nonlinearities. The standard back-propagation-learning algorithm is modified and it is used for both the off-line and on-line supervised training of the proposed hybrid network. The performance of recurrent multilayer perceptron networks in identifying parameters of nonlinear dynamic systems is investigated by estimating the mass properties of a representative large spacecraft. The changes in the spacecraft inertia are predicted using a trained neural network, during two configurations corresponding to the early and late stages of the spacecraft on-orbit assembly sequence. The proposed on-line mass properties estimation capability offers encouraging results, though, further research is warranted for training and testing the predictive capabilities of these networks beyond nominal spacecraft operations. Author

A91-49694#
MODELING AND CONTROL OF LARGE SPACE STRUCTURES USING CIRCUIT ANALOGIES
L. LENNING and U. OZGUNER (Ohio State University, Columbus) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1208-1218. refs
(Contract F49620-89-C-0046)
(AIAA PAPER 91-2736) Copyright

Circuit analogies of mechanical systems are used to establish a framework in which large flexible structures may be analyzed. Impedance and scattering parameters of flexible structures are derived directly from either partial differential equation or finite element models of the structures. A cantilevered beam example is used for illustration and comparison of the two derivations. Component mode synthesis and controlled component synthesis of structures are discussed and related to circuits. Various design methods for shaping scattering parameters of flexible structures for desired scattering properties are formulated including H-infinity-based designs. Author

A91-49695#
IDENTIFICATION EXPERIMENTS ON ASTREX
J. RAMAKRISHNAN, A. HU, R. VANDER VOORT (Dynacs Engineering Co., Palm Harbor, FL), J. BERG, and D. F. COSSEY (USAF, Phillips Laboratory, Edwards AFB, CA) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1219-1228. refs
(AIAA PAPER 91-2737) Copyright

Identification experiments on the Air Force Phillips Laboratory's (formerly the Astronautics Laboratory) Advanced Space Structure Technology Research Experiment facility (Astrex) is described in this paper. A finite element model of Astrex was constructed to provide modal vector information (necessary for control law development) and also to provide a comparison for the identified models derived from experimental data. The q-Markov COVER (covariance equivalent realization) and frequency response functions were used for the identification. The identified models show good correlation with the time history and frequency response data obtained in the laboratory. Author

A91-49704#
REORIENTATION OF SPACE MULTIBODY SYSTEMS MAINTAINING ZERO ANGULAR MOMENTUM
MAHMUT REYHANOGLU and N. H. MCCLAMROCH (Michigan, University, Ann Arbor) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1330-1340. refs
(Contract NSF MSM-87-22266)
(AIAA PAPER 91-2747) Copyright

The reorientation of planar multibody systems in space with angular momentum-preserving controls is studied. Rest-to-rest maneuvers for the absolute orientation of a multibody system which maintains zero angular momentum is considered. A control strategy is proposed for a system which is composed of N planar rigid bodies interconnected by ideal pin joints in the form of an open kinematic chain, and joint torque motors which actuate the motions at the joints. The holomony is found to depend only on the path traversed in the shape space and not on the time history of the joint angular velocities. The proposed strategy is demonstrated by computer simulations of a three-link example. Consideration is given to the applications of the developed theory, namely, a variety of multibody control problems in space, including space robotics, astronaut maneuvers, and satellite antenna deployment. P.D.

A91-49707#
A SYSTEM MODE APPROACH FOR SIMULATION OF FLEXIBLE DYNAMICS IN REAL TIME
J. F. KELLEY, B. MORGOWICZ, and D. S. UETRECHT (Hughes Aircraft Co., El Segundo, CA) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1360-1369. refs
(AIAA PAPER 91-2750) Copyright

A description of a real time compatible hybrid approach for modeling nonlinear rigid dynamics with linearized flexible dynamics is given. The approach is based on combining the nonlinear rigid equations of motion with linear representations of flexibility effects expressed in a floating coordinate frame. The resultant simulations are fundamentally efficient due to characterization of flexible effects in terms of system rather than component modes. Means for accommodating large motions between component bodies are also described. Accompanying the motivating derivation are sample results and measured execution times for a 12-mode model of a flexible satellite. This model has been tested in faster-than-real-time simulations and could in principle achieve execution speeds 100 times faster than real time. Author

A91-49744*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
A FUZZY LOGIC BASED SPACECRAFT CONTROLLER FOR SIX DEGREE OF FREEDOM CONTROL AND PERFORMANCE RESULTS
ROBERT N. LEA (NASA, Johnson Space Center, Houston, TX), JEFFREY HOBLIT, and YASHVANT JANI (LinCom Corp., Houston, TX) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1680-1690. refs
(AIAA PAPER 91-2800) Copyright

The development philosophy of the fuzzy logic controller is explained, details of the rules and membership functions used are given, and the early results of testing of the control system for a representative range of scenarios are reported. The fuzzy attitude controller was found capable of performing all rotational maneuvers, including rate hold and rate maneuvers. It handles all orbital perturbations very efficiently and is very responsive in correcting errors. P.D.

A91-49783*# Grumman Aerospace Corp., Reston, VA.

MASS PROPERTY IDENTIFICATION - A COMPARISON STUDY BETWEEN EXTENDED KALMAN FILTER AND NEURO-FILTER APPROACHES

QUANG LAM, RICHARD CHIPMAN (Grumman Corp., Space Station Program Support Div., Reston, VA), and JOHN SUNKEL (NASA, Johnson Space Center, Houston, TX) AIAA, Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991. 12 p. refs

(AIAA PAPER 91-2664) Copyright

Two algorithms, extended Kalman filter and neuro-filter, are formulated to perform mass property identification for the Space Station Freedom. Control moment gyros that are part of the Station's basic momentum management system are chosen to provide input excitation in the form of applied torques. These torques together with the measured angular body rate responses are supplied to the filters. From these data, both algorithms are shown to accurately identify the station mass properties when excitation levels are high and balanced between axes. The neuro-filter, however, is shown to be more robust and to perform well even with weakly persistent, unbalanced signals contaminated with noise. Author

A91-49790#

PARAMETER ESTIMATION USING AN OPTIMIZED LEARNING NETWORK

QUANG M. LAM and LESTER FOSTER (Grumman Corp., Space Station Program Support Div., Reston, VA) AIAA, Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991. 10 p. refs

(AIAA PAPER 91-2774) Copyright

An improved neural network estimator or neuro-estimator is developed in this paper for parameter estimation and system identification. The neuro-estimation algorithm employs the discrete Hopfield network with the fundamental error backpropagation technique. Then, these two methods are coupled with the optimized learning rate to produce an improved algorithm. The neuro-estimator presented requires linearized equations in the state space realization form where the output is the full state measurement collocated with the input excitation. However, the formulation is generalized for a multilayer network which can be used when the output is a linear combination of the states. The new algorithm is faster and more robust when compared to recently developed neuro-estimators. The proposed neuro-estimator is tested with simulated data from several systems. First, it is tested with a mass spring oscillator to verify the improved learning rate in the presence of different noise levels. Then, the parameter identification with the neuro-estimator is performed on a free-free bar and the Space Station Freedom in low earth orbit. Author

A91-49940* Howard Univ., Washington, DC.

ORIENTATION AND SHAPE CONTROL OF A WEIGHT OPTIMUM FREE-FREE BEAM IN A CIRCULAR ORBIT

PETER M. BAINUM (Howard University, Washington, DC) and K. SATYANARAYANA (Computer Sciences Corp., Lanham, MD) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 39, July-Sept. 1991, p. 383-391. Research supported by NASA and Howard University. refs

Copyright

In this study, the vibration and orientation control of large space structures using the linear quadratic regulator technique is investigated. Emphasis is placed on the control of both a class of optimally designed structures and uniform structures meeting the mission requirements using a long free-free beam in orbit as an example. The open loop and closed loop dynamics are compared and the transient responses are obtained to determine the effectiveness of the control system design. Author

A91-50613

CONTROL AND DYNAMIC SYSTEMS. VOL. 36 - ADVANCES IN LARGE SCALE SYSTEMS DYNAMICS

C. T. LEONDES, ED. (California, University, Los Angeles; Washington, University, Seattle) San Diego, CA, Academic Press, Inc., 1990, 421 p. For individual items see A91-50614 to A91-50617.

Copyright

Papers contained in this volume provide a significant reference source for practicing professional and research workers in the area of large-scale systems. Attention is given to multiobjective decision-tree analysis in industrial systems, methods for economic policy design, methods in the analysis of multistage commodity markets, a control problem for processing discrete parts with random arrivals, model reduction for flexible structures, distributed transducers for structural measurement and control, robust adaptive identification and control design techniques, and techniques in the optimal control of distributed parameter systems. O.G.

A91-50614 Jet Propulsion Lab., California Inst. of Tech., Pasadena.

MODEL REDUCTION FOR FLEXIBLE STRUCTURES

WODEK GAWRONSKI (JPL, Pasadena, CA) and JER-NAN JUANG (NASA, Langley Research Center, Hampton, VA) IN: Control and dynamic systems. Vol. 36 - Advances in large scale systems dynamics. San Diego, CA, Academic Press, Inc., 1990, p. 143-222. refs

Copyright

Several conditions for a near-optimal reduction of general dynamic systems are presented focusing on the reduction in balanced and modal coordinates. It is shown that model and balanced reductions give very different results for the flexible structure with closely-spaced natural frequencies. In general, balanced reduction is found to give better results. A robust model reduction technique was developed to study the sensitivity of modeling error to variations in the damping of a structure. New concepts of grammians defined over a finite time and/or a frequency interval are proposed including computational procedures for evaluating them. Application of the model reduction technique to these grammians is considered to lead to a near-optimal reduced model which closely reproduces the full system output in the time and/or frequency interval. O.G.

A91-50615

DISTRIBUTED TRANSDUCERS FOR STRUCTURAL MEASUREMENT AND CONTROL

SHAWN E. BURKE and JAMES E. HUBBARD, JR. (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: Control and dynamic systems. Vol. 36 - Advances in large scale systems dynamics. San Diego, CA, Academic Press, Inc., 1990, p. 223-273. refs

Copyright

Research efforts aimed at designing and implementing distributed parameter control schemes with both distributed sensing and actuation are described. This union of distributed parameter systems with distributed parameter transducers and concepts is considered to lead to simple and realiable control system designs. The design method under consideration does not require plant model truncations and offers the possibility of controlling all modes of flexible structural components with simple compensator topologies. The analytical development provides insight into the utilization of both distributed and discrete transducers for structural measurement and control. Experimental implementations of the design examples are summarized. O.G.

A91-52012

CONTROLLABILITY AND OBSERVABILITY OF GYROELASTIC VEHICLES

C. J. DAMAREN (Royal Roads Military College, Victoria, Canada) and G. M. T. D'ELEUTERIO (Toronto, University, Downsview, Canada) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Sept.-Oct. 1991, p. 886-894. refs

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Stored angular momentum devices such as reaction wheels and control moment gyros have been used extensively for space vehicle attitude control. They represent a potential source of actuation for vibration and shape control of large space structures where they can potentially be distributed in large numbers. The vibration characteristics of these gyroelastic vehicles are affected by the presence of stored angular momentum and, hence, so are the conditions for controllability and observability. In this paper, these conditions are derived for systems modeled as gyroelastic continua, i.e., vehicles with continuous distributions of mass, stiffness, and gyricity (stored angular momentum). The conditions are expressed in terms of the gyroelastic modes and cover the case of pointwise actuators and those modeled in a continuum fashion. A numerical example is used to show that the degree of controllability in the continuum case can be interpreted as that corresponding to the limit of a sequence of piontwise control problems. The observability conditions are developed for a general class of measurements. The concept of a gyroelastic node is introduced and related to the problem of locating sensors. Author

A91-52013
MEASURE OF CONTROLLABILITY FOR ACTUATOR PLACEMENT
JOHN L. JUNKINS (Texas A & M University, College Station) and YOUDAN KIM Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Sept.-Oct. 1991, p. 895-902. Research supported by Texas Advanced Technology Program. Previously cited in issue 21, p. 3433, Accession no. A90-47714. refs
(Contract F49620-87-C-0078)
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A91-52024
MISSION FUNCTION CONTROL FOR A SLEW MANEUVER EXPERIMENT
HIRONORI FUJII (Tokyo Metropolitan Institute of Technology, Japan), TOSHIYUKI OHTSUKA, and SATOSHI UDOU Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Sept.-Oct. 1991, p. 986-992. refs
Copyright

A control algorithm named mission function control is experimentally demonstrated and verified on a slew maneuver of a flexible space structure model. The mission function control algorithm employs a Liapunov-type function that consists of generalized energy functions. The model consists of a rigid body having a cantilevered flexible appendage; it is controlled to slew in a horizontal plane by a torque motor. Analytical study indicates that vibrational motion of the flexible appendage can be sensed by strain gauges as a bending moment and shear force at the root of the appendage. Results of the experiment show that a simple implementation of the algorithm leads to excellent controlled behavior of the slew maneuver as well as excellent control robustness. Author

A91-52025* Virginia Polytechnic Inst. and State Univ., Blacksburg.
ACTIVE VIBRATION CONTROL WITH MODEL CORRECTION ON A FLEXIBLE LABORATORY GRID STRUCTURE
GEORGE C. SCHAMEL, II and RAPHAEL T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Sept.-Oct. 1991, p. 993-1000. refs
(Contract NAG1-224)
Copyright

This paper presents experimental and computational comparisons of three active damping control laws applied to a complex laboratory structure. Two reduced structural models were used with one model being corrected on the basis of measured mode shapes and frequencies. Three control laws were investigated, a time-invariant linear quadratic regulator with state estimation and two direct rate feedback control laws. Experimental results for all designs were obtained with digital implementation. It was found that model correction improved the agreement between analytical and experimental results. The best agreement was obtained with the simplest direct rate feedback control. Author

A91-52026* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INTEGRATED STRUCTURE/CONTROL LAW DESIGN BY MULTILEVEL OPTIMIZATION
MICHAEL G. GILBERT (NASA, Langley Research Center, Hampton, VA) and DAVID K. SCHMIDT (Arizona State University, Tempe) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Sept.-Oct. 1991, p. 1001-1007. Previously cited in issue 23, p. 3703, Accession no. A89-52564. refs
Copyright

A91-52027
HYBRID STATE EQUATIONS OF MOTION FOR FLEXIBLE BODIES IN TERMS OF QUASI-COORDINATES
LEONARD MEIROVITCH (Virginia Polytechnic Institute and State University, Blacksburg) (Dynamics of controlled mechanical systems; Proceedings of the IUTAM/IFAC Symposium, Zurich, Switzerland, May 30-June 3, 1988, p. 37-48) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Sept.-Oct. 1991, p. 1008-1013. Previously cited in issue 04, p. 450, Accession no. A90-16517. refs
(Contract F49620-88-C-0044)
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A91-52029* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTICAL MODELING FOR DYNAMICS AND CONTROL ANALYSIS
DAVID C. REDDING (JPL, Pasadena, CA; Charles Stark Draper Laboratory, Inc., Cambridge, MA) and WILLIAM G. BRECKENRIDGE (JPL, Pasadena, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Sept.-Oct. 1991, p. 1021-1032. Previously cited in issue 21, p. 3333, Accession no. A90-47638. refs
Copyright

A91-52599
STABILITY OF ATTITUDE CONTROL SYSTEMS UNDER THE RANDOM INTERRUPTION OF THE CONTROL ACTION [OB USTOICHIVOSTI SISTEM ORIENTATSII V USLOVIIAKH SLUCHAINOGO PRERYVANIIA UPRAVLIAIUSHCHEGO VOZDEISTVIIA]
G. IA. LEDENEV Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, July-Aug. 1991, p. 651-654. In Russian. refs
Copyright

The spacecraft attitude control action can be interrupted as a result of the effect of noise on the attitude-sensor signals. These disruptions are connected with an interruption of the relay control signal for a certain period of time, which can lead to spacecraft instability. The stability of an attitude control system under random interruption of the control signal is analyzed here, making it possible to determine the system motion stability on each arc of the phase trajectory and on the entire trajectory. L.M.

A91-53249
TEST/ANALYSIS MODEL CORRELATION FOR THE GAMMA RAY OBSERVATORY
Y. T. CHUNG and S. S. SIMONIAN (TRW Space and Technology Group, Redondo Beach, CA) International Journal of Analytical and Experimental Modal Analysis (ISSN 0886-9367), vol. 6, July 1991, p. 161-173. refs
Copyright

A test-verified Gamma Ray Observatory finite element model was developed based on the modal survey results. Twenty-eight modes were identified from the measured frequency response functions using the polyreference mode extraction technique. Orthogonality check of the test modes with respect to the reduced mass matrix shows that the primary modes satisfy the goal of having off-diagonal terms less than 0.1. The orthogonality check of the secondary modes was greatly improved with a local mode shape tuning procedure by assuming the coupled mode is the linear combination of its adjacent modes. An optimal corrected stiffness matrix was derived to provide a validated analytical model such that the test mode shapes and the frequencies were preserved. Author

A91-53250

COMPARISON OF DIFFERENT METHODS OF MODAL TEST ON A SPACECRAFT REPRESENTATIVE STRUCTURE

R. K. SINGAL, F. R. VIGNERON, T. STEELE (Canadian Space Agency, Ottawa, Canada), A. BERTRAM (Interkeller AG, Bruettisellen, Switzerland), and M. DEGENER (DLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) International Journal of Analytical and Experimental Modal Analysis (ISSN 0886-9367), vol. 6, July 1991, p. 175-187. refs

Copyright

Three methods of dynamic identification are examined by applying them to a model of a typical modular spacecraft in lightly damped and medium-damped conditions. The model, called Flecs, is employed to validate: the phase-resonance method with appropriate excitation; the mode-separation method with complex exponential; and a driven-base method with unidirectional base excitation. The test structure is described, and the performance of the modal surveys is evaluated by comparing frequencies for particular Flecs configurations. The mode shapes of both configurations are found to be of three classes: isolated motion of the center body, isolated motion of individual beams with end masses, and combined motion of the center body and at least one beam module. The results of the phase-resonance and mode-separation surveys are found to be similar, and 30 and 27 common modes are identified for the unmodified and damped configurations, respectively. C.C.S.

A91-53275* North Carolina Agricultural and Technical State Univ., Greensboro.

DYNAMIC ANALYSIS OF TRUSS-BEAM SYSTEM

ELIAS G. ABU-SABA, WILLIAM M. MCGINLEY (North Carolina Agricultural and Technical State University, Greensboro), and RAYMOND C. MONTGOMERY (NASA, Langley Research Center, Hampton, VA) Journal of Aerospace Engineering (ISSN 0893-1321), vol. 4, Oct. 1991, p. 347-354. refs

(Contract NAG1-997)

Copyright

A simple truss-beam method for determining the dynamic characteristics of the space structures intended to perform various tasks in orbit is presented. Algorithms are provided to determine the flexibility matrix of the truss beam for use in the equation of motion. The natural frequencies obtained through this method are compared with those obtained through the finite element method. An experimental procedure for verifying the theoretical results is described. It is concluded that the truss-beam method is a simple analysis technique that yields reasonably accurate results with a minimum of computational effort, especially for the critical lower bending modes of flexible structures. The method takes less computer time than more conventional methods and can be programed in both BASIC and FORTRAN for use in micro- and mainframe computers. O.G.

A91-53846

RAYLEIGH-RITZ BASED SUBSTRUCTURE SYNTHESIS FOR FLEXIBLE MULTIBODY SYSTEMS

L. MEIROVITCH and M. K. KWAK (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 29, Oct. 1991, p. 1709-1719. Previously cited in issue 10, p. 1500, Accession no. A90-26825. refs

(Contract F49620-89-C-0049)

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A91-54131

SLIDING-MODE CONTROL SYSTEM FOR THE THREE-AXIS ATTITUDE CONTROL OF RIGID-BODY SPACECRAFT WITH UNKNOWN DYNAMICS PARAMETERS

S. J. DODDS and A. B. WALKER (East London, Polytechnic, Dagenham, England) International Journal of Control (ISSN 0020-7179), vol. 54, Oct. 1991, p. 737-761. refs

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In sliding-mode control for three-axis attitude control of rigid-body spacecraft, system accuracy depends almost entirely on the attitude-measurement system, control-actuator misalignments, and scale-factor errors that are permitted. Control-smoothing integrators are treated as part of the controlled plant by including the three angular acceleration components as the state feedback. The ideal multivariable control system eliminates closed-loop interaxis coupling. Attention is presently given to results obtained for slewing maneuvers, including actuator failure and response to a disturbance torque. O.C.

A91-54132

BOUNDARY CONTROL OF A TIMOSHENKO BEAM ATTACHED TO A RIGID BODY - PLANAR MOTION

OMER MORGUL (Bilkent University, Ankara, Turkey) International Journal of Control (ISSN 0020-7179), vol. 54, Oct. 1991, p. 763-791. Research supported by Scientific and Technical Research Council of Turkey. refs

(Contract NSF ECS-85-00993)

Copyright

A flexible spacecraft modeled as a rigid body which rotates in an inertial space is considered; a light flexible beam is clamped to the rigid body at one end and free at the other end. The equations of motion are obtained by using the geometrically exact beam model for the flexible beam, and it is then shown that under planar motion assumption, linearization of this model yields the Timoshenko beam model. It is shown that suitable boundary controls applied to the free end of the beam and a control torque applied to the rigid body stabilize the system. The proof is obtained by using a Liapunov functional based on the energy of the system. Author

A91-54451

MECHANICS AND CONTROL OF LARGE FLEXIBLE STRUCTURES

JOHN L. JUNKINS, ED. (Texas A & M University, College Station) Washington, DC, American Institute of Aeronautics and Astronautics, Inc. (Progress in Astronautics and Aeronautics. Vol. 129), 1990, 721 p. For individual items see A91-54452 to A91-54475.

Copyright

Attention is first given to structural modeling, identification, and dynamic analysis. The following topics are discussed: the orthogonal projection approach to multibody dynamics; the integrated structure-control optimization of space structures; the dynamics and control of tethered spacecraft during deployment and retrieval; and the precision pointing of large antennas by static shape estimation. Control, stability analysis, and optimization are then discussed. Particular emphasis is placed on the boundary element method for shape control of distributed-parameter elastostatic systems; a minimum sensitivity design method for output feedback controllers; and controller design by eigenspace assignment. Finally, controls/structure interactions are considered, with attention given to large-angle maneuver experiments in ground-based laboratories, the near-minimum-time maneuvers of flexible vehicles, and a Liapunov approach to the feedback control of space structures. L.M.

A91-54452* Texas Univ., Austin.

RECENT LITERATURE ON STRUCTURAL MODELING, IDENTIFICATION, AND ANALYSIS

ROY R. CRAIG, JR. (Texas, University, Austin) IN: Mechanics and control of large flexible structures. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 3-29. Research supported by NASA. refs

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The literature on the mathematical modeling of large space structures is first reviewed, with attention given to continuum models, model order reduction, substructuring, and computational techniques. System identification and mode verification are then discussed with reference to the verification of mathematical models of large space structures. In connection with analysis, the paper surveys recent research on eigensolvers and dynamic response solvers for large-order finite-element-based models. L.M.

A91-54453
ORTHOGONAL PROJECTION APPROACH TO MULTIBODY DYNAMICS
H. FLASHNER (Southern California, University, Los Angeles, CA) IN: Mechanics and control of large flexible structures. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 31-53. refs
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The orthogonal projection approach to modeling linear and nonlinear multibody systems is presented. The paper starts with an analysis of linear systems and the nonlinear numerical simulation is presented as an iterative extension of the linear analysis. The approach is demonstrated on a number of examples (e.g., synthesis using analytically computed modes and the modeling of a spacecraft) that show the efficiency and numerical stability of the method. L.M.

A91-54454
INTEGRATED STRUCTURE-CONTROL OPTIMIZATION OF SPACE STRUCTURES
RAPHAEL T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg) IN: Mechanics and control of large flexible structures (A91-54451 23-39). Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 55-69. Previously cited in issue 10, p. 1444, Accession no. A90-26777. refs
Copyright

A91-54455
MULTIBODY DYNAMICS FORMULATIONS VIA KANE'S EQUATIONS
RONALD L. HUSTON (Cincinnati, University, OH) IN: Mechanics and control of large flexible structures (A91-54451 23-39). Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 71-86. Previously cited in issue 10, p. 1492, Accession no. A90-26816. refs
(Contract NSF MSM-86-12970)
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A91-54456* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INPUT/OUTPUT SYSTEM IDENTIFICATION - LEARNING FROM REPEATED EXPERIMENTS
JER-NAN JUANG, LUCAS G. HORTA (NASA, Langley Research Center, Hampton, VA), and RICHARD W. LONGMAN (Columbia University, New York) IN: Mechanics and control of large flexible structures. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 87-99. refs
Copyright

The paper describes three approaches and possible variations for the determination of the Markov parameters for forced response data using general inputs. It is shown that, when the parameters in the solution procedure are bootstrapped, the results can be obtained very efficiently, but the errors propagate throughout all parameters. By arranging the data in a different form and using singular value decomposition, the resulting identified parameters are more accurate, in the least number of successive experiments, at the expense of a large matrix singular value decomposition. When a recursive procedure is employed, the calculations can be performed very efficiently, but the number of repetitions of the experiments is much greater for a given accuracy than for any of the previous approaches. An alternative formulation is proposed to combine the advantages of each of the approaches. L.M.

A91-54457
MULTIBODY DYNAMICS FORMULATIONS USING MAGGI'S APPROACH
A. J. KURDILA (Texas A & M University, College Station) IN: Mechanics and control of large flexible structures (A91-54451 23-39). Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 101-144. Previously cited in issue 10, p. 1493, Accession no. A90-26828. refs
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A91-54459* Colorado Univ., Boulder.
STAGGERED SOLUTION PROCEDURES FOR MULTIBODY DYNAMICS SIMULATION
K. C. PARK, J. C. CHIOU, and J. D. DOWNER (Colorado, University, Boulder) IN: Mechanics and control of large flexible structures (A91-54451 23-39). Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 183-210. Previously cited in issue 10, p. 1492, Accession no. A90-26826. refs
(Contract NAG1-756)
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A91-54460
PRECISION POINTING OF LARGE ANTENNAS BY STATIC SHAPE ESTIMATION
R. E. SCHEID and G. RODRIGUEZ (California Institute of Technology, Pasadena) IN: Mechanics and control of large flexible structures. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 211-233. refs
Copyright

The paper proposes and analyzes a concept which combines a real-time measurement system, a structural estimator, and a parabolic fitting algorithm to determine antenna pointing offsets resulting from unmodeled structural distortions. These pointing offset data can be employed to generate real-time command biases to correct for pointing errors. Simulations with a reduced-order antenna finite-element model demonstrate that a 10:1 reduction in boresight uncertainty can be achieved. As a specific application, the paper examines the use of this methodology to solve the problem of compensating for static deflections in achieving precise pointing of the large ground antennas that are part of the NASA Deep Space Network used to track and communicate with planetary spacecraft. L.M.

A91-54461
OPTIMAL PROJECTION APPROACH TO ROBUST FIXED-STRUCTURE CONTROL DESIGN
DENNIS S. BERNSTEIN and DAVID C. HYLAND (Harris Corp., Melbourne, FL) IN: Mechanics and control of large flexible structures. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 237-293. Research supported by DARPA, MIT, USAF, et al. refs
Copyright

After a brief review of basic optimal projection theory, the paper considers the numerical solution of the optimal projection equations, relationships between the optimal projection approach and model/controller reduction techniques, and the unification of optimal projection theory and H-infinity theory. Also considered are optimal projection/guaranteed cost theory and optimal projection/positive real theory. L.M.

A91-54462
LOW-ORDER CONTROL OF LINEAR FINITE-ELEMENT MODELS OF LARGE FLEXIBLE STRUCTURES USING SECOND-ORDER PARALLEL ARCHITECTURES
MARK J. BALAS (Colorado, University, Boulder) IN: Mechanics and control of large flexible structures. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 295-313. refs
Copyright

Advanced compensation techniques for CSI (controller/structure interaction) problems in large space structures are developed using very low-order RMF (residual mode filter) ideas on finite-element structure models. The closed-loop format consists of a reduced-order-model (ROM)-based controller designed for performance and CSI compensation adjoined to produce stability without substantial loss of performance. The ROM controller considered has essentially the same second-order architecture as the LFS (large flexible structure) model. This architecture consists of an unnatural second-order observer based on the ROM with a linear corrector signal derived from a P-dimensional first-order filter, where P is the number of sensors; signal processors (no additional dynamics) create the control signals from the above. L.M.

A91-54463
BOUNDARY-ELEMENT METHOD FOR SHAPE CONTROL OF DISTRIBUTED-PARAMETER ELASTOSTATIC SYSTEMS
GOONG CHEN and JIANXIN ZHOU (Texas A & M University, College Station) IN: Mechanics and control of large flexible structures (A91-54451 23-39). Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 315-348. Previously cited in issue 10, p. 1555, Accession no. A90-26793. refs
(Contract AF-AFOSR-87-0334; AF-AFOSR-88-0091; NSF DMS-87-18510)
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A91-54464
STABILITY OF TIME-VARYING STRUCTURAL DYNAMIC SYSTEMS
S. PRADEEP (Indian Institute of Technology, Kanpur, India) IN: Mechanics and control of large flexible structures (A91-54451 23-39). Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 349-372. Previously cited in issue 10, p. 1498, Accession no. A90-26785. refs
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A91-54465* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ROBUST EIGENSYSTEM ASSIGNMENT FOR SECOND-ORDER DYNAMIC SYSTEMS
JER-NAN JUANG and PEIMAN G. MAGHAMI (NASA, Langley Research Center, Hampton, VA) IN: Mechanics and control of large flexible structures (A91-54451 23-39). Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 373-387. Previously cited in issue 10, p. 1555, Accession no. A90-26778. refs
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A91-54466
MINIMUM SENSITIVITY DESIGN METHOD FOR OUTPUT FEEDBACK CONTROLLERS
JOHN L. JUNKINS and YOUDAN KIM (Texas A & M University, College Station) IN: Mechanics and control of large flexible structures (A91-54451 23-39). Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 389-409. Previously cited in issue 10, p. 1555, Accession no. A90-26791. refs
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A91-54468
CONTROLLER DESIGN BY EIGENSPACE ASSIGNMENT
G. L. SLATER and Q. ZHANG (Cincinnati, University, OH) IN: Mechanics and control of large flexible structures (A91-54451 23-39). Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 435-462. Previously cited in issue 10, p. 1555, Accession no. A90-26779. refs
Copyright

A91-54469
RECENT LITERATURE ON EXPERIMENTAL STRUCTURAL DYNAMICS AND CONTROL RESEARCH
WILLIAM L. HALLAUER, JR. (U.S. Air Force Academy, Colorado Springs, CO) IN: Mechanics and control of large flexible structures. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 465-489. refs

This review covers literature published primarily during 1985-1989 concerning the experimental investigation of the dynamics and control of large spacecraft structures (LSS). The main topics surveyed are experimental studies, facilities, and methods relevant to LSS in the areas of structural dynamics, passive control, and active control, with emphasis on the last area. Active control experiments conducted with grounded actuators as well as with structure-borne actuators are discussed. L.M.

A91-54470
LARGE-ANGLE MANEUVER EXPERIMENTS IN GROUND-BASED LABORATORIES
ALOK DAS (USAF, Astronautics Laboratory, Edwards AFB, CA) IN: Mechanics and control of large flexible structures (A91-54451 23-39). Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 491-506. Previously cited in issue 10, p. 1441, Accession no. A90-26817. refs

A91-54471* State Univ. of New York, Buffalo.
CONTROL/STRUCTURE INTERACTION - EFFECTS OF ACTUATOR DYNAMICS
DANIEL J. INMAN (New York, State University, Buffalo) IN: Mechanics and control of large flexible structures (A91-54451 23-39). Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 507-533. Previously cited in issue 10, p. 1556, Accession no. A90-26806. refs
(Contract NAG1-993)
Copyright

A91-54472
CONTROLLED COMPONENT SYNTHESIS - A CSI APPROACH TO DECENTRALIZED CONTROL OF STRUCTURES
K. D. YOUNG (California, University, Livermore) IN: Mechanics and control of large flexible structures. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 535-564. refs
(Contract W-7405-ENG-48)
Copyright

The controlled component synthesis method is shown to be an effective tool for the design of decentralized control for truss structures. A novel component modeling approach, which is similar in many respects to component mode synthesis but more appropriate for controlled component synthesis, is introduced for developing component models of complex structures. It is also shown that the model of a large space structure may be too large to be engaged in existing decentralized control methods, especially those using the information constraint approach. L.M.

A91-54473
NEAR-MINIMUM-TIME MANEUVERS OF FLEXIBLE VEHICLES - A LIAPUNOV CONTROL LAW DESIGN METHOD
JOHN L. JUNKINS, Z. RAHMAN, and H. BANG (Texas A & M University, College Station) IN: Mechanics and control of large flexible structures (A91-54451 23-39). Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 565-593. Research supported by Texas Advanced Technology Program. Previously cited in issue 06, p. 778, Accession no. A90-19974. refs
(Contract F49620-87-C-0078)
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A91-54474
MINIMUM-TIME MANEUVERS OF FLEXIBLE SPACECRAFT
G. SINGH, P. T. KABAMBA, and N. H. MCCLAMROCH (Michigan, University, Ann Arbor) IN: Mechanics and control of large flexible structures. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 595-637. refs
Copyright

Two control problems are considered in connection with the minimum-time maneuvers of a flexible spacecraft: (1) the time-optimal rest-to-rest slewing problem, which brings the rigid-body mode and a finite number of vibrational modes to rest at the final time; and (2) the time-optimal spin-up problem, which brings a finite number of vibrational modes to rest and leaves the rigid-body mode with a finite velocity at the final time. The control histories are shown to be bang-bang with multiple switches. It is proved that the time-optimal controls for both problems have important time-symmetry properties. A system of nonlinear algebraic equations satisfied by the optimal switching times, the optimal final time, and the optimal costates at midmaneuver is derived. In addition the upper bounds on the spillover are derived for a finite-dimensional evaluation model; and it is observed that, for a scalar control input, the time-optimal control history is independent of the control input location. L.M.

A91-54856

MULTI-FLEXIBLE BODY DYNAMICS CAPTURING MOTION-INDUCED STIFFNESS

A. K. BANERJEE and M. E. LEMAK (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) ASME, Transactions, Journal of Applied Mechanics (ISSN 0021-8936), vol. 58, Sept. 1991, p. 766-775. Previously announced in STAR as N90-23013. refs

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A multi-flexible-body dynamics formulation incorporating a recently developed theory for capturing motion-induced stiffness for an arbitrary structure undergoing large rotation and translation accompanied by small vibrations is presented. In essence, the method consists of correcting prematurely linearized dynamical equations for an arbitrary flexible body with generalized active forces due to geometric stiffness corresponding to a system of 12 inertia forces and 9 inertia couples distributed over the body. Equations of motion are derived by means of Kane's method. A useful feature of the formulation is its treatment of prescribed motions and interaction forces. Results of simulations of motions of three flexible spacecraft, involving stiffening during spinup motion, dynamic buckling, and a repositioning maneuver, demonstrate the validity and generality of the theory. Author

A91-54896

SEMI-ACTIVE VIBRATION CONTROL OF STRUCTURES VIA VARIABLE DAMPING ELEMENTS

K. W. WANG and Y. S. KIM (Pennsylvania State University, University Park) Mechanical Systems and Signal Processing (ISSN 0888-3270), vol. 5, Sept. 1991, p. 421-430. Research supported by Pennsylvania State University and Ford Motor Co. refs

Copyright

A semiactive control strategy is developed to suppress vibration of flexible structures by on-line varying the characteristics of variable dampers. This novel algorithm is designed on the basis of sliding mode control theory. The approach is insensitive to the spillover problem encountered in the fully-active control case. The control law is synthesized and illustrated on a beam structure example. Computer simulations are performed to examine the theoretical predictions. The results of this fundamental study are essential for advancing the technology of designing and controlling complex structural and mechanical systems. Author

A91-55139 National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

STRATEGIES FOR LARGE SCALE STRUCTURAL PROBLEMS ON HIGH-PERFORMANCE COMPUTERS

AHMED K. NOOR and JEANNE M. PETERS (NASA, Langley Research Center, Hampton; Virginia, University, Charlottesville) Communications in Applied Numerical Methods (ISSN 0748-8025), vol. 7, Sept. 1991, p. 465-478. refs

(Contract NCCW-0011; AF-AFOSR-90-0369)

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Novel computational strategies are presented for the analysis of large and complex structures. The strategies are based on generating the response of the complex structure using large perturbations from that of a simpler model, associated with a simpler structure (or a simpler mathematical/discrete model of the original structure). Numerical examples are presented to demonstrate the effectiveness of the strategies developed. Author

A91-55457

GROUND VERIFICATION METHOD OF HIGH-ACCURACY ON-BOARD ANTENNA-DRIVE CONTROL SYSTEM

HIROSHI TANAKA and YOICHI KAWAKAMI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 39, Aug. 1991, p. 426-431. In Japanese. refs

This paper describes a ground-verification method for a high-accuracy on-board antenna-drive control system which compensates the antenna's pointing error. A ground-test system for this control system was investigated to predict the control performance in orbit. A laser beam was used instead of the RF beacon signal, and an RF converter which simulates the RF characteristics of the antenna system has been composed in order to realize the closed-loop test system. The ground-test system was constructed using a vacuum chamber to simulate the thermal vacuum environment. Gravity compensation was applied to the antenna-pointing mechanism and 1.6 x 10 exp -4 G environment was obtained by adjusting the suspension-point location. Control performance of the antenna-drive control system which is planned for the launch on ETS-VI spacecraft was evaluated by this ground-test system. Author

A91-55479

VIBRATION LOCALIZATION BY DISORDER - A VIABLE ALTERNATIVE TO DAMPING?

CHRISTOPHE PIERRE (Michigan, University, Ann Arbor) IN: Elastic waves and ultrasonic nondestructive evaluation; Proceedings of the IUTAM Symposium on Elastic Wave Propagation and Ultrasonic Evaluation, Boulder, CO, July 30-Aug. 3, 1989. Amsterdam and New York, North-Holland, 1990, p. 39-46. refs

(Contract NSF MSM-87-00820)

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Localization phenomena are reviewed in terms of disordered structural systems to show that local small-scale variations can significantly affect global structural dynamics. Expressions of localization factors are developed by treating the structural irregularities statistically with emphasis given to system parameters and frequency. Weak and strong localization are defined, and the importance of strong localization is illustrated theoretically. Small irregularities can affect the dynamics of periodic structures such as truss beams and lattices in space structures, particularly in the case of weak coupling. Strong localization can be effectively employed to provide amplitude attenuation - that is not possible from the exclusive use of damping - by utilizing the phenomena to inhibit the propagation of incident waves. C.C.S.

A91-55827* City Coll. of the City Univ. of New York, NY.

MINIMUM-SIZE DESIGN OF REGULATION SYSTEMS AND THE APPLICATION TO SPACE STATION

A. S. S. R. REDDY (City College, New York) and MIFANG RUAN IN: Space utilization and applications in the Pacific; Proceedings of the 3rd Pacific Basin International Symposium on Advances in Space Science Technology and its Applications, Los Angeles, CA, Nov. 6-8, 1989. San Diego, CA, Univelt, Inc., 1990, p. 317-331. Research supported by NASA. refs

(AAS PAPER 89-630) Copyright

A method is proposed to determine the sizes of the regulator and observer and to design the feedback and Kalman gain matrices for the reduced system. The sizes determined are minimum in the sense of satisfying the specified eigenvalue limits when the interaction between the regulator and the observer can be neglected. The resulting sizes will depend on the properties of the original system and the desired response. If the interaction between the regulator and the observer becomes substantial, more modes in the observer should be included, or other methods should be used for reducing the observation spillover or control spillover. O.G.

A91-55843

AN APPROACH TO SYSTEM MODES AND DYNAMICS OF THE EVOLVING SPACE STATION FREEDOM

V. J. MODI and A. SULEMAN (British Columbia, University, Vancouver, Canada) IN: Space utilization and applications in the Pacific; Proceedings of the 3rd Pacific Basin International Symposium on Advances in Space Science Technology and its Applications, Los Angeles, CA, Nov. 6-8, 1989. San Diego, CA, Univelt, Inc., 1990, p. 537-552. refs

(Contract NSERC-STR-32682)

(AAS PAPER 89-654) Copyright

A preliminary libration/vibration interaction dynamics study of Space Station Freedom during its evolutionary phases is presented. A relatively general formulation, applicable to a system of interconnected plate and beam-type structural members forming a tree topology is employed. System modes, acquired through a finite element analysis, are used in the discretization process and the response study is confined to the orbital plane to emphasize interactions between librational dynamics and flexibility. Results provide information relative to the levels of vibrational and librational response and the associated acceleration field, which may prove helpful in appropriately locating monitoring instruments and experiments. R.E.P.

A91-55844* City Coll. of the City Univ. of New York, NY.
ACTUATOR SELECTION FOR LARGE SPACE STRUCTURES
A. S. S. R. REDDY (City College, New York) and MIFANG RUAN IN: Space utilization and applications in the Pacific; Proceedings of the 3rd Pacific Basin International Symposium on Advances in Space Science Technology and its Applications, Los Angeles, CA, Nov. 6-8, 1989. San Diego, CA, Univelt, Inc., 1990, p. 553-570. refs
(AAS PAPER 89-655) Copyright

The paper discusses the process of selecting the actuator locations and the determination of the required number of actuators for large space structures. The selection is based on the definitions of the degree of controllability, the independence of actuators, and the effectiveness of the individual actuators. An algorithm is developed that can be used for the selection of the essential number of actuators and for finding some defects of the system, such as the insuffiency of the available actuator locations for effective control of the whole system or a too crowded frequency distribution. The efficiency of the algorithm was demonstrated by an application to the Space Station. I.S.

A91-55853
THE DECENTRALIZED VARIABLE STRUCTURE CONTROL OF A SPACE STATION WITH MODULAR GROWTH
WENHU HUANG, XIAOHAO XU, YAOHUA WU, and SHIJIE XU (Harbin Institute of Technology, People's Republic of China) IN: Space utilization and applications in the Pacific; Proceedings of the 3rd Pacific Basin International Symposium on Advances in Space Science Technology and its Applications, Los Angeles, CA, Nov. 6-8, 1989. San Diego, CA, Univelt, Inc., 1990, p. 701-710. Research supported by NNSFC. refs
(AAS PAPER 89-665) Copyright

Associated with the motion equations of a Space Station with simple configuration and the dynamic description of Shuttle docking, the overall reaching of the sliding manifold for the Space Station is derived. The scheme of decentralized control in which the local controller relys solely on its own subsystem is proposed and this scheme is employed in the design of a decentralized control system for the Space Station. Computer simulation results taken under large initial deflection and docking procedures with the Shuttle demonstrate the validity of the concept. R.E.P.

A91-56683* California Univ., Los Angeles.
COMPENSATOR DESIGN FOR STABILITY ENHANCEMENT WITH COLLOCATED CONTROLLERS
A. V. BALAKRISHNAN (California, University, Los Angeles) IEEE Transactions on Automatic Control (ISSN 0018-9286), vol. 36, Sept. 1991, p. 994-1007. refs
(Contract NAS1-18585)
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A continuum model rather than a finite element model is used. The optimal compensator design is formulated as a stochastic regulator problem and is shown to be solvable by the general infinite-dimensional theory developed by the author despite the lack of exponential stabilizability. Infinite-dimensional steady-state Riccati equations characterizing the feedback control gain and the Kalman filter gain operators can be solved explicitly. The associated performance indexes including the mean-square control-effort are calculated in closed form. As a first approximation, the compensator transfer function can be realized as a bank of bandpass filters in parallel centered at the undamped mode frequencies. Numerical calculations for the gain and bandwidths for a typical configuration are presented. The performance of the compensator is evaluated when in fact in the true model there is no actuator noise. The theoretical problem involved is to show that the infinite-dimensional stochastic process is asymptotically stationary. It is possible to calculate the steady-state covariance in closed form and thereby calculate performance indexes of interest explicitly, facilitating the choice of optimal design parameters. I.E.

N91-21171# Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil). Dept. of Mechanical Engineering.
A STOCHASTIC APPROACH TO THE PROBLEM OF SPACECRAFT OPTIMAL MANOEUVRES
ANTONIO FERNANDO BER DEALMEIDAPRADO and ATAIR RIOS NETO Nov. 1990 8 p Presented at the 11th World Congress of the International Federation of Automatic Control, Tallin, USSR, 13-17 Aug. 1990
(INPE-5192-PRE/1660) Avail: CASI HC A02/MF A01

The problem of spacecraft orbit transfer with minimum fuel consumption is considered. A new version of the suboptimal and hybrid control approach of numerically treating the problem, where one can take into account the accuracy in the satisfaction of constraints, is developed. To solve the nonlinear programming problem in each iteration, a stochastic version of the projection of the gradient method is used together with the well known hybrid approach to find the optimal control in this kind of dynamic problem. For the maneuvers considered, the spacecraft is supposed to be in keplerian motion perturbed by the thrustors whenever they are active. These thrustors are assumed to be of fixed magnitude (either low or high) and operating in an on-off mode. The solution is given in terms of the location of the burning arcs, time histories of thrustors attitude (pitch or yaw), final orbit acquired, and fuel consumed. Numerical results are presented. Author

N91-21176* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TORSIONAL SUSPENSION SYSTEM FOR TESTING SPACE STRUCTURES Patent
WILMER H. REED, III, inventor (to NASA) and RONALD R. GOLD, inventor (to NASA) 26 Feb. 1991 6 p Filed 26 May 1989 Supersedes N89-28547 (27 - 23, p 3253)
(NASA-CASE-LAR-14149-1-SB; US-PATENT-4,995,272; US-PATENT-APPL-SN-357757; US-PATENT-CLASS-73-865.6; US-PATENT-CLASS-73-866.4; US-PATENT-CLASS-73-663; INT-PATENT-CLASS-G01M-7/02; INT-PATENT-CLASS-G01M-19/00) Avail: US Patent and Trademark Office CSCL 14B

A low frequency torsional suspension system for testing a space structure uses a plurality of suspension stations attached to the space structure along the length thereof in order to suspend the space structure from an overhead support. Each suspension station includes a disk pivotally mounted to the overhead support, and two cables which have upper ends connected to the disk and lower ends connected to the space structure. The two cables define a parallelogram with the center of gravity of the space structure being vertically beneath the pivot axis of the disk. The vertical distance between the points of attachment of the cables to the disk and the pivot axis of the disk is adjusted to lower the frequency of the suspension system to a level which does not interfere with frequency levels of the space structure, thereby enabling accurate measurement.
Official Gazette of the U.S. Patent and Trademark Office

N91-21186*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE SPACECRAFT CONTROL LABORATORY EXPERIMENT OPTICAL ATTITUDE MEASUREMENT SYSTEM
SHARON S. WELCH, RAYMOND C. MONTGOMERY, and MICHAEL F. BARSKY (Virginia Polytechnic Inst. and State Univ., Blacksburg.) Mar. 1991 21 p

(Contract RTOP 590-14-11-02)
(NASA-TM-102624; NAS 1.15:102624) Avail: CASI HC A03/MF A01 CSCL 22B

A stereo camera tracking system was developed to provide a near real-time measure of the position and attitude of the Spacecraft COntrol Laboratory Experiment (SCOLE). The SCOLE is a mockup of the shuttle-like vehicle with an attached flexible mast and (simulated) antenna, and was designed to provide a laboratory environment for the verification and testing of control laws for large flexible spacecraft. Actuators and sensors located on the shuttle and antenna sense the states of the spacecraft and allow the position and attitude to be controlled. The stereo camera tracking system which was developed consists of two position sensitive detector cameras which sense the locations of small infrared LEDs attached to the surface of the shuttle. Information on shuttle position and attitude is provided in six degrees-of-freedom. The design of this optical system, calibration, and tracking algorithm are described. The performance of the system is evaluated for yaw only. Author

N91-21206*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MICROGRAVITY VIBRATION ISOLATION: AN OPTIMAL CONTROL LAW FOR THE ONE-DIMENSIONAL CASE
RICHARD D. HAMPTON, CARLOS M. GRODSINSKY, PAUL E. ALLAIRE, DAVID W. LEWIS, and CARL R. KNOSPE (Virginia Univ., Charlottesville.) *In* NASA, Langley Research Center, Aerospace Applications of Magnetic Suspension Technology, Part 2 p 413-476 Mar. 1991
Avail: CASI HC A04/MF A04 CSCL 22B

Certain experiments contemplated for space platforms must be isolated from the accelerations of the platform. An optimal active control is developed for microgravity vibration isolation, using constant state feedback gains (identical to those obtained from the Linear Quadratic Regulator (LQR) approach) along with constant feedforward gains. The quadratic cost function for this control algorithm effectively weights external accelerations of the platform disturbances by a factor proportional to (1/omega) exp 4. Low frequency accelerations are attenuated by greater than two orders of magnitude. The control relies on the absolute position and velocity feedback of the experiment and the absolute position and velocity feedforward of the platform, and generally derives the stability robustness characteristics guaranteed by the LQR approach to optimality. The method as derived is extendable to the case in which only the relative positions and velocities and the absolute accelerations of the experiment and space platform are available. Author

N91-21213*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.
MODEL CORRELATION AND DAMAGE LOCATION FOR LARGE SPACE TRUSS STRUCTURES: SECANT METHOD DEVELOPMENT AND EVALUATION Final Report, 1 Feb. 1989 - 31 Jan. 1991
SUZANNE WEAVER SMITH and CHRISTOPHER A. BEATTIE Jan. 1991 60 p
(Contract NAG1-960)
(NASA-CR-188102; NAS 1.26:188102) Avail: CASI HC A04/MF A01 CSCL 22B

On-orbit testing of a large space structure will be required to complete the certification of any mathematical model for the structure dynamic response. The process of establishing a mathematical model that matches measured structure response is referred to as model correlation. Most model correlation approaches have an identification technique to determine structural characteristics from the measurements of the structure response. This problem is approached with one particular class of identification techniques - matrix adjustment methods - which use measured data to produce an optimal update of the structure property matrix, often the stiffness matrix. New methods were developed for identification to handle problems of the size and complexity expected for large space structures. Further development and refinement of these secant-method identification algorithms were undertaken. Also, evaluation of these techniques is an approach for model correlation and damage location was initiated. Author

N91-21572*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CLOSED-FORM SOLUTIONS FOR LINEAR REGULATOR DESIGN OF MECHANICAL SYSTEMS INCLUDING OPTIMAL WEIGHTING MATRIX SELECTION
BRANTLEY R. HANKS and ROBERT E. SKELTON (Purdue Univ., West Lafayette, IN.) Mar. 1991 12 p Presented at the 32nd Structures, Structural Dynamics and Materials Conference, Baltimore, MD, 8-10 Apr. 1991
(Contract RTOP 590-14-61-01)
(NASA-TM-104052; NAS 1.15:104052) Avail: CASI HC A03/MF A01 CSCL 20K

Vibration in modern structural and mechanical systems can be reduced in amplitude by increasing stiffness, redistributing stiffness and mass, and/or adding damping if design techniques are available to do so. Linear Quadratic Regulator (LQR) theory in modern multivariable control design, attacks the general dissipative elastic system design problem in a global formulation. The optimal design, however, allows electronic connections and phase relations which are not physically practical or possible in passive structural-mechanical devices. The restriction of LQR solutions (to the Algebraic Riccati Equation) to design spaces which can be implemented as passive structural members and/or dampers is addressed. A general closed-form solution to the optimal free-decay control problem is presented which is tailored for structural-mechanical system. The solution includes, as subsets, special cases such as the Rayleigh Dissipation Function and total energy. Weighting matrix selection is a constrained choice among several parameters to obtain desired physical relationships. The closed-form solution is also applicable to active control design for systems where perfect, collocated actuator-sensor pairs exist. Author

N91-21574*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPARISON OF SEVERAL SYSTEM IDENTIFICATION METHODS FOR FLEXIBLE STRUCTURES
J.-S. LEW (Old Dominion Univ., Norfolk, VA.), JER-NAN JUANG, and RICHARD W. LONGMAN Mar. 1991 17 p Presented at the 32nd Structures, Structural Dynamics and Materials Conference, Baltimore, MD, 8-10 Apr. 1991
(Contract RTOP 590-14-21-01)
(NASA-TM-104046; NAS 1.15:104046) Avail: CASI HC A03/MF A01 CSCL 20K

In the last few years various methods of identifying structural dynamics models from modal testing data have appeared. A comparison is presented of four of these algorithms: the Eigensystem Realization Algorithm (ERA), the modified version ERA/DC where DC indicated that it makes use of data correlation, the Q-Markov Cover algorithm, and an algorithm due to Moonen, DeMoor, Vandenberghe, and Vandewalle. The comparison is made using a five mode computer module of the 20 meter Mini-Mast truss structure at NASA Langley Research Center, and various noise levels are superimposed to produced simulated data. The results show that for the example considered ERA/DC generally gives the best results; that ERA/DC is always at least as good as ERA which is shown to be a special case of ERA/DC; that Q-Markov requires the use of significantly more data than ERA/DC to produce comparable results; and that is some situations Q-Markov cannot produce comparable results. Author

N91-21576*# Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics.
GROUND-BASED TESTING OF THE DYNAMICS OF FLEXIBLE SPACE STRUCTURES USING BAND MECHANISMS Progress Report, period ending 15 Mar. 1991
L. F. YANG and MENG-SANG CHEW May 1991 41 p
(Contract NAG1-1117; NAG1-830)

(NASA-CR-188154; NAS 1.26:188154) Avail: CASI HC A03/MF A01 CSCL 20K

A suspension system based on a band mechanism is studied to provide the free-free conditions for ground based validation testing of flexible space structures. The band mechanism consists of a noncircular disk with a convex profile, preloaded by torsional springs at its center of rotation so that static equilibrium of the test structure is maintained at any vertical location; the gravitational force will be directly counteracted during dynamic testing of the space structure. This noncircular disk within the suspension system can be configured to remain unchanged for test articles with the different weights as long as the torsional spring is replaced to maintain the originally designed frequency ratio of W/k sub s. Simulations of test articles which are modeled as lumped parameter as well as continuous parameter systems, are also presented. Author

N91-21578*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ACTIVE VIBRATION ABSORBER FOR CSI EVOLUTIONARY MODEL: DESIGN AND EXPERIMENTAL RESULTS
ANNE M. BRUNER (Lockheed Engineering and Sciences Co., Hampton, VA.), W. KEITH BELVIN, LUCAS G. HORTA, and JER-NAN JUANG Mar. 1991 12 p Presented at the 32nd Structures, Structural Dynamics and Materials Conference, Baltimore, MD, 8-10 Apr. 1991
(Contract RTOP 590-14-61-01)
(NASA-TM-104048; NAS 1.15:104048) Avail: CASI HC A03/MF A01 CSCL 20K

The development of control of large flexible structures technology must include practical demonstration to aid in the understanding and characterization of controlled structures in space. To support this effort, a testbed facility was developed to study practical implementation of new control technologies under realistic conditions. The design is discussed of a second order, acceleration feedback controller which acts as an active vibration absorber. This controller provides guaranteed stability margins for collocated sensor/actuator pairs in the absence of sensor/actuator dynamics and computational time delay. The primary performance objective considered is damping augmentation of the first nine structural modes. Comparison of experimental and predicted closed loop damping is presented, including test and simulation time histories for open and closed loop cases. Although the simulation and test results are not in full agreement, robustness of this design under model uncertainty is demonstrated. The basic advantage of this second order controller design is that the stability of the controller is model independent. Author

N91-21729*# Colorado Univ., Boulder. Center for Space Structures and Controls.
ANALYSIS, PRELIMINARY DESIGN AND SIMULATION SYSTEMS FOR CONTROL-STRUCTURE INTERACTION PROBLEMS Final Report
K. C. PARK and KENNETH F. ALVIN Jan. 1991 164 p
(Contract NAG1-1021)
(NASA-CR-188018; NAS 1.26:188018; CU-CSSC-91-6) Avail: CASI HC A08/MF A02 CSCL 09B

Software aspects of control-structure interaction (CSI) analysis are discussed. The following subject areas are covered: (1) implementation of a partitioned algorithm for simulation of large CSI problems; (2) second-order discrete Kalman filtering equations for CSI simulations; and (3) parallel computations and control of adaptive structures.

N91-21730*# Colorado Univ., Boulder. Center for Space Structures and Controls.
IMPLEMENTATION OF A PARTITIONED ALGORITHM FOR SIMULATION OF LARGE CSI PROBLEMS
KENNETH F. ALVIN and K. C. PARK *In its* Analysis, Preliminary Design and Simulation Systems for Control-Structure Interaction Problems 113 p Jan. 1991
(CU-CSSC-91-4) Avail: CASI HC A06/MF A02 CSCL 09B

The implementation of a partitioned numerical algorithm for determining the dynamic response of coupled structure/controller/estimator finite-dimensional systems is reviewed. The partitioned approach leads to a set of coupled first and second-order linear differential equations which are numerically integrated with extrapolation and implicit step methods. The present software implementation, ACSIS, utilizes parallel processing techniques at various levels to optimize performance on a shared-memory concurrent/vector processing system. A general procedure for the design of controller and filter gains is also implemented, which utilizes the vibration characteristics of the structure to be solved. Also presented are: example problems; a user's guide to the software; the procedures and algorithm scripts; a stability analysis for the algorithm; and the source code for the parallel implementation. Y.S.

N91-21731*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SECOND-ORDER DISCRETE KALMAN FILTERING EQUATIONS FOR CONTROL-STRUCTURE INTERACTION SIMULATIONS
K. C. PARK, W. KEITH BELVIN, and KENNETH F. ALVIN (Colorado Univ., Boulder.) *In* Colorado Univ., Analysis, Preliminary Design and Simulation Systems for Control-Structure Interaction Problems 28 p Jan. 1991
(CU-CSSC-91-5) Avail: CASI HC A03/MF A02 CSCL 09B

A general form for the first-order representation of the continuous, second-order linear structural dynamics equations is introduced in order to derive a corresponding form of first-order Kalman filtering equations (KFE). Time integration of the resulting first-order KFE is carried out via a set of linear multistep integration formulas. It is shown that a judicious combined selection of computational paths and the undetermined matrices introduced in the general form of the first-order linear structural systems leads to a class of second-order discrete KFE involving only symmetric, N x N solution matrix. Author

N91-21732*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PARALLEL COMPUTATIONS AND CONTROL OF ADAPTIVE STRUCTURES
K. C. PARK, KENNETH F. ALVIN, W. KEITH BELVIN, K. P. CHONG, ed., S. C. LIU, ed., and J. C. LI, ed. (National Central Univ., Chung-Li, Taiwan) *In* Colorado Univ., Analysis, Preliminary Design and Simulation Systems for Control-Structure Interaction Problems 19 p Jan. 1991 Repr. from Intelligent Structures (London, England) p 439-458
(Contract F49620-87-C-0074)
Avail: CASI HC A03/MF A02 CSCL 09B

The equations of motion for structures with adaptive elements for vibration control are presented for parallel computations to be used as a software package for real-time control of flexible space structures. A brief introduction of the state-of-the-art parallel computational capability is also presented. Time marching strategies are developed for an effective use of massive parallel mapping, partitioning, and the necessary arithmetic operations. An example is offered for the simulation of control-structure interaction on a parallel computer and the impact of the approach presented for applications in other disciplines than aerospace industry is assessed. Author

N91-22150*# Cincinnati Univ., OH. Dept. of Aerospace Engineering.
ATTITUDE CONTROL REQUIREMENTS FOR VARIOUS SOLAR SAIL MISSIONS
TREVOR WILLIAMS *In* NASA. Lewis Research Center, Vision-21: Space Travel for the Next Millennium p 170-178 Apr. 1990
Avail: CASI HC A02/MF A06 CSCL 22A

The differences are summarized between the attitude control requirements for various types of proposed solar sail missions (Earth orbiting; heliocentric; asteroid rendezvous). In particular, it is pointed out that the most demanding type of mission is the Earth orbiting one, with the solar orbit case quite benign and asteroid station keeping only slightly more difficult. It is then shown, using numerical results derived for the British Solar Sail Group Earth orbiting design, that the disturbance torques acting on a realistic sail can completely dominate the torques required for nominal maneuvering of an 'ideal' sail. This is obviously an important consideration when sizing control actuators; not so obvious is the fact that it makes the standard rotating vane actuator unsatisfactory in practice. The reason for this is given, and a set of new actuators described which avoids the difficulty. Author

N91-22302*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RIGID-BODY-CONTROL SUBSYSTEM SIZING FOR AN EARTH SCIENCE GEOSTATIONARY PLATFORM
A. DON SCOTT, JAMES A. DURICY, and CHERYL C. JACKSON (Flight Mechanics and Control, Inc., Hampton, VA.) Washington May 1991 22 p
(Contract RTOP 506-49-21-02)
(NASA-TP-3087; L-16796; NAS 1.60:3087) Avail: CASI HC A03/MF A01 CSCL 22B

The Mission to Planet Earth Program envisions both low-Earth and geostationary orbiting spacecraft supporting instruments that will measure and monitor land, ocean, and atmospheric variables that are important to understanding Earth's global change mechanisms. In order to minimize the number of spacecraft required in geostationary orbit, large multi-purpose platforms were proposed which will carry many high resolution science instruments and sensors. Several of these instruments are large antennas which tend to accentuate the environmental and spacecraft-induced disturbances, thereby affecting spacecraft controllability. A rigid-body pointing analysis was conducted to determine if the subject spacecraft could maintain pointing to within a very precise 18-arcsec measured at the rigid payload module. Two reaction wheel assemblies, the NASA standard and the Space Telescope, were investigated as attitude control devices. The results indicate that the spacecraft can theoretically be controlled to maintain the 18-arcsec requirement along each axis. Of the two reaction wheel assemblies, the Space Telescope assembly provided the highest degree of pointing accuracy along with a slight increase in mass and power requirements. The reaction wheels investigated are all representatives of what is currently available. A computer-aided engineering system called space systems integrated simulation (SPASIS) was used to support this analysis. Author

N91-22305*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NASA FUTURE MISSION NEEDS AND BENEFITS OF CONTROLS-STRUCTURES INTERACTION TECHNOLOGY
WILLIAM L. GRANTHAM Jan. 1991 24 p
(Contract RTOP 590-14-41-01)
(NASA-TM-104034; NAS 1.15:104034) Avail: CASI HC A03/MF A01 CSCL 22B

Two questions are addressed: (1) which future missions need Controls-Structures Interaction (CSI) technology for implementing large spacecraft in orbit; and (2) what specific benefits are to be derived if the technology is available? The answers to these questions were used to help formulate and direct the CSI technology development program. Many future NASA missions have common CSI technology needs which can best be developed in a broad-based, but focused, technology program to provide the greatest benefit to the largest number of users. Three CSI benefit studies were completed to date as part of ongoing assessment process: (1) missions requiring large antennas; (2) missions requiring large optical systems; and (3) missions requiring the use of closed-loop controlled, flexible, remote manipulator systems (RMS) for in-space assembly. The large antenna and flexible RMS mission benefits are discussed. Author

N91-22307*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FOURTH NASA WORKSHOP ON COMPUTATIONAL CONTROL OF FLEXIBLE AEROSPACE SYSTEMS, PART 1
LAWRENCE W. TAYLOR, JR., comp. Mar. 1991 457 p
Workshop held in Williamsburg, VA, 11-13 Jul. 1990
(Contract RTOP 506-46-11-01)
(NASA-CP-10065-PT-1; NAS 1.55:10065-PT-1) Avail: CASI HC A20/MF A04 CSCL 22B

The proceedings of the workshop are presented. Some areas of discussion are as follows: modeling, systems identification, and control of flexible aircraft, spacecraft, and robotic systems.

N91-22308*# Rockwell International Science Center, Thousand Oaks, CA.
SPILLOVER, NONLINEARITY, AND FLEXIBLE STRUCTURES
ROBERT W. BASS and DEAN ZES (McDonnell-Douglas Helicopter Co., Mesa, AZ.) *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 1 p 1-14 Mar. 1991
Avail: CASI HC A03/MF A04 CSCL 22B

Many systems whose evolution in time is governed by Partial Differential Equations (PDEs) are linearized around a known equilibrium before Computer Aided Control Engineering (CACE) is considered. In this case, there are infinitely many independent vibrational modes, and it is intuitively evident on physical grounds that infinitely many actuators would be needed in order to control all modes. A more precise, general formulation of this grave difficulty (spillover problem) is due to A.V. Balakrishnan. A possible route to circumvention of this difficulty lies in leaving the PDE in its original nonlinear form, and adding the essentially finite dimensional control action prior to linearization. One possibly applicable technique is the Liapunov Schmidt rigorous reduction of singular infinite dimensional implicit function problems to finite dimensional implicit function problems. Omitting details of Banach space rigor, the formalities of this approach are given. Author

N91-22312*# Colorado State Univ., Fort Collins.
A FAST ALGORITHM FOR CONTROL AND ESTIMATION USING A POLYNOMIAL STATE-SPACE STRUCTURE
JAMES R. SHULTS, THOMAS BRUBAKER, and GORDON K. F. LEE (North Carolina State Univ., Raleigh.) *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 1 p 41-56 Mar. 1991
(Contract NAG1-926)
Avail: CASI HC A03/MF A04 CSCL 09B

One of the major problems associated with the control of flexible structures is the estimation of system states. Since the parameters of the structures are not constant under varying loads and conditions, conventional fixed parameter state estimators can not be used to effectively estimate the states of the system. One alternative is to use a state estimator which adapts to the condition of the system. One such estimator is the Kalman filter. This filter is a time varying recursive digital filter which is based upon a model of the system being measured. This filter adapts the model according to the output of the system. Previously, the Kalman filter has only been used in an off-line capacity due to the computational time required for implementation. With recent advances in computer technology, it is becoming a viable tool for use in the on-line environment. A distributed Kalman filter implementation is described for fast estimation of the state of a flexible arm. A key issue, is the sensor structure and initial work on a distributed sensor that could be used with the Kalman filter is presented. Author

N91-22315*# Lockheed Missiles and Space Co., Sunnyvale, CA.
COUPLED RICCATI EQUATIONS FOR COMPLEX PLANE CONSTRAINT
KRISTIN M. STRONG and JOHN R. SESAK *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 1 p 79-90 Mar. 1991
Avail: CASI HC A03/MF A04 CSCL 22B

A new Linear Quadratic Gaussian design method is presented which provides prescribed imaginary axis pole placement for optimal control and estimation systems. This procedure contributes another degree of design freedom to flexible spacecraft control. Current design methods which interject modal damping into the system tend to have little affect on modal frequencies, i.e., they predictably shift open plant poles horizontally in the complex plane to form the closed loop controller or estimator pole constellation, but make little provision for vertical (imaginary axis) pole shifts. Imaginary axis shifts which reduce the closed loop model frequencies (the bandwidths) are desirable since they reduce the sensitivity of the system to noise disturbances. The new method drives the closed loop modal frequencies to predictable (specified) levels, frequencies as low as zero rad/sec (real axis pole placement) can be achieved. The design procedure works through rotational and translational destabilizations of the plant, and a coupling of two independently solved algebraic Riccati equations through a structured state weighting matrix. Two new concepts, gain transference and Q equivalency, are introduced and their use shown. Author

N91-22319*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.
A RECURSIVE APPROACH TO THE EQUATIONS OF MOTION FOR THE MANEUVERING AND CONTROL OF FLEXIBLE MULTI-BODY SYSTEMS
MOON K. KWAK and LEONARD MEIROVITCH *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 1 p 157-179 Mar. 1991
(Contract F49620-89-C-0049)
Avail: CASI HC A03/MF A04 CSCL 22B

Interest lies in a mathematical formulation capable of accommodating the problem of maneuvering a space structure consisting of a chain of articulated flexible substructures. Simultaneously, any perturbations from the 'rigid body' maneuvering and any elastic vibration must be suppressed. The equations of motion for flexible bodies undergoing rigid body motions and elastic vibrations can be obtained conveniently by means of Lagrange's equations in terms of quasi-coordinates. The advantage of this approach is that it yields equations in terms of body axes, which are the same axes that are used to express the control forces and torques. The equations of motion are nonlinear hybrid differential quations. The partial differential equations can be discretized (in space) by means of the finite element method or the classical Rayleigh-Ritz method. The result is a set of nonlinear ordinary differential equations of high order. The nonlinearity can be traced to the rigid body motions and the high order to the elastic vibration. Elastic motions tend to be small when compared with rigid body motions. Author

N91-22321*# DYNACS Engineering Co., Inc., Clearwater, FL.
A GENERIC MULTI-FLEX-BODY DYNAMICS, CONTROLS SIMULATION TOOL FOR SPACE STATION
KEN W. LONDON, JOHN F. LEE, RAMEN P. SINGH, and BUDDY SCHUBELE *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 1 p 211-230 Mar. 1991 Prepared for Honeywell, Inc., Clearwater, FL
Avail: CASI HC A03/MF A04 CSCL 22B

An order (n) multiflex body Space Station simulation tool is introduced. The flex multibody modeling is generic enough to model all phases of Space Station from build up through to Assembly Complete configuration and beyond. Multibody subsystems such as the Mobile Servicing System (MSS) undergoing a prescribed translation and rotation are also allowed. The software includes aerodynamic, gravity gradient, and magnetic field models. User defined controllers can be discrete or continuous. Extensive preprocessing of 'body by body' NASTRAN flex data is built in. A significant aspect, too, is the integrated controls design capability which includes model reduction and analytic linearization. Author

N91-22322*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN INTEGRATED CONTROL/STRUCTURE DESIGN METHOD USING MULTI-OBJECTIVE OPTIMIZATION
SANDEEP GUPTA (Vigyan Research Associates, Inc., Hampton, VA.) and SURESH M. JOSHI *In its* Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 1 p 231-252 Mar. 1991
Avail: CASI HC A03/MF A04 CSCL 22B

The benefits are demonstrated of a multiobjective optimization based control structure integrated design methodology. An application of the proposed CSI methodology to the integrated design of the Spacecraft COntrol Lab Experiment (SCOLE) configuration is presented. Integrated design resulted in reducing both the control performance measure and the mass. Thus, better overall performance is achieved through integrated design optimization. The mutliobjective optimization approach used provides Pareto optimal solutions by unconstrained minimization of a differentiable KS function. Furthermore, adjusting the parameters gives insight into the trade-offs involved between different objectives. Author

N91-22323*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMBINED STRUCTURES-CONTROLS OPTIMIZATION OF LATTICE TRUSSES
A. V. BALAKRISHNAN *In its* Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 1 p 253-290 Mar. 1991
(Contract NAS1-18585)
Avail: CASI HC A03/MF A04 CSCL 22B

The role that distributed parameter model can play in CSI is demonstrated, in particular in combined structures controls optimization problems of importance in preliminary design. Closed form solutions can be obtained for performance criteria such as rms attitude error, making possible analytical solutions of the optimization problem. This is in contrast to the need for numerical computer solution involving the inversion of large matrices in traditional finite element model (FEM) use. Another advantage of the analytic solution is that it can provide much needed insight into phenomena that can otherwise be obscured or difficult to discern from numerical computer results. As a compromise in level of complexity between a toy lab model and a real space structure, the lattice truss used in the EPS (Earth Pointing Satellite) was chosen. The optimization problem chosen is a generic one: of minimizing the structure mass subject to a specified stability margin and to a specified upper bond on the rms attitude error, using a co-located controller and sensors. Standard FEM treating each bar as a truss element is used, while the continuum model is anisotropic Timoshenko beam model. Performance criteria are derived for each model, except that for the distributed parameter model, explicit closed form solutions was obtained. Numerical results obtained by the two model show complete agreement. Author

N91-22324*# Hughes Aircraft Co., El Segundo, CA.
CONTROL AND DYNAMICS OF A FLEXIBLE SPACECRAFT DURING STATIONKEEPING MANEUVERS
D. LIU, J. YOCUM, and D. S. KANG (Draper, Charles Stark Lab., Inc., Cambridge, MA) *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 1 p 291-330 Mar. 1991 Sponsored in part by Draper (Charles Stark) Lab., Inc., Cambridge MA
Avail: CASI HC A03/MF A04 CSCL 22B

A case study of a spacecraft having flexible solar arrays is presented. A stationkeeping attitude control mode using both earth and rate gyro reference signals and a flexible vehicle dynamics modeling and implementation is discussed. The control system is designed to achieve both pointing accuracy and structural mode stability during stationkeeping maneuvers. Reduction of structural mode interactions over the entire mode duration is presented. The control mode using a discrete time observer structure is described to show the convergence of the spacecraft attitude transients during Delta-V thrusting maneuvers without preloading thrusting bias to the onboard control processor. The simulation performance using the three axis, body stabilized nonlinear dynamics is provided. The details of a five body dynamics model are discussed. The spacecraft is modeled as a central rigid body having cantilevered flexible antennas, a pair of flexible articulated solar arrays, and to gimballed momentum wheels. The vehicle is free to undergo unrestricted rotations and translations relative to inertial space. A direct implementation of the equations of motion is compared to an indirect implementation that uses a symbolic manipulation software to generate rigid body equations. Author

N91-22325*# Massachusetts Inst. of Tech., Cambridge.
TRANSFORM METHODS FOR PRECISION CONTINUUM AND CONTROL MODELS OF FLEXIBLE SPACE STRUCTURES
VICTOR D. LUPI, JAMES D. TURNER, and HON M. CHUN (Photon Research Associates, Inc., Cambridge, MA.) *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 1 p 331-340 Mar. 1991 Previously announced in IAA as A90-53029
(Contract F49620-89-C-0082)
Avail: CASI HC A02/MF A04 CSCL 22B

An open loop optimal control algorithm is developed for general flexible structures, based on Laplace transform methods. A distributed parameter model of the structure is first presented, followed by a derivation of the optimal control algorithm. The control inputs are expressed in terms of their Fourier series expansions, so that a numerical solution can be easily obtained. The algorithm deals directly with the transcendental transfer functions from control inputs to outputs of interest, and structural deformation penalties, as well as penalties on control effort, are included in the formulation. The algorithm is applied to several structures of increasing complexity to show its generality. Author

N91-22326*# SDRC, Inc., San Diego, CA.
STRUCTURAL REPRESENTATION FOR ANALYSIS OF A CONTROLLED STRUCTURE
PAUL A. BLELLOCH *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 1 p 341-358 Mar. 1991 Sponsored by NASA. Lewis Research Center
Avail: CASI HC A03/MF A04 CSCL 22B

The purpose was to determine what reduced order structural representation is most appropriate for coupling with a control system. The goal was to choose a reduced order structural model which retains as closely as possible the characteristics of the closed loop model with a full order structural representation. By characteristics of the closed loop model, it is meant that the closed loop eigenvalues and the closed loop transfer functions from commands to loads and from commands to response. This process does not address the accuracy of the full order model (usually a finite element model) but only the loss of accuracy associated with reducing th model. For the purposes of this study, only collocated sensors and actuators are examined. The choice of a structural representation for noncollocated sensors and actuators is not so clear. Author

N91-22327*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PDEMOD: SOFTWARE FOR CONTROL/STRUCTURES OPTIMIZATION
LAWRENCE W. TAYLOR, JR. and DAVID ZIMMERMAN (Florida Univ., Gainesville.) *In its* Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 1 p 359-392 Mar. 1991
Avail: CASI HC A03/MF A04 CSCL 09B

Because of the possibility of adverse interaction between the control system and the structural dynamics of large, flexible spacecraft, great care must be taken to ensure stability and system performance. Because of the high cost of insertion of mass into low earth orbit, it is prudent to optimize the roles of structure and control systems simultaneously. Because of the difficulty and the computational burden in modeling and analyzing the control structure system dynamics, the total problem is often split and treated iteratively. It would aid design if the control structure system dynamics could be represented in a single system of equations. With the use of the software PDEMOD (Partial Differential Equation Model), it is now possible to optimize structure and control systems simultaneously. The distributed parameter modeling approach enables embedding the control system dynamics into the same equations for the structural dynamics model. By doing this, the current difficulties involved in model order reduction are avoided. The NASA Mini-MAST truss is used an an example for studying integrated control structure design. Author

N91-22328*# Howard Univ., Washington, DC. Dept. of Mechanical Engineering.
MANEUVER SIMULATIONS OF FLEXIBLE SPACECRAFT BY SOLVING TPBVP
PETER M. BAINUM and FEIYUE LI *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 1 p 393-418 Mar. 1991
(Contract NSG-1414)
Avail: CASI HC A03/MF A04 CSCL 22B

The optimal control of large angle rapid maneuvers and vibrations of a Shuttle mast reflector system is considered. The nonlinear equations of motion are formulated by using Lagrange's formula, with the mast modeled as a continuous beam. The nonlinear terms in the equations come from the coupling between the angular velocities, the modal coordinates, and the modal rates. Pontryagin's Maximum Principle is applied to the slewing problem, to derive the necessary conditions for the optimal controls, which are bounded by given saturation levels. The resulting two point boundary value problem (TPBVP) is then solved by using the quasilinearization algorithm and the method of particular solutions. In the numerical simulations, the structural parameters and the control limits from the Spacecraft Control Lab Experiment (SCOLE) are used. In the 2-D case, only the motion in the plane of an Earth orbit or the single axis slewing motion is discussed. In the 3-D slewing, the mast is modeled as a continuous beam subjected to 3-D deformations. The numerical results for both the linearized system and the nonlinear system are presented to compare the differences in their time response. Author

N91-22329*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Aerospace and Ocean Engineering.
CONTROL EFFORT ASSOCIATED WITH MODEL REFERENCE ADAPTIVE CONTROL FOR VIBRATION DAMPING
RICHARD SCOTT MESSER and RAPHAEL T. HAFTKA *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 1 p 419-441 Mar. 1991
(Contract NAG1-603)
Avail: CASI HC A03/MF A04 CSCL 09B

The performance of Model Reference Adaptive Control (MRAC) is studied in numerical simulations with the objective of understanding the effects of differences between the plant and the reference model. MRAC is applied to two structural systems with adjustable error between the reference model and the actual plant. Performance indices relating to control effort and response characteristics are monitored in order to determine what effects small errors have on the control effort and performance of the two systems. It is shown that reasonable amounts of error in the reference model can cause dramatic increases in both the control effort and response magnitude (as measured by energy integrals) of the plant. Author

N91-22330*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COMPONENT MODE DAMPING ASSIGNMENT TECHNIQUES
ALLAN Y. LEE *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 1 p 443-457 Mar. 1991
Avail: CASI HC A03/MF A04 CSCL 22B

A relation between the system modal damping matrix and the component modal damping matrix is derived from First Principles. An optimization problem is then formulated to select all the component modes' damping ratios that best satisfy the above derived relation. A weighting matrix is used in the cost functional to stress the relative importance of the diagonal terms in the damping matrix. Inequality constraints are also added to the optimization problem to pick only nonnegative component modes' damping factors. The optimization problem may be solved algebraically or iteratively. The proposed techniques are successfully used on a high order, finite element model of the Galileo spacecraft. Author

N91-22331#** National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FOURTH NASA WORKSHOP ON COMPUTATIONAL CONTROL OF FLEXIBLE AEROSPACE SYSTEMS, PART 2
LAWRENCE W. TAYLOR, JR., comp. Mar. 1991 464 p
Workshop held in Williamsburg, VA, 11-13 Jul. 1990
(Contract RTOP 506-46-11-01)
(NASA-CP-10065-PT-2; NAS 1.55:10065-PT-2) Avail: CASI HC A20/MF A04 CSCL 22B

A collection of papers presented at the Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems is given. The papers address modeling, systems identification, and control of flexible aircraft, spacecraft and robotic systems.

N91-22338#** Cincinnati Univ., OH.
ACTIVE VERSUS PASSIVE DAMPING IN LARGE FLEXIBLE STRUCTURES
GARY L. SLATER and MARK D. MCLAREN (Ford Aerospace Corp., Palo Alto, CA.) *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 2 p 655-661 Mar. 1991 Sponsored in part by AFOSR and Cray Research, Inc.
Avail: CASI HC A02/MF A04 CSCL 22B

Optimal passive and active damping control can be considered in the context of a general control/structure optimization problem. Using a mean square output response approach, it is shown that the weight sensitivity of the active and passive controllers can be used to determine an optimal mix of active and passive elements in a flexible structure. Author

N91-22339#** Buffalo Univ., NY. Dept. of Mechanical and Aerospace Engineering.
VIBRATION SUPPRESSION AND SLEWING CONTROL OF A FLEXIBLE STRUCTURE
DANIEL J. INMAN, EPHRAHIM GARCIA, and BRETT POKINES *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 2 p 663-671 Mar. 1991
Avail: CASI HC A02/MF A04 CSCL 22B

Examined here are the effects of motor dynamics and secondary piezoceramic actuators on vibration suppression during the slewing of flexible structures. The approach focuses on the interaction between the structure, the actuators, and the choice of control law. The results presented here are all simulated, but are based on experimentally determined parameters for the motor, structure, piezoceramic actuators, and piezofilm sensors. The simulation results clearly illustrate that the choice of motor inertia relative to beam inertia makes a critical difference in the performance of the system. In addition, the use of secondary piezoelectric actuators reduces the load requirements on the motor and also reduces the overshoot of the tip deflection. The structures considered here are a beam and a frame. The majority of results are based on a Euler Bernoulli beam model. The slewing frame introduces substantial torsional modes and a more realistic model. The slewing frame results are incomplete and represent work in progress. Author

N91-22340#** Buffalo Univ., NY. Dept. of Mechanical and Aerospace Engineering.
CANDIDATE PROOF MASS ACTUATOR CONTROL LAWS FOR THE VIBRATION SUPPRESSION OF A FRAME
JEFFREY W. UMLAND and DANIEL J. INMAN *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 2 p 672-690 Mar. 1991
Avail: CASI HC A03/MF A04 CSCL 22B

The vibration of an experimental flexible space truss is controlled with internal control forces produced by several proof mass actuators. Four candidate control law strategies are evaluated in terms of performance and robustness. These control laws are experimentally implemented on a quasi free-free planar truss. Sensor and actuator dynamics are included in the model such that the final closed loop is self-equilibrated. The first two control laws considered are based on direct output feedback and consist of tuning the actuator feedback gains to the lowest mode intended to receive damping. The first method feeds back only the position and velocity of the proof mass relative to the structure; this results in a traditional vibration absorber. The second method includes the same feedback paths as the first plus feedback of the local structural velocity. The third law is designed with robust H infinity control theory. The fourth strategy is an active implementation of a viscous damper, where the actuator is configured to provide a bending moment at two points on the structure. The vibration control system is then evaluated in terms of how it would benefit the space structure's position control system. Author

N91-22341#** National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SIMULATOR EVALUATION OF SYSTEM IDENTIFICATION WITH ON-LINE CONTROL LAW UPDATE FOR THE CONTROLS AND ASTROPHYSICS EXPERIMENT IN SPACE
RAYMOND C. MONTGOMERY, DAVE GHOSH, MICHAEL A. SCOTT, and DIRK WARNAAR (Lockheed Engineering and Sciences Co., Hampton, VA.) *In its* Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 2 p 691-725 Mar. 1991
Avail: CASI HC A03/MF A04 CSCL 22B

A procedure for optimizing the performance of large flexible spacecraft that require active vibration suppression to achieve required performance is presented. The procedure is to conduct on-orbit testing and system identification followed by a control system design. It is applied via simulation to a spacecraft configuration currently being considered for flight test by NASA - the Controls, Astrophysics, and Structures Experiment in Space (CASES). The system simulator is based on a NASTRAN finite element structural model. A finite number of modes is used to represent the structural dynamics. The system simulator also includes models of the electronics, actuators, sensors, the digital controller, and the internal and external disturbances. Nonlinearities caused by quantization are included in the study to examine tolerance of the procedure to modelling errors. Disturbance and sensor noise is modelled as a Gaussian process. For system identification, the system is excited using sinusoidal inputs at the resonant frequencies of the structure using each actuator. Mode shapes, frequencies, and damping ratios are identified from the unforced response sensor data after each excitation. Then, the excitation data is used to identify the actuator influence coefficients. The results of the individual parameter identification analyses are assembled into an aggregate system model. The control design is accomplished based only on the identified model using multi-input/output linear quadratic Gaussian theory. Its performance is evaluated based on time-to-damp as compared with the uncontrolled structure. Author

N91-22343#** Harris Corp., Melbourne, FL. Goverment Aerospace Systems Div.
ACTIVE AND PASSIVE VIBRATION SUPPRESSION FOR SPACE STRUCTURES
DAVID C. HYLAND *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 2 p 743-779 Mar. 1991
Avail: CASI HC A03/MF A04 CSCL 22B

The relative benefits of passive and active vibration suppression for large space structures (LSS) are discussed. The intent is to sketch the true ranges of applicability of these approaches using previously published technical results. It was found that the distinction between active and passive vibration suppression approaches is not as sharp as might be thought at first. The relative simplicity, reliability, and cost effectiveness touted for passive measures are vitiated by 'hidden costs' bound up with detailed engineering implementation issues and inherent performance limitations. At the same time, reliability and robustness issues are often cited against active control. It is argued that a continuum of vibration suppression measures offering mutually supporting capabilities is needed. The challenge is to properly orchestrate a spectrum of methods to reap the synergistic benefits of combined advanced materials, passive damping, and active control. Author

N91-22345*# Pennsylvania State Univ., University Park. Dept. of Aerospace Engineering.
FINITE ELEMENT MODELING OF TRUSS STRUCTURES WITH FREQUENCY-DEPENDENT MATERIAL DAMPING
GEORGE A. LESIEUTRE *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 2 p 795-811 Mar. 1991
Avail: CASI HC A03/MF A04 CSCL 22B

A physically motivated modelling technique for structural dynamic analysis that accommodates frequency dependent material damping was developed. Key features of the technique are the introduction of augmenting thermodynamic fields (AFT) to interact with the usual mechanical displacement field, and the treatment of the resulting coupled governing equations using finite element analysis methods. The AFT method is fully compatible with current structural finite element analysis techniques. The method is demonstrated in the dynamic analysis of a 10-bay planar truss structure, a structure representative of those contemplated for use in future space systems. Author

N91-22347*# State Univ. of New York, Buffalo. Dept. of Mechanical and Aerospace Engineering.
TIME DOMAIN MODAL IDENTIFICATION/ESTIMATION OF THE MINI-MAST TESTBED
MICHAEL J. ROEMER and D. JOSEPH MOOK *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 2 p 825-843 Mar. 1991
Avail: CASI HC A03/MF A04 CSCL 22B

The Mini-Mast is a 20 meter long 3-dimensional, deployable/retractable truss structure designed to imitate future trusses in space. Presented here are results from a robust (with respect to measurement noise sensitivity), time domain, modal identification technique for identifying the modal properties of the Mini-Mast structure even in the face of noisy environments. Three testing/analysis procedures are considered: sinusoidal excitation near resonant frequencies of the Mini-Mast, frequency response function averaging of several modal tests, and random input excitation with a free response period. Author

N91-22349*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LIKELIHOOD ESTIMATION FOR DISTRIBUTED PARAMETER MODELS FOR NASA MINI-MAST TRUSS
JI-YAO SHEN, JEN-KUANG HUANG (Old Dominion Univ., Norfolk, VA.), and LAWRENCE W. TAYLOR, JR. *In its* Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 2 p 881-906 Mar. 1991
Avail: CASI HC A03/MF A04 CSCL 22B

A maximum likelihood estimation for distributed parameter models of large flexible structures was formulated. Distributed parameter models involve far fewer unknown parameters than independent modal characteristics or finite element models. The closed form solutions for the partial differential equations with corresponding boundary conditions were derived. The closed-form expressions of sensitivity functions led to highly efficient algorithms for analyzing ground or on-orbit test results. For an illustration of this approach, experimental data of the NASA Mini-MAST truss was used. The estimations of modal properties involve lateral bending modes and torsional modes. The results show that distributed parameter models are promising in the parameter estimation of large flexible structures. Author

N91-22351*# North Carolina Univ., Charlotte. Dept. of Electrical Engineering.
A MODEL FOR THE THREE-DIMENSIONAL SPACECRAFT CONTROL LABORATORY EXPERIMENT
YOGENDRA P. KAKAD *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 2 p 921-932 Mar. 1991
Avail: CASI HC A03/MF A04 CSCL 22B

A model for the three-dimensional Spacecraft Control Laboratory Experiment (SCOLE) is developed. The objective behind this method of modelling is to utilize the basic partial differential equations of motion for this distributed parameter system and not to use the modal expansion in developing the model. The final model obtained is in terms of a transfer function matrix which relates the flexible mast parameters like displacement, slope, shear stress, etc. to external forces and moments. Author

N91-22359*# Astro Aerospace Corp., Carpinteria, CA.
INFLUENCE OF UTILITY LINES AND THERMAL BLANKETS ON THE DYNAMICS AND CONTROL OF SATELLITES WITH PRECISION POINTING REQUIREMENTS
RICHARD K. MILLER, MARK W. THOMSON, and JOHN M. HEDGEPETH Washington NASA May 1991 50 p
(Contract NAS1-18567; RTOP 506-43-41-02)
(NASA-CR-4366; NAS 1.26:4366; AAC-TN-1161) Avail: CASI HC A03/MF A01 CSCL 22B

Most spacecraft control design techniques, for situations in which control structures interaction is an important design consideration, require that the behavior of the spacecraft and its structure be very well known. Large multipurpose spacecraft such as the Space Station will have a larger portion of their mass (e.g., the utility lines) in the ill managed category. As an initial step to address this problem, a study was performed of the residual free vibrations of a rigid body with an appendage consisting of an initially slack string or membrane (utility or thermal blanket) after completing a slew reorientation maneuver. Parametric studies of the effects of the initial strain, both positive and negative, were studied, and results are presented in terms of nondimensional variables. The results indicate that the amplitude of free oscillations increases dramatically when the initial strain is made negative (slack initial behavior). This result is particularly significant for high pointing precision applications, such as the Large Deployable Reflector. Applications are provided for the selection of appropriate design tension for the LDR sunshade in a proposed baseline design. Author

N91-22362# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Hubschrauber und Flugzeuge.
STRUCTURAL OPTIMIZATION WITH CONSTRAINTS FROM DYNAMICS IN LAGRANGE
GUENTER KNEPPE, F. PFEIFFER, and C. ROSS (Technische Univ., Munich, Germany, F.R.) 5 Nov. 1990 9 p Presented at the 3rd Air Force/NASA Symposium on Recent Advances in Multidisciplinary Analysis and Optimization, San Francisco, CA, 24-26 Sep. 1990
(MBB-FW522/S/PUB/431; ETN-91-99251) Copyright Avail: CASI HC A02/MF A01

Structural optimization problems are mostly solved under constraints fron statics, such as stresses, strains or displacements under static loads. But in the design process dynamic quantities like eigenfrequencies or accelerations under dynamic loads become more and more important. Therefore it is obvious that constraints from dynamics must be considered in structural optimization packages. The dynamics branch in LAGRANGE are addressed. Two topics, namely the different formulations for eigenfrequency constraints and frequency response constraints are focused upon. For the latter the necessity of a system reduction is emphasized. The methods implemented in LAGRANGE are presented and examples are given. ESA

N91-22604*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

THE DYNAMIC EFFECTS OF INTERNAL ROBOTS ON SPACE STATION FREEDOM

JEFFREY H. MILLER (Sverdrup Technology, Inc., Brook Park, OH.), CHARLES LAWRENCE, and DOUGLAS A. ROHN 1991 16 p
Presented at the Guidance Navigation and Control Conference, New Orleans, LA, 12-14 Aug. 1991; sponsored by AIAA
(Contract RTOP 694-03-03)
(NASA-TM-104345; E-6119; NAS 1.15:104345; AIAA PAPER 91-2822) Avail: CASI HC A03/MF A01 CSCL 20K

Many of the planned experiments of the Space Station Freedom (SSF) will require acceleration levels to be no greater than microgravity (10 exp -6 g) levels for long periods of time. Studies have demonstrated that without adequate control, routine operations may cause disturbances which are large enough to affect on-board experiments. One way to both minimize disturbances and make the SSF more autonomous is to utilize robots instead of astronauts for some operations. The present study addresses the feasibility of using robots for microgravity manipulation. Two methods for minimizing the dynamic disturbances resulting from the robot motions are evaluated. The first method is to use a robot with kinematic redundancy (redundant links). The second method involves the use of a vibration isolation device between the robot and the SSF laboratory module. The results from these methods are presented along with simulations of robots without disturbance control. Author

N91-23831 Texas Univ., Austin.

CONTROL SYNTHESIS BASED UPON A GAME THEORETIC APPROACH Ph.D. Thesis

IHNSEOK RHEE 1990 166 p
Avail: Univ. Microfilms Order No. DA9105644

The relationship between the linear exponential Gaussian problem and the linear quadratic game is elaborated. A disturbance attenuation problem for finite-time is considered by a game theoretic approach where the control, restricted to the function of the measurement history, plays against adversaries composed of the process and measurement disturbances, and the initial conditions. A zero-sum game, formulated as a quadratic performance criterion subject to linear, time-varying dynamics and measurements, is solved by a calculus of variation technique. Necessary and sufficient conditions for the saddle point to be strictly concave with respect to all disturbances and initial conditions, and sufficient conditions for various process disturbance strategies to satisfy the saddle point condition are given. A disturbance attenuation problem is solved based on the results of the game problem. For time-invariant systems, it is shown that, under certain conditions, the time-varying controller becomes time-invariant on the infinite time interval. The resulting controller satisfies an H(infinity) norm bound. A game theoretic approach is easily accommodated to designing a controller for a linear time invariant system with parameter uncertainties. The uncertain system is represented as an internal feedback loop where the parameter uncertainties are embedded in the system as fictitious disturbances. The consideration of the fictitious disturbances as players against the control leads to the construction of a finite time linear quadratic game. It is shown that the resulting time invariant controller stabilizes the uncertain system for a prescribed parameter uncertainty bound. The game theoretic controller is applied to the momentum management/attitude control of the space station whose moments of inertia are subject to variations. Dissert. Abstr.

N91-24049*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

APPLICATIONS OF FUZZY LOGIC TO CONTROL AND DECISION MAKING

ROBERT N. LEA and YASHVANT JANI (LinCom Corp., Houston, TX.) *In* NASA, Washington, Technology 2000, Volume 2 p 67-75 1991
Avail: CASI HC A02/MF A03 CSCL 09B

Long range space missions will require high operational efficiency as well as autonomy to enhance the effectivity of performance. Fuzzy logic technology has been shown to be powerful and robust in interpreting imprecise measurements and generating appropriate control decisions for many space operations. Several applications are underway, studying the fuzzy logic approach to solving control and decision making problems. Fuzzy logic algorithms for relative motion and attitude control have been developed and demonstrated for proximity operations. Based on this experience, motion control algorithms that include obstacle avoidance were developed for a Mars Rover prototype for maneuvering during the sample collection process. A concept of an intelligent sensor system that can identify objects and track them continuously and learn from its environment is under development to support traffic management and proximity operations around the Space Station Freedom. For safe and reliable operation of Lunar/Mars based crew quarters, high speed controllers with ability to combine imprecise measurements from several sensors is required. A fuzzy logic approach that uses high speed fuzzy hardware chips is being studied. Author

N91-24222*# Harris Corp., Melbourne, FL. Government Aerospace Systems Div.

HIGH PERFORMANCE, ACCELEROMETER-BASED CONTROL OF THE MINI-MAST STRUCTURE AT LANGLEY RESEARCH CENTER Final Report

EMMANUEL G. COLLINS, JR., JAMES A. KING, DOUGLAS J. PHILLIPS, and DAVID C. HYLAND Washington NASA May 1991 98 p
(Contract NAS1-18872; RTOP 585-01-91-01)
(NASA-CR-4377; NAS 1.26:4377) Avail: CASI HC A05/MF A02 CSCL 22B

Many large space system concepts will require active vibration control to satisfy critical performance requirements such as line of sight pointing accuracy and constraints on rms surface roughness. In order for these concepts to become operational, it is imperative that the benefits of active vibration control be shown to be practical in ground based experiments. The results of an experiment shows the successful application of the Maximum Entropy/Optimal Projection control design methodology to active vibration control for a flexible structure. The testbed is the Mini-Mast structure at NASA-Langley and has features dynamically traceable to future space systems. To maximize traceability to real flight systems, the controllers were designed and implemented using sensors (four accelerometers and one rate gyro) that are actually mounted to the structure. Ground mounted displacement sensors that could greatly ease the control design task were available but were used only for performance evaluation. The use of the accelerometers increased the potential of destabilizing the system due to spillover effects and motivated the use of precompensation strategy to achieve sufficient compensator roll-off. Author

N91-25162 Auburn Univ., AL.

A MULTIOBJECTIVE CONTROL SYNTHESIS FOR ARTICULATED SPACE STRUCTURES Ph.D. Thesis

NORMAN GEORGE FITZ-COY 1990 149 p
Avail: Univ. Microfilms Order No. DA9109060

A method for determining closed-loop control strategies which exploit the natural characteristics of the system being controlled by dividing the overall control task into subsets, was developed and utilized to control articulated space structures. The control strategy is based on the solution to a two-player, nonzero-sum, linear quadratic, time-invariant, infinite horizon, differential game obtained using a Nash solution strategy. The closed-loop control strategy is determined by the solution to a set of coupled algebraic Riccati equations. An algorithm based on a Newton-Raphson-Kantorovich iterative procedure was developed to solve the system of coupled nonlinear equations. Intermediate sets of equations which must be solved in the iterative procedure are of a coupled Lyapunov form. These equations are solved by transforming them into a set of uncoupled, linear algebraic equations using properties of the Kronecker product. This transformation exploits the symmetric property of a Riccati matrix, so that the iterative algorithm deals with n(exp 2) + n equations instead of the 2(n exp 2) equations which would be required for a general nth order system. Several closed-loop scenarios for articulated space structures performing conflicting controlled tasks were simulated. For each scenario, time histories of the motion of the articulated systems were obtained using the new control strategy and a comparable linear quadratic regulator (LQR) strategy. In each case, the use of the new control strategy resulted in better performance than the LQR strategy. Studies were also conducted to investigate the effects of the cross-coupling weights on the control strategy. Best results were obtained when the cross-coupling weights precisely conveyed the strategy of each controller to the other. Dissert. Abstr.

N91-25168*# McDonnell-Douglas Space Systems Co., Huntsville, AL.
CONTROL AND STRUCTURAL OPTIMIZATION FOR MANEUVERING LARGE SPACECRAFT Final Report
H. M. CHUN, J. D. TURNER, and C. C. YU Oct. 1990 86 p
Prepared in cooperation with Photon Research Associates, Inc., Cambridge, MA
(Contract NAS1-18763; RTOP 590-14-51-01)
(NASA-CR-187490; NAS 1.26:187490) Avail: CASI HC A05/MF A01 CSCL 22B

Presented here are the results of an advanced control design as well as a discussion of the requirements for automating both the structures and control design efforts for maneuvering a large spacecraft. The advanced control application addresses a general three dimensional slewing problem, and is applied to a large geostationary platform. The platform consists of two flexible antennas attached to the ends of a flexible truss. The control strategy involves an open-loop rigid body control profile which is derived from a nonlinear optimal control problem and provides the main control effort. A perturbation feedback control reduces the response due to the flexibility of the structure. Results are shown which demonstrate the usefulness of the approach. Software issues are considered for developing an integrated structures and control design environment. Author

N91-25645# National Aerospace Lab., Tokyo (Japan).
ON SYSTEM IDENTIFICATION USING HANKEL MATRICES BY THE TIME DOMAIN APPROACH
ISAO YAMAGUCHI and TAKASHI KIDA Oct. 1990 25 p In JAPANESE; ENGLISH summary
(ISSN 0389-4010)
(NAL-TR-1084) Avail: CASI HC A03/MF A01

The theory and application of a method of system identification using Hankel matrices in the time domain are described. The Eigen-System Realization Algorithm (ERA) is a typical system realization method utilizing Hankel matrices. The method, however, assumes ideal impulse response. Here, a new iterative algorithm using the least square method is developed for practical applications in the space environment. Numerical examples for the ETS-VI structural model and ground based experiments on an air-bearing table attached by the flexible isogrid panel are carried out to demonstrate the validity of the new method. Author

N91-25695 Stanford Univ., CA.
RECURSIVE DERIVATION OF EXPLICIT EQUATIONS OF MOTION FOR EFFICIENT DYNAMIC/CONTROL SIMULATION OF LARGE MULTIBODY SYSTEMS Ph.D. Thesis
KURT SCOTT ANDERSON 1990 168 p
Avail: Univ. Microfilms Order No. DA9108778

The demands of spacecraft, robot, and machinery design have motivated the development of general purpose multibody computer programs for dynamic analysis. Such programs enable the analyst to simulate, with minimal manual effort, motions of large systems of rigid bodies, or to calculate the control forces and torques which must be applied to obtain a desired motion of such systems. Multibody programs tend to be plagued by two basic inefficiencies. The first, and most severe, arises from computational requirements associated with the determination of state derivative values. If n is the number of degrees of freedom of a system, the number of computational operations required to calculate state derivative values tends to be a cubic function in n, and thus can become prohibitively large for even modest values of n. The second inefficiency manifests itself when equations are derived for the most general system, as they frequently are. Such implicit programs generally are replete with unnecessary computations or logical statements. Presented here is an approach which does not suffer from either of these deficiencies. State derivative values are calculated in a highly efficient manner, the number of computational operations being a linear function in n. Problem specific equations are generated through the use of symbolic manipulation, which yields explicit equations devoid of needless operations. Finally, the equations are cast in a highly concurrent form, allowing the production of a simulation code that can be used on conventional sequential computers, but is well suited for parallel computers with distributed architecture. Dissert. Abstr.

N91-26190# Georgia Inst. of Tech., Atlanta. Computational Mechanics Center.
STUDIES IN MODELING, DYNAMICS, AND CONTROL OF SPACE STRUCTURES Final Technical Report
SATYA N. ATLURI Feb. 1991 12 p
(Contract AF-AFOSR-0020-84; AF PROJ. 2302)
(AD-A235059; CMC-GIT-90-1; AFOSR-91-0248TR) Avail: CASI HC A03/MF A01 CSCL 12D

This report presents a summary of 30 papers published in archival literature, dealing with the issues of reduced order modeling, dynamics and control of space structures. Field/boundary element methods for control of nonlinear dynamic response of continuum models of space structures are discussed. Explicit expressions for tangent stiffnesses of truss and frame-type lattice structures are presented. Weak formulations of multibody dynamics problems with constraint are presented. GRA

N91-26549# WEA, Cambridge, MA.
NDE PATTERN RECOGNITION OF LSS STATES VIA WAVE PROPAGATION Final Report, 15 Jan. 1988 - 15 Jan. 1991
JAMES H. WILLIAMS, JR. 15 Jan. 1991 28 p
(Contract F49620-88-C-0036)
(AD-A234772; AFOSR-91-0230TR) Avail: CASI HC A03/MF A01 CSCL 22B

Nondestructive characterizations of structural states and structural parameters of large space structures (LSS) (i.e., space stations and space platforms) via wave propagation are considered. If a wave is introduced into or is generated within a structure, the existing structural states and parameters govern its propagation and detection. The structural states and parameters of LSS can be described by material properties, geometric forms and properties, environmental conditions and measurement conditions. Some of these structural properties and conditions are modulus of elasticity, structural dimensions, joint details, lattice patterns of structural components, lattice element connectivities, structural discontinuities and material defects states. There are many wave propagation parameters that can be measured by monitoring waves. A few of these are the initial wave arrival time, maximum wave amplitude, wave duration, and wave amplitude at specified frequencies evaluated using the Fourier transform. Thus, a large amount of data can be generated from a single wave propagation measurement. GRA

N91-26833# Princeton Univ., NJ. Dept. of Electrical Engineering and Computer Science.
H-INFINITY-OPTIMAL CONTROL FOR DISTRIBUTED PARAMETER SYSTEMS Final Report, 1 Jan. 1989 - 31 Dec. 1990
DAVID S. FLAMM, HONG YANG, and KATHERINE KLIPEC 28 Feb. 1991 94 p
(Contract AF-AFOSR-0205-89; AF PROJ. 2304)
(AD-A234931; AFOSR-91-0358TR) Avail: CASI HC A05/MF A01 CSCL 09A

This report describes progress in the development and application of H-infinity optimal control theory to distributed parameter systems. This research is intended to develop both theory and algorithms capable of providing realistic control systems for physical plants which are appropriately modeled as infinite dimensional linear systems, such as large space structures. In pursuing this program, we have focused on issues motivated by specific models of infinite dimensional systems. We have extended outer factor absorption results to cover certain irrational outer factors. This is in order to justify transformations used in a step for further explicit solution. We have generalized previous results on the single-input/single-output (SISO) mixed sensitivity problem to the case of irrational outer factor and unstable plant. We have solved a multi-input/output mixed sensitivity problem which cannot be treated by previous results. Finally, we developed a technique for numerically computing the optimal value of weighted mixed sensitivity for SISO systems, for the case where explicit symbolic inner/outer factorizations are not possible. GRA

N91-27099*# Texas A&M Univ., College Station. Dept. of Aerospace Engineering.
A NONRECURSIVE ORDER N PRECONDITIONED CONJUGATE GRADIENT: RANGE SPACE FORMULATION OF MDOF DYNAMICS Final Report
ANDREW J. KURDILA *In* Houston Univ., NASA/ASEE Summer Faculty Fellowship Program, 1990, Volume 1 16 p Dec. 1990
(Contract NGT-44-005-803)
Avail: CASI HC A03/MF A03 CSCL 09B

While excellent progress has been made in deriving algorithms that are efficient for certain combinations of system topologies and concurrent multiprocessing hardware, several issues must be resolved to incorporate transient simulation in the control design process for large space structures. Specifically, strategies must be developed that are applicable to systems with numerous degrees of freedom. In addition, the algorithms must have a growth potential in that they must also be amenable to implementation on forthcoming parallel system architectures. For mechanical system simulation, this fact implies that algorithms are required that induce parallelism on a fine scale, suitable for the emerging class of highly parallel processors; and transient simulation methods must be automatically load balancing for a wider collection of system topologies and hardware configurations. These problems are addressed by employing a combination range space/preconditioned conjugate gradient formulation of multi-degree-of-freedom dynamics. The method described has several advantages. In a sequential computing environment, the method has the features that: by employing regular ordering of the system connectivity graph, an extremely efficient preconditioner can be derived from the 'range space metric', as opposed to the system coefficient matrix; because of the effectiveness of the preconditioner, preliminary studies indicate that the method can achieve performance rates that depend linearly upon the number of substructures, hence the title 'Order N'; and the method is non-assembling. Furthermore, the approach is promising as a potential parallel processing algorithm in that the method exhibits a fine parallel granularity suitable for a wide collection of combinations of physical system topologies/computer architectures; and the method is easily load balanced among processors, and does not rely upon system topology to induce parallelism. Author

N91-27111*# California Univ., San Diego, La Jolla. Dept. of AMES.
DEVELOPMENT OF LOAD-DEPENDENT RITZ VECTOR METHOD FOR STRUCTURAL DYNAMIC ANALYSIS OF LARGE SPACE STRUCTURES Final Report
JAMES M. RICLES *In* Houston Univ., NASA/ASEE Summer Faculty Fellowship Program, 1990, Volume 2 16 p Dec. 1990
(Contract NGT-44-005-803)
Avail: CASI HC A03/MF A02 CSCL 20K

The development and preliminary assessment of a method for dynamic structural analysis based on load-dependent Ritz vectors are presented. The vector basis is orthogonalized with respect to the mass and structural stiffness in order that the equations of motion can be uncoupled and efficient analysis of large space structure performed. A series of computer programs was developed based on the algorithm for generating the orthogonal load-dependent Ritz vectors. Transient dynamic analysis performed on the Space Station Freedom using the software was found to provide solutions that require a smaller number of vectors than the modal analysis method. Error norm based on the participation of the mass distribution of the structure and spatial distribution of structural loading, respectively, were developed in order to provide an indication of vector truncation. These norms are computed before the transient analysis is performed. An assessment of these norms through a convergence study of the structural response was performed. The results from this assessment indicate that the error norms can provide a means of judging the quality of the vector basis and accuracy of the transient dynamic solution. Author

N91-27115*# Stevens Inst. of Tech., Hoboken, NJ. Dept. of Electrical Engineering and Computer Science.
HIGH ACCURACY OPTICAL RATE SENSOR Final Report
J. UHDE-LACOVARA *In* Houston Univ., NASA/ASEE Summer Faculty Fellowship Program, 1990, Volume 2 13 p Dec. 1990
(Contract NGT-44-005-803)
Avail: CASI HC A03/MF A02 CSCL 20F

Optical rate sensors, in particular CCD arrays, will be used on Space Station Freedom to track stars in order to provide inertial attitude reference. An algorithm to provide attitude rate information by directly manipulating the sensor pixel intensity output is presented. The star image produced by a sensor in the laboratory is modeled. Simulated, moving star images are generated, and the algorithm is applied to this data for a star moving at a constant rate. The algorithm produces accurate derived rate of the above data. A step rate change requires two frames for the output of the algorithm to accurately reflect the new rate. When zero mean Gaussian noise with a standard deviation of 5 is added to the simulated data of a star image moving at a constant rate, the algorithm derives the rate with an error of 1.9 percent at a rate of 1.28 pixels per frame. Author

N91-27578*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTS FOR LOCATING DAMAGED TRUSS MEMBERS IN A TRUSS STRUCTURE
PAUL E. MCGOWAN, SUZANNE W. SMITH, and MEHZAD JAVEED (Lockheed Engineering and Sciences Co., Hampton, VA.) May 1991 46 p Presented at the 2nd USAF/NASA Workshop on System Identification and Health Monitoring of Precision Space Structures, Pasadena, CA, 27-29 Mar. 1990
(Contract RTOP 590-14-31-01)
(NASA-TM-104093; NAS 1.15:104093) Avail: CASI HC A03/MF A01 CSCL 20K

Locating damaged truss members in large space structures will involve a combination of sensing and diagnostic techniques. Methods developed for damage location require experimental verification prior to on-orbit applications. To this end, a series of experiments for locating damaged members using a generic, ten bay truss structure were conducted. A 'damaged' member is a member which has been removed entirely. Previously developed identification methods are used in conjunction with the experimental data to locate damage. Preliminary results to date are included, and indicate that mode selection and sensor location are important issues for location performance. A number of experimental data sets representing various damage configurations were compiled using the ten bay truss. The experimental data and the corresponding finite element analysis models are available to researchers for verification of various methods of structure identification and damage location. Author

N91-28640 Virginia Polytechnic Inst. and State Univ., Blacksburg.
THE SOLUTION OF VARIABLE-GEOMETRY TRUSS PROBLEMS USING NEW HOMOTOPY CONTINUATION METHODS Ph.D. Thesis
VEERARAGHAVAN ARUN 1990 145 p
Avail: Univ. Microfilms Order No. DA9116621

Basic Variable-Geometry Truss (VGT) Theory is described, and criteria used in the determination of valid VGT unit cells is presented. The VGT's have been widely recognized as adaptive or collapsing structures for space and military applications. Four of the VGT unit cells, tetrahedral, octahedral, decahedral, and dodecahedral, are discussed in detail. The typical modeling and formulation procedure for developing the kinematic equations associated with the forward kinematic problem of each type of cell is described. A new and efficient technique for solving the forward kinematics problem of VGT's is also presented. All VGT problems lead to systems of eqautions. Commonly, such systems are solved by an iterative numerical method, usually a Newton method or a variant. For such methods to yield a solution, a starting point sufficiently close to the actual solution must be supplied. For systems of the size of those encountered in VGT problems, this is a formidable task. On the other hand, recently developed methods in homotopy continuation for polynomials are not only global, but also exhaustive. Homotopies are a traditional part of topology and have only recently begun to be used for practical numerical computation. Polynomial continuation is used to track the solutions of the systems of equations describing the kinematics of VGT's. Dissert. Abstr.

N91-29211*# Draper (Charles Stark) Lab., Inc., Cambridge, MA.
EQUATIONS OF MOTION FOR A FLEXIBLE SPACECRAFT-LUMPED PARAMETER IDEALIZATION
JOEL STORCH and STEPHEN GATES Sep. 1982 71 p
(Contract NAS9-16023)
(NASA-CR-188727; NAS 1.26:188727; CSDL-R-1582) Avail: CASI HC A04/MF A01 CSCL 22B

The equations of motion for a flexible vehicle capable of arbitrary translational and rotational motions in inertial space accompanied by small elastic deformations are derived in an unabridged form. The vehicle is idealized as consisting of a single rigid body with an ensemble of mass particles interconnected by massless elastic structure. The internal elastic restoring forces are quantified in terms of a stiffness matrix. A transformation and truncation of elastic degrees of freedom is made in the interest of numerical integration efficiency. Deformation dependent terms are partitioned into a hierarchy of significance. The final set of motion equations are brought to a fully assembled first order form suitable for direct digital implementation. A FORTRAN program implementing the equations is given and its salient features described. Author

N91-29212*# Arizona State Univ., Tempe. Dept. of Mechanical and Aerospace Engineering.
EXPERIMENTAL DEMONSTRATION OF A CLASSICAL APPROACH FOR FLEXIBLE SPACE STRUCTURE CONTROL: NASA CSI TESTBEDS Final Report
WIE BOND 31 Aug. 1991 54 p
(Contract NAG1-965; NAG1-1083)
(NASA-CR-188724; NAS 1.26:188724) Avail: CASI HC A04/MF A01 CSCL 22B

The results of active control experiments performed for the Mini-Mast truss structure are presented. The primary research objectives were: (1) to develop active structural control concepts and/or techniques; (2) to verify the concept of robust non-minimum-phase compensation for a certain class of non-colocated structural control problems through ground experiments; (3) to verify a 'dipole' concept for persistent disturbance rejection control of flexible structures; and (4) to identify CSI (Control Structure Interaction) issues and areas of emphasis for the next generation of large flexible spacecraft. The classical SISO (Single Input and Single Output) control design approach was employed. Author

N91-29214# Harris Corp., Melbourne, FL. Government Aerospace Systems Div.
EXPERIMENTAL VERIFICATION OF AN INNOVATIVE PERFORMANCE-VALIDATION METHODOLOGY FOR LARGE SPACE SYSTEMS Final Report, 15 Aug. 1987 - 14 Feb. 1991
DAVID C. HYLAND 9 Feb. 1991 171 p
(Contract F49620-87-C-0108)
(AD-A237864; AFOSR-91-0232TR) Avail: CASI HC A08/MF A02 CSCL 22B

A technology gap exists in verifying performance of large space systems. To fill that gap the proposed program seeks to develop and validate an efficient pre-flight performance verification methodology. The approach involves selective component testing along with analysis of subsystem interactions. The methodology exploits MEOP (Maximum Entropy/Optimal Projection) Control System Design and Majorant Robustness Analysis. The approach is formulated for several representative large space systems and experimentally verified on a 3-meter diameter multi-hex panel ground-based active control tested. GRA

N91-30148# Air Force Flight Dynamics Lab., Wright-Patterson AFB, OH.
PROCEEDINGS OF THE 4TH NASA/DOD CONTROL/STRUCTURES INTERACTION TECHNOLOGY CONFERENCE Final Report
ANDREW D. SWANSON 15 Jan. 1991 769 p Conference held in Orlando, FL, 5-7 Nov. 1990
(Contract AF PROJ. 2401)
(AD-A235843; WL-TR-91-3013) Avail: CASI HC A99/MF A10 CSCL 22A

The topics covered include: control systems development, sensors and actuators, integrated design, and ground and flight experiments. Major subtopics include: large space structures, passive damping, control/structures interaction, and vibration control. GRA

N91-30161*# Control Dynamics Co., Huntsville, AL.
MECHANISM TEST BED. FLEXIBLE BODY MODEL REPORT
JIMMY COMPTON Jul. 1991 118 p
(Contract NAS8-38771)
(NASA-CR-184189; NAS 1.26:184189) Avail: CASI HC A06/MF A02 CSCL 14B

The Space Station Mechanism Test Bed is a six degree-of-freedom motion simulation facility used to evaluate docking and berthing hardware mechanisms. A generalized rigid body math model was developed which allowed the computation of vehicle relative motion in six DOF due to forces and moments from mechanism contact, attitude control systems, and gravity. No vehicle size limitations were imposed in the model. The equations of motion were based on Hill's equations for translational motion with respect to a nominal circular earth orbit and Newton-Euler equations for rotational motion. This rigid body model and supporting software were being refined. Author

N91-30197# Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil).
ANALYSIS OF THE DYNAMICS AND CONTROL OF AN ARTIFICIAL SATELLITE WITH EXTENDABLE SOLAR ARRAYS M.S. Thesis - 20 Nov. 1990 [ANALISE DINAMICA E CONTROLE DE UM SATELITE ARTIFICIAL COM PAINEIS SOLARES FLEXIVEIS]
ALEXANDRE MEGIORINROMA Mar. 1991 197 p In PORTUGUESE; ENGLISH summary
(INPE-5220-TDL/436) Avail: CASI HC A09/MF A03

Presented here is a systematic way to derive the equations of attitude motion for a particularly important class of spacecraft: those composed of a central rigid body containing reaction wheels, also assumed to be rigid, and extendable solar arrays, which are considered flexible only after the deployment phase. A Lagrangian formulation is used simultaneously with the Assumed Modes Method to avoid a hybrid set of equations of motion. Software employing the symbolic manipulator Reduce is developed to obtain, in some cases, these equations. With this software, the nonlinear set of equations for the transient deployment phase and the linearized set of equations for the next phase, including panel flexibility, is derived for a satellite used as an example. For this satellite, the transient phase is analyzed. Dyadic changes in time and attitude motion induced by the deployment of the panels is observed. In this case, the impact between the central body and each panel is introduced. For a linearized set of equations of motion, a control design, employing the Eigenstructure Assignment technique is implemented, stabilizing the attitude motion and damping the elastic vibrations. Author

N91-30509# Boston Univ., MA. Coll of Engineering.
THE NONLINEAR CONTROL THEORY OF COMPLEX MECHANICAL SYSTEMS Final Report
J. BAILLIEU and M. LEVI 15 Oct. 1990 59 p
(Contract AF-AFOSR-0144-85)
(AD-A229474; AFOSR-90-1155TR) Avail: CASI HC A04/MF A01 CSCL 22A

A body of research dealing with the nonlinear control theory of complex mechanical systems is summarized. The principal focus is on the dynamics of rotating systems with uncontrolled degrees of freedom, and specific model problems of pointing, shape, and orientation control of complex spacecraft in a zero gravity environment are solved. The dynamics are also examined of rotating kinematic chains. The list of references cites all major contributions to the literature of rotational mechanics. Two papers in particular - Rotational Elastic Dynamics and Equilibrium Mechanics of Rotating Systems form the principal basis for the present report. Indeed, these papers are reproduced here with occasional remarks and comments inserted regarding very recent developments in the field. GRA

N91-31487 Old Dominion Univ., Norfolk, VA.
INTEGRATED CONTROL OF THERMALLY DISTORTED LARGE SPACE ANTENNAS Ph.D. Thesis
ROBERT HEATH TOLSON 1990 100 p
Avail: Univ. Microfilms Order No. DA9118082

Studies on controlling the thermal distortion of large space antennae have generally studied a single orbital position and have optimized actuator locations based on minimizing the RMS surface deviation from the original parabolic shape. One study showed the benefits of directly using far zone electric field characteristics as the performance measure; but, this approach resulted in a nonlinear programming problem. The objective of the current study is to develop an approach to designing a control system that recognizes the time dependence of the distortion and controls variables that are directly related to far field performance in a quadratic cost sense. The first objective, to include time dependence, is accomplished using a principal component analysis to expand an aperture phase function into components that are orthogonal in space and time. The approach for the second objective is to expand the far zone electric field in a Zernike-Bessel series. For surface distortions of less than 1/4 wavelength, it is shown that the coefficients of this series provide a reliable measure of far field performance. Dissert. Abstr.

N91-31609*# Photon Research Associates, Inc., Cambridge, MA. Research Div.
ADVANCED OPTICAL SENSING AND PROCESSING TECHNOLOGIES FOR THE DISTRIBUTED CONTROL OF LARGE FLEXIBLE SPACECRAFT Final Report
G. M. WILLIAMS and J. C. FRASER Washington NASA Oct. 1991 131 p Prepared in cooperation with McDonnell-Douglas Space Systems Co., Huntsville, Al
(Contract NAS1-18763; RTOP 590-14-11-02)
(NASA-CR-4399; NAS 1.26:4399) Avail: CASI HC A07/MF A02 CSCL 20F

The objective was to examine state-of-the-art optical sensing and processing technology applied to control the motion of flexible spacecraft. Proposed large flexible space systems, such an optical telescopes and antennas, will require control over vast surfaces. Most likely distributed control will be necessary involving many sensors to accurately measure the surface. A similarly large number of actuators must act upon the system. The used technical approach included reviewing proposed NASA missions to assess system needs and requirements. A candidate mission was chosen as a baseline study spacecraft for comparison of conventional and optical control components. Control system requirements of the baseline system were used for designing both a control system containing current off-the-shelf components and a system utilizing electro-optical devices for sensing and processing. State-of-the-art surveys of conventional sensor, actuator, and processor technologies were performed. A technology development plan is presented that presents a logical, effective way to develop and integrate advancing technologies. Author

N91-31643# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
APPLICATION OF MULTIVARIABLE CONTROL SYSTEM DESIGN METHODOLOGIES TO ROBUST BEAM CONTROL OF A SPACE-BASED LASER M.S. Thesis
KELLY D. HAMMETT Jun. 1991 179 p
(AD-A239460; AFIT/CI/CIA-91-058) Avail: CASI HC A09/MF A02 CSCL 09C

The complexity of large-scale dynamic systems provides a challenging proving ground for modern control system analysis and design techniques. High plant dimensionality inherent in large-scale systems can lead to breakdowns in numerics of state-space algorithms or intolerably long computational times, necessitating use of model reduction techniques. Reducing plant order consequently introduces unmodeled dynamics into the system, which must then be accounted for via stability and performance robustness considerations. A design framework is adopted herein which allows stability robustness to be guaranteed via unstructured uncertainty representation and the Small Gain Theorem, and performance robustness to be independently verified. The applicability of modern multivariable controller design techniques to large-scale systems is demonstrated by synthesis of robustly stable H2 optimal, H at infinity optimal, and H2/H at infinity loop-shaped compensators for a space-based laser forebody using reduced order models. Performance goals are expressed in terms of both allowable 2-norms and root-mean-square values of line-of-sight and segment phasing errors, and an evolutionary process leads to a final controller design. First, ideally performing but non-robust unconstrained bandwidth H2 and H at infinity designs are presented which illustrate the danger of ignoring unmodeled high-frequency dynamics. GRA

N91-31671 Virginia Polytechnic Inst. and State Univ., Blacksburg.
THE CONTROL OF FLEXIBLE STRUCTURE VIBRATIONS USING A CANTILEVERED ADAPTIVE TRUSS Ph.D. Thesis
ROBERT H. WYNN, JR. 1991 131 p
Avail: Univ. Microfilms Order No. DA9118816

Analytical and experimental procedures and design tools are presented for control of flexible structure vibrations using a cantilevered adaptive truss. A specific six-actuator, octa-/octra-hedral truss effects the control of different flexible structures. These structures could represent space structures or robotic manipulators or a variety of other flexible structures where unwanted structural vibration could reduce the performance of the system. Three of these structures; a slender beam, a single curved beam, and two curved beams are controlled both in simulation and with an experimental test article. The test article, comprised of the flexible structure, the adaptive truss, and the actuators shows excellent agreement between simulated and experimental responses to initial conditions in both open loop and (LQR) closed loop control. As an example of the ability of the truss to control the slender beam, a first mode simulated frequency of 3.11 Hz and damping ratio of 0.0044 are controlled to produce a 3.20 Hz fre quency and a damping ratio of 0.2876. This 600 pct. increase in damping without a great change in the modal frequency shows the potential of the adaptive truss in vibration control. Dissert. Abstr.

N91-31684*# Comtek Co., Grafton, VA.
LARGE ANGLE TRANSIENT DYNAMICS (LATDYN) DEMONSTRATION PROBLEM MANUAL Final Report
SHIH-CHIN WU Washington NASA Oct. 1991 62 p
(Contract NAS1-18478)
(NASA-CR-4400; NAS 1.26:4400) Avail: CASI HC A04/MF A01 CSCL 20K

LATDYN is a computer code for modeling the Large Angle Transient Dynamics of structures. The objective in developing the code was to investigate new techniques for analyzing flexible deformation and control/structure interaction problems associated with large angular motions of spacecraft. Such motions may consist of pointing the entire spacecraft or articulation of individual components, events which occur frequently during construction, operation, and maintenance of large spacecraft. This type of analysis is beyond the routine capability of conventional analytical tools without simplifying assumptions. In some instances, the motion may be sufficiently slow and the spacecraft (or component) sufficiently rigid to simplify the analysis of dynamics and controls by making pseudo-static and/or rigid body assumptions. LATDYN introduces a new approach to the problem by combining finite element structural analysis, multi-body dynamics, and control system analysis in a single tool. It includes a new type of finite element that can deform and rotate through large angles at the same time, and which can be connected to other finite elements either rigidly or through mechanical joints. LATDYN also provides symbolic capabilities for modeling control systems which are interfaced directly with the finite element structural model. Thus, the nonlinear equations representing the structural model are integrated along with the equations representing sensors, processing, and controls as a coupled system. Author

N91-31685*# Comtek Co., Grafton, VA.
LARGE ANGLE TRANSIENT DYNAMICS (LATDYN) USER'S MANUAL Final Report
A. LOUIS ABRAHAMSON, CHE-WEI CHANG, MICHAEL G. POWELL, SHIH-CHIN WU, BRADFORD D. BINGEL, and PAULA M. THEOPHILOS (Computer Sciences Corp., Hampton, VA.) Washington NASA Oct. 1991 129 p
(Contract NAS1-18478; RTOP 505-63-53)
(NASA-CR-4401; NAS 1.26:4401) Avail: CASI HC A07/MF A02 CSCL 20K

A computer code for modeling the large angle transient dynamics (LATDYN) of structures was developed to investigate techniques for analyzing flexible deformation and control/structure interaction problems associated with large angular motions of spacecraft. This type of analysis is beyond the routine capability of conventional analytical tools without simplifying assumptions. In some instances, the motion may be sufficiently slow and the spacecraft (or component) sufficiently rigid to simplify analyses of dynamics and controls by making pseudo-static and/or rigid body assumptions. The LATDYN introduces a new approach to the problem by combining finite element structural analysis, multi-body dynamics, and control system analysis in a single tool. It includes a type of finite element that can deform and rotate through large angles at the same time, and which can be connected to other finite elements either rigidly or through mechanical joints. The LATDYN also provides symbolic capabilities for modeling control systems which are interfaced directly with the finite element structural model. Thus, the nonlinear equations representing the structural model are integrated along with the equations representing sensors, processing, and controls as a coupled system. Author

N91-31686*# Comtek Co., Grafton, VA.
A FINITE ELEMENT APPROACH FOR THE DYNAMIC ANALYSIS OF JOINT-DOMINATED STRUCTURES
CHE-WEI CHANG and SHIH-CHIN WU Oct. 1991 39 p
(Contract NAS1-18478; RTOP 505-63-53)
(NASA-CR-4402; NAS 1.26:4402) Avail: CASI HC A03/MF A01 CSCL 20K

A finite element method to model dynamic structural systems undergoing large rotations is presented. The dynamic systems are composed of rigid joint bodies and flexible beam elements. The configurations of these systems are subject to change due to the relative motion in the joints among interconnected elastic beams. A body fixed reference is defined for each joint body to describe the joint body's displacements. Using the finite element method and the kinematic relations between each flexible element and its corotational reference, the total displacement field of an element, which contains gross rigid as well as elastic effects, can be derived in terms of the translational and rotational displacements of the two end nodes. If one end of an element is hinged to a joint body, the joint body's displacements and the hinge degree of freedom at the end are used to represent the nodal displacements. This results in a highly coupled system of differential equations written in terms of hinge degrees of freedom as well as the rotational and translational displacements of joint bodies and element nodes. Author

N91-32252*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ALGORITHMS FOR STRUCTURAL NATURAL-FREQUENCY DESIGN
R. LEVY *In its* The Telecommunications and Data Acquisition Report p 23-29 15 Aug. 1991
(Contract RTOP 310-20-65-86-04)
Avail: CASI HC A02/MF A04 CSCL 17B

The algorithms used in the Jet Propulsion Laboratory (JPL) Iterative Design of Antenna Structures (IDEAS) program are furnished. The algorithms are based upon the operational research method of optimality criteria and the structural analysis method of virtual work. Examples of the natural frequency constrained design of an antenna tripod structure are included. Author

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ASSEMBLY, MAINTENANCE, and EXTRAVEHICULAR ACTIVITY

Description of on-orbit deployment or assembly including tools. Includes space suits and other EVA equipment or support.

A91-33671* Texas Univ., Austin.
MINIMUM-FUEL RESCUE TRAJECTORIES FOR THE EXTRAVEHICULAR EXCURSION UNIT
W. T. FOWLER (Texas, University, Austin) and J. M. NEFF Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 39, Jan.-Mar. 1991, p. 21-45. refs
(Contract NGT-50222)
(AAS PAPER 89-371) Copyright

The problem of determining minimum-fuel trajectories for rescuing astronauts or equipment which become separated from a Space Station is addressed. Using the Clohessy-Wiltshire equations of relative motion and assuming impulsive Delta-Vs, the minimum-fuel rescue problem is shown to be a parameter optimization problem. Minimum-fuel rescue trajectories are found for seventeen test cases using a recursive quadratic programming algorithm. The results are analyzed and general rules for astronaut rescue and equipment retrieval are developed. Author

A91-34258
SPACE SUITS FOR EVA [AUSGEH-ANZUG FUER DEN WELTRAUM]
HELGA L. HILLEBRAND Luft- und Raumfahrt (ISSN 0173-6264), vol. 12, no. 1-2, 1991, p. 16-18. In German.
Copyright

Space suits being developed for use with the Columbus Free Flyer are discussed. The basic physical problems of pressure which the design of the suits must meet are reviewed, showing the ways that existing suits deal with them. The choice of materials for the suits and the design of their joints, and the composition of their individual layers are addressed. The industrial organization which is developing the suits is depicted. C.D.

A91-39391
ADVANCED TECHNOLOGY APPLICATION IN THE PRODUCTION OF SPACE SUIT GLOVES
PHIL SPAMPINATO, DAVE CADOGAN, and TONY MCKEE (ILC Dover, Frederica, DE) IN: Annual SAFE Symposium, 27th, New Orleans, LA, Dec. 5-8, 1989, Proceedings. Newhall, CA, SAFE

Association, 1990, p. 164-169.
Copyright

The present study reviews a new space-suit glove designed for NASA Johnson and describes its production method. The advantages of three distinct manufacturing technologies are characterized: laser scanning, CAD/CAM, and stereo lithography. A two-phase plan to determine the feasibility of utilizing these advanced technologies included evaluation and selection of optical sensing equipment, interfacing and manipulation of scanned data on a CAD system, and evaluation of bladder form fabrication methods. The feasibility of implementing these technologies is considered proven. The second phase is to include a cost/benefit analysis to determine if and when the equipment cost for implementation will pay for itself in savings and glove production. Another conclusion confirmed by this study is that these technologies have been far more potential than for gloves alone.
P.D.

A91-39684 National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, FL.
ASTRONAUTS GIVE GRO A HELPING HAND
ROELOF L. SCHULLING (NASA, Kennedy Space Center, Cocoa Beach, FL) and STEVEN YOUNG (NASA, Johnson Space Center, Houston, TX) Spaceflight (ISSN 0038-6340), vol. 33, June 1991, p. 194-205.
Copyright

The eighth mission of the Space Shuttle Atlantis, during which an emergency spacewalk was performed to help deploy the Gamma-Ray Observatory (GRO), is described and illustrated with extensive photographs. The countdown and liftoff are recalled, and a day-by-day history of the mission is provided. Particular attention is given to the Extravehicular Activity Development Flight Experiment, designed to obtain data for future spacewalks, and the Crew and Equipment Translation Aid, aimed at testing carts that spacewalking astronauts could use to move along the truss structure of the Space Station. O.G.

A91-42799
SHUTTLE REHEARSALS FOR FREEDOM
DONALD F. ROBERTSON Interavia Space Markets (ISSN 0258-4212), vol. 7, no. 3, 1991, p. 5-8, 10.
Copyright

NASA has planned a number of test flights for critical Space Station components and activities on Space Shuttle missions. Missions of this type which have already flown include a space truss-building experiment and an advanced heat pipe-radiator element; the latter has demonstrated the necessity of actual orbital experience with such novel technologies. At least six sets of Shuttle-based tests remain, which will respectively undertake: EVA development flight experiments; tests of environmental oxygen interaction with materials; an additional heat-pipe radiator test; life-support and life-science experiments; the assembly of the Space Station's components by EVA; and an orbital test of the Flight Telerobotic Servicer. O.C.

A91-43518
ELECTRON BEAM WELDING, SOVIET STYLE - A FRONT RUNNER FOR SPACE
BOB IRVING Welding Journal (ISSN 0043-2296), vol. 70, July 1991, p. 55-59.
Copyright

Experiments conducted on the versatile hand tool (VHT), the manual electron beam welding gun used during a Soviet space flight in 1984, are briefly discussed. The VHT has been used to perform electron beam welding, brazing, and spraying in space. Attention is also given to hydrogen-free welds and brazing problems. It is concluded that the weld metal is well wetted by the heat from its own melt and there is no lack of fusion in space welds. Magnesium and zinc, both of which vaporize at relatively low temperatures, display more porosity when welded in space. Due to the faster weld cooling rates and shorter liquid states with such materials as aluminum and titanium alloys, stainless steels and heat-resistant steels, the welds display finer grain structures.
O.G.

A91-45875
FUTURE SPACE SUIT DESIGN CONSIDERATIONS
Aerospace Engineering (ISSN 0736-2536), vol. 11, July 1991, p. 13-16.
Copyright

This paper examines the space suit design requirements dictated by the environmental factors to be encountered during manned expeditions to the moon and to Mars. To meet the environmental challenges, engineers are studying both lightweight structural materials for use in space suit system assemblies and the incorporation of dust-proof protective measures. Consideration is given to the comparative values of extravehicular mobility unit system weights, habitat pressure versus suit pressure, and commonly used metals for space suit structural components. Techniques being considered for bearing dust protection include separate environmental protective seals, labyrinth seals, and lubricant-impregnated felt seals, or combinations of these.
R.E.P.

A91-50543
SPACE STATION AND ADVANCED EVA TECHNOLOGIES; INTERSOCIETY CONFERENCE ON ENVIRONMENTAL SYSTEMS, 20TH, WILLIAMSBURG, VA, JULY 9-12, 1990, TECHNICAL PAPERS
Conference sponsored by SAE. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-830), 1990, 149 p. For individual items see A91-50544 to A91-50549.
(SAE SP-830) Copyright

A collection of papers is presented with a wide spectrum of EVA subjects, including component technology development, SSF design for integration of EVA, optimization of crew and robotic EVA, and the EVA requirements for the lunar and Mars missions. Particular attention is given to development of a fuel cell for the EMU, advanced technology application in the production of spacesuit gloves, telerobotics as an EVA tool, design considerations for future planetary space suits, a methodology for choosing candidate materials for the fabrication of planetary space suit structures, development of a regenerable metal oxide CO removal system, characterization of metal oxide absorbents for regenerative carbon dioxide and water vapor removal for advanced portable life support systems, an air bearing fan for EVA suit ventilation, and a direct-interface fusible heat sink for astronaut cooling.
O.G.

A91-50544* Hamilton Standard, Windsor Locks, CT.
SHUTTLE EXTRAVEHICULAR MOBILITY UNIT (EMU) OPERATIONAL ENHANCEMENTS
ROBERT BALINSKAS (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT), JAMES W. MCBARRON, II (NASA, Johnson Space Center, Houston, TX), and PHILIP M. SPAMPINATO (ILC Dover, Frederica, DE) IN: Space Station and advanced EVA technologies; Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990, Technical Papers. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 1-10.
(SAE PAPER 901317) Copyright

An EMU program activity is considered aimed at achieving a 25 percent reduction in ground turnaround man-hours and processing time between missions and extending EVA on-orbit capabilities. Tasks being implemented with expected benefits to NASA-manned spaceflight programs are identified and described. It is concluded that the EMU enhancements made to increase durability and reduce ground processing time will also provide the capability for on-orbit suit resizing and make possible the extension of the present on-orbit certification limit from 3 to 5 EVAs. O.G.

A91-50546* Lockheed Engineering and Sciences Co., Houston, TX.

INVESTIGATION INTO VENTING AND NON-VENTING TECHNOLOGIES FOR THE SPACE STATION FREEDOM EXTRAVEHICULAR ACTIVITY LIFE SUPPORT SYSTEM

JOHN L. WILSON (Lockheed Engineering and Sciences Co., Houston, TX) and B. MICHAEL LAWSON (NASA, Johnson Space Center, Houston, TX) IN: Space Station and advanced EVA technologies; Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990, Technical Papers. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 19-33. refs

(SAE PAPER 901319) Copyright

Various venting and non-venting technologies for SSF EVA life support system are described, and the estimated weights and volumes for the options on a component and system level are reviewed. It is noted that a final design concept for the SSF extravehicular mobility unit has not been chosen. O.G.

A91-50547

TELEROBOTICS AS AN EVA TOOL

DAVID E. ANDERSON and LISA M. ROCKOFF (McDonnell Douglas Space Systems Co., Space Station Div., Huntington Beach, CA) IN: Space Station and advanced EVA technologies; Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990, Technical Papers. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 43-49. refs

(SAE PAPER 901397) Copyright

Possible uses of telerobotic devices in EVA are discussed, drawing from Propellant Tank Farm neutral buoyancy testing. Recommendations are presented for using telerobots such as the flight telerobotic servicer, the special-purpose dexterous manipulator, the remote manipulator system, and the Japanese experiment module arms in the evolution of SSF. It is concluded that to maintain feasibility and control cost, more extensive and routine use of telerobots will be required. Addition of ground control capability of on-orbit telerobots will substitute ground crew time for space crew time, considerably reducing operational costs. O.G.

A91-50548

FREE-FLYERS FOR SPACE STATION EVA OPERATIONS

LISA M. ROCKOFF and DAVID E. ANDERSON (McDonnell Douglas Space Systems Co., Space Station Div., Huntington Beach, CA) IN: Space Station and advanced EVA technologies; Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990, Technical Papers. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 59-64. refs

(SAE PAPER 901399) Copyright

The advantages of free-flyers to on-orbit operations are examined, and free-flyers presently under developemnt are described. Their advantages include increased accessibility to certain worksites, crew and equipment retrieval, remote servicing, and crew and equipment translation. It is concluded that free-flyers could prove to be extremely useful as a means of reducing EVA time and increasing EVA workspace. O.G.

A91-50549

EVA CREW AND EQUIPMENT TRANSLATION TECHNIQUES AND ROUTING

CHARLOTTE A. GRIGGS (McDonnell Douglas Space Systems Co., Space Station Div., Huntington Beach, CA) IN: Space Station and advanced EVA technologies; Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990, Technical Papers. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 65-70. refs

(SAE PAPER 901401) Copyright

Consideration is given to a crew and equipment translation techniques and routing (CETTR) trade study aimed at determining safe and efficient translation paths to high EVA activity areas on the SSF. These areas include representative truss-mounted equipment locations, the solar alpha rotary joint (SARJ), the module pattern, and the airlock. It is concluded that by minimizing translation time to and from these areas, additional time is made available to the EVA crewmember for task performance, thereby contributing to the overall productivity of each mission. O.G.

A91-50996* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ASSEMBLY PLANNING FOR LARGE TRUSS STRUCTURES IN SPACE

L. S. HOMEM DE MELLO and R. S. DESAI (JPL, Pasadena, CA) IN: IEEE International Conference on Systems Engineering, 2nd, Pittsburgh, PA, Aug. 9-11, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 404-407. refs

Copyright

The approach is based on a graph search algorithm. A relational data structure is used to represent a truss structure. There are four types of entities: units, faces, edges, and vertices. There are contain/contained relationships for every pair of entity types, as well as in-contact relationships between faces. A best-first algorithm constitutes the core of the planner. The cost function in the current implementation corresponds to a combination of the rigidity of the intermediate structures and the total distance to be traversed by the agent executing the assembly tasks. I.E.

A91-51077

A HOLOGRAPHIC HELMET MOUNTED DISPLAY APPLICATION FOR THE EXTRAVEHICULAR MOBILITY UNIT

M. WEINSTOCK, W. PISHTEY, J. LARUSSA (Technology Innovation Group, Inc., Pleasantville, NY), and C. L. TRITSCH (Lockheed Engineering and Sciences Co., Houston, TX) IN: Helmet-mounted displays II; Proceedings of the Meeting, Orlando, FL, Apr. 19, 20, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 2-8. refs

Copyright

The design of a helmet-mounted display (HMD) created for use in the Space Station Extravehicular Mobility Unit (EMU) is described. This HMD provides the user with a biocular virtual image in a 25 deg diagonal field of view, maximum combiner transparency, minimal volume dimension, and an unencumbered working field of view. C.D.

A91-55823

ADDRESSING THE PROBLEM OF INTERRUPTIBILITY IN THE CONSTRUCTION OF LARGE SPACE STRUCTURES

GEORGE W. MORGENTHALER (Colorado, University, Boulder) and R. A. DAVIDSON IN: Space utilization and applications in the Pacific; Proceedings of the 3rd Pacific Basin International Symposium on Advances in Space Science Technology and its Applications, Los Angeles, CA, Nov. 6-8, 1989. San Diego, CA, Univelt, Inc., 1990, p. 259-272. refs

(AAS PAPER 89-626) Copyright

A Program Interruptibility and Risk Evaluation Technique (PIRET) is described. The goals of PIRET are to arrive at analytical simulation models, to quantitatively study the interruptibility problem for multilaunch, space construction project, and to develop design and operational construction suggestions, which take into account a variety of possible failures and external interruptions of the planned construction sequence. The PIRET analysis of SSF shows that this method is capable of producing reasonable estimates and pointing out legitimate concerns and recommendations. O.G.

N91-23575# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).

EVA SERVICING: THE HERMES CAPABILITY

A. ACCENSI, I. SKOOG, and J. CHEVALLIER (Avions Marcel Dassault-Breguet Aviation, Saint-Cloud, France) *In its* Space and Sea p 89-94 Dec. 1990

Copyright Avail: CASI HC A02/MF A03

Experience demonstrates that external intervention capabilities are an integral part of an in orbit infrastructure; allied to the development of Hermes and Columbus, ESA has embarked upon the establishment of an Extra Vehicular Activity (EVA) capability. Following the establishment of EVA mission requirements, ESA initiated in 1987, preparatory studies for the evaluation of operational scenarii and alternative design concepts which resulted in the definition of the technical requirements for the Europen EVA system. The various design options for meeting these requirements were evaluated in detail within the on going Hermes phase C activities. The design tradeoff placed particular attention to the close man system integration of the EVA system; crew safety and human factors engineering were consequently used as key design drivers in the derivation of the EVA system design reference. ESA

N91-23583# McDonnell-Douglas Space Systems Co., Houston, TX. Space Station Div.
EVA/ROBOTICS INTEGRATION FOR SPACE STATION FREEDOM
R. M. MACHELL, L. V. RAMON, and D. E. ANDERSON *In* ESA, Space and Sea p 145-149 Dec. 1990
Copyright Avail: CASI HC A01/MF A03

Space Station Freedom is being designed to be assembled and maintained on orbit by astronauts in space suits and by the use of telerobotic devices. Undersea experience in the cooperative use of divers and robots is being applied to the integration of astronauts in Extra Vehicular Activity (EVA) and telerobots for on orbit assembly and external maintenance tasks. Evaluation of on orbit assembly and external maintenance tasks and worksites will determine which tasks should be done by EVA and which by telerobots. Priority emphasis is being given to telerobotics wherever practical. Neutral buoyancy testing in underwater test tanks is being conducted to evaluate EVA worksites and tasks in simulated weightlessness. Common designs for EVA and telerobotics hardware interfaces are being developed. The extensive analysis and test activities provide substantial confidence in the ability to assemble and maintain the Space Station Freedom on orbit. ESA

N91-24604*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CETA TRUCK AND EVA RESTRAINT SYSTEM
DAVID C. BEALS and WAYNE R. MERSON (Lockheed Engineering and Sciences Co., Hampton, VA.) *In* JPL, The 25th Aerospace Mechanisms Symposium p 1-14 May 1991
Avail: CASI HC A03/MF A03 CSCL 05H

The Crew Equipment Translation Aid (CETA) experiment is an extravehicular activity (EVA) Space Transportation System (STS) based flight experiment which will explore various modes of transporting astronauts and light equipment for Space Station Freedom (SSF). The basic elements of CETA are: (1) two 25 foot long sections of monorail, which will be EVA assembled in the STS cargo bay to become a single 50 ft. rail called the track; (2) a wheeled baseplate called the truck which rolls along the track and can accept three cart concepts; and (3) the three carts which are designated manual, electric, and mechanical. The three carts serve as the astronaut restraint and locomotive interfaces with the track. The manual cart is powered by the astronaut grasping the track's handrail and pulling himself along. The electric cart is operated by an astronaut turning a generator which powers the electric motor and drives the cart. The mechanical cart is driven by a Bendix type transmission and is similar in concept to a man-propelled railroad cart. During launch and landing, the truck is attached to the deployable track by means of EVA removable restraint bolts and held in position by a system of retractable shims. These shims are positioned on the exterior of the rail for launch and landing and rotate out of the way for the duration of the experiment. The shims are held in position by strips of Velcro nap, which rub against the sides of the shim and exert a tailored force. The amount of force required to rotate the shims was a major EVA concern, along with operational repeatability and extreme temperature effects. The restraint system was tested in a thermal-vac and vibration environment and was shown to meet all of the initial design requirements. Using design inputs from the astronauts who will perform the EVA, CETA evolved through an iterative design process and represented a cooperative effort. Author

N91-27098*# Texas Univ., San Antonio. Div. of Engineering.
REEXAMINATION OF METMAN, RECOMMENDATIONS ON ENHANCEMENT OF LCVG, AND DEVELOPMENT OF NEW CONCEPTS FOR EMU HEAT SINK Final Report
AMIR KARIMI *In* Houston Univ., NASA/ASEE Summer Faculty Fellowship Program, 1990, Volume 1 16 p Dec. 1990
(Contract NGT-44-005-803)
Avail: CASI HC A03/MF A03 CSCL 20D

METMAN is a 41-node transient metabolic computer code developed in 1970 and revised in 1989 by Lockheed Engineering and Sciences, Inc. This program relies on a mathematical model to predict the transient temperature distribution in a body influenced by metabolic heat generation and thermal interaction with the environment. A more complex 315-node model is also available that not only simulates the thermal response of a body exposed to a warm environment, but is also capable of describing the thermal response resulting from exposure to a cold environment. It is important to compare the two models for the prediction of the body's thermal response to metabolic heat generation and exposure to various environmental conditions. Discrepancies between the twi models may warrant an investigation of METMAN to ensure its validity for describing the body's thermal response in space environment. The Liquid Cooling and Ventilation Garment is a subsystem of the Extravehicular Mobility Unit (EMU). This garment, worn under the pressure suit, contains the liquid cooling tubing and gas ventilation manifolds; its purpose is to alleviate or reduce thermal stress resulting from metabolic heat generation. There is renewed interest in modifying this garment through identification of the locus of maximum heat transfer at body-liquid cooled tubing interface. The sublimator is a vital component of the Primary Life Support System (PLSS) in the EMU. It acts as a heat sink to remove heat and humidity from the gas ventilating circuit and the liquid cooling loop of the LCVG. The deficiency of the sublimator is that the ice, used as the heat sink, sublimates into space. There is an effort to minimize water losses in the feedwater circuit of the EMU. This requires developing new concepts to design an alternative heat sink system. Efforts are directed to review and verify the heat transfer formulation of the analytical model employed by METMAN. A conceptual investigation of regenerative non-venting heat-sink subsystem for the EMU is recommended. Author

N91-27180*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LAUNCH VEHICLE INTEGRATION OPTIONS FOR A LARGE EARTH SCIENCES GEOSTATIONARY PLATFORM CONCEPT
JAMES L. GARRISON and LAWRENCE F. ROWELL Jul. 1991 49 p
(Contract RTOP 506-49-21-02)
(NASA-TP-3083; L-16819; NAS 1.60:3083) Avail: CASI HC A03/MF A01 CSCL 22B

Concepts are derived for the packaging of the components of a large Earth sciences geostationary platform to be launched in either the Space Shuttle or the Titan IV Complementary Expendable Launch Vehicle. Geometric data from a proposed conceptual design for the spacecraft, antenna sizing results from thermal and structural finite element analysis, and independent mass and volume estimates are used to determine sizes, shapes, and masses of the major platform components and support equipment. Solid modeling software is utilized to evaluate proposed launch integration schemes in terms of meeting volume and mass constraints, checking for interference between components, verifying that center-of-gravity locations fall within vehicle specifications, and designing suitable interface structures which do not violate any of these constraints. Construction at Space Station Freedom is assumed, and a space-based orbital transfer vehicle is determined to be necessary for inserting the spacecraft, once assembled, into geostationary orbit. Author

N91-27182*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PACKAGING, DEVELOPMENT, AND ON-ORBIT ASSEMBLY OPTIONS FOR LARGE GEOSTATIONARY SPACECRAFT
WILLIAM T. DAVIS and CHARLES B. KING (Bionetics Corp., Hampton, VA.) Washington Jul. 1991 34 p
(Contract RTOP 506-49-31-01)
(NASA-TP-3088; L-16863; NAS 1.60:3088) Avail: CASI HC A03/MF A01 CSCL 22B

Large spacecraft, particularly in geostationary Earth orbit (GEO), require special attention to the design challenges of launch vehicle packaging, deployment, and/or on-orbit assembly. Design studies of two different GEO spacecraft required that packaging, deployment, and on-orbit assembly analyses be conducted to establish the viability of these concepts for future NASA missions. This study used these analyses as strawman concepts for an investigation of packaging, deployment, and on-orbit assembly techniques. It also revealed generic guidelines for in-space assembly and highlighted the importance of early integration of packaging, deployment, and on-orbit assembly requirements into the spacecraft design. The first of the study spacecraft were used to study the definition and analyses of on-orbit assembly options for large GEO spacecraft. The second study spacecraft required investigation of the feasibility of deploying large spacecraft at GEO. The second spacecraft was also used to examine the packaging requirements of a deployable spacecraft and the packaging requirements for a hybrid assembled/deployable version of that spacecraft. This investigation was done with attention to minimum volume (and minimum launches) and to the relationship between packaging and spacecraft deployment and final configuration. Author

N91-27541*# Alabama Univ., Huntsville.
LASER WELDING IN SPACE Final Report
GARY L. WORKMAN and WILLIAM F. KAUKLER 26 Oct. 1989 101 p *Original contains color illustrations*
(Contract NAS9-17962)
(NASA-CR-185638; NAS 1.26:185638) Avail: CASI HC A06/MF A02; 5 functional color pages CSCL 13I

Solidification type welding process experiments in conditions of microgravity were performed. The role of convection in such phenomena was examined and convective effects in the small volumes obtained in the laser weld zone were observed. Heat transfer within the weld was affected by acceleration level as indicated by the resulting microstructure changes in low gravity. All experiments were performed such that both high and low gravity welds occurred along the same weld beam, allowing the effects of gravity alone to be examined. Results indicate that laser welding in a space environment is feasible and can be safely performed IVA or EVA. Development of the hardware to perform the experiment in a Hitchhiker-g platform is recomended as the next step. This experiment provides NASA with a capable technology for welding needs in space. The resources required to perform this experiment aboard a Shuttle Hitchhiker-pallet are assessed. Over the four year period 1991 to 1994, it is recommended that the task will require 13.6 manyears and $914,900. In addition to demonstrating the technology and ferreting out the problems encountered, it is suggested that NASA will also have a useful laser materials processing facility for working with both the scientific and the engineering aspects of materials processing in space. Several concepts are also included for long-term optimization of available solar power through solar pumping solid state lasers directly for welding power. Author

N91-28106*# Bowie State Univ., MD.
AUTOMATED ASSEMBLY IN SPACE
SANDANAND SRIVASTAVA, SUREN N. DWIVEDI (West Virginia Univ., Morgantown.), TOH TECK SOON, REDDY BANDI, SOUMEN BANERJEE, and CECILIA HUGHES *In* Alabama A & M Univ., NASA-HBCU Space Science and Engineering Research Forum Proceedings p 313-322 1989
Avail: CASI HC A02/MF A04 CSCL 22A

The installation of robots and their use of assembly in space will create an exciting and promising future for the U.S. Space Program. The concept of assembly in space is very complicated and error prone and it is not possible unless the various parts and modules are suitably designed for automation. Certain guidelines are developed for part designing and for an easy precision assembly. Major design problems associated with automated assembly are considered and solutions to resolve these problems are evaluated in the guidelines format. Methods for gripping and methods for part feeding are developed with regard to the absence of gravity in space. The guidelines for part orientation, adjustments, compliances and various assembly construction are discussed. Design modifications of various fasteners and fastening methods are also investigated. Author

09

ROBOTICS & REMOTE OPERATIONS

Simulations, models, analytical techniques, and requirements for remote, automated or robotic mechanical systems. Includes remote control of experiments.

A91-34929#
COOPERATIVE CONTROL OF MULTIPLE SPACE MANIPULATORS
M. NAHON and J. ANGELES (McGill University, Montreal, Canada) IN: CASI Conference on Astronautics, 6th, Ottawa, Canada, Nov. 19-21, 1990, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1990, p. 28-37. Ministere de l'Education du Quebec-supported research. refs
(Contract NSERC-A-4532)

The control of multiarmed robotic systems is inherently more complex than that of single-arm systems. Whereas a single manipulator can be controlled purely through positions or velocities, multiple manipulators handling a common payload must also be controlled in terms of forces. In this paper, the problem of finding force setpoints for the controller is formulated as a constrained optimization problem where the constraints are provided by the dynamics equations and the actuator capabilities. A number of potential objective functions which may be minimized are reviewed including the 'internal force', a norm of the vector of actuator torques, and power losses in the system. These are then compared for a task in which the Special Purpose Dextrous Manipulator moves a payload in the absence of gravity. It is concluded that the actuator torque criterion appears to offer the worst compromise in performance, while the minimum internal force and minimum power loss criteria each have their advantages. Author

A91-34930#
VISION SYSTEM REQUIREMENTS AND CONCEPT FOR THE SPECIAL PURPOSE DEXTEROUS MANIPULATOR SYSTEM (SPDM)
LEON ZUCHERMAN (Spar Aerospace, Ltd., Mississauga, Canada) IN: CASI Conference on Astronautics, 6th, Ottawa, Canada, Nov. 19-21, 1990, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1990, p. 38-44. NSERC-supported research. refs

An account is presented of the design features and operational capabilities of the Artificial Vision System (AVS) employed by the Canadian Space Station Program's Special Purpose Dexterous Manipulator (SPDM) in its tracking, capturing, handling, berthing, and tool-manipulation operations. A comparison of the performance of SPDM vision-assisted operations with those of the Space Station Remote Manipulator System shows that the SPDM operations in general, and its maintenance and assembly operations in particular, involve an additional dimension of task complexity that must be matched by AVS performance. Alternative future concepts in the field of SPDM-related vision are discussed. O.C.

A91-34954#
VISION DEVELOPMENT TEST BED - THE CRADLE OF THE MSS ARTIFICIAL VISION SYSTEM
LEON ZUCHERMAN and JOHN STOVMAN (Spar Aerospace, Ltd., Mississauga, Canada) IN: CASI Conference on Astronautics, 6th, Ottawa, Canada, Nov. 19-21, 1990, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1990, p. 296-304. Canadian Space Agency-supported research. refs

The concept of the Vision Development Test Bed (VDTB) developed in order to perform development work on the Artificial Vision System (AVS) for the Mobile Servicing System (MSS) is presented. The MSS is being developed as a Canadian contribution to the NASA Space Station Freedom. It is emphasized that the VDTB can provide reliable and robust target autoacquisition and robotic autotracking capabilities when operating in the contrasty illumination of the space environment. The VDTB is based on the conventional high-speed image-processing hardware and software and can assist in overcoming the target-recognition and false-target rejection problems. Other applications for the VDTB work, such as AVS real-time simulations, application software development, and evaluation and trade-off studies are also discussed. O.G.

A91-34956#
A CONCEPT FOR A SUPERVISED AUTONOMOUS ROBOT
S. KALAYCIOGLU (Thomson-CSF Systems Canada, Inc., Nepean) IN: CASI Conference on Astronautics, 6th, Ottawa, Canada, Nov. 19-21, 1990, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1990, p. 314-330. Canadian Space Agency-supported research. refs

A Telerobotics System Concept for the Mobile Servicing System (MSS) is introduced. Main functions of the telerobotics system include assembly and maintenance of the Space Station Freedom(SSF); loading/unloading from the Space Shuttle; and retrieval and deployment of the Shuttle. The functional responsibility division between an operator and the system is intended to provide an effective operational solution and to address the problems of time delays and bandwidth restrictions. Attention is also given to the functional and physical architectures of the system, the operational scenario for maintenance of the SSF, and the procedures for changing an Orbital Replacement Unit on the MSS or SSF. O.G.

A91-35232
SPACE MANIPULATOR MOTIONS WITH NO SATELLITE ATTITUDE DISTURBANCES
Z. VAFA (General Electric Co., Schenectady, NY) IN: 1990 IEEE International Conference on Robotics and Automation, Cincinnati, OH, May 13-18, 1990, Proceedings. Vol. 3. Los Alamitos, CA, IEEE Computer Society Press, 1990, p. 1770-1775. refs
Copyright

An algorithm that eliminates the satellite attitude disturbances due to manipulator motions is presented. This algorithm is analyzed for a 9-DOF (degree of freedom) and a 6-DOF manipulator. It is shown that both of the manipulators' motions will not result in satellite attitude disturbances. The 9-DOF redundant manipulator end-effector can go through any path with any desired orientation. The 6-DOF manipulator can only go through a desired path, and its end-effector orientation changes according to the manipulator dynamics. I.E.

A91-38220
A CLOSED-FORM DYNAMICAL ANALYSIS OF AN ORBITING FLEXIBLE MANIPULATOR
J. K. CHAN and V. J. MODI (British Columbia, University, Vancouver, Canada) Acta Astronautica (ISSN 0094-5765), vol. 25, Feb. 1991, p. 67-75. refs
(Contract NSERC-5-80029)
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The governing equations of motion for the in-plane dynamics of a Space Station based manipulator with flexible links and joints are presented. In general, the coupled nonlinear equations are also nonautonomous due to the presence of prescribed maneuvers of the robot. An approximate analytic closed-form solution for the system in the post-maneuver phase is obtained using the variation of parameters method. Accuracy of the solution is verified by comparison with results obtained through numerical integration of the exact equations of motion. The results suggest that the approximate solution predicts the system response with adequate accuracy, even in the presence of relatively large disturbances. The approach can be used to advantage in conducting detailed parametric analysis to identify critical conditions with a considerable saving in computational cost. Author

A91-38743* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DYNAMICS AND CONTROL OF MULTIBODY/ROBOTIC SYSTEMS WITH SPACE APPLICATIONS; PROCEEDINGS OF THE ASME WINTER ANNUAL MEETING, SAN FRANCISCO, CA, DEC. 10-15, 1989
SURESH M. JOSHI, ED. (NASA, Langley Research Center, Hampton, VA), LARRY SILVERBERG, ED. (North Carolina State University, Raleigh), and THOMAS E. ALBERTS, ED. (Old Dominion University, Norfolk, VA) Meeting sponsored by ASME. New York, American Society of Mechanical Engineers, 1989, 69 p. For individual items see A91-38744 to A91-38750.
Copyright

The present conference on the dynamics and control methods of multibody robotic systems applicable to outer space applications first gives attention to such topics in multibody dynamics and control as the substructure synthesis approach to flexible multibody system control, an elastic finite-element kinematic analysis of a multirigid body, computational methods for high speed vehicles on flexible guideways, and multiarm coordination and control. Attention is then given to such issues in space manipulator dynamics and control methods as the global navigation of a free-flying space robot, dynamic singularities in the control of free-floating space manipulators, experimental results for compact space robot actuator control, and a 17-degree-of-freedom dexterous manipulator. O.C.

A91-38745
MULTI-RIGID-BODY KINEMATIC ANALYSIS WITH ELASTIC FINITE ELEMENTS
J. W. EISCHEN and H. K. SUN (North Carolina State University, Raleigh) IN: Dynamics and control of multibody/robotic systems with space applications; Proceedings of the ASME Winter Annual Meeting, San Francisco, CA, Dec. 10-15, 1989. New York, American Society of Mechanical Engineers, 1989, p. 7-17. refs
Copyright

The purpose of this paper is to show how kinematic analysis of certain multi-rigid-body systems may be accomplished by discretization with finite elements having extensional, bending, and shear flexibilities. The novel feature of the method is that kinematic analysis of multi-rigid-body systems is treated in a manner completely consistent with multi-flexible-body systems. Several numerical examples are presented dealing with planar mechanisms composed of slender links connected by revolute and/or prismatic joints. Author

A91-38746
MULTI-ARM COORDINATION AND CONTROL
D. P. GARG (Duke University, Durham, NC) IN: Dynamics and control of multibody/robotic systems with space applications; Proceedings of the ASME Winter Annual Meeting, San Francisco, CA, Dec. 10-15, 1989. New York, American Society of Mechanical Engineers, 1989, p. 27-35. U.S. Army-supported research. refs
Copyright

This paper deals with the adaptive control aspects of multi-arm coordination, and the design, development, and control of a twin-arm manipulator system. The configuration illustrates an example of a research tool designed to develop a better understanding of the inherent kinematic and dynamic characteristics and desirable control strategies for trajectory tracking and arm coordination while grasping and maneuvering a specific payload. Author

A91-38747* Stanford Univ., CA.
EXPERIMENTS IN GLOBAL NAVIGATION AND CONTROL OF A FREE-FLYING SPACE ROBOT
M. ULLMAN and R. H. CANNON, JR. (Stanford University, CA) IN: Dynamics and control of multibody/robotic systems with space applications; Proceedings of the ASME Winter Annual Meeting, San Francisco, CA, Dec. 10-15, 1989. New York, American Society of Mechanical Engineers, 1989, p. 37-43. refs
(Contract NCC2-333)
Copyright

This paper reviews initial work at the Stanford University Aerospace Robotics Laboratory (ARL) in developing and controlling a free-flying space robot. The objective of this project is to develop a laboratory version of a space robot that is capable of performing target tracking, acquisition, and manipulation. In particular, this paper focuses on the problems associated with capturing a free-floating object that is initially out of reach of the robot. A set of rules is presented for generating an appropriate intercept trajectory. A controller architecture suitable for carrying out these motions is also described. Finally the results of computer simulations illustrating the behavior of these algorithms are shown along with a description of the physical hardware on which they will be tested. Author

A91-38748* Massachusetts Inst. of Tech., Cambridge.
ON THE DYNAMIC SINGULARITIES IN THE CONTROL OF FREE-FLOATING SPACE MANIPULATORS
E. PAPADOPOULOS and S. DUBOWSKY (MIT, Cambridge, MA) IN: Dynamics and control of multibody/robotic systems with space applications; Proceedings of the ASME Winter Annual Meeting, San Francisco, CA, Dec. 10-15, 1989. New York, American Society of Mechanical Engineers, 1989, p. 45-52. refs
(Contract NAG1-489)
Copyright

It is shown that free-floating space manipulator systems have configurations which are dynamically singular. At a dynamically singular position, the manipulator is unable to move its end effector in some direction. This problem appears in any free-floating space manipulator system that permits the vehicle to move in response to manipulator motion without correction from the vehicle's attitude control system. Dynamic singularities are functions of the dynamic properties of the system; their existence and locations cannot be predicted solely from the kinematic structure of the manipulator, unlike the singularities for fixed base manipulators. It is also shown that the location of these dynamic singularities in the workplace is dependent upon the path taken by the manipulator in reaching them. Dynamic singularities must be considered in the control, planning and design of free-floating space manipulator systems. A method for calculating these dynamic singularities is presented, and it is shown that the system parameters can be selected to reduce the effect of dynamic singularities on a system's performance. Author

A91-38749
EXPERIMENTAL CONTROL RESULTS IN A COMPACT SPACE ROBOT ACTUATOR
S. W. TILLEY, M. G. HOLLARS, and K. S. EMERICK (Loral Aerospace Corp., Space Systems Div., Palo Alto, CA) IN: Dynamics and control of multibody/robotic systems with space applications; Proceedings of the ASME Winter Annual Meeting, San Francisco, CA, Dec. 10-15, 1989. New York, American Society of Mechanical Engineers, 1989, p. 53-57. refs
Copyright

In the Space Station era, more operations will be performed robotically in space in the areas of servicing, assembly, and experiment tending. These robots may have various sets of requirements for accuracy, speed, and compliance, and force generation. A prototype of a single degree of freedom robot joint utilizing a dc brushless motor and harmonic drive has been built. This experiment addresses some inherent mechanical limitations, namely the joint's backdriveability and low frequency structural resonances. These effects are controlled and diminished by instrumenting the actuator system with a torque transducer on the output shaft. This noncollocated inner loop is closed to ensure that commanded joint torque is accurately delivered to the manipulator link. The added use of torque feedback is demonstrated to yield superior performance in positioning accuracy while allowing for an order of magnitude larger range of programmable joint compliances. Author

A91-38750
A 17 DEGREE OF FREEDOM DEXTEROUS MANIPULATOR
J. P. KARLEN, J. M. THOMPSON, H. I. VOLD, J. D. FARRELL, and P. H. EISMANN (Robotics Research Corp., Technical Center, Milford, OH) IN: Dynamics and control of multibody/robotic systems with space applications; Proceedings of the ASME Winter Annual Meeting, San Francisco, CA, Dec. 10-15, 1989. New York, American Society of Mechanical Engineers, 1989, p. 59-64. refs
Copyright

The paper describes the K/B-2017, a 17-axis manipulator designed for 1-G experiments and demonstrations of space-servicing operations. The device is rather anthropomorphic in appearance and has two relatively short manipulator arms which are mounted on a long torsolike link to increase overall reach while preserving tool-handling dexterity. It provides coordinated control of two 7-DOF arms mounted on a 3-DOF torso waist assembly. The manipulator's desirable capabilities and characteristics include: reflexive collision avoidance, suspension emulation, impedance control, mechanical advantage and positioning resolution management, torque management and redistribution, and pose optimization. It is proposed as an ideal testbed for research in 'man-equivalent' telerobots for space servicing, nuclear servicing, and defense applications. P.D.

A91-39425#
TRAJECTORY DESIGN FOR ROBOTIC MANIPULATORS IN SPACE APPLICATIONS
C. W. DE SILVA (British Columbia, University, Vancouver, Canada) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, May-June 1991, p. 670-674. refs
Copyright

An original trajectory design method for space robots is presented. The design of an end-effector trajectory of a robotic manipulator according to motion specifications (such as acceleration and jerk limits) and the design of joint trajectories to minimize base reactions are developed. Curtate cycloids used to represent the end-effector motion have the benefits of finite acceleration and finite jerk. Kinematic redundancy exploited in designing joint trajectories will minimize a quadratic cost function in base reaction components. The need to study the use of alternative cost functions, the sensitivity of the weighting matrix in emphasizing certain reaction components, and the potential advantages and disadvantages of using other types of shape functions are considered. P.D.

A91-41494* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
HEAD-COUPLED REMOTE STEREOSCOPIC CAMERA SYSTEM FOR TELEPRESENCE APPLICATIONS
M. T. BOLAS (Fake Space Laboratories, Palo Alto, CA) and S. S. FISHER (NASA, Ames Research Center, Moffett Field, CA) IN: Stereoscopic displays and applications; Proceedings of the Meeting, Santa Clara, CA, Feb. 12-14, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 113-123. refs
Copyright

The Virtual Environment Workstation Project (VIEW) at NASA's Ames Research Center has developed a remotely controlled stereoscopic camera system that can be used for telepresence research and as a tool to develop and evaluate configurations for head-coupled visual systems associated with space station telerobots and remore manipulation robotic arms. The prototype camera system consists of two lightweight CCD video cameras mounted on a computer controlled platform that provides real-time pan, tilt, and roll control of the camera system in coordination with head position transmitted from the user. This paper provides an overall system description focused on the design and implementation of the camera and platform hardware configuration and the development of control software. Results of preliminary performance evaluations are reported with emphasis on engineering and mechanical design issues and discussion of related psychophysiological effects and objectives. Author

A91-42069
DYNAMICS OF THE SPACE STATION BASED MOBILE FLEXIBLE MANIPULATOR
V. J. MODI and J. K. CHAN (British Columbia, University, Vancouver, Canada) Acta Astronautica (ISSN 0094-5765), vol. 25, March 1991, p. 149-156. refs
(Contract NSERC-5-80029; NSERC-5-55380)
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The governing equations of motion for the in-plane dynamics of the Space Station based manipulator with flexible links and joints are presented. The hybrid equations, derived using the Lagrangian approach, are highly nonlinear, nonautonomous, and coupled. A linear dynamic model of the system is analyzed for the eigenvalues, corresponding to the natural vibration frequencies for the flexible system, as affected by the system configuration and loading. Results show the system frequencies to change by as much as 80 percent during a typical maneuver. On the other hand, in general, the linear response described the system performance satisfactorily with some disparity at higher frequencies. Author

A91-47836#
INVESTIGATION OF VISUAL INTERFACE ISSUES IN SPACE TELEOPERATION USING A VIRTUAL TELEOPERATOR
M. A. MACHLIS and H. L. ALEXANDER (MIT, Cambridge, MA) IN: AIAA Flight Simulation Technologies Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 330-336. refs
(AIAA PAPER 91-2950) Copyright

A simulator has been developed to examine human factors issues in teleoperation. A graphic workstation simulates the visual feedback which would be provided to an operator by vehicle-mounted video cameras on an actual teleoperator. The software design allows easy modification of vehicle dynamics and content of the simulated environment. Command input is via a combination of hand- and foot-controllers, and visual feedback is provided by a CRT monitor or a VPL Eyephones stereoscopic head-mounted display. A mechanical-linkage head tracker allows transformation of views based on operator head orientation. Using the head-mounted display with head-slaved views was found to provide a strong sense of telepresence. A representation of the body of the teleoperator was added to the visual scenes. It was expected that, when using the head-mounted display with head-slaved views, this would reduce operator disorientation by providing precise visual cues to gaze direction. Preliminary results indicate that including a vehicle body does reduce disorientation and increases performance on some tasks. Author

A91-49765*# Case Western Reserve Univ., Cleveland, OH.
THE USE OF LOCALLY OPTIMAL TRAJECTORY MANAGEMENT FOR BASE REACTION CONTROL OF ROBOTS IN A MICROGRAVITY ENVIRONMENT
N. J. LIN and R. D. QUINN (Case Western Reserve University, Cleveland, OH) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1879-1888. refs
(Contract NAG3-761)
(AIAA PAPER 91-2823) Copyright

A locally-optimal trajectory management (LOTM) approach is analyzed, and it is found that care should be taken in choosing the Ritz expansion and cost function. A modified cost function for the LOTM approach is proposed which includes the kinetic energy along with the base reactions in a weighted and scale sum. The effects of the modified functions are demonstrated with numerical examples for robots operating in two- and three-dimensional space. It is pointed out that this modified LOTM approach shows good performance, the reactions do not fluctuate greatly, joint velocities reach their objectives at the end of the manifestation, and the CPU time is slightly more than twice the manipulation time. V.T.

A91-49766#
DYNAMIC CONTROL OF FREE FLYING ROBOT FOR CAPTURING MANEUVERS
TOSHIAKI IWATA, YOSHITUGU TODA, and KAZUO MACHIDA (Electrotechnical Laboratory, Tsukuba, Japan) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1889-1898. refs
(AIAA PAPER 91-2824) Copyright

This paper deals with control problems of a free flying space robot for capturing a floating object. The dynamic equations of a two dimensional free flying robot with dual manipulator arms are derived and control methods are considered in four phases. The first phase is approaching a moving object. The computed torque method in joint space and resolved motion acceleration control in robot and inertial coordinates for continuous path were used. The second phase is capturing the object. The process is considered as a sort of collision. An active limp control which is a kind of force control in robot coordinates is proposed for it. The third phase is retrieval. Since the properties of the object such as the mass are unknown, to estimate them and control the trajectory, an adaptive control in joint space is employed. The fourth phase is berthing. Adaptive control in inertial space is used in this phase. Author

A91-49767#
AN EXPERIMENTAL SYSTEM FOR FREE-FLYING SPACE ROBOTS AND ITS SYSTEM IDENTIFICATION
YOSHISADA MUROTSU, SHOZO TSUJIO, AKIRA MITSUYA, and KEI SENDA (Osaka Prefecture, University, Sakai, Japan) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1899-1909. Research supported by MOESC. refs
(AIAA PAPER 91-2825) Copyright

An experimental system simulating free-flying space robots is used to verify the feasibility of modeling, identification methods, and control schemes. The system is described, and the scope and goals of an experimental study are presented. Two methods of system identification are discussed: in the first one, the experimental manipulator is identified by using an identification method for conventional manipulators when the satellite is fixed to an inertial foundation, the other estimates the dynamic parameters of free-flying manipulators moving on a two-dimensional plane from the kinematics of the manipulators. The feasibility of the second method is verified on a two-body system on a two-dimensional plane. V.T.

A91-49768*# Illinois Univ., Chicago.
IMPLEMENTATION OF 3-D ISOPARAMETRIC FINITE ELEMENTS ON SUPERCOMPUTER FOR THE FORMULATION OF RECURSIVE DYNAMICAL EQUATIONS OF MULTI-BODY SYSTEMS
N. H. SHAREEF and F. M. L. AMIROUCHE (Illinois, University, Chicago) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1910-1916. Research supported by U.S. Army. refs
(Contract NAG3-1092)
(AIAA PAPER 91-2826) Copyright

A computational algorithmic procedure is developed and implemented for the dynamic analysis of a multibody system with rigid/flexible interconnected bodies. The algorithm takes into consideration the large rotation/translation and small elastic deformations associated with the rigid-body degrees of freedom and the flexibility of the bodies in the system respectively. Versatile three-dimensional isoparametric brick elements are employed for the modeling of the geometric configurations of the bodies. The formulation of the recursive dynamical equations of motion is based on the recursive Kane's equations, strain energy concepts, and the techniques of component mode synthesis. In order to minimize CPU-intensive matrix multiplication operations and speed up the execution process, the concepts of indexed arrays is utilized in the formulation of the equations of motion. A spin-up maneuver of a space robot with three flexible links carrying a solar panel is used as an illustrative example. V.T.

A91-49769#

NONLINEAR CONTROL OF A FREE-FLYING FLEXIBLE ROBOT

A. K. BANERJEE (Lockheed Research Laboratories, Palo Alto, CA) and P. K. A. MENON (Georgia Institute of Technology, Atlanta) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1917-1922. refs

(AIAA PAPER 91-2827) Copyright

The problem of modeling and control of a free-flying flexible robot is considered. The robot is made up of two long, highly flexible beams connected to each other by a revolute joint. Nonlinear equations for large overall motion are obtained using an order-n algorithm to expedite the control law computations. A colocated nonlinear control law based on feedback linearization employing a tip-force generator as the actuator is synthesized. The command following performance of the nonlinear control law is demonstrated in a simulation for a large initial deformation of the beams. Author

A91-50987

ON CONTROL AND PLANNING OF A SPACE STATION ROBOT WALKER

HIROSHI UENO, YANGSHENG XU, H. B. BROWN, JR., MIYUKI UENO, and TAKEO KANADE (Carnegie Mellon University, Pittsburgh, PA) IN: IEEE International Conference on Systems Engineering, 2nd, Pittsburgh, PA, Aug. 9-11, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 220-223. refs

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A walking robot which can step from one node of a space station trusswork to the next is described. The five-degree-of-freedom (DOF) robot consists of two light-weight flexible links, configured like an upside-down V, with a rotary joint at the vertex and a gripper connected by two-DOF joints at each free end. The development of the control software, including the control strategy for the walking motion, low-level control schemes for the robot, and the trajectory planning, is presented. One step of the walking motion is divided into four phases: coarse motion, fine motion, insertion, and extraction. In the coarse motion, the robot moves its gripper from one node to the vicinity of another node. In the fine motion, the robot moves precisely to the top of the hole. Once the gripper is at the top of the hole, it is inserted along the vertical motion to complete one step, and the other gripper is extracted to start the next step. The low-level controllers were designed based on a rigid model, with low-pass filtering used to eliminate the high-mode vibration of the flexible links. Acceleration feedback was introduced in the control to improve the system bandwidth. A trajectory for specific walking motion is presented for generating efficient and stable motion. I.E.

A91-51451

DEVELOPMENT OF EQUIPMENT EXCHANGE UNIT FOR JAPANESE EXPERIMENT MODULE OF SPACE STATION. II - RESULTS OF PRE-BREAD BOARD MODEL TEST

Ishikawajima-Harima Engineering Review (ISSN 0578-7904), vol. 31, May 1991, p. 139-144. In Japanese. Research sponsored by NASDA.

The equipment exchange unit (EEU) is installed in the exposed facility (EF) composing the Japanese Experiment Module (JEM) of the Space Station to be launched in the latter half of the 1990s. This paper describes the status of the EEU development activity. The EEU is capable of attaching and detaching automatically an experimental apparatus transferred by the remote manipulator system aboard the JEM and at the same time connecting utilities such as electric power, coolant, data, and communications. The EEU Pre-Board Model test was conducted to obtain basic performance data in 1990. Author

A91-51799

DESIGN METHODOLOGY FOR SPACE AUTOMATION AND ROBOTICS SYSTEMS

A. ELFVING (ESTEC, Noordwijk, Netherlands) and U. KIRCHHOFF (Isytec, Bremen, Federal Republic of Germany) ESA Journal (ISSN 0379-2285), vol. 15, no. 2, 1991, p. 149-164. refs

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Logical reference models are derived which postulate the essential functions of an automation and robotics (A&R) system and are employed for structuring operator requirements and transforming them into distinct design solutions. These reference models cover mobile vehicles, robots and process control and reflect the manner in which the system is to be operated (automatic or teleoperated). The methodology can be extended to encompass other related A&R subjects, e.g., 'designing for automation' and 'group technology' to ensure efficient development within ESA. R.E.P.

A91-54300* Florida Univ., Gainesville.

A KINEMATIC ANALYSIS OF THE SPACE STATION REMOTE MANIPULATOR SYSTEM (SSRMS)

CARL D. CRANE, III, JOSEPH DUFFY (Florida, University, Gainesville), and TIM CARNAHAN (NASA, Goddard Space Flight Center, Greenbelt, MD) Journal of Robotic Systems (ISSN 0741-2223), vol. 8, Oct. 1991, p. 637-658. refs

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An efficient reverse analysis of three 6-degree-of-freedom (dof) subchains of the 7-dof SSRMS is presented. The first subchain is formed by locking the seventh joint. The second subchain is formed by locking the second joint, while the third subchain is formed by locking the first joint (the grounded joint is counted as the first joint in the chain). There are a maximum of eight different arm configurations in each of the three subchains, and these were determined by employing a computer-efficient algorithm, which required the rooting of only at most quadratic polynomials. The algorithms were implemented, and the SSRMS was employed in an animated environment to perform and practice a number of useful tasks for Space Station servicing. The locking of the second joint has the advantage in that an operator can choose the orientation of the plane that contains the two longest links so as to avoid collisions with obstacles. However, it has the disadvantage that when the second joint angle equals 0 deg or 180 deg, the manipulator is in a singularity configuration. This plane can also be oriented by specifying the first joint angle, so that the plane can be oriented arbitrarily and, in this, the singularity is avoided. Author

A91-55828

EQUIPMENT EXCHANGE UNIT (EEU) FOR JAPANESE EXPERIMENT MODULE OF SPACE STATION

GAKUMEI HATTORI, KAZUHIKO KAMESAKI (NASDA, Tokyo, Japan), FUMIAKI SANO, KATSUMI FUSEGI, SHINICHI MORI, and YOSHITERU YAMAMOTO (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) IN: Space utilization and applications in the Pacific; Proceedings of the 3rd Pacific Basin International Symposium on Advances in Space Science Technology and its Applications, Los Angeles, CA, Nov. 6-8, 1989. San Diego, CA, Univelt, Inc., 1990, p. 333-344.

(AAS PAPER 89-631) Copyright

A baseline configuration of the EEU for the Japanese Experiment Module (JEM) of the Space Station is considered, and the status of the EEU development is described. The EEU is applied to the Exposed Facility (EF) of the JEM. The JEM EF, the facility for international experiment payloads for science observation, earth observation, communication, and material processing, is composed of EF-1 and EF-2 and attached to the aft end of the JEM Pressurized Module. These payloads shall be handled by the JEM Remote Manipulator System and attached to the JEM EF on orbit without the support of crew EVAs. Results of preliminary design studies performed from 1985 to 1989 are presented. O.G.

A91-55839* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

NASA'S TELEROBOTIC TESTBED

J. F. STOCKY (JPL, Pasadena, CA) IN: Space utilization and applications in the Pacific; Proceedings of the 3rd Pacific Basin International Symposium on Advances in Space Science Technology and its Applications, Los Angeles, CA, Nov. 6-8, 1989. San Diego, CA, Univelt, Inc., 1990, p. 487-494. refs

(AAS PAPER 89-649) Copyright

As part of the Advanced Technology Program in Telerobotics Technology conducted by NASA's Office of Aeronautics and Space Technology, a Telerobotics Testbed has been placed into use at the Jet Propulsion Laboratory. The Telerobotics Testbed represents an integration of the discipline technologies represented by its subsystems: (1) Operator Control Station, (2) Planning and Reasoning, (3) Run Time Control, (4) Sensing and Perception, and (5) Manipulation and Control Mechanization. The features provided initially by the Telerobotic Testbed are described both at the subsystem level and at the level of a fully integrated, end-to-end system. The capabilities of the total system as displayed experimentally are discussed, and the capabilities of which the Telerobotic Testbed will be capable are described. The experimental program to define the performance of the Telerobotic Testbed is discussed. Author

A91-56821

MSS COLLISION DETECTION

TERRY NG, R. RAVINDRAN, and H. SAKATA (Spar Aerospace, Ltd., Mississauga, Canada) *Canadian Aeronautics and Space Journal* (ISSN 0008-2821), vol. 37, March 1991, p. 4-8. refs

The Mobile Servicing System (MSS) currently under development in Canada to be capable of avoiding collisions with other objects on the Space Station is presented. The MSS is a robotic system that will perform a variety of functions that include Space Station construction and assembly, payload handling, and EVA support. Attention is given to the collision detection system, its implementation and prototype development, and preliminary test results. R.E.P.

N91-21527*# Stanford Univ., CA. Aerospace Robotics Lab.

CONTROL OF FREE-FLYING SPACE ROBOT MANIPULATOR SYSTEMS Semiannual Technical Report No. 9, Mar. - Aug. 1990

ROBERT H. CANNON, JR. 1990 34 p

(Contract NCC2-333)

(NASA-CR-188026; NAS 1.26:188026) Avail: CASI HC A03/MF A01 CSCL 13I

New control techniques for self contained, autonomous free flying space robots were developed and tested experimentally. Free flying robots are envisioned as a key element of any successful long term presence in space. These robots must be capable of performing the assembly, maintenance, and inspection, and repair tasks that currently require human extravehicular activity (EVA). A set of research projects were developed and carried out using lab models of satellite robots and a flexible manipulator. The second generation space robot models use air cushion vehicle (ACV) technology to simulate in 2-D the drag free, zero g conditions of space. The current work is divided into 5 major projects: Global Navigation and Control of a Free Floating Robot, Cooperative Manipulation from a Free Flying Robot, Multiple Robot Cooperation, Thrusterless Robotic Locomotion, and Dynamic Payload Manipulation. These projects are examined in detail. Author

N91-21528*# Stanford Univ., CA. Dept. of Aeronautics and Astronautics.

EXPERIMENTS IN THRUSTERLESS ROBOT LOCOMOTION CONTROL FOR SPACE APPLICATIONS Ph.D. Thesis

WARREN JOSEPH JASPER Sep. 1990 110 p

(Contract NCC2-333)

(NASA-CR-188027; NAS 1.26:188027; SUDAAR-595) Avail: CASI HC A06/MF A02 CSCL 13I

While performing complex assembly tasks or moving about in space, a space robot should minimize the amount of propellant consumed. A study is presented of space robot locomotion and orientation without the use of thrusters. The goal was to design a robot control paradigm that will perform thrusterless locomotion between two points on a structure, and to implement this paradigm on an experimental robot. A two arm free flying robot was constructed which floats on a cushion of air to simulate in 2-D the drag free, zero-g environment of space. The robot can impart momentum to itself by pushing off from an external structure in a coordinated two arm maneuver, and can then reorient itself by activating a momentum wheel. The controller design consists of two parts: a high level strategic controller and a low level dynamic controller. The control paradigm was verified experimentally by commanding the robot to push off from a structure with both arms, rotate 180 degs while translating freely, and then to catch itself on another structure. This method, based on the computed torque, provides a linear feedback law in momentum and its derivatives for a system of rigid bodies. Author

N91-21529*# Stanford Univ., CA. Aerospace Robotics Lab.

EXPERIMENTS IN COOPERATIVE-ARM OBJECT MANIPULATION WITH A TWO-ARMED FREE-FLYING ROBOT Ph.D. Thesis

ROSS KONINGSTEIN Oct. 1990 217 p

(Contract NCC2-333)

(NASA-CR-188028; NAS 1.26:188028; SUDAAR-597) Avail: CASI HC A10/MF A03 CSCL 13I

Developing computed-torque controllers for complex manipulator systems using current techniques and tools is difficult because they address the issues pertinent to simulation, as opposed to control. A new formulation of computed-torque (CT) control that leads to an automated computer-torque robot controller program is presented. This automated tool is used for simulations and experimental demonstrations of endpoint and object control from a free-flying robot. A new computed-torque formulation states the multibody control problem in an elegant, homogeneous, and practical form. A recursive dynamics algorithm is presented that numerically evaluates kinematics and dynamics terms for multibody systems given a topological description. Manipulators may be free-flying, and may have closed-chain constraints. With the exception of object squeeze-force control, the algorithm does not deal with actuator redundancy. The algorithm is used to implement an automated 2D computed-torque dynamics and control package that allows joint, endpoint, orientation, momentum, and object squeeze-force control. This package obviates the need for hand-derivation of kinematics and dynamics, and is used for both simulation and experimental control. Endpoint control experiments are performed on a laboratory robot that has two arms to manipulate payloads, and uses an air bearing to achieve very-low drag characteristics. Simulations and experimental data for endpoint and object controllers are presented for the experimental robot - a complex dynamic system. There is a certain rather wide set of conditions under which CT endpoint controllers can neglect robot base accelerations (but not motions) and achieve comparable performance including base accelerations in the model. The regime over which this simplification holds is explored by simulation and experiment. Author

N91-22293# VEGA Space Systems Engineering Ltd., Harpenden (England).

TELESCIENCE: A SCIENTIST'S DREAM OR AN OPERATIONAL NIGHTMARE

J. CLEAR and M. CLENDINING (European Space Agency. European Space Operations Center, Darmstadt, Germany, F.R.) *In* ESA, Ground Data Systems for Spacecraft Control p 647-652 Oct. 1990

Copyright Avail: CASI HC A02/MF A06

The results of an ESA study into the applicability and possible usage of telescience are reported. Its purpose is to analyze the impact of telescience on all aspects of spacecraft operations. An analysis of the requirements of both the users and the operators is presented. A classification of previous and planned missions is given, followed by an analysis of the applicability of the telescience operations to each mission class. A number of major problems are identified, including programmatic, operational, and technical difficulties. It is shown that most of these problems can be solved, but with increased costs to the users and potentially to the mission control. Future developments in telescience operations and the necessary activities to be completed before the telescience 'dream' becomes a reality are discussed. ESA

N91-22342*# Carleton Univ., Ottawa (Ontario). Dept. of Mechanical and Aerospace Engineering.
DYNAMICS MODELING AND ADAPTIVE CONTROL OF FLEXIBLE MANIPULATORS
J. Z. SASIADEK *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 2 p 727-741 Mar. 1991
Avail: CASI HC A03/MF A04 CSCL 09B

An application of Model Reference Adaptive Control (MRAC) to the position and force control of flexible manipulators and robots is presented. A single-link flexible manipulator is analyzed. The problem was to develop a mathematical model of a flexible robot that is accurate. The objective is to show that the adaptive control works better than 'conventional' systems and is suitable for flexible structure control. Author

N91-22350*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPATIAL OPERATOR APPROACH TO FLEXIBLE MULTIBODY SYSTEM DYNAMICS AND CONTROL
G. RODRIGUEZ *In* NASA. Langley Research Center, Fourth NASA Workshop on Computational Control of Flexible Aerospace Systems, Part 2 p 907-919 Mar. 1991
Avail: CASI HC A03/MF A04 CSCL 22B

The inverse and forward dynamics problems for flexible multibody systems were solved using the techniques of spatially recursive Kalman filtering and smoothing. These algorithms are easily developed using a set of identities associated with mass matrix factorization and inversion. These identities are easily derived using the spatial operator algebra developed by the author. Current work is aimed at computational experiments with the described algorithms and at modelling for control design of limber manipulator systems. It is also aimed at handling and manipulation of flexible objects. Author

N91-22569*# Maryland Univ., College Park. Dept. of Electrical Engineering.
REAL TIME CONTROL FOR NASA ROBOTIC GRIPPER Final Report
CAROLE A. SALTER and JOHN S. BARAS Mar. 1990 20 p
(Contract NAG5-1047)
(NASA-CR-187957; NAS 1.26:187957) Avail: CASI HC A03/MF A01 CSCL 13I

The ability to easily manipulate objects in a zero gravity environment will pay a key role in future space activities. Emphasis will be placed on robotic manipulation. This will serve to increase astronaut safety and utility in addition to several other benefits. The aim is to develop control laws for the zero gravity robotic end effectors. A hybrid force/position controller will be used. Sensory data available to the controller are obtained from an array of strain gauges and a linear potentiometer. Applying well known optimal control theoretical principles, the control which minimizes the transition time between positions is obtained. A robust force control scheme is developed which allows the desired holding force to be achieved smoothly without oscillation. In addition, an algorithm is found to determine contact force and contact location. Author

N91-23045*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
ROBOTICS IN SPACE-AGE MANUFACTURING
CHIP JONES *In* National Aeronautics and Space Administration, Technology 2000, Volume 1 p 199-207 Mar. 1991
Avail: CASI HC A02/MF A04 CSCL 13I

Robotics technologies are developed to improve manufacturing of space hardware. The following applications of robotics are covered: (1) welding for the space shuttle and space station Freedom programs; (2) manipulation of high-pressure water for shuttle solid rocket booster refurbishment; (3) automating the application of insulation materials; (4) precision application of sealants; and (5) automation of inspection procedures. Commercial robots are used for these development programs, but they are teamed with advanced sensors, process controls, and computer simulation to form highly productive manufacturing systems. Many of the technologies are also being actively pursued in private sector manufacturing operations. Author

N91-23063*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
THE FLIGHT TELEROBOTIC SERVICER AND TECHNOLOGY TRANSFER
JAMES F. ANDARY and KAYLAND Z. BRADFORD (Martin Marietta Corp., Denver, CO.) *In* National Aeronautics and Space Administration, Technology 2000, Volume 1 p 336-343 Mar. 1991
Avail: CASI HC A02/MF A04 CSCL 13I

The Flight Telerobotic Servicer (FTS) project at the Goddard Space Flight Center is developing an advanced telerobotic system to assist in and reduce crew extravehicular activity (EVA) for Space Station Freedom (SSF). The FTS will provide a telerobotic capability in the early phases of the SSF program and will be employed for assembly, maintenance, and inspection applications. The current state of space technology and the general nature of the FTS tasks dictate that the FTS be designed with sophisticated teleoperational capabilities for its internal primary operating mode. However, technologies such as advanced computer vision and autonomous planning techniques would greatly enhance the FTS capabilities to perform autonomously in less structured work environments. Another objective of the FTS program is to accelerate technology transfer from research to U.S. industry. Author

N91-23064*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
FARMS: THE FLEXIBLE AGRICULTURAL ROBOTICS MANIPULATOR
PAUL S. GILL *In* National Aeronautics and Space Administration, Technology 2000, Volume 1 p 344-349 Mar. 1991
Avail: CASI HC A02/MF A04 CSCL 13I

A technology utilization project was established with the Marshall Space Flight Center and the University of Georgia to develop an Earth-based, robotic end effector to process live plant (geranium) material which will improve productivity and efficiency in agricultural systems such as commercial nurseries and greenhouse systems. The aim is to apply this technology to NASA's presence in space, including permanently manned space stations and manned planetary communities requiring large scale food production needs. Author

N91-23580# MATRA Espace, Toulouse (France).
SPACE AND TELESCIENCE ROBOTICS: DEVELOPMENT OF CONCEPTS AND REFERENCE TECHNOLOGIES FOR TELEDETECTION AND ROBOTICS IN EXTREME ENVIRONMENTS [ROBOTIQUE SPATIALE ET TELESCIENCE: ESSOR DE CONCEPTS ET TECHNOLOGIES DE REFERENCE POUR LA TELEDETECTION ET LA ROBOTIQUE EN MILIEUX EXTREMES]
G. ANDRE and J. TAILHADES *In* ESA, Space and Sea p 117-129 Dec. 1990 In FRENCH
Copyright Avail: CASI HC A03/MF A03

Recent progress in the technology of teleoperation and spatial robotics within European projects are presented. The concepts of internal and external service robotics as well as telescience are recalled. The present developments in critical technologies and simulators which support the system studies are described. The common points with regard to the needs and technology transfer potential within the domain of robotic intervention in extreme environments are evoked. ESA

N91-23581# Tecnomare S.p.A. (Italy).
TELEROBOTICS: A KEY AREA FOR POSSIBLE TECHNOLOGY TRANSFER FROM UNDERWATER TO SPACE
WALTER PRENDIN, ANTONIO TERRIBILE, and SIMONETTA DIPIPPO (Italian Space Agency, Rome.) *In* ESA, Space and Sea p 131-137 Dec. 1990
Copyright Avail: CASI HC A02/MF A03

Underwater telerobotics have significantly developed in the last decades due to the increasing interest to substitute divers for inspection maintenance and repair of hydrocarbon production platforms. Technologies being developed by Tecnomare such as: supervisory control, man machine interface, visions systems, manipulation and manipulator vehicle control, which could find direct application to space robotics are discussed. Examples of possible expected applications of said technologies to the development of the Italian Space Agency (ASI) SPIDER program are specifically given with indication of the necessary adaptations. ESA

N91-23582# National Space Development Agency, Ibaraki (Japan).
RESEARCH AND DEVELOPMENT OF FUTURE SPACE ROBOTICS IN NASDA
TSUTOMU IWATA, MITSUSHIGE ODA, and TAICHI NAKAMURA *In* ESA, Space and Sea p 139-143 Dec. 1990
Copyright Avail: CASI HC A01/MF A03

Space robotics is a key technology for future space activities. The space robotics will support and extend manned capability in orbit. NASDA, recognizing that the space automation and robotics are key issues for future space activities, is making every effort of research and development in this technology area. Japanese Experimental Module Remote Manipulator System (JEMRMS) which will be a part of Space Station Freedom is under development. Research on the space robotics is now concentrated on advanced space robotics. In the robotics mission of Engineering Test Satellite 7 (ETS-7) which is to be launched in 1996, fundamental robotics technologies such as dynamic cooperative control, teleoperation and exchange of Orbital Replacement Units (ORUs) will be demonstrated in orbit. ESA

N91-23587# Fokker Space and Systems, Amsterdam (Netherlands).
BUILDING REAL-TIME SIMULATORS FOR SPACE APPLICATIONS
J. A. HOOGSTRATEN *In* ESA, Space and Sea p 179-186 Dec. 1990
Copyright Avail: CASI HC A02/MF A03

Simulation is used in nearly all fields of engineering to study situations that would be too hazardous, time consuming, costly or otherwise unable to be created in real life. Situations involving real world interfaces, such as the control exercised by a human operator, are extra demanding due to the real time behavior they require of the simulator. The role of real time simulation for space applications in the context of the development of a robotic arm, the Hermes Robot Arm (HERA) is described and illustrated. It is shown that the general approach is valid also for other applications in the space environment. Some considerations on commonality in the context of the design and development of a generally applicable simulation facility, the European Real Time Operations Simulator (EUROSIM), are listed. ESA

N91-24605*# Spar Aerospace Ltd., Toronto (Ontario). Advanced Technological Systems Group.
SYSTEM REQUIREMENTS AND DESIGN FEATURES OF SPACE STATION REMOTE MANIPULATOR SYSTEM MECHANISMS
RAJNISH KUMAR and ROBERT HAYES *In* JPL, The 25th Aerospace Mechanisms Symposium p 15-30 May 1991
Avail: CASI HC A03/MF A03 CSCL 13I

The Space Station Remote Manipulator System (SSRMS) is a long robotic arm for handling large objects/payloads on the International Space Station Freedom. The mechanical components of the SSRMS include seven joints, two latching end effectors (LEEs), and two boom assemblies. The joints and LEEs are complex aerospace mechanisms. The system requirements and design features of these mechanisms are presented. All seven joints of the SSRMS have identical functional performance. The two LEES are identical. This feature allows either end of the SSRMS to be used as tip or base. As compared to the end effector of the Shuttle Remote Manipulator System, the LEE has a latch and umbilical mechanism in addition to the snare and rigidize mechanisms. The latches increase the interface preload and allow large payloads (up to 116,000 Kg) to be handled. The umbilical connectors provide power, data, and video signal transfer capability to/from the SSRMS. Author

N91-24898*# Loral Defense Systems, Akron, OH.
THE 3D LASER RADAR VISION PROCESSOR SYSTEM Final Report
T. M. SEBOK Oct. 1990 41 p
(Contract NAS9-18187)
(NASA-CR-185640; NAS 1.26:185640; ER-17453) Avail: CASI HC A03/MF A01 CSCL 20F

Loral Defense Systems (LDS) developed a 3D Laser Radar Vision Processor system capable of detecting, classifying, and identifying small mobile targets as well as larger fixed targets using three dimensional laser radar imagery for use with a robotic type system. This processor system is designed to interface with the NASA Johnson Space Center in-house Extra Vehicular Activity (EVA) Retriever robot program and provide to it needed information so it can fetch and grasp targets in a space-type scenario. Author

N91-25393# National Inst. of Standards and Technology, Gaithersburg, MD. Robot Systems Div.
SHORT-TERM EVOLUTION FOR THE FLIGHT TELEROBOTIC SERVICER
R. LUMIA Dec. 1990 61 p
(PB91-144352; NISTIR-4463) Avail: CASI HC A04/MF A01 CSCL 13I

Near term technology developments which would have significant impact on the evolution of the Flight Telerobotic Servicer (FTS) toward autonomous operation are identified. Analysis of anticipated FTS tasks is used to identify operations that might be performed autonomously, rather than in a purely teleoperated fashion. Alternative techniques for automating these operations are described. A discussion of FTS long-term evolution is included. Author

N91-27556# Carnegie-Mellon Univ., Pittsburgh, PA. Robotics Inst.
TORCS: A TELEOPERATED ROBOT CONTROL SYSTEM FOR THE SELF MOBILE SPACE MANIPULATOR
MIYUKI UENO, WILLIAM ROSS, and MARK FRIEDMAN Apr. 1991 32 p
(AD-A236821; CMU-RI-TR-91-07) Avail: CASI HC A03/MF A01 CSCL 13I

This document describes the Teleoperated Robot Control System (TORCS) developed to control the Self Mobile Space Manipulator (SM) robot which is being developed in the Vision and Autonomous Systems Center. This robot is a semi-autonomous free-walking system being developed for space applications. TORCS provides a remote operator with comprehensive control of the robot on a number of different levels ranging from traditional teleoperation to completely autonomous walking. The heat of the TORCS system is an interactive, real-time X window based display tool which supports the controls for the robot and displays information on robot position and status. TORCS supports several well-integrated devices for teleoperation including a joystick, a six degree of freedom polhemus, and an isomorphic master controller.

The operator can also perform teleoperation by specifying robot joint angles with the workstation mouse. Autonomous features include the ability to take single or multiple steps independently of operator intervention and to plan routes from one location to another. At the highest level, the operator need only specify a destination and TORCS will handle the rest. Provisions are included for the operator to oversee autonomous operations and to interrupt any operation in progress. The TORCS display includes a three-dimensional view of the robot during operations as well as close-up views of the robot gripper and readouts of exact robot status. GRA

N91-27565*# National Inst. of Standards and Technology, Gaithersburg, MD. Robot Systems Div.
RECOMMENDED FINE POSITIONING TEST FOR THE DEVELOPMENT TEST FLIGHT (DTF-1) OF THE NASA FLIGHT TELEROBOTIC SERVICER (FTS)
N. DAGALAKIS, A. J. WAVERING, and P. SPIDALIERE (National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.) Feb. 1991 124 p
(NASA-CR-188683; NAS 1.26:188683; PB91-185090; NISTIR-4478) Avail: CASI HC A06/MF A02 CSCL 13I

Test procedures are proposed for the NASA DTF (Development Test Flight)-1 positioning tests of the FTS (Flight Telerobotic Servicer). The unique problems associated with the DTF-1 mission are discussed, standard robot performance tests and terminology are reviewed and a very detailed description of flight-like testing and analysis is presented. The major technical problem associated with DTF-1 is that only one position sensor can be used, which will be fixed at one location, with a working volume which is probably smaller than some of the robot errors to be measured. Radiation heating of the arm and the sensor could also cause distortions that would interfere with the test. Two robot performance testing committees have established standard testing procedures relevant to the DTF-1. Due to the technical problems associated with DTF-1, these procedures cannot be applied directly. These standard tests call for the use of several test positions at specific locations. Only one position, that of the position sensor, can be used by DTF-1. Off-line programming accuracy might be impossible to measure and in that case it will have to be replaced by forward kinetics accuracy. Author

N91-27773*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ADVANCING AUTOMATION AND ROBOTICS TECHNOLOGY FOR THE SPACE STATION FREEDOM AND FOR THE U.S. ECONOMY. SUBMITTED TO THE CONGRESS OF THE U.S. MAY 1991 Progress Report No. 12, 23 Aug. 1990 - 14 Feb. 1991
HENRY LUM, JR. May 1991 44 p
(Contract RTOP 476-14-01)
(NASA-TM-103851; A-91105; NAS 1.15:103851) Avail: CASI HC A03/MF A01 CSCL 22B

In April 1985, as required by Public Law 98-371, the NASA Advanced Technology Advisory Committee (ATAC) reported to Congress the results of its studies on advanced automation and robotics technology for use on Space Station Freedom. This material was documented in the initial report (NASA Technical Memorandum 87566). A further requirement of the law was that ATAC follow NASA's progress in this area and report to Congress semiannually. The report describes the progress made by Levels 1, 2 and 3 of the Office Space Station in developing and applying advanced automation and robotics technology. Emphasis has been placed upon the Space Station Freedom Program responses to specific recommendations made in ATAC Progress Report 11, the status of the Flight Telerobotic Servicer, and the status of the Advanced Development Program. In addition, an assessment is provided of the automation and robotics status of the Canadian Space Station Program. Author

N91-30518 Stanford Univ., CA.
EXPERIMENTS IN COOPERATIVE-ARM OBJECT MANIPULATION WITH A TWO-ARMED FREE-FLYING ROBOT Ph.D. Thesis
ROSS KONINGSTEIN 1991 217 p
Avail: Univ. Microfilms Order No. DA9115798

Developing computed-torque controllers for complex manipulator systems using current techniques and tools is difficult because they address the issues pertinent to simulation, as opposed to control. A new formulation of computed-torque (CT) control that leads to an automated computed-torque robot controller program is presented. This automated tool is used for simulations and experimental demonstrations of endpoint and object control from a free-flying robot. A new computed-torque formulation states the multibody control problem in an elegant, homogeneous, and practical form. A recursive dynamics algorithm is presented that numerically evaluates kinematics and dynamics terms for multibody systems given a topological description. Manipulators may be free-flying, and may have closed-chain constraints. With the exception of object squeeze-force control, the algorithm does not deal with actuator redundancy. The algorithm is used to implement an automated 2D computed-torque dynamics and control package that allows joint, endpoint, orientation, momentum, and object squeeze-force control. This package obviates the need for hand-derivation of kinematics and dynamics, and is used for both simulation and experimental control. Endpoint control experiments are performed on a laboratory robot that has two arms to manipulate payloads, and uses an air bearing to achieve very-low drag characteristics. The robot's base body mass and inertia are considerably larger than that of the manipulator arm segments, much like NASA's proposed Orbital Maneuvering Vehicle. Simulations and experimental data for endpoint and object controllers are presented for the experimental robot - a complex dynamic system. There is a certain rather wide set of conditions under which CT endpoint controllers can neglect robot base accelerations (but not motions) and achieve comparable performance to including base accelerations in the model. The regime over which this simplification holds is explored by simulation and experiment. These simplifications can result in a savings of an order of magnitude of computation in the controller. Momentum control via external forces and torques (e.g., thrusters) is provided for in the formulations, but is not done in this study. Dissert. Abstr.

N91-30536*# Catholic Univ. of America, Washington, DC. Dept. of Electrical Engineering.
A STUDY OF SPACE-RATED CONNECTORS USING A ROBOTIC END-EFFECTOR Semiannual Progress Report, 1 Apr. - 1 Sep. 1991
CHARLES C. NGUYEN and SAMI S. ANTRAZI Sep. 1991 85 p
(Contract NAG5-1415)
(NASA-CR-188776; NAS 1.26:188776) Avail: CASI HC A05/MF A01 CSCL 13I

The fabrication and testing of a pair of robot fingers designed to grasp two types of Orbital Replacement Unit (ORU) interfaces, the H Handle type and the Micro Square type are discussed. A closed-form solution is given for the force inverse kinematics. A numerical solution using the Newton-Raphson Method for force forward kinematics is given. Mathematical expressions are derived to compute forces/torques applied to the finger. Suggestions are given for improving finger fabrication. The results of numerous experiments conducted to study the characteristics and feasibility of the fingers are given. The first part of the study was devoted to obtaining data on the forces applied by the finger to the interfaces under various translational and rotational misalignments; the second part was devoted to determining the maximum allowed capture angles that would insure successful mating; and the third part was devoted to the processing and interpretation of the forces/torque data. Author

N91-30542# National Aerospace Lab., Amsterdam (Netherlands). Space Div.
EQUIVALENT FLEXIBILITY MODELLING: A NOVEL APPROACH TOWARDS RECURSIVE SIMULATION OF FLEXIBLE SPACECRAFT-MANIPULATOR DYNAMICS
P. T. L. M. VANWOERKOM 22 Aug. 1989 12 p Presented at 2nd European In-Orbit Operations Technology Symposium, Toulouse, France, 12-14 Sep. 1989 Previously announced as N90-24316
(Contract NIVR-02506N)
(NLR-TP-89293-U; ETN-91-99645; AD-B152408L) Avail: CASI HC A03/MF A01

For the simulation of rigid spacecraft manipulator dynamics there exists efficient recursive software. Extension of this software for the simulation of flexible spacecraft-manipulator dynamics would have important advantages. The method of Equivalent Flexibility Modeling (EFM) is outlined. Each flexible body is remodeled as a concatenation of rigid bodies, acted upon by fictitious loads in addition to the real loads. To calculate the fictitious loads, some modifications of the software are required. A number of tests cases are analyzed. The errors detected in these test cases are within the realm of computational inaccuracy. ESA

N91-31647 Rensselaer Polytechnic Inst., Troy, NY.
MODELING AND SIMULATION OF MULTIPLE COOPERATING MANIPULATORS ON A MOBILE PLATFORM Ph.D. Thesis
STEPHEN HENRY MURPHY 1990 190 p
Avail: Univ. Microfilms Order No. DA9120236

The problem is examined of modeling and simulation of multiple cooperating manipulators on a mobile platform. The system of cooperating robot manipulators forms a closed kinematic chain where the forces of interaction must be included in the formulation of robot and platform dynamics. The formulation includes the full dynamic interactions from arms-to-platform and arm-tip to arm-tip and the possible translation and rotation of the platform. The structure of the closed chain dynamics allows the use of any solution for the open topological tree of base and manipulator links. A simulation of two cooperating manipulators on a mobile platform is presented and the motion is graphically displays. Additional dynamic model accuracy is achieved through the development of Newton-Euler modeling techniques for geared manipulators and manipulators with nonnegligible joint flexibility. The resulting Newton-Euler models of flexibly jointed manipulators and geared manipulators have many advantages over the traditional Lagrange-Euler methods; the complete effects of the gear rations and the gyroscopic effects of the spinning motor/gear are included in the recursive formulation. Dissert. Abstr.

10

MECHANICAL SYSTEMS

Design and operation of mechanical equipment, including gyroscopes and pointing mechanisms. Includes lubrication and lubricants.

A91-41529
ULTRALOW FRICTION FILMS OF MOS2 FOR SPACE APPLICATIONS
E. W. ROBERTS (U.K. Atomic Energy Authority, National Centre of Tribology, Risley, England) IN: Metallurgical coatings 1989; Proceedings of the 16th International Conference, San Diego, CA, Apr. 17-21, 1989. Vol. 2. London and New York, Elsevier Applied Science, 1989, p. 461-473. USAF-supported research. refs
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Under vacuum, thin films of molydbenum disulphide can give rise to coefficients of friction in the order of 0.01 and are thus of considerable interest for space applications. Levels of friction of this order are termed ultralow friction (ULF). This paper examines the various means of fabricating such ULF films, with particular emphasis on sputtering. Comparative measurements of friction coefficient and durability of films produced by three different processes, namely RF, dc triode, and magnetron sputtering, are presented. The tribological behavior of such films and the manner in which their properties change with contact stress, sliding speed, environment and the materials to which they are applied, are discussed. The manner in which the tribological behavior of sputtered MoS2 films depends strongly on the bulk and surface (mechanical) properties of the substrate is described. The means by which such effects may be exploited further by surface, interface and bulk modifications is assessed and the implications such advances may have on the performance of tribocomponents are examined. Author

A91-41773#
LONG LIFE AND RELIABILITY - EXPECTATION FOR ADVANCED TURBOMACHINERY IN SPACE
J. P. GIRAULT (SEP, Vernon, France) and K. W. LANG (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p. refs
(AIAA PAPER 91-2416) Copyright

A project undertaken to demonstrate the application of magnetic bearings to an actual liquid hydrogen hydropump is described. Attention is given to the bearing specifications and design, the associated rotordynamics, the modifications and constraints encountered in the turbopump layout, and the test program. The preliminary design phase resulted in a concept that permitted the integration of two radial active magnetic bearing in an existing LH2 turbopump. K.K.

A91-51511
THE DEVELOPMENT OF A RANGE OF SMALL MECHANICAL CRYOCOOLERS FOR SPACE AND AVIONIC APPLICATIONS
BARRY HOCKING (Lucas Aerospace, Ltd., Engine Systems Div., Birmingham, England) IN: Infrared technology and applications; Proceedings of the Meeting, London, England, June 26-28, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 126-138.
Copyright

The design features of a mechanical cryocooler, including a compressor, displacer, connecting pipe, and electronic controller are described. The complete system is filled with helium gas to a pressure of 10 bar. Long life, low exported vibration, and good refrigeration within the defined temperature range are emphasized as the main requirements. A number of improvements with regard to the reliability required for long-life space coolers are outlined, and emphasis is placed on the improved sealing for the helium gas and the outgassing properties of all components. Scaling up of the cryocooler design for increased refrigeration is reviewed as well as a space-system interface. Testing of space-rated cryocooler systems producing nominal 0.5 W and 1 W cooling at 65 K from a single system is discussed. V.T.

N91-21225*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DYNAMIC AND CONTROL ASSESSMENT OF THE SPACE STATION FREEDOM PAYLOAD POINTING SYSTEM
DAVID T. SHANNON, JR. Feb. 1991 35 p
(Contract RTOP 476-14-06-01)
(NASA-TM-101667; NAS 1.15:101667) Avail: CASI HC A03/MF A01 CSCL 22B

An analysis of the proposed Space Station Freedom Payload Pointing System (PPS) was performed to assess its dynamic payload pointing capability in the dynamic environment of the Space Station Freedom (SSF). In addition, the stability and control the the SSF was examined to verify the capability of its control devices to accommodate the impact of PPS operations. An analysis of the PPS ability to provide continuous, accurate pointing was performed and compared to the program requirements specified in the 1988 Program Definition and Requirement Document (PDRD). Results indicated that the PPS was not able to perform within the program requirements during the worst case scenario of a shuttle hard docking maneuver to the port side SSF docking adapter. The PPS maintained marginal pointing accuracy during crew treadmill activity. The Space Station attitude control system easily accommodated all PPS operations simulated. The PPS caused a negligible impact on the SSF's control environment. Author

N91-24603*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

THE 25TH AEROSPACE MECHANISMS SYMPOSIUM

May 1991 346 p Symposium held in Pasadena, CA, 8-10 May 1991; sponsored by NASA, Washington, California Inst. of Tech., and LMSC

(Contract NAS7-918)

(NASA-CP-3113; NAS 1.55:3113) Avail: CASI HC A15/MF A03 CSCL 20K

Twenty-two papers are documented regarding aeronautical and spacecraft hardware. Technological areas include actuators, latches, cryogenic mechanisms, vacuum tribology, bearings, robotics, ground support equipment for aerospace applications, and other mechanisms.

N91-24606*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

DEAD-BLOW HAMMER DESIGN APPLIED TO A CALIBRATION TARGET MECHANISM TO DAMPEN EXCESSIVE REBOUND

BRIAN Y. LIM *In its* The 25th Aerospace Mechanisms Symposium p 31-44 May 1991

Avail: CASI HC A03/MF A03 CSCL 14B

An existing rotary electromagnetic driver was specified to be used to deploy and restow a blackbody calibration target inside of a spacecraft infrared science instrument. However, this target was much more massive than any other previously inherited design applications. The target experienced unacceptable bounce when reaching its stops. Without any design modification, the momentum generated by the driver caused the target to bounce back to its starting position. Initially, elastomeric dampers were used between the driver and the target. However, this design could not prevent the bounce, and it compromised the positional accuracy of the calibration target. A design that successfully met all the requirements incorporated a sealed pocket 85 percent full of 0.75 mm diameter stainless steel balls in the back of the target to provide the effect of a dead-blow hammer. The energy dissipation resulting from the collision of balls in the pocket successfully dampened the excess momentum generated during the target deployment. The disastrous effects of new requirements on a design with a successful flight history, the modifications that were necessary to make the device work, and the tests performed to verify its functionality are described. Author

N91-24609*# Tsukuba Space Center, Ibaragi (Japan).

AN ANTENNA-POINTING MECHANISM FOR THE ETS-6 K-BAND SINGLE ACCESS (KSA) ANTENNA

NOBORU TAKADA, TAKAHIRO AMANO, TOSHIRO OHHASHI, and SHIGEO WACHI (Toshiba Corp., Kanagawa, Japan) *In* JPL, The 25th Aerospace Mechanisms Symposium p 77-92 May 1991

Avail: CASI HC A03/MF A03 CSCL 13I

Both the design philosophy for the Antenna Pointing Mechanism (APM) to be used for the K-band Single Access (KSA) antenna system and experimental results of the APM Engineering Model (EM) tests are described. The KSA antenna system will be flown on the Engineering Test Satellite 6 (ETS-6). Author

N91-24610*# Ball Corp., Boulder, CO. Electro-Optics/Cryogenics Div.

POINTING/ROLL MECHANISM FOR THE ULTRAVIOLET CORONAGRAPH SPECTROMETER

MIROSLAW A. OSTASZEWSKI and LARRY J. GUY *In* JPL, The 25th Aerospace Mechanisms Symposium p 93-105 May 1991

Avail: CASI HC A03/MF A03 CSCL 14B

A pointing/roll mechanism for the Ultraviolet Coronagraph Spectrometer (UVCS) is presented along with a description of the mechanism control algorithm. The mechanism, operating in space, will position the 2.1 meter long, 0.7 meter diameter UVCS instrument in pitch and yaw, within a 54 arc-minute half angle cone, and will also allow it to rotate + or - 179.75 deg. After considerable design effort, an optimum mechanical solution was achieved, which meets all scientific requirements as well as weight, volume, and power budgets. Evolution of the mechanism is presented along with the design status. Author

N91-24613*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.

A SYNCHRONOUS CHOPPER MECHANISM FOR USE AT CRYOGENIC TEMPERATURE

CLAEF HAKUN, ALLEN TYLER, and CORNELIS DEKRAMER *In* JPL, The 25th Aerospace Mechanisms Symposium p 135-150 May 1991

Avail: CASI HC A03/MF A03 CSCL 13I

A mechanically resonant synchronous chopper mechanism is described for use at cryogenic temperatures. The mechanism is a critical optical component of the Diffuse Infrared Background Experiment (DIRBE) and has been operating on orbit without incident since Nov. 1989. The requirements, electromechanical design, and testing of the mechanism are described. A description of the problems encountered and solutions implemented during the development of the mechanism is provided. Finally, a modified chopper design, which incorporated lessons learned and that has several advantages over the flight chopper design, is offered.
Author

N91-24615*# Lockheed Missiles and Space Co., Sunnyvale, CA.

SPIN BEARING RETAINER DESIGN OPTIMIZATION

EDWARD A. BOESIGER and MARK H. WARNER (Honeywell, Inc., Glendale, AZ.) *In* JPL, The 25th Aerospace Mechanisms Symposium p 161-178 May 1991

Avail: CASI HC A03/MF A03 CSCL 13I

The dynamics behavior of spin bearings for momentum wheels (control-moment gyroscope, reaction wheel assembly) is critical to satellite stability and life. Repeated bearing retainer instabilities hasten lubricant deterioration and can lead to premature bearing failure and/or unacceptable vibration. These instabilities are typically distinguished by increases in torque, temperature, audible noise, and vibration induced by increases into the bearing cartridge. Ball retainer design can be optimized to minimize these occurrences. A retainer was designed using a previously successful smaller retainer as an example. Analytical methods were then employed to predict its behavior and optimize its configuration.
Author

N91-24616*# Toshiba Corp., Kawasaki (Japan).

WEAR CHARACTERISTICS OF BONDED SOLID FILM LUBRICANT UNDER HIGH LOAD CONDITION

NAOFUMI HIRAOKA, AKIRA SASAKI, NORITSUGU KAWASHIMA, and TOSHIO HONDA *In* JPL, The 25th Aerospace Mechanisms Symposium p 179-193 May 1991

Avail: CASI HC A03/MF A03 CSCL 13I

Wear properties of phenolic resin bonded molybdenum disulfide film lubricant were studied. In-vacuo journal bearing tests were performed to evaluate the wear-life of this film lubricant. The wear-life depends on substrate materials and on sliding velocity. Pretreated substrate surfaces were examined to reveal the reasons for these results. Additionally, investigations on film wear mechanisms were made. Author

N91-24617*# Nissan Motor Co. Ltd., Tokyo (Japan). Aerospace Div.

DEVELOPMENT OF SOLID-LUBRICATED BALL-SCREWS FOR USE IN SPACE

MASATOSHI CHIBA, TORU GYOUGI, MAKOTO NISHIMURA, and KATSUMI SEKI (National Aerospace Lab., Tokyo, Japan) *In* JPL, The 25th Aerospace Mechanisms Symposium p 195-204 May 1991

Avail: CASI HC A02/MF A03 CSCL 13I

Ball-screws lubricated by solid lubricant films containing molybdenum disulphide are developed. The ball-screws (shaft diameter: phi 25 mm, length: 667 mm) were operated under a load of 40 to 120 N at a speed of 1.5 to 200 rpm at 10(exp -5) Pa. First, ball-screws made of stainless steel SUS 440C were studied using test equipment originally designed for this study. To reduce weight, the next step taken was to develop a ball-screw made of 6Al-4V-titanium. Long wear-life of more than 1 x 10(exp 7) revolutions was achieved with solid lubricated ball-screws made of SUS 440C and 6Al-4V-titanium in a hard vacuum. According to the surface profile of the shaft measured after 1 x 10(exp 7) revolutions, more solid lubricant remained on the surface of 6Al-4V-titanium than that of stainless steel. Auger and EPMA analysis confirmed lubrication was maintained by solid lubricant on nuts and screws after the lubricant films on the balls were worn off. Author

N91-30532*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SPACE MECHANISMS NEEDS FOR FUTURE NASA LONG DURATION SPACE MISSIONS
ROBERT L. FUSARO 1991 12 p Presented at the Conference on Advanced Space Exploration Initiative Technologies, Cleveland, OH, 4-6 Sep. 1991; sponsored by AIAA, NASA, and OAI
(Contract RTOP 505-63-5B)
(NASA-TM-105204; E-6507; NAS 1.15:105204) Avail: CASI HC A03/MF A01 CSCL 13I

Future NASA long duration missions will require high performance, reliable, long lived mechanical moving systems. In order to develop these systems, high technology components, such as bearings, gears, seals, lubricants, etc., will need to be utilized. There has been concern in the NASA community that the current technology level in these mechanical component/tribology areas may not be adequate to meet the goals of long duration NASA mission such as Space Exploration Initiative (SEI). To resolve this concern, NASA-Lewis sent a questionnaire to government and industry workers (who have been involved in space mechanism research, design, and implementation) to ask their opinion if the current space mechanisms technology (mechanical components/tribology) is adequate to meet future NASA Mission needs and goals. In addition, a working group consisting of members from each NASA Center, DoD, and DOE was established to study the technology status. The results of the survey and conclusions of the working group are summarized. Author

11

THERMAL ENVIRONMENTS & CONTROL

Descriptions of analysis for passive or active thermal control techniques. External and internal thermal experiments and analyses. Trade studies of thermal requirements.

A91-34946#
SPACECRAFT THERMAL DESIGN VERIFICATION IN CANADA
E. CHOUEIRY (Canadian Space Agency, Ottawa, Canada) and M. DONATO (Spar Aerospace, Ltd., Sainte-Anne-de-Bellevue, Canada) IN: CASI Conference on Astronautics, 6th, Ottawa, Canada, Nov. 19-21, 1990, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1990, p. 212-220. refs

Solar beam and IR simulation methods can be used to test the integrity of spacecraft thermal design. While solar beam simulation involves xenon lamps and mirrors which produce a collimated, high-intensity light approximating that of the sun, IR sources for solar simulation are as varied as IR lamps, resistance-heating elements, and temperature-controlled walls. Attention is presently given to an IR thermal balance test method which employs specialized radiometers and IR lamps, and furnishes Canadian spacecraft designers with a complete-system thermal integrity verification capability. This capability has been validated in the case of the Olympus spacecraft, and is currently in use for the Radarsat program. O.C.

A91-35118#
THERMAL CONDUCTIVITY ENHANCEMENT OF SOLID-SOLID PHASE-CHANGE MATERIALS FOR THERMAL STORAGE
C. H. SON and J. H. MOREHOUSE (South Carolina, University, Columbia) Journal of Thermophysics and Heat Transfer (ISSN 0887-8722), vol. 5, Jan. 1991, p. 122-124. Previously cited in issue 09, p. 1377, Accession no. A89-25204. refs
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A91-35542
EMPLOYMENT OF COMBINED FINITE DIFFERENCE FINITE ELEMENT METHODS FOR THE ANALYSIS OF THERMAL PROBLEMS IN SPACECRAFT STRUCTURES
E. FISSETTE, M. VIDUSSONI, M. KLEIN, O. BRUNNER, and C. STAVRINIDIS (ESTEC, Noordwijk, Netherlands) IN: International Modal Analysis Conference, 8th, Kissimmee, FL, Jan. 29-Feb. 1, 1990, Proceedings. Vol. 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1990, p. 750-759. refs
Copyright

Thermal analysis of spacecraft systems is generally performed with finite difference programs where thermal properties are represented with lumped parameters. The heat transfer in satellites is mainly dominated by radiation, and the evaluation of radiative exchange is costly. Finite difference formulations are particularly suitable in thermal analysis where radiation effects are dominant. The methodology is presented in a case study for an ERS satellite experiment to demonstrate the effectiveness of the procedure. Author

A91-38019* Sverdrup Technology, Inc., Brook Park, OH.
RAPID THERMAL CYCLING OF NEW TECHNOLOGY SOLAR ARRAY BLANKET COUPONS
DAVID A. SCHEIMAN (Sverdrup Technology, Inc., Brook Park, OH), BRYAN K. SMITH (NASA, Lewis Research Center, Cleveland, OH), RICHARD M. KURLAND, and HANS G. MESCH (TRW Space and Technology Group, Redondo Beach, CA) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 575-580. refs
(Contract NAS3-25226)
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NASA Lewis Research Center is conducting thermal cycle testing of a new solar array blanket technologies. These technologies include test coupons for Space Station Freedom (SSF) and the advanced photovoltaic solar array (APSA). The objective of this testing is to demonstrate the durability or operational lifetime of the solar array interconnect design and blanket technology within a low earth orbit (LEO) or geosynchronous earth orbit (GEO) thermal cycling environment. Both the SSF and the APSA array survived all rapid thermal cycling with little or no degradation in peak performance. This testing includes an equivalent of 15 years in LEO for SSF test coupons and 30 years of GEO plus ten years of LEO for the APSA test coupon. It is concluded that both the parallel gap welding of the SSF interconnects and the soldering of the APSA interconnects are adequately designed to handle the thermal stresses of space environment temperature extremes. I.E.

A91-38045* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
SPACE STATION SOLAR WATER HEATER
D. C. HORAN (MASA, Marshall Space Flight Center, Huntsville, AL), RICHARD E. SOMERS, and R. D. HAYNES (Remtech, Inc., Huntsville, AL) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 2. New York, American Institute of Chemical Engineers, 1990, p. 136-141.
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The feasibility of directly converting solar energy for crew water heating on the Space Station Freedom (SSF) and other human-tended missions such as a geosynchronous space station, lunar base, or Mars spacecraft was investigated. Computer codes were developed to model the systems, and a proof-of-concept thermal vacuum test was conducted to evaluate system performance in an environment simulating the SSF. The results indicate that a solar water heater is feasible. It could provide up to 100 percent of the design heating load without a significant configuration change to the SSF or other missions. The solar heater system requires only 15 percent of the electricity that an all-electric system on the SSF would require. This allows a reduction in the solar array or a surplus of electricity for onboard experiments. I.E.

A91-38780* Wisconsin Univ., Milwaukee.

HEAT TRANSFER IN SPACE SYSTEMS; PROCEEDINGS OF THE SYMPOSIUM, AIAA/ASME THERMOPHYSICS AND HEAT TRANSFER CONFERENCE, SEATTLE, WA, JUNE 18-20, 1990

S. H. CHAN, ED. (Wisconsin, University, Milwaukee), E. E. ANDERSON, ED. (Texas Tech University, Lubbock), R. J. SIMONEAU, ED. (NASA, Lewis Research Center, Cleveland, OH), C. K. CHAN, ED. (TRW, Inc., Cleveland, OH), D. W. PEPPER, ED. (Marquardt Co., Van Nuys, CA) et al. Symposium sponsored by ASME. New York, American Society of Mechanical Engineers, 1990, 154 p. For individual items see A91-38781 to A91-38798.

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Theoretical and experimental studies of heat-tranfer in a space environment are discussed in reviews and reports. Topics addressed include a small-scale two-phase thermosiphon to cool high-power electronics, a low-pressure-drop heat exchanger with integral heat pipe, an analysis of the thermal performance of heat-pipe radiators, measurements of temperature and concentration fields in a rectangular heat pipe, and a simplified aerothermal heating method for axisymmetric blunt bodies. Consideration is given to entropy production in a shock wave, bubble-slug transition in a two-phase liquid-gas flow under microgravity, plasma arc welding under normal and zero gravity, the Microgravity Thaw Experiment, the flow of a thin film on stationary and rotating disks, an advanced ceramic fabric body-mounted radiator for Space Station Freedom phase 0 design, and lunar radiators with specular reflectors. T.K.

A91-38782* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.

MODELING THE USE OF A BINARY MIXTURE AS A CONTROL SCHEME FOR TWO-PHASE THERMAL SYSTEMS

S. M. BENNER (NASA, Goddard Space Flight Center, Greenbelt, MD) and FREDERICK A. COSTELLO (Frederick A. Costello, Inc., Herndon, VA) IN: Heat transfer in space systems; Proceedings of the Symposium, AIAA/ASME Thermophysics and Heat Transfer Conference, Seattle, WA, June 18-20, 1990. New York, American Society of Mechanical Engineers, 1990, p. 11-14.

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Two-phase thermal loops using mechanical pumps, capillary pumps, or a combination of the two have been chosen as the main heat transfer systems for the space station. For these systems to operate optimally, the flow rate in the loop should be controlled in response to the vapor/liquid ratio leaving the evaporator. By substituting a mixture of two non-azeotropic fluids in place of the single fluid normally used in these systems, it may be possible to monitor the temperature of the exiting vapor and determine the vapor/liquid ratio. The flow rate would then be adjusted to maximize the load capability with minimum energy input. A FLUINT model was developed to study the system dynamics of a hybrid capillary pumped loop using this type of control and was found to be stable under all the test conditions. Author

A91-38797

ADVANCED CERAMIC FABRIC BODY MOUNTED RADIATOR FOR SPACE STATION FREEDOM PHASE 0 DESIGN

B. J. WEBB, Z. I. ANTONIAK, and K. A. PAULEY (Battelle Pacific Northwest Laboratory, Richland, WA) IN: Heat transfer in space systems; Proceedings of the Symposium, AIAA/ASME Thermophysics and Heat Transfer Conference, Seattle, WA, June 18-20, 1990. New York, American Society of Mechanical Engineers, 1990, p. 143, 144. Previously announced in STAR as N91-10104.

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A body mounted radiator concept constructed of advanced ceramic fabric materials for use with the Phase 0 design of Space Station Freedom is described. The radiator is expected to weigh between 1.4 and 3.5 kg/sq m of single sided radiating surface, use ammonia working fluid, be highly deployable, and exhibit good reliability characteristics. This compares well with the 11.8 kg/sq m for two sided radiators proposed for the current space station design. Author

A91-42252#

METAL HYDRIDE HEAT PUMPS FOR UPGRADING SPACECRAFT WASTE HEAT

HAE-JIN CHOI and ANTHONY F. MILLS (California, University, Los Angeles) Journal of Thermophysics and Heat Transfer (ISSN 0887-8722), vol. 5, Apr.-June 1991, p. 135-141. Research supported by *San Jose State University Foundation.* refs

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Spacecraft waste heat may be upgraded using a metal hydride heat pump. Thermodynamic analysis is used to choose suitable hydride pairs and to estimate system efficiency; promising reductions in radiator weight are indicated. To investigate whether such reductions can be realized in practice, the dynamic response of two coupled hydride beds is modeled accounting for heat transfer, absorption kinetics, and hydrogen flow. Parametric calculations are reported for the Mg(2.4)Ni/LaNi(4.9)Al(0.1) pair, which show an optimal cycle time of 10 to 12 min. Actual radiator weight savings prove to be substantially less than thermodynamic analysis estimates. Use of hydride heat pumps shows possible merit only in the case of high sink temperatures when using hardened radiators. Author

A91-42267#

THERMAL CONDUCTANCE OF TWO SPACE STATION COLD PLATE ATTACHMENT TECHNIQUES

G. P. PETERSON, G. STARKS, and L. S. FLETCHER (Texas A & M University, College Station) Journal of Thermophysics and Heat Transfer (ISSN 0887-8722), vol. 5, Apr.-June 1991, p. 246-248. Previously cited in issue 18, p. 2777, Accession no. A89-43219. refs

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A91-42626*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

THERMAL REDESIGN OF THE GALILEO SPACECRAFT FOR A VEEGA TRAJECTORY

RONALD T. REEVE (JPL, Pasadena, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Mar.-Apr. 1991, p. 130-138. Previously cited in issue 18, p. 2777, Accession no. A89-43261.

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A91-42627*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

THERMAL DESIGN OF THE GALILEO SPUN AND DESPUN SCIENCE

JAMES W. STULTZ (JPL, Pasadena, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Mar.-Apr. 1991, p. 139-145. Previously cited in issue 18, p. 2777, Accession no. A89-43263. refs

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A91-42628*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

THERMAL DESIGN OF THE GALILEO BUS AND RETROPROPULSION MODULE

JAMES W. STULTZ (JPL, Pasadena, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Mar.-Apr. 1991, p. 146-151. Previously cited in issue 18, p. 2777, Accession no. A89-43262. refs

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A91-43342#
TWO-PHASE HEAT-TRANSPORT SYSTEMS FOR SPACECRAFT
W. SUPPER (ESTEC, Noordwijk, Netherlands) ESA Bulletin (ISSN 0376-4265), no. 66, May 1991, p. 64-70.
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Due to the increased power dissipations aboard many of today's satellites, more and more two-phase heat-transfer devices such as heat pipes are being employed to enhance heat transportation and to increase radiator efficiency. For future large-scale space applications, such as the International Space Station Freedom, and possibly also Europe's Columbus and Polar Platform Projects, thermal-management systems imploying two-phase heat-transfer loops are currently being considered. Compared to today's single-phase loops, they offer several worthwhile advantages, including reduced overall mass, reduced pump-power consumption, nearly isothermal behavior, adjustable working temperature, considerable flexibility in terms of the siting of heat-dissipating components, and high growth potential. Author

A91-43376#
FLTSATCOM THERMAL TEST AND FLIGHT EXPERIENCE
J. A. MOSES (TRW, Inc., Redondo Beach, CA) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 7 p.
(Contract F04701-73-C-0011)
(AIAA PAPER 91-1300) Copyright

FLTSATCOM satellites providing Navy, Air Force, and DOD communications through a constellation of six in geostationary orbits are outlined with emphasis on thermal configurations and mission environments. The thermal design of such a satellite accommodates 12 solid-state UHF transmitters with dissipations ranging from 25 to 77 watts by using such passive techniques as body-mounted second surface mirror radiators and multilayer insulation blankets. Thermal testing including high-fidelity solar simulation, infrared-simulator verification, and infrared thermal balance workmanship verification tests is discussed along with telemetered temperatures from operational satellites providing data on the fabrication repeatability of thermal characteristics, correlation of an analytical model, and mirror solar-absorptance degradation. V.T.

A91-43377#
THERMAL DESIGN VERIFICATION OF LARGE DEPLOYABLE ANTENNA FOR ETS-VI
H. TSUNODA, K. NAKAJIMA, and A. MIYASAKA (NTT, Radio Communication Systems Laboratories, Kanagawa, Japan) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 10 p. refs
(AIAA PAPER 91-1301) Copyright

Thermal balance tests on a large deployable antenna for a communications satellite are limited by the volume of a space simulation chamber used and the deployment mechanisms cannot support the antenna reflectors without suffering damage due to the gravitational conditions on the ground. In order to overcome these problems, a method of two-step thermal design verification, which consists of conducting thermal balance tests on the antenna components and on the whole antenna system, is devised. The antenna system test is performed by using supporting structures which support the hard-points of each main-reflector in order to minimize the effect of gravity on the antenna deployment mechanisms. This paper describes the thermal design of the antenna module, a method of two-step thermal design verification and the results of a thermal design estimation for an antenna in a geostationary orbit. Author

A91-43396#
BIDIRECTIONAL REFLECTANCE AND SURFACE SPECULARITY RESULTS FOR A VARIETY OF SPACECRAFT THERMAL CONTROL MATERIALS
B. L. DROLEN (Hughes Aircraft Co., Space and Communications Group, El Segundo, CA) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 12 p. Research supported by Hughes Aircraft Co. refs
(AIAA PAPER 91-1326) Copyright

Many spacecraft external payloads are sensitive to focused solar heating caused by specular reflections from exterior thermal control surfaces. This paper presents a method of calculating specularity using bidirectional reflectance distribution function (BRDF) input. Definitions are presented for directional and hemispherical specularity as a function of the conical half-angle surrounding the specular ray. Measured BRDF data are presented for twelve commonly used thermal control materials including six plastic films and six paints. Angles of incidence range from 5 deg to 78 deg, and data are taken both in and out of the plane of incidence. Most measurements are made at a wavelength of 0.488 micron, though measurements for two white paints are also made at 1.06, 3.39, and 10.63 microns. The BRDF values are found to increase with both angle of incidence and wavelength. A computer code, SPECULAR, is described that numerically integrates BRDF data to yield both directional and hemispherical specularity as a function of cone half-angle around the specular ray. Specularity results are presented for all twelve materials studied. Author

A91-43397# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EVALUATION OF THERMAL CONTROL COATINGS FOR USE ON SOLAR DYNAMIC RADIATORS IN LOW EARTH ORBIT
JOYCE A. DEVER (NASA, Lewis Research Center, Cleveland, OH), ELVIN RODRIGUEZ (Cleveland State University, OH), WAYNE S. SLEMP (NASA, Langley Research Center, Hampton, VA), and JOSEPH E. STOYACK (LTV Missiles and Electronics Group, Grand Prairie, TX) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 12 p. Previously announced in STAR as N91-22367. refs
(AIAA PAPER 91-1327) Copyright

Thermal control coatings with high thermal emittance and low solar absorptance are needed for Space Station Freedom (SSF) solar dynamic power module radiator (SDR) surfaces for efficient heat rejection. Additionally, these coatings must be durable to low earth orbital (LEO) environmental effects of atomic oxygen, ultraviolet radiation and deep thermal cycles which occur as a result of start-up and shut-down of the solar dynamic power system. Eleven candidate coatings were characterized for their solar absorptance and emittance before and after exposure to ultraviolet (UV) radiation (200 to 400 nm), vacuum UV (VUV) radiation (100 to 200 nm) and atomic oxygen. Results indicated that the most durable and best performing coatings were white paint thermal control coatings Z-93, zinc oxide pigment in potassium silicate binder, and YB-71, zinc orthotitanate pigment in potassium silicate binder. Optical micrographs of these materials exposed to the individual environmental effects of atomic oxygen and vacuum thermal cycling showed that no surface cracking occurred. Author

A91-43422#
RESULTS FROM THE CASCADED VARIABLE CONDUCTANCE HEATPIPE EXPERIMENT ON LDEF
MICHAEL G. GROTE (McDonnell-Douglas Electronics Systems Co., Laser and Electronic Systems Div., Saint Louis, MO) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 9 p. refs
(AIAA PAPER 91-1356) Copyright

A variable conductance heatpipe experiment (CVCHPE) was successfully flown on the Long Duration Exposure Experiment (LDEF) and demonstrated temperature control better than +/- 0.3 C during 50 days of on-orbit data collection in a widely varying external environment. The experiment used two series connected, dry reservoir variable conductance heatpipes which require no electrical power for operation. The heatpipes used a central artery design with ammonia working fluid and nitrogen control gas. The LDEF was in orbit for almost six years, and posttest data indicated that the set point drifted upward less than 1 C per year. There were significant changes to the appearance of all external thermal control surfaces primarily due to atomic oxygen degradation. These changes, though, had little effect on the CVCHPE performance. Author

A91-43423#

DEVELOPMENT OF AN OXYGEN AXIAL GROOVE HEATPIPE FOR A MICROGRAVITY FLIGHT EXPERIMENT

DAVID ANTONIUK and JOHN POHNER (TRW Space and Technology Group, Redondo Beach, CA) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 7 p.

(AIAA PAPER 91-1357) Copyright

An axial groove heatpipe with oxygen as the working fluid was developed for the upcoming cryogenic heatpipe flight experiment intended to verify startup and predicted maximum heat transport capacity. The development program consisted of: (1) design of heatpipe extrusion which meets the experiment-imposed performance requirements; (2) fabrication of a straight heatpipe and measurement of its heat transport capacity; (3) fabrication of flight and qualification heatpipes in an s-shaped configuration; and (4) performance and qualification testing of the flight design. A novel method for leak-checking the fill tube closure was developed. Measured performance of the s-shaped heatpipes during ground testing agreed well with predictions obtained with a computer code. Author

A91-43424#

OXYGEN HEAT PIPE 0-G PERFORMANCE EVALUATION BASED ON 1-G TESTS

G. L. FLEISCHMAN (Hughes Aircraft Co., Torrance, CA), T. C. CHIANG, and R. D. RUFF (Hughes Aircraft Co., El Segundo, CA) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 10 p. refs

(AIAA PAPER 91-1358) Copyright

Two analytical methods were used to gain a better understanding of oxygen heat pipe performance characteristics, and to gain confidence in the use of oxygen as a working fluid for space heat pipe applications. The first method involved simple corrections to the conventional heat pipe model for puddle flow in ground testing. The second method used the NASA Groove Analysis Program (GAP). The correlation between predictions based on these models and actual test data was excellent. GAP results tracked the effects of temperature, underfill, and overfill extremely well. Because the analytical models agree with test performance over a wide range of conditions, it is concluded that they can be used with confidence for 0-g predictions. Testing to determine the relationship of heat pipe performance to end cap design was also conducted. Although the seal ring design did show a reduction in groove draining effects at the higher tilts, it showed no advantage at the lower tilts. Author

A91-43425*# Grumman Aerospace Corp., Bethpage, NY.

DESIGN OF THE SHARE II MONOGROOVE HEAT PIPE

RICHARD BROWN, ROBERT KOSSON (Grumman Aerospace Corp., Space and Electronics Div., Bethpage, NY), and EUGENE UNGAR (NASA, Johnson Space Center, Houston, TX) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 14 p. refs

(AIAA PAPER 91-1359) Copyright

The SHARE II experiment will fly on STS-43, scheduled for mid-1991. The experiment consists of two prototypical heat pipe radiator elements, one of which is supplied by Grumman Aerospace Corp. The heat pipes are designed to overcome the shortcomings of the SHARE experiment, which flew on STS-29 in March 1989 and was only partially successful. This paper reviews the SHARE experiment and the results of its flight test. The design solutions considered for use in the Grumman SHARE II heat pipe are discussed. A description of the reduced gravity testing of the design solutions is provided, as is a discussion of the final SHARE II design. In addition, the 1-g acceptance testing and thermal/vacuum certification testing of the Grumman SHARE II flight article is described. Author

A91-43426#

EXPERIMENTAL INVESTIGATION OF A FLAT PLATE HEAT PIPE AND COLD PLATES IN THERMAL MANAGEMENT SYSTEM UNDER MICRO-GRAVITY ENVIRONMENT

TETSUROU OGUSHI, MASAAKI MURAKAMI (Mitsubishi Electric Corp., Central Research Laboratory, Amagasaki, Japan), TAKASHI TAKADA, AKIRA YAO, YASUSHI SAKURAI (Mitsubishi Electric Corp., Kamakura, Japan) et al. AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 6 p.

(AIAA PAPER 91-1360) Copyright

This paper describes an experimental investigation of heat transfer performance and liquid behavior of a flat plate heat pipe and a cold plate with grooved heat transfer surface in which surface tension of a working fluid is effectively utilized under microgravity environment. From the experiment, flat plate heat pipe with sharp edged corners as liquid distributors was verified to operate normally under microgravity and temperature drop of the heat pipe was five times smaller than that of a solid aluminum plate which weight is equal to the heat pipe. The grooved cold plate showed more uniform temperature profile and much larger evaporative heat transfer performance under microgravity compared with some other types of cold plate such as swirl tubing and U-shaped tubing cold plate. Author

A91-43427#

CHARACTERIZATION OF AGING MECHANISMS IN ALUMINUM/AMMONIA HEATPIPES

R. J. LAPINSKI and DAVID ANTONIUK (TRW Space and Technology Group, Redondo Beach, CA) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 8 p. refs

(AIAA PAPER 91-1361) Copyright

Aging effects are assessed for fixed-conductance aluminum/slab wick/ammonia heatpipes to determine the materials and manufacturing methods which optimize the effective lives of the pipes. Data are presented for five 12-16-year-old pipes, four of which employ 6061 Al shells and 5056 Al wicks, and one with an Al shell and a 304 stainless steel wick. A puncture valve is used to extract fluid for analysis, and NCG gas generation, surface degradation mechanisms, and the potential effects of galvanic coupling are considered. Galvanic coupling results in corrosion at a microscopic level but is not observed between the stainless steel wick and the aluminum shell, and deposits of aluminum and magnesium amorphous oxides of various quantities are noted in all the heatpipes. The reduction of NCG generation is primarily an effect of surface passivation resulting from the introduction of water in the ammonia during reflux. Hydrogen generated by the corrosion reactions is the primary component of NCG gas. C.C.S.

A91-43465*# Lockheed Missiles and Space Co., Sunnyvale, CA.

TRANSIENT RESPONSE OF A HIGH-CAPACITY HEAT PIPE FOR SPACE STATION FREEDOM

J. H. AMBROSE and H. R. HOLMES (Lockheed Missiles and Space Co., Sunnyvale, CA) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 7 p. NASA-supported research. refs

(AIAA PAPER 91-1403) Copyright

High-capacity heat pipe radiator panels have been proposed as the primary means of heat rejection for Space Station Freedom. In this system, the heat pipe would interface with the thermal bus condensers. Changes in system heat load can produce large temperature and heat load variations in individual heat pipes. Heat pipes could be required to start from an initially cold state, with heat loads temporarily exceeding their low-temperature transport capacity. The present research was motivated by the need for accurate prediction of such transient operating conditions. In this work, the cold startup of a 6.7-meter long high-capacity heat pipe is investigated experimentally and analytically. A transient thermohydraulic model of the heat pipe was developed which allows simulation of partially-primed operation. The results of cold startup tests using both constant temperature and constant heat flux evaporator boundary conditions are shown to be in good agreement with predicted transient response. Author

A91-43467#
EXPERIMENTAL VS ANALYTICAL COMPARISON OF A CCHP/VCHP THERMAL CONTROL SYSTEM FOR SPACECRAFT APPLICATIONS
ARISTEO J. PEREZ (Hughes Aircraft Co., Los Angeles, CA) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 8 p.
(AIAA PAPER 91-1405) Copyright
The paper investigates the ability of a constant-conductance heat-pipe/variable-conductance heat-pipe (CCHP/VCHP) thermal control system to meet the thermal control requirements of future spacecraft. An algorithm developed for predicting heat pipe performance is described, and its predictions are verified against test data. Attention is focused on the heat-pipe system design, VCHP evaporator/interface flange configuration, heat-pipe wick design, and radiator heat-pipe layout. Horizontal-shelf CCHP performance, VCHP transport capability, and heat dissipation are analyzed along with vertical-shelf unit dissipation and system transient response with a reflux heater. V.T.

A91-43469*# California Univ., Irvine.
COMPUTATIONAL METHODOLOGY FOR RADIATION HEAT TRANSFER IN THE FLOWFIELD OF AN AOTV
P. L. FUEHRER, D. K. EDWARDS (California, University, Irvine), and D. S. BABIKIAN (Eloret Institute, Palo Alto, CA) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 10 p. University of California-supported research. refs
(Contract NAG2-353)
(AIAA PAPER 91-1407) Copyright
A computational methodology is developed for the calculation of radiation heat transfer in a non-scattering medium where nonequilibrium conditions exist and give rise to complex spectra. The specific problem of radiation in an aeroassisted orbital transfer vehicle (AOTV) flowfield is addressed. Nonequilibrium radiation from the gases around a hypersonic vehicle is evaluated using the NASA-Ames NEQAIR program together with a three-dimensional geometrical flowfield model. Nonequilibrium compositions and temperatures are taken from NASA-Langley 3-D hypersonic flowfield calculations that include real-gas effects and finite-rate chemical kinetics. It is shown that the concept of a transmission path adjustment, together with precomputations of curves of growth based upon local properties at flowfield locations, facilitates radiation calculations. Sample calculations of directional and spectral distributions of gas radiation received upon a hypersonic vehicle are presented. Author

A91-43479#
EXTERNAL HEAT LOADS ON A CRYOGENIC RADIATOR
R. K. WEDEL and T. ZINGALE (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 12 p.
(AIAA PAPER 91-1418) Copyright
Cryogenic radiators are necessary for instruments on earth-orbiting spacecraft for applications in the infrared spectral regions to maintain operating temperatures of 75-100 K. The radiator size can be greatly affected by parasitic heat loads. This paper presents the results of a study which calculated the heat fluxes from solar arrays, masts, and other external appendages to a cryogenic radiator in a synchronous orbit. The analyses showed that care must be taken in the location of spacecraft components that may see a cryogenic radiator. Without proper shielding heat fluxes can easily exceed the radiators cooling capability. Author

A91-43480#
THERMAL DESIGN OF A COMMON PRESSURE VESSEL NICKEL-HYDROGEN BATTERY
W. H. KELLY, M. W. EARL, and W.-S. JIANG (COMSAT Laboratories, Clarksburg, MD) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 8 p. COMSAT Corp.-sponsored research. refs
(AIAA PAPER 91-1421) Copyright
The thermal design of a common pressure vessel (CPV) nickel-hydrogen battery under development for use in both low earth orbit (LEO) and geosynchronous orbit (GEO) is presented. Innovative thermal control design concepts are applied to the critical heat transfer path between the cell stack interior and the pressure vessel wall. Results of parametric analyses optimizing both cell internal temperature and thermal control weight are given. Internal cell temperatures during discharge/charge cycling are predicted for both LEO and GEO satellites. Test data and assembly photographs from the first engineering model CPV battery are presented. Representative spacecraft battery mounting configurations are analyzed thermally and mechanically to provide a realistic estimate of achievable specific energy vs capacity. Author

A91-43551#
THREE-DIMENSIONAL THERMAL ANALYSIS FOR LASER-STRUCTURAL INTERACTIONS
HARTMUT H. LEGNER, ALBERT W. BAILEY, and MICHAEL F. HINDS (Physical Sciences, Inc., Andover, MA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 14 p. Northrop Corp.-sponsored research. refs
(AIAA PAPER 91-1508) Copyright
A three-dimensional thermal analysis code with direct application to laser-structural interactions has been developed. This robust, implicit finite-volume technique solves the enthalpic form of the heat conduction equation for laser radiation interacting with three-dimensional aerospace structures. It utilizes finite elements derived from the structural analysis and accomodates arbitrary beam profiles to compute the ablative material response. Several examples illustrate the broad features of the code including oblique interactions, complex structures, multiple materials, and beam slewing. Author

A91-45197#
HEAT TRANSFER ENHANCEMENT TECHNIQUES FOR SPACE STATION COLD PLATES
G. P. PETERSON and L. S. FLETCHER (Texas A & M University, College Station) Journal of Thermophysics and Heat Transfer (ISSN 0887-8722), vol. 5, July-Sept. 1991, p. 423-428. Previously cited in issue 06, p. 815, Accession no. A90-19901. refs
Copyright

A91-45550*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PRELIMINARY THERMAL DESIGN OF THE COLD-SAT SPACECRAFT
HUGH ARIF (NASA, Lewis Research Center, Cleveland, OH) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 38 p. Previously announced in STAR as N91-25161.
(AIAA PAPER 91-1305) Copyright
The COLD-SAT free-flying spacecraft was to perform experiments with LH2 in the cryogenic fluid management technologies of storage, supply and transfer in reduced gravity. The Phase A preliminary design of the Thermal Control Subsystem (TCS) for the spacecraft exterior and interior surfaces and components of the bus subsystems is described. The TCS was composed of passive elements which were augmented with heaters. Trade studies to minimize the parasitic heat leakage into the cryogen storage tanks are described. Selection procedure for the thermally optimum on-orbit spacecraft attitude was defined. TRASYS-2 and SINDA'85 verification analysis was performed on the design and the results are presented. Author

A91-46767* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TEXSYS - A LARGE SCALE DEMONSTRATION OF MODEL-BASED REAL-TIME CONTROL OF A SPACE STATION SUBSYSTEM
B. J. GLASS, W. K. ERICKSON, and K. J. SWANSON (NASA, Ames Research Center, Moffett Field, CA) IN: IEEE Conference on Artificial Intelligence Applications, 7th, Miami Beach, FL, Feb. 24-28, 1991, Proceedings. Los Alamitos, CA, IEEE Computer

Society Press, 1991, p. 378-384. refs
Copyright

A hybrid approach to qualitative and temporal reasoning, using a device-oriented model-based representation in conjunction with both consistency-based and classification diagnosis methods, can be effectively used to monitor and control a complex electromechanical system. An example of this approach is given in some recent tests of the Thermal Expert System (TEXSYS) in control of the Boeing Aerospace Thermal Bus System (BATBS), a prototype two-phase Space Station Freedom thermal bus. The constraints of realtime performance and changing target hardware led to significant changes in the initial approach, including a reduction in the use of deep structural reasoning and the addition of temporal reasoning capabilities. TEXSYS test results show the successful completion of both nominal control and fault recovery actions with the BATBS. Author

A91-48845

OPTIMAL TEMPERATURE ESTIMATION FOR MODELING THE THERMAL ELASTIC SHOCK DISTURBANCE TORQUE

DARRELL F. ZIMBELMAN, RAYMOND V. WELCH (Fairchild Space and Defense Corp., Germantown, MD), and GEORGE H. BORN (Colorado, University, Boulder) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, July-Aug. 1991, p. 448-456. refs
Copyright

This paper describes a predictive temperature estimation technique that can be used to drive a model of the thermal elastic shock disturbance torque experienced by low-earth-orbiting spacecraft. The twice per orbit impulsive disturbance torque is attributed to vehicle passage in and out of the earth's umbra, during which large flexible appendages undergo rapidly changing thermal conditions. Flexible members, in particular, solar arrays, experience rapid cooling during umbra entrance and rapid heating during exit. The fundamental equations used to model the thermal elastic shock disturbance torque for a typical solar array will be described. For this derivation, the array is assumed to be a thin cantilevered beam. The time-varying thermal gradient is shown to be the driving force behind predicting the thermal elastic shock disturbance torque and, therefore, motivates the need for accurate estimates of temperature. Thus, the development of a technique to optimally estimate appendage surface temperatures is highlighted. The objective analysis method used is structured on the Gauss-Markov theorem and provides an optimal temperature estimate at a prescribed location given data from a distributed thermal sensor network. The optimally estimated surface temperatures are then used to compute the thermal gradient across the array. Author

A91-48846

THERMOELASTIC ANALYSIS OF SPACE STRUCTURES IN PERIODIC MOTION

DAN GIVOLI and OMRI RAND (Technion - Israel Institute of Technology, Haifa) (ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2, p. 1529-1533) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, July-Aug. 1991, p. 457-464. Research supported by L. Kraus Research Fund. Previously cited in issue 09, p. 1338, Accession no. A91-24458. refs
Copyright

A91-49820*# Boeing Co., Huntsville, AL.

AEROTHERMODYNAMIC ENVIRONMENTS OF AEROBRAKING VEHICLES FOR MANNED MARS MISSIONS

STEPHEN T. LEDOUX and IRWIN E. VAS (Boeing Defense and Space Group, Huntsville, AL) AIAA, Atmospheric Flight Mechanics Conference, New Orleans, LA, Aug. 12-14, 1991. 12 p. Research supported by Boeing Defense and Space Group. refs
(Contract NAS8-37857)
(AIAA PAPER 91-2872) Copyright

The aerothermodynamic environments of manned spacraft aerobraking in the Martian and earth atmospheres are evaluated. Thermal performance of aerobrake concepts are examined for current cryogenic-aerobrake and advanced propulsion missions entailing three different modes of aerobraking: (1) aerocapture into an orbit about Mars, (2) descent and landing at Mars, and (3) Mars return direct entry at earth. Analyses for these vehicles and modes included both radiative and convective heating, where radiative heating is shown to be a significant portion of the total stagnation point heating induced on the vehicle. A comprehensive parametric study of the effects of ballistic coefficient, nose radius, entry velocity, and L/D on stagnation point heating is described. Optimal nose radii for ranges of ballistic coefficient and entry velocity are determined. The peak heating rates are shown to be 83 W/sq cm and 90 W/sq cm for a low and high L/D Mars transfer vehicle configuration, respectively. Heating profiles for these vehicles using boundary layer techniques show that a high L/D shape will result in a smaller high-temperature region provided the flow is laminar. An examination of a crew return vehicle for a Mars return direct entry trajectory shows that the thermal protection for this aerobrake will require an ablative material for heat rejection due to the large heating rates (about 1 kW/sq cm). Author

A91-51361

A PRELIMINARY ANALYSIS OF THE PASSIVE THERMAL CONTROL SYSTEM FOR SPACE STATION FREEDOM

M. E. SCHLAPBACH, J. B. SHARP, and M. D. SZETO (Boeing Aerospace and Electronics, Huntsville, AL) IN: Space Station environmental/thermal control and life support systems; Proceedings of the 20th Intersociety Conference on Environmental Systems, Williamsburg, VA, July 9-12, 1990. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 77-92.
(SAE PAPER 901403) Copyright

A passive thermal control system (PTCS) and concepts related to PTCS operation are described in relation to the requirements of the Space Station Freedom. The PTCS combines multilayer insulation (MLI), thermal control coatings, electric heaters, thermal isolators, and plumbing insulation to keep the temperature below 113 F to protect the crew and above 62 F to prevent condensation. Design considerations for MLI materials are set forth, and issues such as emissivity, meteoroid damage, and cost-effectiveness are addressed individually. Extensive graphic descriptions are given of MLI treatment, types of thermal control coatings, and thermal performance data. Potential tests are outlined for the MLI, meteoroid protection, the performance of the thermal vacuum, the use of an IR camera, and the applications of heaters. A general outline is given of the basic requirements for an effective PTCS as required by a mission such as that of the Space Station Freedom. C.C.S.

A91-51367* Lockheed Engineering and Sciences Co., Houston, TX.

MODULAR, THERMAL BUS-TO-RADIATOR INTEGRAL HEAT EXCHANGER DESIGN FOR SPACE STATION FREEDOM

JOE CHAMBLISS (Lockheed Engineering and Sciences Co., Houston, TX) and MICHAEL EWERT (NASA, Johnson Space Center, Houston, TX) IN: Space Station environmental/thermal control and life support systems; Proceedings of the 20th Intersociety Conference on Environmental Systems, Williamsburg, VA, July 9-12, 1990. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 137-148. refs
(Contract NAS9-17900)
(SAE PAPER 901435) Copyright

The baseline concept is introduced for the 'integral heat exchanger' (IHX) which is the interface of the two-phase thermal bus with the heat-rejecting radiator panels. A direct bus-to-radiator heat-pipe integral connection replaces the present interface hardware to reduce the weight and complexity of the heat-exchange mechanism. The IHX is presented in detail and compared to the baseline system assuming certain values for heat rejection, mass per unit width, condenser capacity, contact conductance, and assembly mass. The spreadsheet comparison can be used to examine a variety of parameters such as radiator length and configuration. The IHX is shown to permit the reduction of panel size and system mass in response to better conductance and packaging efficiency. The IHX is found to be a suitable heat-rejection system for the Space Station Freedom because it uses present technology and eliminates the interface mechanisms. C.C.S.

A91-51368* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
FATIGUE TESTING OF CORRUGATED AND TEFLON HOSES
STEVE M. BENNER, THEODORE D. SWANSON (NASA, Goddard Space Flight Center, Greenbelt, MD), and FREDERICK A. COSTELLO (Frederick A. Costello, Inc., Herndon, VA) IN: Space Station environmental/thermal control and life support systems; Proceedings of the 20th Intersociety Conference on Environmental Systems, Williamsburg, VA, July 9-12, 1990. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 149-160.
(SAE PAPER 901436) Copyright

Single and two-phase heat transport systems for the thermal control of large space facilities require fluid lines that traverse joints and either rotate or move in some other manner. Flexible hoses are being considered as one means of traversing these joints. To test the resilience of flexible hoses to bending stress, a test assembly was constructed to determine the number of flexing cycles the hoses could withstand before losing their ability to maintain a constant pressure. Corrugated metal hoses and Teflon hoses were tested at different pressures with nitrogen gas. The metal hoses had lives ranging from 30,000 to 100,000 flexing cycles. But, even after 400,000 cycles, the Teflon hoses remained essentially intact, though some leakage in the convoluted Teflon is noted. Author

A91-51369
SPACE STATION FREEDOM THERMAL MODELING USING THE IDEAS2 TRASYS INTERFACE
SUSAN L. ROUKIS, DAVID F. MAIDT (Grumman Corp., Grumman Space Station Program Support Div., Reston, VA), and JOHN A. HABERMEYER (SDRC, Inc., San Diego, CA) IN: Space Station environmental/thermal control and life support systems; Proceedings of the 20th Intersociety Conference on Environmental Systems, Williamsburg, VA, July 9-12, 1990. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 161-171.
(SAE PAPER 901438) Copyright

The use of the IDEAS2 TRASYS (IT) interface to analyze thermal control issues for the Space Station Freedom is described, and two sample applications are given. The IDEAS2 system is outlined with a functional flowchart, and the IT interface data flow is described. The IT interface is designed to permit thermal, structural, and flight mechanics models to be based on a geometric configuration defined in IDEAS2; TRASYS models are then used with interactive graphics to construct the model geometry. The two applications presented involve a battery temperature study and a module cluster study. The IT interface is found to be suitable for generating many thermal-radiation-path models to assess alternative spacecraft configurations and the multiple stages of the assembly sequence. The thermal geometric data can also be used as the geometry for structural analysis and flight-mechanics analysis, thereby facilitating the overall design modeling process. C.C.S.

A91-52395*# Space Power, Inc., San Jose, CA.
THE TELESCOPING BOOM RADIATOR CONCEPT FOR MULTIMEGAWATT SPACE POWER SYSTEMS
J. K. KOESTER (Space Power, Inc., San Jose, CA) and A. J. JUHASZ (NASA, Lewis Research Center, Cleveland, OH) AIAA, NASA, and OAI, Conference on Advanced SEI Technologies, Cleveland, OH, Sept. 4-6, 1991. 7 p. refs
(Contract NAS3-25208)
(AIAA PAPER 91-3497) Copyright

Development of the telescoping boom radiator from concept studies through a detailed design is reviewed. Particular attention is given to the scaling law for specific mass of cylindrical radiator geometries and radiator mass projections for large scale heat rejection systems. The concept of the telescoping, cylindrical radiator is identified as a leading candidate for rejecting tens of megawatts of thermal energy while maintaining a reasonable launch. O.G.

A91-52598
EXTERNAL THERMAL LOADS FOR EQUIPMENT MOUNTED ON A SPACECRAFT [VNESHNIE TEPLOVYE NAGRUZKI DLIA APPARATURY, USTANAVLIVAEMOI NA KOSMICHESKOM APPARATE]
G. A. BRIL' Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, July-Aug. 1991, p. 647-650. In Russian. refs
Copyright

The external thermal load (whose primary component in the solar system is the thermal effect of direct solar radiation) has a substantial and sometimes a dominant effect on the temperature regime of a spacecraft, its external scientific instrumentation, and its external structural elements. The errors of estimated values of thermal loads for external spacecraft equipment and external structural elements are calculated, and their significance for thermal control evaluations is discussed. L.M.

A91-55836
STUDY ON THE DYNAMICS AND THE CONTROLLABILITY OF A MECHANICALLY PUMPED TWO-PHASE THERMAL CONTROL SYSTEM
K. OHTOMI, T. SHIOYAMA, K. FURUHAMA, K. MIMURA, S. OSHIMA, M. KOMORI, M. SHIGEHARA (Toshiba Corp., Tokyo, Japan), M. FURUKAWA, Y. ISHII, and Y. MIYAZAKI (NASDA, Tsukuba Space Center, Japan) IN: Space utilization and applications in the Pacific; Proceedings of the 3rd Pacific Basin International Symposium on Advances in Space Science Technology and its Applications, Los Angeles, CA, Nov. 6-8, 1989. San Diego, CA, Univelt, Inc., 1990, p. 425-440. refs
(AAS PAPER 89-645) Copyright

A feasibility study on the dynamic problems and on the controllability of a mechanically pumped two-phase thermal control system designed for microgravity environments is presented. For this study, a prototype system having a 0.5 kW class thermal control system was designed to perform the experiment. Attention is given to an analytical study of the dynamical problems for transient flows in the liquid line, vapor line and evaporators, and for the fluid motion inside the accumulator. R.E.P.

A91-56415* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HIGH EMITTANCE SURFACES FOR HIGH TEMPERATURE SPACE RADIATOR APPLICATIONS
BRUCE A. BANKS, SHARON K. RUTLEDGE (NASA, Lewis Research Center, Cleveland, OH), and DEBORAH HOTES (Cleveland State University, OH) IN: Optical surfaces resistant to severe environments; Proceedings of the Meeting, San Diego, CA, July 11, 12, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 66-77. refs
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Surface modification techniques are evaluated for emittance enhancement of radiator surfaces. These techniques include acid etching, heat treating, abrasion, sputter texturing, electrochemical texturing, arc texturing, and atomic oxygen beam texturing. Candidate radiator surface materials under consideration include Nb-1 pct Zr, Cu, Ti, Ti-6 pct Al-4 pct V, 304 stainless steel, Al6061-T6, Mo, W, and Ta. O.G.

A91-56417
THE EFFECT OF THE SPACE ENVIRONMENT ON THERMAL CONTROL COATINGS
YOSHIRO HARADA, RICHARD J. MELL (IIT Research Institute, Chicago, IL), and DONALD R. WILKES (AZ Technology, Huntsville, AL) IN: Optical surfaces resistant to severe environments; Proceedings of the Meeting, San Diego, CA, July 11, 12, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 90-101. refs
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Stable polymeric and inorganic materials developed for both near-earth and geosynchronous orbital missions are reviewed. It is concluded that both the polymeric (S13G/LO-1) and inorganic (93 and YB-71) coatings show good resistance to the UV and charged particle radiation, atomic oxygen, and vacuum-induced behavior to be encountered in space. It is suggested that other hostile threats including micrometeoroid hits, plasmas, electrical discharge, and laser and nuclear effects can all seriously compromise the survivability of these spacecraft materials. O.G.

A91-56418
NEXT GENERATION THERMAL CONTROL COATINGS
JAMES GRIESER, RICHARD SWISHER, JAMES PHIPPS, DOUGLAS PELLEYMOUNTER, and EUGENE HILDRETH (Sheldahl, Inc., Northfield, MN) IN: Optical surfaces resistant to severe environments; Proceedings of the Meeting, San Diego, CA, July 11, 12, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 111-118. Research supported by Martin Marietta Corp.
Copyright

Spacecraft and space structures have an obvious need for thermal control coatings to minimize temperature excursions due to sun/shade cycles and to dissipate internally developed heat. Sheldahl, Inc. has produced a new thermal control coating utilizing Teflon A.F. 2400 (amorphous fluoropolymer), a product recently developed by the Dupont Co.. With this new Teflon coating, alpha/epsilon ratios of 0.14 on aluminum are easily obtainable. Sheldahl's coatings have been prepared on a range of substrates and tested for space compatibility. Testing done to date includes temperature cycling, salt fog exposure, vacuum bakes, vacuum outgassing, abrasion testing, and some synergistic effects. Author

N91-22367*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EVALUATION OF THERMAL CONTROL COATINGS FOR USE ON SOLAR DYNAMIC RADIATORS IN LOW EARTH ORBIT
JOYCE A. DEVER, ELVIN RODRIGUEZ, WAYNE S. SLEMP, and JOSEPH E. STOYACK (LTV Missiles and Electronics Group, Grand Prairie, TX.) 1991 13 p Proposed for presentation at the 26th Thermophysics Conference, Honolulu, HI, 24-26 Jun. 1991; sponsored by AIAA
(Contract RTOP 474-52-10)
(NASA-TM-104335; E-6103; NAS 1.15:104335; AIAA PAPER 91-1327) Avail: CASI HC A03/MF A01 CSCL 10B

Thermal control coatings with high thermal emittance and low solar absorptance are needed for Space Station Freedom (SSF) solar dynamic power module radiator (SDR) surfaces for efficient heat rejection. Additionally, these coatings must be durable to low earth orbital (LEO) environmental effects of atomic oxygen, ultraviolet radiation and deep thermal cycles which occur as a result of start-up and shut-down of the solar dynamic power system. Eleven candidate coatings were characterized for their solar absorptance and emittance before and after exposure to ultraviolet (UV) radiation (200 to 400 nm), vacuum UV (VUV) radiation (100 to 200 nm) and atomic oxygen. Results indicated that the most durable and best performing coatings were white paint thermal control coatings Z-93, zinc oxide pigment in potassium silicate binder, and YB-71, zinc orthotitanate pigment in potassium silicate binder. Optical micrographs of these materials exposed to the individual environmental effects of atomic oxygen and vacuum thermal cycling showed that no surface cracking occurred. Author

N91-23058*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
ADVANCED THERMAL CONTROL TECHNOLOGY FOR COMMERCIAL APPLICATIONS
THEODORE D. SWANSON *In* National Aeronautics and Space Administration, Technology 2000, Volume 1 p 301-306 Mar. 1991
Avail: CASI HC A02/MF A04 CSCL 20D

A number of the technologies previously developed for the thermal control of spacecraft have found their way into commercial application. Specialized coatings and heat pipes are but two examples. The thermal control of current and future spacecraft is becoming increasingly more demanding, and a variety of new technologies are being developed to meet these needs. Closed two-phase loops are perceived to be the answer to many of the new requirements. All of these technologies are discussed, and their spacecraft and current terrestrial applications are summarized. Author

N91-23408*# TRW Space Technology Labs., Redondo Beach, CA.
IN-SPACE TECHNOLOGY EXPERIMENTS PROGRAM. A HIGH EFFICIENCY THERMAL INTERFACE (USING CONDENSATION HEAT TRANSFER) BETWEEN A 2-PHASE FLUID LOOP AND HEATPIPE RADIATOR: EXPERIMENT DEFINITION PHASE Final Report
JOHN A. POHNER, BRIAN P. DEMPSEY, and LEROY M. HEROLD Jul. 1990 52 p
(Contract NAS5-30357)
(NASA-CR-186869; NAS 1.26:186869; TRW-P331.LM1.90.185)
Avail: CASI HC A04/MF A01 CSCL 20D

Space Station elements and advanced military spacecraft will require rejection of tens of kilowatts of waste heat. Large space radiators and two-phase heat transport loops will be required. To minimize radiator size and weight, it is critical to minimize the temperature drop between the heat source and sink. Under an Air Force contract, a unique, high-performance heat exchanger is developed for coupling the radiator to the transport loop. Since fluid flow through the heat exchanger is driven by capillary forces which are easily dominated by gravity forces in ground testing, it is necessary to perform microgravity thermal testing to verify the design. This contract consists of an experiment definition phase leading to a preliminary design and cost estimate for a shuttle-based flight experiment of this heat exchanger design. This program will utilize modified hardware from a ground test program for the heat exchanger. Author

N91-25156*# Cockerham (John M.) and Associates, Inc., Huntsville, AL.
THERMAL CONTROL SURFACES EXPERIMENT: INITIAL FLIGHT DATA ANALYSIS Final Report
DONALD R. WILKES and LEIGH L. HUMMER Jun. 1991 123 p Prepared in cooperation with AZ Technology, Huntsville, AL
(Contract NAS8-36289)
(NASA-CR-188600; NAS 1.26:188600) Avail: CASI HC A06/MF A02 CSCL 22A

The behavior of materials in the space environment continues to be a limiting technology for spacecraft and experiments. The thermal control surfaces experiment (TCSE) aboard the Long Duration Exposure Facility (LDEF) is the most comprehensive experiment flown to study the effects of the space environment on thermal control surfaces. Selected thermal control surfaces were exposed to the LDEF orbital environment and the effects of this exposure were measured. The TCSE combined in-space orbital measurements with pre and post-flight analyses of flight materials to determine the effects of long term space exposure. The TCSE experiment objective, method, and measurements are described along with the results of the initial materials analysis. The TCSE flight system and its excellent performance on the LDEF mission is described. A few operational anomalies were encountered and are discussed. Author

N91-25161*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PRELIMINARY THERMAL DESIGN OF THE COLD-SAT SPACECRAFT
HUGH ARIF 1991 39 p Presented at the 26th Thermophysics Conference, Honolulu, HI, 24-26 Jun. 1991; sponsored by AIAA
(Contract RTOP 506-48-00)
(NASA-TM-104440; E-6247; NAS 1.15:104440; AIAA PAPER 91-1305) Copyright Avail: CASI HC A03/MF A01 CSCL 22B

The COLD-SAT free-flying spacecraft was to perform experiments with LH2 in the cryogenic fluid management technologies of storage, supply and transfer in reduced gravity. The Phase A preliminary design of the Thermal Control Subsystem (TCS) for the spacecraft exterior and interior surfaces and components of the bus subsystems is described. The TCS was composed of passive elements which were augmented with heaters. Trade studies to minimize the parasitic heat leakage into the cryogen storage tanks are described. Selection procedure for the thermally optimum on-orbit spacecraft attitude was defined. TRASYS-2 and SINDA'85 verification analysis was performed on the design and the results are presented. Author

N91-27213*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DESIGN CONSIDERATIONS FOR SPACE RADIATORS BASED ON THE LIQUID SHEET (LSR) CONCEPT
ALBERT J. JUHASZ and DONALD L. CHUBB 1991 8 p
Presented at the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, 4-9 Aug. 1991; sponsored by ANS, SAE, ACS, AIAA, ASME, IEEE, and AIChE
(Contract RTOP 506-41-51)
(NASA-TM-105158; E-6446; NAS 1.15:105158) Avail: CASI HC A02/MF A01 CSCL 10B

Concept development work on space heat rejection subsystems tailored to the requirements of various space power conversion systems is proceeding over a broad front of technologies at NASA LeRC. Included are orbital and planetary surface based radiator concepts utilizing pumped loops, a variety of heat pipe radiator concepts, and the innovative liquid sheet radiator (LSR). The basic feasibility of the LSR concept was investigated in prior work which generated preliminary information indicating the suitability of the LSR concept for space power systems requiring cycle reject heat to be radiated to the space sink at low-to-mid temperatures (300 to 400 K), with silicon oils used for the radiator working fluid. This study is directed at performing a comparative examination of LSR characteristics as they affect the basic design of low earth orbit solar dynamic power conversion systems. The power systems considered were based on the closed Brayton (CBC) and the Free Piston Stirling (FPS) cycles, each with a power output of 2 kWe and using previously tested silicone oil (Dow-Corning Me2) as the radiator working fluid. Conclusions indicate that, due to its ability for direct cold end cooling, an LSR based heat rejection subsystem is far more compatible with a Stirling space power system than with a CBC, which requires LSR coupling by means of an intermediate gas/liquid heat exchanger and adjustment of cycle operating conditions. Author

N91-29377# Pacific Northwest Lab., Richland, WA.
THE 0-G EXPERIMENTS WITH ADVANCED CERAMIC FABRIC WICK STRUCTURES
Z. I. ANTONIAK, B. J. WEBB, J. M. BATES, M. F. COOPER, and K. A. PAULEY Jul. 1991 17 p Presented at the ASME/AIChE/ANS National Heat Transfer Conference, Minneapolis, MN, 26-31 Jul. 1991
(Contract DE-AC06-76RL-01830)
(DE91-015531; PNL-SA-18880; CONF-910739-26) Avail: CASI HC A03/MF A01

Both Air Force and NASA future spacecraft thermal management needs span the temperature range from cryogenic to liquid metals. Many of these needs are changing and not well defined and will remain so until goals, technology, and missions converge. Nevertheless, it is certain that high-temperature (less than 800 K) and medium-temperature (about 450 K) radiator systems will have to be developed that offer significant improvements over current designs. This paper discusses experiments performed in the lower temperature regime as part of a comprehensive advanced ceramic fabric (ACF) heat pipe development program. These experiments encompassed wicking tests with various ceramic fabric samples, and heat transfer tests with a 1-m long prototype ACF water heat pipe. A prototype ceramic fabric/titanium water heat pipe has been constructed and tested; it transported up to 60 W of power at about 390 K. Startup and operation both with and against gravity examined. Wick testing was begun to aid in the design and construction of an improved prototype heat pipe, with a 38 micron stainless steel linear covered by a biaxially-braided Nextel (trademark of the 3M Co., St. Paul, Minnesota) sleeve that is approximately 300 microns thick. Wick testing took place in 1-g; limited testing in 0-g was initiated, and results to date suggest that in 0-g, wick performance improves over that in 1-g. DOE

N91-30194*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
THERMAL CONTROL SURFACES EXPERIMENT FLIGHT SYSTEM PERFORMANCE
DONALD R. WILKES, LEIGH L. HUMMER (AZ Technology, Huntsville, AL.), and JAMES M. ZWIENER 1991 45 p
(NASA-TM-105036; NAS 1.15:105036) Avail: CASI HC A03/MF A01 CSCL 22B

The Thermal Control Surfaces Experiment (TCSE) is the most complex system, other than the LDEF, retrieved after long term space exposure. The TCSE is a microcosm of complex electro-optical payloads being developed and flow by NASA and the DoD including SDI. The objective of TCSE was to determine the effects of the near-Earth orbital environment and the LDEF induced environment on spacecraft thermal control surfaces. The TCSE was a comprehensive experiment that combined in-space measurements with extensive post flight analyses of thermal control surfaces to determine the effects of exposure to the low earth orbit space environment. The TCSE was the first space experiment to measure the optical properties of thermal control surfaces the way they are routinely measured in a lab. The performance of the TCSE confirms that low cost, complex experiment packages can be developed that perform well in space. Author

N91-30486# National Aerospace Lab., Amsterdam (Netherlands). Space Div.
TEST LOOPS FOR TWO-PHASE THERMAL MANAGEMENT SYSTEM COMPONENTS
A. A. M. DELIL and J. F. HEEMSKERK 4 May 1990 13 p
Presented at 20th Intersociety Conference on Environmental Systems International Thermal Control Technology Session, Williamsburg, VA, 9-12 Jul. 1990 Previously announced in IAA as A90-49339
(Contract NIVR-2404N)
(NLR-TP-90155-U; ETN-91-99648; AD-B154276L) Avail: CASI HC A03/MF A01

Two mechanically pumped two phase test rigs were built, in order to experimentally study critical issues of spacecraft two phase thermal management systems: a 5 kW, 31 mm ID, freon loop, focusing in the critical components of the ESA two phase heat transport system; a 30,000 W, 4.93 mm ID, ammonia loop, to support the development of the ESA capillary pumped loop experiment (for the in orbit demonstration of two phase heat transport system technology) and to experimentally support two phase thermal modeling and scaling activities. The rigs are described in detail. Typical test results are presented. ESA

N91-32186# Oregon State Univ., Newport. Dept. of Nuclear Engineering.
MATERIALS COMPATIBILITY ISSUES FOR FABRIC COMPOSITE RADIATORS
T. S. MARKS and A. C. KLEIN 1991 6 p Presented at the 8th Symposium on Space Nuclear Power Systems, Albuquerque, NM, 6-10 Jan. 1991
(Contract DE-FG07-89ER-12901)
(DE91-017556; CONF-910116-22) Avail: CASI HC A02/MF A01

Short term materials compatibility tests have been completed on potential materials to be used in fabric composite radiators for space applications. Specific materials tested include copper, aluminum, titanium, FEP Teflon tubing, and three high strength fabric fibers: alumina-boria-silica, silicon carbide, and silicon dioxide. These materials have been exposed to pure water, methanol, and acetone for periods of time up to 5000 hours at variety of appropriate temperatures. DOE

N91-32330# Centre de Recherches en Physique de l'Environnement, Issy-les-Moulineaux (France).

NEW TECHNOLOGIES FOR INTEGRATING THERMAL CONTROL, AND RADIATION PROTECTION IN HYBRID TECHNOLOGY

A. YOUSSEF, A. MEYER, J. B. DUCROCQ (Alcatel Espace, Toulouse, France), and A. ROUX *In* ESA, ESA Electronic Components Conference p 243-245 Mar. 1991

Copyright Avail: CASI HC A01/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

Techniques of integrating thermal control and radiation protection in hybrid technology are outlined. Hybridation allows for significant reduction in weight and volume of subsystems. There are however, some specific constraints associated with spaceborne instrumentation, namely the temperatures met during eclipses or during missions in deep space cannot be withstood by the components, especially when they are located outside the body of the spacecraft. Very efficient thermal control is required. Radiation doses can also be a very serious constraint requiring efficient protection. The number of models is small; hence the design has to be compatible with several missions in order to decrease the cost. ESA

12

POWER SYSTEMS

Analyses, systems and trade studies of electric power generation, storage, conditioning and distribution.

A91-32388

A THREE-DIMENSIONAL INVERSE THERMOELASTICITY PROBLEM FOR A MEDIUM WITH AN ELASTIC INHOMOGENEITY [ODNA TREKHMERNAIA OBRATNAIA ZADACHA TERMOUPRUGOSTI DLIA SREDY S UPRUGOI NEODNORODNOST'IU]

V. S. KIRILIUK (AN USSR, Institut Mekhaniki, Kiev, Ukrainian SSR) Prikladnaia Mekhanika (ISSN 0032-8243), vol. 27, Jan. 1991, p. 40-44. In Russian. refs

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The paper is concerned with an inverse static thermoelasticity problem whereby the specified mechanical and thermophysical properties of the medium and the inclusion and loading conditions are used to determine the geometrical shape of the inhomogeneity corresponding to the equal-strength (based on the von Mises criterion) stressed state along the interface both in the matrix and the inclusion. It is shown that the equal-strength state is achieved for an ellipsoidal inhomogeneity. Equations for the half-axis ratio of the inhomogeneity are presented. V.L.

A91-34933#

MULTIPLE FAULT DIAGNOSIS OF SPACECRAFT ELECTRICAL POWER SYSTEMS

PETER ADAMOVITS (Canadian Space Agency, Shirley Bay, Canada) IN: CASI Conference on Astronautics, 6th, Ottawa, Canada, Nov. 19-21, 1990, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1990, p. 68-76. refs

The system described in this paper addresses the fault detection/diagnosis aspects of spacecraft electrical power system (EPS) management. The Multiple Fault Diagnostic System (MFDS) project is a software implementation of actions performed at a typical ground segment operations center used to control and manage spacecraft subsystem operations. The MFDS software includes many concepts from the Artificial Intelligence (AI) research community, including model-based reasoning (Adams, 1986; deKleer, 1987), distributed knowledge bases, qualitative reasoning (Forbus, 1984; Kuipers, 1986), and an assumption-based truth maintenance system (deKleer, 1986). It is projected that software systems using techniques similar to those described herein will play an increasing role in spacecraft operations on future missions. It is expected that designs such as these will greatly enhance the reliability of ground operations decisions and operational availability of the controlled subsystems. Author

A91-36832* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

POWER ELECTRONIC APPLICATIONS FOR SPACE STATION FREEDOM

ROY L. PICKRELL (NASA, Lewis Research Center, Cleveland, OH) and IGOR LAZBIN (Analex Corp., Fairview Park, OH) IN: PESC '90 - Annual IEEE Power Electronics Specialists Conference, 21st, San Antonio, TX, June 11-14, 1990, Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 628-635.

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NASA plans to orbit a permanently manned space station in the late 1990s, which requires development and assembly of a photovoltaic (PV) power source system to supply up to 75 kW of electrical power average during the orbital period. The electrical power requirements are to be met by a combination of PV source, storage, and control elements for the sun and eclipse periods. The authors discuss the application of power electronics and controls to manage the generation, storage, and distribution of power to meet the station loads, as well as the computer models used for analysis and simulation of the PV power system. The requirements for power source integrated controls to adjust storage charge power during the insolation period current limiting, breaker interrupt current values, and the electrical fault protection approach are defined. Based on these requirements, operating concepts have been defined which then become drivers for specific system and element design. I.E.

A91-37926

IECEC-90; PROCEEDINGS OF THE 25TH INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, RENO, NV, AUG. 12-17, 1990. VOLS. 1-6

PAUL A. NELSON, ED., WILLIAM W. SCHERTZ, ED. (Argonne National Laboratory, IL), and RUSSELL H. TILL, ED. Conference sponsored by AIChE, IEEE, AIAA, et al. New York, American Institute of Chemical Engineers, 1990, p. Vol. 1, 620 p.; vol. 2, 509 p.; vol. 3, 531 p.; vol. 4, 480 p.; vol. 5, 599 p.; vol. 6, 483 p. For individual items see A91-37927 to A91-38185.

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Topics discussed include aerospace power systems, conversion technologies, electrochemical conversion, and new technologies for energy utilization. Consideration is also given to policy impact on energy, renewable resource systems, Stirling engines, and systems ansd cycles. B.J.

A91-37927

SPACE SYSTEMS REQUIREMENTS AND ISSUES - THE NEXT DECADE

WILLIAM U. BORGER and LOWELL D. MASSIE (USAF, Aero Propulsion and Power Laboratory, Wright-Patterson AFB, OH) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 1-5. refs

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Some of the more important space power technology issues, requirements, and challenges are described, and the impact of new component technology on the overall performance of space power systems is assessed. Advanced component, subsystem, and system technologies which will make a difference in the future in terms of the performance, reliability, and survivability of next-generation baseload and burst-mode space power systems are emphasized. Technology disciplines related to power sources (solar, nuclear, and chemical), power conversion, energy storage, power conditioning, distribution, and control, and waste heat acquisition, transport, and rejection are addressed. For some of these technology disciplines, performance trends are developed which can be used on the basis for projecting future advanced power system performance. Performance capabilities for several different types of space power systems for both baseload and burst-mode applications are postulated based on evolving technology and point designs which incorporate projections of advanced component capabilities. The technology options for meeting higher power baseload (5-100 kW steady state) and burst mode power requirements (tens to hundreds of Megawatts/hundreds to thousands of seconds) are summarized. I.E.

A91-37929 National Aeronautics and Space Administration, Washington, DC.

NASA'S FUTURE SPACE POWER NEEDS AND REQUIREMENTS

A. D. SCHNYER (NASA, Washington, DC) and RONALD J. SOVIE (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 13-17.

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The National Space Policy of 1988 established the U.S.'s long-range civil space goals, and has served to guide NASA's recent planning for future space mission operations. One of the major goals was to extend the human presence beyond earth's boundaries and to advance the scientific knowledge of the solar system. A broad spectrum of potential civil space mission opportunities and interests are currently being investigated by NASA to meet the espoused goals. Participation in many of these missions requires power systems with capabilities far beyond what exists today. In other mission examples, advanced power systems technology could enhance mission performance significantly. Power system requirements and issues that need resolution to ensure eventual mission accomplishment are addressed, in conjunction with the ongoing NASA technology development efforts and the need for even greater innovative efforts to match the ambitious solar exploration mission goals. Particular attention is given to potential lunar surface operations and technology goals, based on investigations to date. It is suggested that the nuclear reactor power systems can best meet long-life requirements as well as dramatically reduce the earth-surface-to-lunar-surface transportation costs due to the lunar day/night cycle impact on the solar system's energy storage mass requirements. The state of the art of candidate power systems and elements for the lunar application and the respective exploration technology goals for mission life requirements from 10 to 25 years are examined. I.E.

A91-37941

SPACE NUCLEAR REACTOR INTEGRATION STUDY

D. F. NICHOLS (USAF, Weapons Laboratory, Kirtland AFB, NM) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 94-99.

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A feasibility study pertaining to the integration of space nuclear reactor power sources (SNRPSs) with an electrooptical surveillance system (EOSS) spacecraft has been performed. Phase one of the study indicated that a 10-kWe SNRPS could begin to show significant mass savings for the EOSS satellite when compared to an equivalent solar power source. In addition, the SNRPS offered significantly reduced visibility, freedom from solar orientation, and compact packaging for launch. Phase two of the study examined the impact of utilizing additional power from a SNRPS on the EOSS spacecraft and mission. Four main areas were addressed: electric propulsion (EP), survivability enhancements, spacecraft enhancements, and spacecraft design impacts. The study also outlined the requirements a SNRPS would have to meet to be considered as the power source of choice for a spacecraft designer. It is shown that the mass and volume of nuclear power systems do not increase as quickly with power level as do the mass and volume of solar power systems. At power levels of 10 kWe, SNRPSs have an advantage over equivalent solar power sources with respect to mass and size; this advantage increases with increasing power levels. At power levels of about 25 kWe, a nuclear power system enables increased operational altitude, increased operational capabilities, and enhanced survivability. I.E.

A91-37942

A SUMMARY OVERVIEW OF RECENT ADVANCES IN SPACE NUCLEAR POWER SYSTEMS TECHNOLOGY

MOHAMED S. EL-GENK (New Mexico, University, Albuquerque) and MARK D. HOOVER (Lovelace Biomedical and Environmental Research Institute, Albuquerque, NM) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 100-108. refs

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Recent achievements and developments of the technology of space-based nuclear power and propulsion systems are summarized. Topics covered include direct thermal and electric propulsion, static energy conversion, high-temperature materials, reliability and life, power system concepts, dynamic energy conversion, energy storage, microgravity two-phase flow, radioisotope power systems, and space nuclear safety. I.E.

A91-37943

DESIGN AND PERFORMANCE CHARACTERISTICS FOR LOW POWER SPACE REACTOR SYSTEMS

N. F. SHEPARD, R. E. BIDDISCOMBE, H. CHOE, F. C. GREENWOOD, A. S. KIRPICH (General Electric Co., Astro-Space Div., Philadelphia, PA) et al. IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 109-114.

(Contract DE-AC03-86SF-16006)

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Several missions requiring electrical power in the 10-to-40-kW range have been identified as potential applications for a space reactor power system which uses the technology currently being developed under the SP-100 ground engineering system (GES) program. The conceptual designs proposed for these low-power applications build on these key GES technologies, thereby maximizing the potential applicability of this development effort by fully utilizing the inherent scalability of the design implementations defined as elements of the 100-kWe generic flight system. Design and performance characteristics are provided for a specific point design with a 10-kW rated electrical output. While retaining the major attributes of this design, the system power rating is scaled over the power range from 10 to 40 kWe and important spacecraft integration parameters (such as total mass and radiator area) are presented as a function of allowable self-generated radiation dose at the payload interface plane and separation distance between this plane and the reactor core. A 10-kWe point design was defined to meet military mission objectives which include high power-to-mass ratio, immunity to the effects of single-point failures, survivability when exposed to the specified threat environments, and ground testability to verify system output capability. I.E.

A91-37944

SMALL SPACE NUCLEAR REACTORS, CLOSED BRAYTON CYCLE AND EFFECTIVE MODERATORS

Z. P. TILLIETTE (CEA, Centre d'Etudes Nucleaires de Saclay, Gif-sur-Yvette, France) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 115-120. Research sponsored by CNES and CEA. refs

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Space nuclear power systems in the range of 10-30 kWe are considered. In addition to a reference Brayton cycle, NaK-cooled, fast spectrum, 930-K reactor system, a 1130-K, direct cycle, gas-cooled, ZrH-moderated reactor concept has been investigated. Gas cycle adaptions for core temperature conditioning have been studied and have already enhanced the Brayton converter utilization. Following a recent US proposal of high-power-level, light-water-moderated reactor space power system, research work on applying this technique to small reactors is being performed. It is shown that the Brayton cycle can offer adequate temperature conditions for this. Relevant conversion data are presented. Because of the use of a main low-temperature, pumped-loop radiator, a multiple-tube support structure could be advantageously used for the heat rejection. Comparative results are given. I.E.

A91-37947
STAR-C SPACE NUCLEAR POWER APPLICATION STUDIES
H. J. SNYDER (Energy Systems International, Rancho Santa Fe, CA) and T. A. SGAMMATO (General Atomics, San Diego, CA) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 135-140. refs
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The space thermionic advanced reactor compact, STAR-C, is a space nuclear power system that can be configured to operate over a power range from a few to 50 kWe. This can be accomplished because of the modular nature of the nuclear fuel compacts, the power conversion modules, and the heat rejection components. Spacecraft integration studies have been performed that include power systems level tradeoffs over a range of 5 to 40 kWe, resulting in detailed dimensional and mass parameters at 5 kWe increments over this power range. A 25-kWe STAR-C design and a power subsystem configuration with detailed dimension, mass, and operating parameters was developed for a candidate application. A STAR-C flight qualification assessment has been completed. This includes a more detailed description of the power system and its components, including isometric drawings of each of the components and subassemblies, to illustrate the assembly sequence of the system. Launch, deployment, and operational scenarios are described. A system development and qualification plan has been prepared and costs have been considered. I.E.

A91-37948
AN ASSESSMENT OF THERMOELECTRIC CONVERSION FOR THE ERATO-20 KWE SPACE POWER SYSTEM
JEAN-MICHEL TOURNIER, MOHAMED S. EL-GENK (New Mexico, University, Albuquerque), and FRANK O. CARRE (CEA, Centre d'Etudes Nucleaires de Saclay, Gif-sur-Yvette, France) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 141-146. refs
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Mass optimization studies were performed within the framework of the French ERATO space nuclear power program to investigate the suitability of thermoelectric (TE) converters for an liquid-metal fast breeder reactor (LMFBR)-derivative system. Results indicate that a PbTe converter in conjunction with conventional LMFBR, with a core exit temperature of not greater than about 907 K and cooled by NaK (78 percent), offers a competitive option. The total mass of the ERATO-TE system for a beginning-of-life nominal power of 25 kWe is 2600 kg. This mass is comparable to that of the reference system with a closed Brayton converter. In addition to the inherent reliability of TE converters, the radiator area (110 sq m) and total mass of the ERATO-TE system represents 73 percent of the maximum radiator area compatible with the ARIANE-V launcher and about 50 percent of the launch capacity to high earth orbit, respectively. I.E.

A91-37954
SP-100 GENERIC FLIGHT SYSTEM DESIGN AND DEVELOPMENT PROGRESS
ALLAN T. JOSLOFF, DONALD N. MATTEO, and H. STERLING BAILEY (General Electric Co., Astro-Space Div., Philadelphia, PA) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 173-180. refs
(Contract DE-AC03-86SF-16006)
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The SP-100 space reactor power system (SRPS) is being developed to meet the nation's future space power needs in the ten to hundreds of kWe power range. A 100-kWe generic flight system (GFS) design was established in response to comprehensive specifications which provided bounding requirements that envelope a range of missions from earth-orbiting satellites to planetary probes. The resulting GFS design established the reference for the technology/design validation now being demonstrated as part of the ground engineering system (GES) program. The system design review was completed in May 1988, and major progress has been made since then to demonstrate the flexibility of the GFS design in meeting the special needs of emerging applications from Air Force missions in the 10 to 40 kWe power range to the missions being considered for the Space Exploration Initiative in the multi-hundred kWe power range. Significant accomplishments have been in the areas of hardware demonstration of the key technologies, establishment of the fabrication processes and facilities, and design of the full-scale reactor ground test article and test facility. The status of the GFS design is reviewed and the significant hardware accomplishments during 1989 are discussed. I.E.

A91-37955
SP-100 REACTOR/TURBINE ENERGY CONVERSION SYSTEMS (TECS)
W. D. OTTING, M. MARKO, and R. B. HARTY (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 181-185.
(Contract DE-AC03-88NE-32129)
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System design goals for space nuclear power systems are being developed by the Air Force Weapons Laboratory. The design characteristics for a nuclear power system meeting the military goals using SP-100 reactor and DIPS (dynamics isotope power system)/TECS dynamic power conversion technologies have been investigated. The high-temperature SP-100 reactor heat source coupled to a Brayton dynamic power conversion system with its high conversion efficiency characteristics provide a system with excellent design flexibility and scalability. The high-efficiency design enables the use of a single reactor design and loop arrangement for powers greater than 50 kWe. A simple double-contained primary loop allows for easy lithium thaw. System characteristics, such as power cycle statepoints, radiator area, and reactor thermal power, are provided for system power levels of 10, 20, and 40 kWe. Conceptual configuration and spacecraft arrangement drawings are given for a 10-kWe system. I.E.

A91-37966* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
FAULT ANALYSIS OF MULTICHANNEL SPACECRAFT POWER SYSTEMS
NORMA R. DUGAL-WHITEHEAD and LOUIS F. LOLLAR (NASA, Marshall Space Flight Center, Huntsville, AL) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 243-248. refs
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The NASA Marshall Space Flight Center proposes to implement computer-controlled fault injection into an electrical power system breadboard to study the reactions of the various control elements of this breadboard. Elements under study include the remote power controllers, the algorithms in the control computers, and the artificially intelligent control programs resident in this breadboard. To this end, a study of electrical power system faults is being performed to yield a list of the most common power system faults. The results of this study will be applied to a multichannel high-voltage DC spacecraft power system called the large autonomous spacecraft electrical power system (LASEPS) breadboard. The results of the power system fault study and the planned implementation of these faults into the LASEPS breadboard are described. I.E.

A91-37967* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.

BATTERY TEST EXPERT SYSTEMS

YVETTE B. JOHNSON (NASA, Marshall Space Flight Center, Huntsville, AL) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 249-251.

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The characteristics of NIHBES (nickel-hydrogen battery expert system) are described, with attention also given to NICBES-2 (nickel-cadmium battery expert system-2). The nickel-hydrogen battery testbed is set up almost identically to the nickel-cadmium battery testbed, with the exceptions of no battery protection and reconditioning circuits (BPRCs) and the frequency of transmission of data. The Ni-H2 testbed has no BPRCs and the data are transmitted every 30 s instead of every minute. An expert system shell was chosen to develop this particular expert system. The GoldWorks expert system shell from Gold Hill Computers was chosen for the task. NIHBES will extract the desired data and return fault diagnosis, status and advice, and decision support. Expert systems have been proven to be viable tools in the control and monitoring of space power systems. Presently, the DDAS (digital data acquisition system) monitors and controls the orbit time, and is responsible for limit checking, data acquisition, and data summaries. It is concluded that in the future control of the Hubble Space Telescope breadboard will be passed to NIHBES. NIHBES will be more beneficial to the testbed than the DDAS alone due to the limitations of the DDAS. The DDAS cannot provide long-term trend analysis, plotting capability, fault diagnosis, or advice. I.E.

A91-37969* Martin Marietta Corp., Denver, CO.

MANAGING AUTONOMY LEVELS IN THE SSM/PMAD TESTBED

BARRY R. ASHWORTH (Martin Marietta Astronautics Group, Denver, CO) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 263-268. refs

(Contract NAS8-36433)

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It is pointed out that when autonomous operations are mixed with those of a manual nature, concepts concerning the boundary of operations and responsibility become clouded. The space station module power management and distribution (SSM/PMAD) automation testbed has the need for such mixed-mode capabilities. The concept of managing the SSM/PMAD testbed in the presence of changing levels of autonomy is examined. A knowledge-based approach to implementing autonomy management in the distributed SSM/PMAD utilizing a centralized planning system is presented. Its knowledge relations and system-wide interactions are discussed, along with the operational nature of the currently functioning SSM/PMAD knowledge-based systems. I.E.

A91-37970* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

AUTOMATED ELECTRIC POWER MANAGEMENT AND CONTROL FOR SPACE STATION FREEDOM

JAMES L. DOLCE, PAMELA A. MELLOR, and JAMES A. KISH (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 269-274. Previously announced in STAR as N90-23125. refs

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A comprehensive automation design is being developed for Space Station Freedom's electric power system. It strives to increase station productivity by applying expert systems and conventional algorithms to automate power system operation. An integrated approach to the power system command and control problem is defined and used to direct technology development in: diagnosis, security monitoring and analysis, battery management, and cooperative problem-solving for resource allocation. The prototype automated power system is developed using simulations and test-beds. Author

A91-37971* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.

IMPLEMENTATION OF A VIRTUAL LINK BETWEEN POWER SYSTEM TESTBEDS AT MARSHALL SPACEFLIGHT CENTER AND LEWIS RESEARCH CENTER

RAJIV DORESWAMY (NASA, Marshall Space Flight Center, Huntsville, AL) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 275-277.

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The Marshall Space Flight Center (MSFC) owns and operates a space station module power management and distribution (SSM-PMAD) testbed. This system, managed by expert systems, is used to analyze and develop power system automation techniques for Space Station Freedom. The Lewis Research Center (LeRC), Cleveland, Ohio, has developed and implemented a space station electrical power system (EPS) testbed. This system and its power management controller are representative of the overall Space Station Freedom power system. A virtual link is being implemented between the testbeds at MSFC and LeRC. This link would enable configuration of SSM-PMAD as a load center for the EPS testbed at LeRC. This connection will add to the versatility of both systems, and provide an environment of enhanced realism for operation of both testbeds. I.E.

A91-37972* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

AUTONOMOUS POWER EXPERT SYSTEM

MARK J. RINGER and TODD M. QUINN (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 278-283. Previously announced in STAR as N90-25187. refs

(Contract NAS3-25266)

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The goal of the Autonomous Power System (APS) program is to develop and apply intelligent problem solving and control technologies to the Space Station Freedom Electrical Power Systems (SSF/EPS). The objectives of the program are to establish artificial intelligence/expert system technology paths, to create knowledge based tools with advanced human-operator interfaces, and to integrate and interface knowledge-based and conventional control schemes. This program is being developed at the NASA-Lewis. The APS Brassboard represents a subset of a 20 KHz Space Station Power Management And Distribution (PMAD) testbed. A distributed control scheme is used to manage multiple levels of computers and switchgear. The brassboard is comprised of a set of intelligent switchgear used to effectively switch power from the sources to the loads. The Autonomous Power Expert System (APEX) portion of the APS program integrates a knowledge based fault diagnostic system, a power resource scheduler, and an interface to the APS Brassboard. The system includes knowledge bases for system diagnostics, fault detection and isolation, and recommended actions. The scheduler autonomously assigns start times to the attached loads based on temporal and power constraints. The scheduler is able to work in a near real time environment for both scheduling an dynamic replanning. Author

A91-37973* Martin Marietta Corp., Denver, CO.

DIAGNOSING MULTIPLE FAULTS IN SSM/PMAD

JOEL RIEDESEL (Martin Marietta Space Systems, Denver, CO)

IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 284-290. refs
(Contract NAS8-36433)
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Multiple fault diagnosis for SSM/PMAD (space station module/power management and distribution) using the knowledge management design system as applied to the SSM/PMAD domain (KNOMAD-SSM/PMAD) is discussed. KNOMAD-SSM/PMAD provides a powerful facility for knowledge representation and reasoning which has been used to build the second generation of FRAMES (fault recovery and management expert system). FRAMES now handles the diagnosis of multiple faults and provides support for a more powerful interface for user interaction during autonomous operation. There are two types of multiple fault diagnosis handled in FRAMES. The first diagnoses hard faults, soft faults, and incipient faults simultaneously. The second diagnoses multiple hard faults which occur in close proximity in time to one another. Multiple fault diagnosis in FRAMES is performed using a rule-based approach. This rule-based approach, enabled by the KNOMAD-SSM/PMAD system, has proven to be powerful. Levels of autonomy are discussed, focusing on the approach taken in FRAMES for providing at least three levels of autonomy: complete autonomy, partial autonomy, and complete manual mode. I.E.

A91-37974
HYBRID SYSTEMS FOR AUTONOMOUS SPACE POWER CONTROL
D. F. JANIK, E. W. GHOLDSTON, K. A. NEWTON, and D. A. SEAGAL (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 291-295.
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Control and management of spaceborne electrical power systems (EPSs) have been historically performed by embedded microprocessors whose functionality included data acquisition and control. These controllers were coupled tightly to ground support personnel and provided only a minimum of command and response capability. With the introduction of larger systems, such as Space Station Freedom (SSF), new requirements for EPSs autonomy are being addressed. Designing EPSs to meet future requirements for increased autonomy while maintaining lower operating costs is challenging. The high cost of maintenance onboard SSF will be a direct result of expensive human activity time. It has been suggested that this time could be substantially reduced by addressing the technical issues of integrating symbolic and conventional processing control system. Using a classical control approach with expert system extensions may provide a path to increased systems autonomy. The payoff into expert systems research of this type could be a reduction in maintenance time which would drive operating costs down, and at the same time increase productivity in space. I.E.

A91-37975* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AUTOMATING SECURITY MONITORING AND ANALYSIS FOR SPACE STATION FREEDOM'S ELECTRIC POWER SYSTEM
JAMES L. DOLCE (NASA, Lewis Research Center, Cleveland, OH), DEJAN J. SOBAJIC, and YOH-HAN PAO (Case Western Reserve University, Cleveland, OH) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 296-303. Previously announced in STAR as N90-22324. refs
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Operating a large, space power system requires classifying the system's status and analyzing its security. Conventional algorithms are used by terrestrial electric utilities to provide such information to their dispatchers, but their application aboard Space Station Freedom will consume too much processing time. A novel approach for monitoring and analysis using adaptive pattern techniques is presented. This approach yields an on-line security monitoring and analysis algorithm that is accurate and fast; and thus, it can free the Space Station Freedom's power control computers for other tasks. Author

A91-37976* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ELECTRIC POWER SCHEDULING - A DISTRIBUTED PROBLEM-SOLVING APPROACH
PAMELA A. MELLOR, JAMES L. DOLCE (NASA, Lewis Research Center, Cleveland, OH), and JOSEPH C. KRUPP (Decision Science Applications, Inc., Arlington, VA) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 304-309. Previously announced in STAR as N90-22323. refs
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Space Station Freedom's power system, along with the spacecraft's other subsystems, needs to carefully conserve its resources and yet strive to maximize overall Station productivity. Due to Freedom's distributed design, each subsystem must work cooperatively within the Station community. There is a need for a scheduling tool which will preserve this distributed structure, allow each subsystem the latitude to satisfy its own constraints, and preserve individual value systems while maintaining Station-wide integrity. Author

A91-37977* Auburn Univ., AL.
HARMONIC ANALYSIS OF NONLINEAR DEVICES ON SPACECRAFT POWER SYSTEMS
FRANK WILLIAMSON and GERALD B. SHEBLE (Auburn University, AL) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 322-324. Auburn University-supported research.
(Contract NAGW-1192)
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A nonlinear device modeling algorithm (NOLID) has been developed for use in spacecraft power system analysis. This algorithm is designed to explore the effects of nonlinear devices and loads on a spacecraft power system. Application of this harmonic modeling algorithm in spacecraft power system management programs such as harmonic power flow analysis packages is discussed. It is shown that the NOLID algorithm can be applied in conjunction with a harmonic power flow to give a more accurate description of system state. I.E.

A91-37978* Auburn Univ., AL.
STABILITY ANALYSIS OF SPACECRAFT POWER SYSTEMS
S. M. HALPIN, L. L. GRIGSBY, G. B. SHEBLE, and R. M. NELMS (Auburn University, AL) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 325-330. Auburn University-supported research.
(Contract NAGW-1192)
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The problems in applying standard electric utility models, analyses, and algorithms to the study of the stability of spacecraft power conditioning and distribution systems are discussed. Both single-phase and three-phase systems are considered. Of particular concern are the load and generator models that are used in terrestrial power system studies, as well as the standard assumptions of load and topological balance that lead to the use of the positive sequence network. The standard assumptions regarding relative speeds of subsystem dynamic responses that are made in the classical transient stability algorithm, which forms the backbone of utility-based studies, are examined. The applicability of these assumptions to a spacecraft power system stability study is discussed in detail. In addition to the classical indirect method, the applicability of Liapunov's direct methods to the stability determination of spacecraft power systems is discussed. It is pointed out that while the proposed method uses a solution process similar to the classical algorithm, the models used for the sources, loads, and networks are, in general, more accurate. Some preliminary results are given for a linear-graph, state-variable-based modeling approach to the study of the stability of space-based power distribution networks. I.E.

A91-37980* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

A NEW ENVIRONMENT FOR MULTIPLE SPACECRAFT POWER SUBSYSTEM MISSION OPERATIONS

K. A. BAHRAMI (JPL, Pasadena, CA) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 348-352.
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The engineering analysis subsystem environment (EASE) is being developed to enable fewer controllers to monitor and control power and other spacecraft engineering subsystems. The EASE prototype has been developed to support simultaneous real-time monitoring of several spacecraft engineering subsystems. It is being designed to assist with offline analysis of telemetry data to determine trends, and to help formulate uplink commands to the spacecraft. An early version of the EASE prototype has been installed in the JPL Space Flight Operations Facility for online testing. The EASE prototype is installed in the Galileo Mission Support Area. The underlying concept, development, and testing of the EASE prototype and how it will aid in the ground operations of spacecraft power subsystems are discussed. I.E.

A91-37981

KNOWLEDGE-BASED QUALITATIVE MODELLING AND ADAPTIVE DISTRIBUTION OF POWER

STEPHEN CHIU, SUJEET CHAND (Rockwell International Science Center, Thousand Oaks, CA), and IRVING CHEN (Rockwell International Corp., Space Transportation Systems Div., Downey, CA) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 353-357. Rockwell International Corp.-supported research. refs
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A sudden surge in power demand or a reduction in power supply aboard a vehicle typically requires the removal of the less critical loads to maintain the operation of the more critical ones. A method that automates the distribution of partial power to maximize overall vehicle functionality has been developed. In addition to the use of priority values, fuzzy sets are used to represent the relationships between the fully functional state of a load and its input power. Using this description, power is iteratively distributed to the loads using fuzzy logic decision rules, taking into account the priority of each load and its power requirement relative to the remaining loads in the set. This algorithm represents an initial alternative to the conventional all-or-none power distribution method. The algorithm is efficient and practical for real-time power redistribution during contingencies. Simulation results that demonstrate the effectiveness of the proposed approach are presented. I.E.

A91-37982* Virginia Polytechnic Inst. and State Univ., Blacksburg.

USE OF NONLINEAR DESIGN OPTIMIZATION TECHNIQUES IN THE COMPARISON OF BATTERY DISCHARGER TOPOLOGIES FOR THE SPACE PLATFORM

DAN M. SABLE, BO H. CHO, and FRED C. LEE (Virginia Polytechnic Institute and State University, Blacksburg) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 358-364. NASA-supported research. refs
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A detailed comparison of a boost converter, a voltage-fed, autotransformer converter, and a multimodule boost converter, designed specifically for the space platform battery discharger, is performed. Computer-based nonlinear optimization techniques are used to facilitate an objective comparison. The multimodule boost converter is shown to be the optimum topology at all efficiencies. The margin is greatest at 97 percent efficiency. The multimodule, multiphase boost converter combines the advantages of high efficiency, light weight, and ample margin on the component stresses, thus ensuring high reliability. I.E.

A91-37983

ANALYSIS OF SPACECRAFT BATTERY CHARGER SYSTEMS

SEONG J. KIM and BO H. CHO (Virginia Polytechnic Institute and State University, Blacksburg) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 365-372. refs
(Contract NSF ECS-89-57482)
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In spacecraft battery charger systems, switching regulators are widely used for bus voltage regulation, charge current regulation, and peak power tracking. Small-signal dynamic characteristics of the battery charging subsystem of direct energy transfer (DET) and peak power tracking (PPT) systems are analyzed to facilitate design of the control loop for optimum performance and stability. Control loop designs of the charger in various modes of operation are discussed. Analyses are verified through simulations. It is shown that when the charger operates in the bus voltage regulation mode, the control-to-voltage transfer function has a negative DC gain and two LHP zeros in both the DET and PPT systems. The control-to-inductor current transfer function also has a negative DC gain and a RHP zero. Thus, in the current-mode control, the current loop can no longer be used to stabilize the system. When the system operates in the charge current regulation mode, the charger operates with a fixed duty cycle which is determined by the regulated bus voltage and the battery voltage. Without an input filter, the converter becomes a first-order system. When the peak power tracker is inactive, the operating point of the solar array output moves to the voltage source region. Thus, the solar array behaves as a stiff voltage source to a constant power load. I.E.

A91-37989* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SPACE STATION FREEDOM POWER SUPPLY COMMONALITY VIA MODULAR DESIGN

S. KRAUTHAMER, M. D. GANGAL (JPL, Pasadena, CA), and R. DAS (California State University, Long Beach) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 403-411. refs
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At mature operations, Space Station Freedom will need more than 2000 power supplies to feed housekeeping and user loads. Advanced technology power supplies from 20 to 250 W have been hybridized for terrestrial, aerospace, and industry applications in compact, efficient, reliable, lightweight packages compatible with electromagnetic interference requirements. The use of these hybridized packages as modules, either singly or in parallel, to satisfy the wide range of user power supply needs for all elements of the station is proposed. Proposed characteristics for the power supplies include common mechanical packaging, digital control, self-protection, high efficiency at full and partial loads, synchronization capability to reduce electromagnetic interference, redundancy, and soft-start capability. The inherent reliability is improved compared with conventional discrete component power supplies because the hybrid circuits use high-reliability components such as ceramic capacitors. Reliability is further improved over conventional supplies because the hybrid packages, which may be treated as a single part, reduce the parts count in the power supply. I.E.

A91-37993
POWER DISTRIBUTION STUDY FOR 10-100 KW BASELOAD SPACE POWER SYSTEMS
PAUL M. ANDERSON (Martin Marietta Astronautics Group, Denver, CO) and RENE THIBODEAUX (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 428-433.
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The optimum power distribution topologies for a 10-kW photovoltaic array source, a 20-kW space nuclear reactor thermionic source, a 50-kW solar thermal dynamic Brayton source, and a 100-kW space nuclear reactor thermoelectric source are discussed. In order to properly evaluate and select power distribution options for each selected power system, it was necessary to analyze the effects of bus voltage, AC vs. DC, regulated vs. unregulated, and central vs. distributed power distribution on power distribution system performance. Parametric studies of cabling masses, converter masses, and source masses that input into system mass calculation models were performed. Numerous assumptions about platform size, load profiles, source weights, and design criteria were made in order to allow for the parametric evaluations present in the various trade studies. The results of this study suggest that it is advantageous to design an unregulated, centrally distributed high-voltage bus between 120 and 200 VDC for distribution on power systems between 10 and 100 kWe. I.E.

A91-37998* Auburn Univ., AL.
STATE ESTIMATION FOR SPACECRAFT POWER SYSTEMS
SUSAN H. WILLIAMSON and GERALD B. SHEBLE (Auburn University, AL) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 458-460. Auburn University-supported research. refs
(Contract NAGW-1192)
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A state estimator appropriate for spacecraft power systems is presented. Phasor voltage and current measurements are used to determine the system state. A weighted least squares algorithm with a multireference transmission cable model is used. Bad data are identified and resolved. Once the bad data have been identified, they are removed from the measurement set and the system state can be estimated from the remaining data. An observability analysis is performed on the remaining measurements to determine if the system state can be found from the reduced measurement set. An example of the algorithm for a sample spacecraft power system is presented. I.E.

A91-37999* Louisiana Tech Univ., Ruston.
POWER SYSTEM STATE ESTIMATION FOR A SPACECRAFT POWER SYSTEM
F. C. BERRY, N. L. BENITEZ, and M. D. COX (Louisiana Tech University, Ruston) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 461-466. NASA-supported research. refs
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An application of the maximum likelihood state estimator to a space-based power system is presented. The state estimator uses current and voltage measurements to generate estimates of node voltages for an electrical power distribution system for the Space Shuttle. Preliminary results on the effect of noisy measurements on estimated parameters are reported. The software used in generating these results is part of an overall package being developed at Louisiana Tech University. Intended applications of this package include the analysis of power systems and real-time parallel processing on the Space Shuttle. I.E.

A91-38000* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
DEVELOPMENT OF AN AUTOMATED ELECTRICAL POWER SUBSYSTEM TESTBED FOR LARGE SPACECRAFT
DAVID K. HALL and LOUIS F. LOLLAR (NASA, Marshall Space Flight Center, Huntsville, AL) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 467-470. refs
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The NASA Marshall Space Flight Center (MSFC) has developed two autonomous electrical power system breadboards. The first breadboard, the autonomously managed power system (AMPS), is a two power channel system featuring energy generation and storage and 24-kW of switchable loads, all under computer control. The second breadboard, the space station module/power management and distribution (SSM/PMAD) testbed, is a two-bus 120-Vdc model of the Space Station power subsystem featuring smart switchgear and multiple knowledge-based control systems. NASA/MSFC is combining these two breadboards to form a complete autonomous source-to-load power system called the large autonomous spacecraft electrical power system (LASEPS). LASEPS is a high-power, intelligent, physical electrical power system testbed which can be used to derive and test new power system control techniques, new power switching components, and new energy storage elements in a more accurate and realistic fashion. LASEPS has the potential to be interfaced with other spacecraft subsystem breadboards in order to simulate an entire space vehicle. The two individual systems, the combined systems (hardware and software), and the current and future uses of LASEPS are described. I.E.

A91-38001* Purdue Univ., West Lafayette, IN.
STEADY-STATE AND DYNAMIC CHARACTERISTICS OF A 20-KHZ SPACECRAFT POWER SYSTEM - CONTROL OF HARMONIC RESONANCE
O. WASYNCZUK, P. C. KRAUSE (Purdue University, West Lafayette, IN), J. J. BIESS (TRW Space and Technology Group, Redondo Beach, CA), and R. KAPUSTKA (NASA, Marshall Space Flight Center, Huntsville, AL) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 471-476.
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A detailed computer simulation was used to illustrate the steady-state and dynamic operating characteristics of a 20-kHz resonant spacecraft power system. The simulated system consists of a parallel-connected set of DC-inductor resonant inverters (drivers), a 440-V cable, a node transformer, a 220-V cable, and a transformer-rectifier-filter (TRF) AC-to-DC receiver load. Also included in the system are a 1-kW 0.8-pf RL load and a double-LC filter connected at the receiving end of the 20-kHz AC system. The detailed computer simulation was used to illustrate the normal steady-state operating characteristics and the dynamic system performance following, for example, TRF startup. It is shown that without any filtering the given system exhibits harmonic resonances due to an interaction between the switching of the source and/or load converters and the AC system. However, the double-LC filter at the receiving-end of the AC system and harmonic traps connected in series with each of the drivers significantly reduce the harmonic distortion of the 20-kHz bus voltage. Significant additional improvement in the waveform quality can be achieved by including a double-LC filter with each driver. I.E.

A91-38002
DIGITAL METHODS FOR THE DETECTION OF INCIPIENT FAULT CONDITIONS IN SPACEBORNE POWER SYSTEMS
B. D. RUSSELL, SHIPING LI, and KARAN WATSON (Texas A & M University, College Station) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 477-483. refs
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The application of classical detection theory to the detection of high-impedance faults is described. The systems are suitable for implementation using programmable digital signal processors. The fault-detection problem is formulated as a statistical hypothesis testing in the presence of deterministic signals with random parameters and additive noise. The resulting optimal fault detector is a power detector and can be realized using a digital notch filter and a sliding sum of the squared output of the notched filter. A count of the number of energy bursts at the harmonic frequencies during a time interval is used to distinguish between faults and routine events. The proposed method can be used to detect faults and incipient failure conditions that cannot be detected by conventional protection methods used for spaceborne systems. Numerical examples illustrating detector performance are presented. I.E.

A91-38003* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

AN ANALYSIS OF SPACE POWER SYSTEM MASSES

BARBARA H. KENNY (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH), RONALD C. CULL, and M. D. KANKAM (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 484-489. Previously announced in STAR as N90-25184. refs

(Contract NAS3-25266)

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Various space electrical power system masses are analyzed with particular emphasis on the power management and distribution (PMAD) portion. The electrical power system (EPS) is divided into functional blocks: source, interconnection, storage, transmission, distribution, system control and load. The PMAD subsystem is defined as all the blocks between the source, storage and load, plus the power conditioning equipment required for the source, storage and load. The EPS mass of a wide range of spacecraft is then classified as source, storage or PMAD and tabulated in a database. The intent of the database is to serve as a reference source for PMAD masses of existing and in-design spacecraft. The PMAD masses in the database range from 40 kg/kW to 183 kg/kW across the spacecraft systems studied. Factors influencing the power system mass are identified. These include the total spacecraft power requirements, total amount of load capacity and physical size of the spacecraft. It is found that a new utility class of power systems, represented by Space Station Freedom, is evolving. Author

A91-38008

HIGH EFFICIENCY SOLAR DYNAMIC SPACE POWER GENERATION SYSTEM

ARISTIDE MASSARDO (Genova, Universita, Genoa, Italy) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 511-517. refs

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A design study has been conducted to evaluate the applicability of a combined cycle concept-closed Brayton cycle (CBC) and organic Rankine cycle (ORC) coupling for solar dynamic space power generation systems. In the solution presented (solar dynamic combined cycle or SDCC) the waste heat rejected by the CBC working fluid is utilized to heat the organic working fluid of an ORC system. This allows the SDCC efficiency to be increased compared to the efficiencies of the two subsystems (CBC and ORC). Also in the field of small-size space power systems (up to 50 kW) the efficiency of the SDCC can be comparable with the Stirling performance. However, the CBC and ORC designs are based on a great deal of maturity assessed in previous work on terrestrial and SD power systems; this is not yet true for the Stirling cycles. The performance requirements of the SDCC are analyzed. The significant benefits of the SDCC solution, such as efficiency increase, mass reduction, specific area reduction, are presented and discussed for a low earth orbit space station application. I.E.

A91-38009

RADIANT THERMAL PERFORMANCE ENHANCEMENT OF THE BASE CASE RECEIVER FOR ADVANCED SOLAR DYNAMIC APPLICATIONS

ROGER CRANE, YUAN M. TSAI, and WA KWOK (South Florida, University, Tampa, FL) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 518-523. refs

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The authors explore the potential for countering the nonuniform incident heat flux in the receiver in a solar dynamic power generation system by providing for radiant redistribution within the receiver. This is accomplished by ensuring that all high-temperature surfaces are also high-emissivity surfaces for thermal radiation. The particular system under investigation corresponds to the base case reference design selected by NASA's Lewis Research Center for the Advanced Solar Dynamic Program. I.E.

A91-38010

EXPERIMENTAL AND THEORETICAL ANALYSIS OF HEAT OF FUSION STORAGE FOR SOLAR DYNAMIC SPACE POWER SYSTEMS

STEFAN WEINGARTNER and JUERGEN BLUMENBERG (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 524-529. DLR-supported research. refs

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An experimental and theoretical analysis of heat of fusion storage has been performed. The storage salts LiF and LiF-MgF2 were used for the experiments. Thermophysical data on these media were measured or evaluated by comparison with calculations. A simulation model that is able to predict melt and solidification time and the heat output achievable with a given cooling condition is presented. In order to achieve a suitable charge and discharge characteristic, the heat of fusion storage canisters should be installed around the working fluid tubes or heat pipes, which also should be the heat source for the storage unit during the charge cycle. Potential applications of ceramic materials are considered. Preliminary tests with LiF indicate that the problems caused by the volume contraction of the storage salt can be solved with ceramic foams. A reduction of storage system mass by 25 percent is expected through the use of Sircon (Si3N4-SiC) foams. It is concluded that the heat of fusion storage concept considered here is an optimal storage design for state-of-the-art solar dynamic space power systems with storage temperatures between 950 and 1150 K. I.E.

A91-38011

OPTIMIZED CASSEGRAINIAN COLLECTOR-SYSTEM FOR SOLAR-DYNAMIC SPACE POWER GENERATION

W. ZOERNER, G. STOLZ, and J. BLUMENBERG (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 530-535. refs

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From the various alternatives of solar-dynamic power module collectors, the Cassegrainian collector configuration was chosen for its design and operational advantages and its suitability for the development of an automatic in-orbit deployment concept (collector and receiver with power conversion unit). The optimum collector system geometry to achieve maximum collector/absorber efficiency was determined using a two-dimensional ray-tracing program. Even for high receiver temperatures and average collector quality, an acceptable collector/absorber efficiency of more than 70 percent was found. The space station low-earth-orbit environment, applicable for the solar-dynamic power module's collector, was analyzed and an appropriate design and materials proposal was worked out. On this basis, the optimized collector system was used in an automatic in-orbit deployment simulation. The computer code developed in this study supplied the necessary collector segment and folding geometry to achieve the limited transport size stipulated by the current and near-term transport capacity. I.E.

A91-38016* Harris Corp., Melbourne, FL.
EFFECTS OF OFF-AXIS RADIATION ON REFLECTIVE CONCENTRATING SYSTEMS FOR SPACE POWER
J. S. CAMPBELL and S. D. CASSEL (Harris Corp., Melbourne, FL) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 558-563. NASA-supported research.
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Off-axis incident radiation, resulting from misalignment of a concentrator relative to incident solar flux, can potentially result in high flux concentrations at positions other than the design focal point. It is suggested that the impact of these concentrations should be considered when choosing materials and thermal control strategies for structures adjacent to the concentrator. A numerical (ray tracing) analysis of the effects of off-axis radiation on the proposed solar concentrator for the Space Station Freedom is performed. The magnitude and position of the reflected flux peaks are identified for a matrix of off-axis angles and target distances. The principles of geometric optics are presented to illustrate that the results of the numerical study are justified, and these results are explained in terms of these basic optical principles. A method that allows prediction of the reflected flux field for a generalized parabolic reflective concentrating system is presented. I.E.

A91-38017
IN-ORBIT PERFORMANCE OF HUGHES HS 376 SOLAR ARRAYS - UPDATE
STEVEN W. GELB and LELAND J. GOLDHAMMER (Hughes Aircraft Co., Space and Communications Group, El Segundo, CA) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 564-568. refs
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The synchronous orbit performance of the HS 376 spacecraft solar arrays using the K7 solar cell is updated and compared with ground-based computer predictions for orbital durations greater than eight years. A brief description of each solar array and the general methodology for predicting solar array performance are presented. In addition, the ability to accurately predict solar array performance within telemetry accuracy is demonstrated. This capability combines the solar array electrical measurements in the as-built configuration, manufacturing consistency, and sound computer modeling techniques. The HS 376 spacecraft discussed are the Satellite Business Systems (SBS) F-1, F-2, and F-3 ant the Telesat Canada Anik C-2, C-3, D-1, and D-2. The in-space performance data indicate forward solar array power degradation of 13.8 percent for SBS F-3 after 103 months in orbit, 15.1 percent for Anik C-3 after 79 months in orbit, and 13 percent for Anik D-1 after 82 months in orbit. The predicted solar array outputs are within 2 percent of the actual outputs as obtained through telemetry. I.E.

A91-38018* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LATEST DEVELOPMENTS IN THE ADVANCED PHOTOVOLTAIC SOLAR ARRAY PROGRAM
PAUL M. STELLA (JPL, Pasadena, CA) and RICHARD M. KURLAND (TRW Space and Technology Group, Redondo Beach, CA) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 569-574. refs
(Contract JPL-957990)
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In 1985, the Advanced Photovoltaic Solar Array (APSA) Program was established to demonstrate a producible array system with a specific power greater than 130 W/kg at a 10-kW (BOL) power level. The latest program phase completed fabrication and initial functional testing of a prototype wing representative of a full-scale 5-kW (BOL) wing (except truncated in length to about 1 kW), with weight characteristics that could meet the 130-W/kg (BOL) specific power goal using thin silicon solar cell modules and weight-efficient structural components. The wing configuration and key design details are reviewed, along with results from key component-level and wing-level tests. Projections for future enhancements that may be expected through the use of advanced solar cells and structural components are shown. Performance estimates are given for solar electric propulsion orbital transfer missions through the Van Allen radiation belts. The latest APSA program plans are presented. I.E.

A91-38020* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MONOLITHIC AND MECHANICAL MULTIJUNCTION SPACE SOLAR CELLS
RAJ K. JAIN and DENNIS J. FLOOD (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 581-586. refs
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Monolithic and mechanically stacked tandem solar cells have been fabricated with encouraging AM0 efficiencies summarized as: monolithic GaAs/Ge: 19.1 percent (28 C, 4 sq cm); monolithic InP/Ga0.47In0.53As: 22.2 percent (25 C, 0.296 sq cm); monolithic AlGaAs/GaAs/InGaAs: 27.6 percent (80 C, 0.2 sq cm, 100 X); mechanically stacked GaAs/GaSb: 30.8 percent (25 C, 0.049 sq cm, 100 X); and mechanically stacked GaAs/CuInSe2: 23.1 percent (25 C, 4 sq cm). Significant improvement in tandem cell efficiencies nearing to theoretical predictions has been projected with the improvement in cell material quality and processing. Thin-film cells offer improved specific power. It is pointed out that both the monolithic and mechanically stacked cells have their own problems as to size, processing, current-voltage matching, weight, etc. More information is needed on the effect of temperature and radiation on the cell performance. Proper reference cells and full spectrum range simulators are required to measure efficiencies correctly. I.E.

A91-38023* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
COMPONENT AND PROTOTYPE PANEL TESTING OF THE MINI-DOME FRESNEL LENS PHOTOVOLTAIC CONCENTRATOR ARRAY
MICHAEL F. PISZCZOR, CLIFFORD K. SWARTZ (NASA, Lewis Research Center, Cleveland, OH), and MARK J. O'NEILL (ENTECH, Inc., Dallas, TX) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 598-603. refs
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The mini-dome Fresnel lens concentrator array, a high-efficiency, lightweight space photovoltaic array concept, is described. The three critical elements of the array concept are the Fresnel lens concentrator, the prismatic cell power cover, and the photovoltaic cell. Prototype concentrator lenses have been fabricated and tested, with optical efficiencies reaching 90 percent. Work is progressing on the design and fabrication of the panel structure. The impact of recent advances in 30 percent-efficient multijunction photovoltaic cells on array performance is also discussed. Near-term performance goals of 300 w/sq m and 100 w/kg are now feasible. I.E.

A91-38024* Rockwell International Corp., Canoga Park, CA.
ORIENTATION OF SPACE STATION FREEDOM ELECTRICAL POWER SYSTEM IN ENVIRONMENTAL EFFECTS ASSESSMENT
CHENG-YI LU (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 2. New York, American Institute of Chemical Engineers, 1990, p. 1-6.
(Contract NAS3-25082)
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The orientation effects of six Space Station Freedom Electrical Power System (EPS) components are evaluated for three environmental interactions: aerodynamic drag, atomic oxygen erosion, and orbital debris impact. Designers can directly apply these orientation factors to estimate the magnitude of the examined environment and the environmental effects for the EPS component of interest. The six EPS components are the solar array, photovoltaic module radiator, integrated equipment assembly, solar dynamic concentrator, solar dynamic radiator, and beta gimbal.
I.E.

A91-38025 Utah State Univ., Logan.
INTERACTION OF HV-BIASED CURRENT COLLECTORS WITH THEIR LEO SPACE ENVIRONMENT
W. J. RAITT (Utah State University, Logan) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 2. New York, American Institute of Chemical Engineers, 1990, p. 7-12. refs
(Contract NAG5-607; NAGW-1817; NAG5-658; DNA001-87-C-0015)
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The interaction of spaceborne power systems is considered from the point of view of leakage current flow to the ionospheric plasma and enhanced leakage due to modification of the plasma environment caused by the power system. Following a brief survey of the LEO (low-earth-orbit) environment and the physical processes occurring in the interaction, some relevant experimental results from several sounding rocket flights are presented. Data from NASA experiments where particle beam emission both charges the platform and modifies the plasma environment are given. In addition, other data from a SDIO/DNA program are used to illustrate the effects of differently biased structures at electrical potentials up to 45 kV. In general, the results show that in the ambient LEO environment the interaction at potentials in the tens of kilovolts range is quite benign for the geometry used; however, if that environment is perturbed by the emission of gas from onboard systems, then much higher currents can flow to an exposed power system.
I.E.

A91-38026* Auburn Univ., AL.
THE EFFECTS OF EXTRATERRESTRIAL ENVIRONMENTS ON HIGH VOLTAGE DISTRIBUTION
LLOYD B. GORDON (Auburn University, AL) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 2. New York, American Institute of Chemical Engineers, 1990, p. 13-18. SDIO-supported research. refs
(Contract DNA001-85-C-0183; NAG3-1055)
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The problems encountered in the transmission of high-power (kilowatts to megawatts) in extraterrestrial environments are reviewed. A summary of the work at Auburn University in the study of these problems is presented. These studies include high-voltage breakdown in the space environment as influenced by gas contamination and thermal stress, the modeling of lunar transmission lines, particle contamination, and material degradation by the hypervelocity impact of microparticles.
I.E.

A91-38027
A SPACECRAFT ELECTRICAL BATTERY MODEL AND SIMULATOR
DEANNA TEMKIN, MIKE MCVEY, and UNO CARLSSON (Fairchild Space, Germantown, MD) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 2. New York, American Institute of Chemical Engineers, 1990, p. 19-26.
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The authors describe an electrical model for the nickel-cadmium battery for use in electronic component computer simulations. The primary motivation for developing the model was the desire to predict by computer simulation the small-signal loop response and the large-signal step load response of spacecraft power systems. It is shown how parameter values for the model can be easily extrapolated from the measured battery step load response. The accuracy of the model is verified by comparing computer-simulated step load response with an actual battery step load response. Development of the battery model paved the way for the design of a battery simulator which makes it possible to test system performance conveniently. The simulator accuracy is also verified by comparing the measured step load responses of the real battery and the battery simulator. The battery model and simulator are used to predict and measure the power system's small-signal loop response from a frequency of 1 Hz and up and to predict and measure the power system's response to step loads up to a few seconds in duration. Computer simulations and measured data of the step load response for the model, simulator, and battery are presented and compared, verifying the accuracy of the model and simulator. For step loads of much longer than a few seconds, the standard battery charge/discharge curves (battery voltage vs. amp-hour charge/discharge) are used to predict system performance.
I.E.

A91-38029* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
MODELING A CONSTANT POWER LOAD FOR NICKEL-HYDROGEN BATTERY TESTING USING SPICE
DOUGLAS B. BEARDEN, LOUIS F. LOLLAR (NASA, Marshall Space Flight Center, Huntsville, AL), and R. M. NELMS (Auburn University, AL) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 2. New York, American Institute of Chemical Engineers, 1990, p. 32-36.
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The effort to design and model a constant power load for the HST (Hubble Space Telescope) nickel-hydrogen battery tests is described. The constant power load was designed for three different simulations on the batteries: life cycling, reconditioning, and capacity testing. A dc-dc boost converter was designed to act as this constant power load. A boost converter design was chosen because of the low test battery voltage (4 to 6 VDC) generated and the relatively high power requirement of 60 to 70 W. The SPICE model was shown to consistently predict variations in the actual circuit as various designs were attempted. It is concluded that the confidence established in the SPICE model of the constant power load ensures its extensive utilization in future efforts to improve performance in the actual load circuit.
I.E.

A91-38030
A SIMPLIFIED CURRENT MODE CONTROL MODEL WITH OPTIMUM SLOPE COMPENSATION
DAVID N. MACLEAN (Boeing Aerospace and Electronics, Kent, WA) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 2. New York, American Institute of Chemical Engineers, 1990, p. 37-42.
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A series buck regulator for a spacecraft in low earth orbit is considered where the power source is a solar array that will vary greatly with temperature and time. The loads are fed from a 28 + 4 V direct current bus; batteries are used during occultation and recharged from the array during sunlight periods. The problem of duty cycle operation over 50 percent is solved by summing a stabilizing linear ramp with the current sensing resistor signal. The magnitude of the stabilizing ramp slope and the effect on the stability of the outer voltage feedback loop are evaluated. The stability ramp magnitude that will meet stability requirements in worst-case conditions is determined. This ramp is then used because it is the minimum to ensure stability without losing the advantages of current mode control, such as forced sharing and easy compensation. A time-averaged state-space model of the buck converter with current mode control and a fixed linear stabilizing ramp summed with the current sensor signal is developed. The frequency response of the converter modulator is determined. A circuit that generates the minimum slope compensation necessary for the operating conditions and dynamically changes it has been developed. This circuit adds complexity to the control logic but improves the performance of the power train by operating in current mode control with a minimum stabilizing ramp. I.E.

A91-38039* Virginia Polytechnic Inst. and State Univ., Blacksburg.

MODELING AND SIMULATION OF THE SPACE PLATFORM POWER SYSTEM

A. R. PATIL, S. J. KIM, B. H. CHO, and F. C. LEE (Virginia Polytechnic Institute and State University, Blacksburg) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 2. New York, American Institute of Chemical Engineers, 1990, p. 96-103. Research supported by Fairchild Space, Washington Technical Support Center, and NASA. refs

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A comprehensive computer-aided modeling and simulation technique for the space platform power system is described. Large-signal and small-signal modeling is presented for the system components. The component models have been integrated to form the complete power system model. The system model is shown to be a powerful tool in simulating the behavior of the system with variation of illumination level and load. It can be used to study the bus regulation in each mode and to observe mode changes as the solar array is subjected to transitions from sunlight to eclipse and back to sunlight. System simulations show how the bus regulation is maintained by activating the shunt switching unit, the charger, or the discharger, depending on the available illumination level. The system model is suitable for verifying hardware results of for analyzing the performance of a proposed system where hardware testing is not feasible. The EASY5 dynamic analysis program is used as the host software for the modeling and simulation. I.E.

A91-38040* Virginia Polytechnic Inst. and State Univ., Blacksburg.

MODELING OF SPACE STATION ELECTRIC POWER SYSTEM WITH EMTP

KWA-SUR TAM, LIFENG YANG (Virginia Polytechnic Institute and State University, Blacksburg), and NARAYAN V. DRAVID (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 2. New York, American Institute of Chemical Engineers, 1990, p. 104-109. refs

(Contract NAG3-1120)

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The authors provide an introduction to using the electromagnetic transients (EMTP) program to model aerospace power system components. A brief general overview of EMTP is presented. The modeling of the dc/dc converter unit in the space station electric power system is described as an illustration. I.E.

A91-38041* Analytical Engineering Corp., North Olmsted, OH.

AN EXPERT SYSTEM FOR SIMULATING ELECTRIC LOADS ABOARD SPACE STATION FREEDOM

GEORGE KUKICH (Analytical Engineering Corp., North Olmsted, OH) and JAMES L. DOLCE (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 2. New York, American Institute of Chemical Engineers, 1990, p. 110-114. Previously announced in STAR as N90-22325. refs

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Space Station Freedom will provide an infrastructure for space experimentation. This environment will feature regulated access to any resources required by an experiment. Automated systems are being developed to manage the electric power so that researchers can have the flexibility to modify their experiment plan for contingencies or for new opportunities. To define these flexible power management characteristics for Space Station Freedom, a simulation is required that captures the dynamic nature of space experimentation; namely, an investigator is allowed to restructure his experiment and to modify its execution. This changes the energy demands for the investigator's range of options. An expert system competent in the domain of cryogenic fluid management experimentation, was developed. It will be used to help design and test automated power scheduling software for Freedom's electric power system. The expert system allows experiment planning and experiment simulation. The former evaluates experimental alternatives and offers advice on the details of the experiment's design. The latter provides a real-time simulation of the experiment replete with appropriate resource consumption. Author

A91-38046

STEADY-STATE THERMAL ANALYSIS OF SPACECRAFT TRANSMISSION CABLES

T. A. HASKEW, R. F. CARWILE, and L. L. GRIGSBY (Auburn University, AL) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 2. New York, American Institute of Chemical Engineers, 1990, p. 142-146. SDIO-supported research.

(Contract DNA001-85-C-0183)

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An algorithm is presented which makes it possible to decide whether convective cooling is necessary for spacecraft transmission cables. It is shown that, given certain conditions, finite difference methods can be used to generate the defining algebraic equations for the interior temperature of the cable. Finite difference equations can also be written for the cable boundary to account for solar input and heat radiation. The sets of equations can be solved simultaneously by the Newton-Raphson method. The converged temperature distribution can be used to recompute the resistive heating losses. This process can continue until the overall solution is stabilized. The proposed algorithm is shown to be efficient and accurate. The solutions found by means of this algorithm agree with solutions to various test cases obtained by other methods. I.E.

A91-38048* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

TWO-DIMENSIONAL MODEL OF A SPACE STATION FREEDOM THERMAL ENERGY STORAGE CANISTER

THOMAS W. KERSLAKE (NASA, Lewis Research Center, Cleveland, OH) and MOUNIR B. IBRAHIM (Cleveland State University, OH) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 2. New York, American Institute of Chemical Engineers, 1990, p. 151-159. Previously announced in STAR as N90-26279.

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The Solar Dynamic Power Module being developed for Space Station Freedom uses a eutectic mixture of LiF-CaF2 phase change salt contained in toroidal canisters for thermal energy storage. Results are presented from heat transfer analyses of the phase-change salt containment canister. A 2-D, axisymmetric finite-difference computer program which models the canister walls, salt, void, and heat engine working fluid coolant was developed. Analyses included effects of conduction in canister walls and solid salt, conduction and free convection in liquid salt, conduction and radiation across salt vapor filled void regions, and forced convection in the heat engine working fluid. Void shape, location, and growth or shrinkage (due to density difference between the solid and liquid salt phases) were prescribed based on engineering judgement. The salt phase change process was modeled using the enthalpy method. Discussion of results focuses on the role of free-convection in the liquid salt on canister heat transfer performance. This role is shown to be important for interpreting the relationship between groundbased canister performance (in 1-g) and expected on-orbit performance (in micro-g). Attention is also focused on the influence of void heat transfer on canister wall temperature distributions. The large thermal resistance of void regions is shown to accentuate canister hot spots and temperature gradients. Author

A91-38053

ADVANCED THERMIONIC REACTOR SYSTEMS DESIGN CODE

BRYAN R. LEWIS, RONALD A. PAWLOWSKI, and ANDREW C. KLEIN (Oregon State University, Corvallis) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 2. New York, American Institute of Chemical Engineers, 1990, p. 305-309. Research sponsored by Universal Energy Systems, Inc. and USAF. refs

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An overall systems design code is under development to model an advanced in-core thermionic-energy-conversion-based nuclear reactor system for space applications at power levels of 10 to 50 kWe. The design code will consist of a series of design modules, each responsible for the determination of specific system parameters. The code modules include one for neutronics and core criticality, one for thermionic fuel element performance, a radiation shielding module, a module for waste heat transfer and rejection, and modules for power conditioning and control. The neutronics and core criticality module determines critical core size, core lifetime, and shutdown margins and is achieved by utilizing the criticality calculation capability of the Monte Carlo neutron and photon transport code system (MCNP). The effects of enriched tungsten on the neutron multiplication factor for relatively fast and thermal reactor configurations is considered using a series of core calculations. It is shown that, based on neutronic considerations alone, reactors based on natural tungsten emitters and collectors will be required to utilize driver fuel rods to achieve criticality. Otherwise, enriching the tungsten in isotope 184 will be necessary. Driven reactor cores are also considered, including configurations with distributed driver rods as well as segregated driver and thermionic fuel element regions. I.E.

A91-38077* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

EFFECT OF LEO CYCLING ON 125 AH ADVANCED DESIGN IPV NICKEL-HYDROGEN BATTERY CELLS

JOHN J. SMITHRICK (NASA, Lewis Research Center, Cleveland, OH) and STEPHEN W. HALL (U.S. Navy, Naval Weapons Support Center, Crane, IN) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 3. New York, American Institute of Chemical Engineers, 1990, p. 22-27. Previously announced in STAR as N90-21808. refs

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An advanced 125 Ah individual pressure vessel (IPV) nickel-hydrogen cell was designed. The primary function of the advanced cell is to store and deliver energy for long-term, low earth-orbit (LEO) spacecraft missions. The new features of this design are: (1) use of 26 percent rather than 31 percent potassium hydroxide (KOH) electrolyte, (2) use of a patented catalyzed wall wick, (3) use of serrated-edge separators to facilitate gaseous oxygen and hydrogen flow within the cell, while still maintaining physical contact with the wall wick for electrolyte management, and (4) use of a floating rather than a fixed stack (state-of-the-art) to accommodate nickel electrode expansion. Six 125-Ah flight cells based on this design were fabricated by Eagle-Picher. Three of the cells contain all of the advanced features (test cells) and three are the same as the test cells except they don't have catalyst on the wall wick (control cells). All six cells are in the process of being evaluated in a LEO cycle life test. The cells have accumulated about 4700 LEO cycles (60 percent DOD 10 C). There have been no cell failures; the catalyzed wall wick cells, however, are performing better. Author

A91-38078* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.

ONGOING NICKEL-HYDROGEN ENERGY STORAGE DEVICE TESTING AT GEORGE C. MARSHALL SPACE FLIGHT CENTER

JOHN E. LOWERY, JOHN R. LANIER, JR., CHARLES I. HALL, and THOMAS H. WHITT (NASA, Marshall Space Flight Center, Huntsville, AL) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 3. New York, American Institute of Chemical Engineers, 1990, p. 28-32.

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The primary objective of the testing is to characterize Ni-H2 cells for successful integration into the electrical power system (EPS) of the Hubble Space Telescope (HST). A broad spectrum of Ni-H2 design technology is encompassed by the testing configurations; tests include cells with dates of manufacture as early as 1976. The database includes cells of varied storage times, capacity, plate design, stack design, terminal configuration, pressure vessel thickness, separator material, potassium hydroxide (KOH) concentration, and thermal control. Currently, 196 Ni-H2 cells are being tested, grouped as follows: 12 RNH-35-3, 14 RNH-30-1, 22 HST cells (1 battery, flight spare lot), 132 HST cells (6 batteries, test modules 1 and 2, called TM1 and TM2), 12 HST cells (3 four-cell packs, TM1, TM2, flight spare module FSM), and 4 HST cells (engineering lot). In addition to the characterization and life testing, an extensive thermal vacuum and purge test was conducted in November 1989 and February 1990 using the HST FSM (3 batteries composed of 69 HST cells from the flight spare lot) to help verify thermal design. A report is presented of the progress, significant findings, and future objectives of the testing. I.E.

A91-38082* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

IMPEDANCES OF NI ELECTRODES AND NI/H2 CELLS FROM DIFFERENT MANUFACTURERS

MARGARET A. REID (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 3. New York, American Institute of Chemical Engineers, 1990, p. 48-53. refs

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The consistency of impedance measurements within each group of flightweigth Ni/H2 cells being tested for Space Station Freedom confirms that impedance measurements are reproducible provided that the same conditions of cycling and storage are maintained. However, electrodes and cells from different manufacturers vary widely, even with the same cycling and storage conditions. Measurements on cells from two manufacturers that have been cycled for 500-800 cycles show that there are not only major changes upon cycling, but there are substantial differences in the behavior of cells from different manufacturers with cycling. I.E.

A91-38083

NIH2 BATTERY CELL LIFE TESTS FOR LOW EARTH ORBIT APPLICATIONS

STEPHEN F. SCHIFFER, DORIAN M. MAURER, and CARA A. MARKOWITZ (General Electric Co., Astro-Space Div., Princeton, NJ) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 3. New York, American Institute of Chemical Engineers, 1990, p. 55-60.

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Life testing of nickel-hydrogen cells of two designs has been conducted in real-time simulated low earth orbit test programs for more than five years. Two groups of 50-Ah nameplate cells (four cells each) have exceeded four years of cycling at 40 percent depth of discharge (DOD) and 60 percent DOD, respectively. Two groups of 70-Ah nameplate cells (five cells each) have completed 2.5 years on test at 30 percent DOD and 50 percent DOD, respectively. Over 20,000 cycles of real-time testing at up to 40 percent DOD have now been completed with no notable performance degradation. A description is given of the test programs and updated results for the life cycling of these nickel-hydrogen cells, which are designed for low-earth-orbit applications. I.E.

A91-38087* National Aeronautics and Space Administration, Washington, DC.
THE NASA RESEARCH AND TECHNOLOGY PROGRAM ON BATTERIES
GARY L. BENNETT (NASA, Washington, DC) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 3. New York, American Institute of Chemical Engineers, 1990, p. 80-84. refs
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The NASA research and technology program on batteries is being carried out within the Propulsion, Power and Energy Division (Code RP) of NASA's Office of Aeronautics, Exploration and Technology (OAET). The program includes development of high-performance, long-life, cost-effective primary and secondary (rechargeable) batteries. The NASA OAET battery program is being carried out at Lewis Research Center (LeRC) and the Jet Propulsion Laboratory (JPL). LeRC is focusing primarily on nickel-hydrogen batteries (both individual pressure vessel or IPV and bipolar). LeRC is also involved in a planned flight experiment to test a sodium-sulfur battery design. JPL is focusing primarily on lithium rechargeable batteries, having successfully transferred its lithium primary battery technology to the U.S. Air Force for use on the Centaur upper stage. Both LeRC and JPL are studying advanced battery concepts that offer even higher specific energies. The long-term goal is to achieve 100 Wh/kg. I.E.

A91-38088* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NASA AEROSPACE FLIGHT BATTERY SYSTEMS PROGRAM
MICHELLE A. MANZO and PATRICIA M. O'DONNELL (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 3. New York, American Institute of Chemical Engineers, 1990, p. 85-89. Previously announced in STAR as N90-26397. refs
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The major objective of the NASA Aerospace Flight Battery Systems Program is to provide NASA with the policy and posture to increase and ensure the safety, performance and reliability of batteries for space power systems. The program plan has been modified in the past year to reflect changes in the agency's approach to battery related problems that are affecting flight programs. Primary attention in the Battery Program is being devoted to the development of an advanced nickel-cadmium cell design and the qualification of vendors to produce cells for flight programs. As part of a unified Battery Program, the development of a nickel-hydrogen standard and primary cell issues are also being pursued to provide high-performance NASA Standards and space qualified state-of-the-art primary cells. The resolution of issues is being addressed with the full participation of the aerospace battery community. Author

A91-38090* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
LIFE TESTING OF SECONDARY SILVER-ZINC CELLS FOR THE ORBITING MANEUVERING VEHICLE
JEFFREY C. BREWER, RAJIV DORESWAMY, and LORNA G. JACKSON (NASA, Marshall Space Flight Center, Huntsville, AL) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 3. New York, American Institute of Chemical Engineers, 1990, p. 100-104.
Copyright
Over the past 5 years, extensive testing has been performed at the Marshall Space Flight Center (MSFC) on a variety of secondary (rechargeable) silver-zinc (Ag-Zn) cells for the Orbital Maneuvering Vehicle (OMV). The first tests performed were to determine the feasibility of using such a cell in a long-life (18-month), low-Earth-orbit (LEO) application. Results from these tests were promising, so testing continued with a 250-Ah cell that was specifically designed for this type of application. Once again, results from the tests were promising. Following a review of the data from these previous tests, slight modifications to the 250-Ah design were necessary to alleviate problem areas. Currently, MSFC is testing a 350-Ah design that has incorporated these changes and is the baseline design for the OMV. This test began in mid-November, 1989, and will be complete in the spring of 1991, barring any substantial offline time. A report is presented on the preliminary results from the first few months of this test and they are compared to results obtained in previous tests done at MFSC. I.E.

A91-38091
PERFORMANCE CHARACTERISTICS OF SILVER-ZINC CELLS FOR ORBITING SPACECRAFT
A. P. KARPINSKI and J. A. PATTEN (Whittaker Technical Products, Inc., Pawcatuck, CT) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 3. New York, American Institute of Chemical Engineers, 1990, p. 105-110.
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A 38-month cell test program was completed and includes the results of one group of 250-Ah rated silver-zinc cells. The cell group was subjected to a 10-month period of 30-day wetstand intervals and 70 percent depth of discharge (DOD) cycles, followed by 28 additional months of continuous shallow DOD simulated low earth orbit (LEO) cycling. Periodically, capacity measurements were performed on each cell. The cells have logged over 7280 LEO cycles and a total of 14 full capacity discharge cycles. The overall cell performance was uniform and exceeded program objectives. Testing at higher depths of discharge at similar space-based cycle regimes is recommended in order to assess other space applications. I.E.

A91-38092* TRW, Inc., Redondo Beach, CA.
PRIMARY LITHIUM CELL LIFE STUDIES
JOHN CAPULLI, SAM DONLEY (TRW, Inc., Redondo Beach, CA), FRANK DELIGIANNIS, and DAVID SHEN (JPL, Pasadena, CA) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 3. New York, American Institute of Chemical Engineers, 1990, p. 111-116.
Copyright
One solution for providing a truly independent power source is to package, within the critical subsystem element, a primary battery that can remain dormant for time periods as long as the mission life, which can be 10-15 years, maximum. When primary power from the spacecraft solar array/battery system is interrupted, the backup battery system, which is connected through a diode to the power input line, would automatically support the load to avoid a power interruption to the critical load for a time period long enough to ensure that ground control could access the satellite and correct the anomaly by sending appropriate commands to the spacecraft. Critical subsystems identified for the application are telemetry and command circuits, volatile computer memory, attitude control circuits, and some critical payloads. Due to volume packaging and weight restrictions that exist on most spacecraft, coupled with the long storage periods required, lithium cell technology was selected for the backup power source. Because of the high energy density (200-400 Wh/kg), long shelf life, and load capability, soluble cathode primary lithium technology was chosen. The most important lithium cell properties that require detail characterization for this application are capacity loss, shelf life, and the voltage delay mechanism. These are functions of storage time and temperature. During storage, a passive film builds up on the lithium electrode. The film protects the lithium electrode

from progressive capacity decay but requires time to break down when a load is applied. This phenomenon results in a depressed voltage during the period of film breakdown which can last from fractions of a second to minutes. I.E.

A91-38094

SODIUM-SULFUR BATTERIES FOR SPACE APPLICATIONS

STEPHAN M. WOLANCZYK and STEPHEN P. VUKSON (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 3. New York, American Institute of Chemical Engineers, 1990, p. 122-124.

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Ongoing sodium-sulfur development programs at the Wright Research and Development Center that are designed to meet anticipated future performance capabilities are discussed. Historical efforts are reviewed. Details of current programs with respect to technology status, performance information and projections, test results, conceptual designs, and future plans are also discussed. I.E.

A91-38126* Space Power, Inc., San Jose, CA.

TWO-DIMENSIONAL SIMULATION OF A TWO-PHASE, REGENERATIVE PUMPED RADIATOR LOOP UTILIZING DIRECT CONTACT HEAT TRANSFER WITH PHASE CHANGE

HYOP S. RHEE, LESTER L. BEGG, JOSEPH R. WETCH (Space Power, Inc., San Jose, CA), JONG H. JANG, and ALBERT J. JUHASZ (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 4. New York, American Institute of Chemical Engineers, 1990, p. 8-13. (Contract NAS3-25208)

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An innovative pumped loop concept for 600 K space power system radiators utilizing direct contact heat transfer, which facilitates repeated startup/shutdown of the power system without complex and time-consuming coolant thawing during power startup, is under development. The heat transfer process with melting/freezing of Li in an NaK flow was studied through two-dimensional time-dependent numerical simulations to characterize and predict the Li/NaK radiator performance during startup (thawing) and shutdown (cold-trapping). Effects of system parameters and the criteria for the plugging domain are presented together with temperature distribution patterns in solid Li and subsequent melting surface profile variations in time. I.E.

A91-38137

FREE-PISTON SPACE STIRLING TECHNOLOGY PROGRAM - AN UPDATE

GEORGE DOCHAT (Mechanical Technology, Inc., Latham, NY) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 5. New York, American Institute of Chemical Engineers, 1990, p. 219-223. refs

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The present NASA Lewis Research Center Stirling space power technology program is reviewed. Overall objectives and milestones are presented, in addition to the technical approach in addressing the major concerns. The design of the component test power converter, the first engine in the program that will operate at expected space operating temperatures is presented. Technology and component development progress, a key element in the program, is reviewed, including the status of linear alternators, high-temperature materials, and bearing materials. I.E.

A91-38138

TEN KILOWATT TO MULTIMEGAWATT MODULAR SPACE POWER SYSTEM USING STIRLING ENGINE

D. K. DAROOKA (General Electric Co., Astro Space Div., Philadelphia, PA) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 5. New York, American Institute of Chemical Engineers, 1990, p. 224-230.

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An investigation to evaluate the potential of Stirling engines in space power systems over a broad power range, with special emphasis on their integration characteristics, was recently completed. The results of this investigation, over a range of 10 kWe to multimegawatt power output, utilizing a nuclear reactor heat source are given. A modular design approach was adopted to satisfy the entire power range with minimal or no changes in the basic module design. These and other features of the Stirling engine space power system are discussed. I.E.

A91-38139

TRANSIENT LIQUID PHASE DIFFUSION BONDING FOR STIRLING ENGINE APPLICATIONS

DONALD L. MITTENDORF and WILLIAM G. BAGGENSTOSS (Allied-Signal Aerospace Co., Garrett Fluid Systems Div., Tempe, AZ) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 5. New York, American Institute of Chemical Engineers, 1990, p. 231-236.

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The transient liquid phase diffusion bonding technique is discussed. This technique appears to be ideally suited to meet the difficult requirements of a high-strength, low-distortion bond joint for main engine housing closure. The technique has been used in other applications, such as high-speed turbine wheels and high-temperature fluidic valves, and has demonstrated the bond joint characteristics required for the Stirling engine. Therefore, transient liquid phase diffusion bonding represents an enabling technology that can contribute to the future success of Stirling space power systems. I.E.

A91-38140* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

UPDATE ON RESULTS OF SPRE TESTING AT NASA

JAMES E. CAIRELLI, DIANE M. SWEC (NASA, Lewis Research Center, Cleveland, OH), ROBERT C. SKUPINSKI, and JEFFREY S. RAUCH (NASA, Lewis Research Center; Sverdrup Technology, Inc., Brook Park, OH) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 5. New York, American Institute of Chemical Engineers, 1990, p. 237-244. refs

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The space power research engine (SPRE I), a free-piston Stirling engine with a linear alternator, was tested as a candidate for high-capacity space power. A portion of the test data from the SPRE I, essentially in its baseline configuration while operating with helium at heat exchanger metal temperature ratios ranging from 1.6 to 2.4 and mean cycle pressures of 7.5 and 15.0 Mpa, are presented. HFAST computer code predictions are presented for comparison. The measured results at 7.5 and 15 MPa, from the first day, from the first day of testing, at temperature ratios from 1.6 to 2.0 agreed fairly well with the HFAST code predictions; within -8.8 percent to +11.9 percent for PV power and -2.7 to +1.07 percentage points for PV efficiency. Measured compression-space pressure amplitude was 5.1 to 11.1 percent below predictions; although these results were within the error bands, there was poorer agreement than observed for previous tests, and the transducer calibration is suspect. All of the dynamic pressure transducer calibrations will be verified before testing is resumed. Measured pressure phase angles were within -1.95 percent to +5.37 percent of the predictions, which is much closer than previously observed. The poor agreement of the measured heat flow to the heater with the code appears to be due to thermocouple degradation. I.E.

A91-38141

FREE PISTON STIRLING ENGINE SCALING STUDY

D. JONES (Mechanical Technology, Inc., Latham, NY) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion

Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 5. New York, American Institute of Chemical Engineers, 1990, p. 245-249.
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The design feasibility study of a single-cylinder, free-piston Stirling engine/linear alternator (FPSE/LA) power module generating 150 kW-electric (kWe) at engine temperature ratios from 1.7 to 3.0 is documented. A description of the engine design is provided, followed by a discussion of power module optimization conducted at various operating points. The results of the study show that a single-cylinder FPSE/LA is capable of meeting the efficiency and specific mass goals of the NASA high-capacity power program and has attractive scaling attributes over the power range from 25 to 150 kWe at temperature ratios of 2.0 and greater. A parametric study of power module performance is presented and discussed. For a single-cylinder machine, a dynamic balancer is required to limit the power module vibration level to program requirements. The dynamic balance assembly mass represents 20 to 30 percent of the total single-cylinder power module mass. Joining two modules in a balanced opposed configuration eliminates the need for the balancer, and a hot-end junction can be made without significant addition of structural mass. I.E.

A91-38146
FREE-PISTON STIRLING ENGINES - FOR SPACE, EARTH AND OCEAN APPLICATIONS
BRUCE GOLDWATER (Mechanical Technology, Inc., Latham, NY) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 5. New York, American Institute of Chemical Engineers, 1990, p. 324-330.
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The current level of technology as it relates to the application of free-piston Stirling engines (FPSEs) in space, terrestrial, and undersea markets is discussed. Each application considered presents a unique set of requirements to the designer. The timetable for introduction to the market will vary depending on the level of commitment to commercialization of the needed technology. It is unfortunate that, in general, United States industry has taken a much less than proactive role in developing the technology. A commitment of resources to address the remaining development issues is mandatory before market introduction and acceptance. This market acceptance of the FPSE directly depends on the successful development and introduction of technologies associated with the specific application. I.E.

A91-38151* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
RECENT STIRLING ENGINE LOSS-UNDERSTANDING RESULTS
ROY C. TEW, LANNY G. THIEME, and JAMES E. DUDENHOEFER (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 5. New York, American Institute of Chemical Engineers, 1990, p. 377-385. Previously announced in STAR as N90-21114. refs
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For several years, NASA and other U.S. government agencies have been funding experimental and analytical efforts to improve the understanding of Stirling thermodynamic losses. NASA's objective is to improve Stirling engine design capability to support the development of new engines for space power. An overview of these efforts was last given at the 1988 IECEC. Recent results of this research are reviewed. Author

A91-38158* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LUNAR ORBITING MICROWAVE BEAM POWER SYSTEM
EDGAR H. FAY (NASA, Lewis Research Center; Sverdrup Technology, Inc., Brook Park, OH) and RONALD C. CULL (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 6. New York, American Institute of Chemical Engineers, 1990, p. 4-10. refs
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A microwave-beam power system using lunar orbiting solar-powered satellite(s) and surface rectenna(s) is investigated as a possible energy source for the moon's surface. The concept has the potential of achieving reduced system mass by placing the power source in orbit. This can greatly reduce and/or eliminate the 14-d energy storage requirement of a lunar surface solar system. Also, propellants required to de-orbit to the surface are greatly reduced. To determine the practicality of the concept and the most important factors, a zeroth-order feasibility analysis is performed. Three different operation scenarios employing state of the art technology and forecasts for two different sets of advanced technologies are investigated. To reduce the complexity of the problem, satellite(s) are assumed to be in circular equatorial orbits around the moon, supplying continuous power to a single equatorial base through a fixed horizontal rectenna on the surface. State of the art technology yields specific masses greater than 2500 kg/kw, well above projections for surface systems. The specific masses are on the order of 100 kg/kW using advanced technologies, which is within the range of projections for surface nuclear (20 kg/kW) and solar systems (500 kg/kW). Further studies examining optimization of the scenarios, other technologies, such as laser transmitters and nuclear sources, and operational issues, such as logistics, maintenance, and support, are being carried out to support the Space Exploration Initiative (SEI) to the moon and Mars. I.E.

A91-38159* Lockheed Missiles and Space Co., Sunnyvale, CA.
PROPOSED ADVANCED SATELLITE APPLICATIONS UTILIZING SPACE NUCLEAR POWER SYSTEMS
PATRICK G. BAILEY (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) and LON ISENBERG (JPL, Pasadena, CA) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 6. New York, American Institute of Chemical Engineers, 1990, p. 11-16. refs
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A review of the status of space nuclear reactor systems and their possible applications is presented. Such systems have been developed over the past twenty years and are capable of use in various military and civilian applications in the 5-1000-kWe power range. The capabilities and limitations of the currently proposed nuclear reactor systems are summarized. Statements of need are presented from DoD, DOE, and NASA. Safety issues are identified, and if they are properly addressed they should not pose a hindrance. Applications are summarized for the DoD, DOE, NASA, and the civilian community. These applications include both low- and high-altitude satellite surveillance missions, communications satellites, planetary probes, low- and high-power lunar and planetary base power systems, broadband global telecommunications, air traffic control, and high-definition television. I.E.

A91-38160
BPE - A REAL-TIME EXPERT SYSTEM FOR AUTONOMOUS POWER MANAGEMENT
ROBERT J. SPIER and MARK E. LIFFRING (Boeing Aerospace and Electronics, Seattle, WA) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 6. New York, American Institute of Chemical Engineers, 1990, p. 21-25. refs
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The most recent developments in the Boeing Aerospace Autonomous Power System (APS) testbed are presented. The APS testbed is a dc system with 3-kW capability that was assembled for use in developing improved control techniques for aerospace electrical power systems. The emphasis is on a new expert system shell developed by Boeing specifically for the real-time control of electrical power systems (EPS). The capabilities of this shell, called the Blackboard Programming Environment (BPE), were shown through a series of demonstrations. The advantages of this programming environment for autonomous control and the results of the demonstrations are discussed. I.E.

A91-38163* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

PRELIMINARY FLIGHT TEST RESULTS FROM THE ADVANCED PHOTOVOLTAIC EXPERIMENT

DAVID J. BRINKER (NASA, Lewis Research Center, Cleveland, OH) and JOHN R. HICKEY (Eppley Laboratory, Inc., Newport, RI) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 6. New York, American Institute of Chemical Engineers, 1990, p. 36-41. Previously announced in STAR as N91-11058.

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The Advanced Photovoltaic Experiment is a space flight test designed to provide reference cell standards for photovoltaic measurement as well as to investigate the solar spectrum and the effect of the space environment on solar cells. After a flight of 69 months in low earth orbit as part of the Long Duration Exposure Facility set of experiments, it was retrieved in January, 1990. The electronic data acquisition system functioned as designed, measuring and recording cell performance data over the first 358 days of flight, limited by battery lifetime. Significant physical changes are also readily apparent, including erosion of front surface paint, micrometeoroid and debris catering and contamination. Author

A91-38164

THE TIME DEPENDENCE OF THE POWER PRODUCTION CAPABILITY OF NAVSTAR GLOBAL POSITIONING SYSTEM SATELLITES

EDWARD J. SIMBURGER, GEORGE COLLINS, WARREN C. HWANG, GRAHAM S. ARNOLD, DEAN C. MARVIN (Aerospace Corp., El Segundo, CA) et al. IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 6. New York, American Institute of Chemical Engineers, 1990, p. 42-45. refs

(Contract F04701-88-C-0089; F04701-81-C-0031)

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Analysis of the performance of NAVSTAR Block I satellite power systems has revealed an unanticipated level of degradation. Further data are presented on the performance of the power systems on one of the early Block I vehicles. It has been proposed that the origin of this anomalous degradation is photochemical deposition of contaminant films on the surface on the solar array. More detailed modeling of contaminant flow to the solar array supports this hypothesis. A flight test planned for a Block IIA vehicle will more definitively test the efficacy of preventing this degradation mechanism by sealing vehicle body vents. I.E.

A91-38167

NICKEL-HYDROGEN LOW EARTH ORBIT TESTING AT MARTIN MARIETTA SPACE SYSTEMS

GERALD W. BYERS (Martin Marietta Astronautics Group, Denver, CO) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 6. New York, American Institute of Chemical Engineers, 1990, p. 65-68.

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An extensive test program was initiated to establish a LEO database for nickel-hydrogen, individual pressure vessel (IPV) cells. The main object of this test program was to determine whether or not a 10 C, 40 percent DoD LEO test regime could be supported for 20,000 cycles. Eighty-two nickel-hydrogen cells with a name plate capacity rating of 50 A-h were initially procured. Actual testing was initiated in 1985. Since then, an additional twenty-four 50-A-h cells and twenty-one 100-A cells have been added to the test program, totaling 127 cells. The majority of cells tested contained a 31 percent KOH concentration at activation, although 9 cells were activated using a KOH concentration of 26 percent. An additional 6 cells which maintain a 31 percent KOH concentration under life test were supplied. Cycles completed range from 511 to over 20,000 with 35 cell failures, primarily in the 60 percent DoD test groups. An overview of the nickel-hydrogen LEO test program is presented. I.E.

A91-38168

EFFECT OF REVERSAL AND HIGH TEMPERATURES ON THE PERFORMANCE OF NI/H2 CELLS

H. VAIDYANATHAN and K. BURCH (COMSAT Laboratories, Clarksburg, MD) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 6. New York, American Institute of Chemical Engineers, 1990, p. 69-72. Research sponsored by INTELSAT and COMSAT.

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Continued interest in enhancing the reliability of nickel/hydrogen (Ni/H2) cells has prompted an examination of reversal and the effect of temperature on cell performance. Two types of flight configuration cells representative of the batteries used in the Intelsat V and Intelsat VI programs are used in this investigation. Controlled reversal of Ni/H2 cells results in voltages of -0.119 and -1.6 V for positive- and negative-limited cells, respectively. The -1.6 V obtained for negative-limited cells could be caused by oxygen evolution on the negative electrode and hydrogen evolution on the positive electrode and appears to be highly polarized. One major consequence of reversal is that capacity declines with extended storage. Cell capacity is found to decrease nonlinearly with increased temperature. However, the curve shows an inversion at about 50 C, which is attributed to structural changes in the positive active material. I.E.

A91-38169

NICKEL ELECTRODE DEVELOPMENT FOR SPACE STATION CELLS

MARSHA DAMAN (Ford Aerospace Corp., Palo Alto, CA), ARNOLD HALL, and PHILIP RUSSELL (Yardney Technical Products, Inc., Pawcatuck, CT) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 6. New York, American Institute of Chemical Engineers, 1990, p. 73-78.

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A multipath program that quantifies opportunities for improving the life and capacity of the nickel electrode in nickel-hydrogen battery cells for the Space Station Freedom is described. The effort has been undertaken in three stages: a powder-sintering study, a laboratory electrochemical impregnation (EI) sensitivity investigation, and stress testing of production manufactured electrodes. The initial results indicate that powder type and process conditions are important factors that influence electrode performance. By judicious selection of powder and process parameters, electrode performance and life can be improved in response to initial stress tests. I.E.

A91-38170

EUTELSAT II NICKEL-HYDROGEN STORAGE BATTERY SYSTEM DESIGN AND PERFORMANCE SUMMARY

PHILLIP DUFF (Eagle-Picher Industries, Inc., Joplin, MO) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 6. New York, American Institute of Chemical Engineers, 1990, p. 79-84.

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The Eutelsat II nickel-hydrogen battery system was designed to supply electrical energy for prelaunch, launch, transfer, and geosynchronous orbit, including solar eclipses and peak load operations. The battery system, designated the SAR-10009 battery, consists of twenty-seven hermetically sealed nickel-hydrogen cells electrically connected in series. This battery system provides two main power outputs (power bus and pyro bus) and features three thermal sensors, two system control heating elements, resistive grounding, insulated captivated mounting provisions, individual cell bypass diode circuitry for open circuit protection, redundant electrical insulation, conformal coating, and three electrical interface connectors. The author outlines the major design features of the system and the results obtained from qualification and acceptance-level testing. I.E.

A91-38171

DEVELOPMENT OF COMMON PRESSURE VESSEL NICKEL/HYDROGEN BATTERIES

J. ZAGRODNIK and K. JONES (Johnson Controls, Inc., Milwaukee, WI) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 6. New York, American Institute of Chemical Engineers, 1990, p. 85-90. DOE-supported research. refs

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The individual pressure vessel (IPV) nickel/hydrogen battery, well established as an energy storage subsystem for commercial communication satellites, was adapted to terrestrial applications by developing unique design features and implementing standardized production methods that have resulted in substantial reductions in cost. One of the key design variations of the terrestrial battery is the use of a common pressure vessel (CPV). Although the potential advantages of the CPV concept have been recognized for some time, practical application was inhibited by several design issues. These included concerns of electrolyte bridging between cells, electrolyte/oxygen management, and heat dissipation. CPV battery technology for terrestrial and aerospace applications is discussed. I.E.

A91-38182* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

PRELIMINARY DESIGNS FOR 25 KWE ADVANCED STIRLING CONVERSION SYSTEMS FOR DISH ELECTRIC APPLICATIONS

RICHARD K. SHALTENS and JEFFREY G. SCHREIBER (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 6. New York, American Institute of Chemical Engineers, 1990, p. 310-316. Previously announced in STAR as N90-26729. refs

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Under the Department of Energy's (DOE) Solar Thermal Technology Program, Sandia National Laboratories is evaluating heat engines for terrestrial Solar Distributed Heat Receivers. The Stirling engine has been identified by Sandia as one of the most promising engines for terrestrial applications. The Stirling engine also has the potential to meet DOE's performance and cost goals. The NASA Lewis Research Center is conducting Stirling engine technology development activities directed toward a dynamic power source for space applications. Space power systems requirements include high reliability, very long life, low vibration and high efficiency. The free-piston Stirling engine has the potential for future high power space conversion systems, either nuclear or solar powered. Although both applications appear to be quite different, their requirements complement each other. Preliminary designs feature a free-piston Stirling engine, a liquid metal heat transport system, and a means to provide nominally 25 kW electric power to a utility grid while meeting DOE's performance and long term cost goals. The Cummins design incorporates a linear alternator to provide the electrical output, while the STC design generates electrical power indirectly through a hydraulic pump/motor coupled to an induction generator. Both designs for the ASCS's will use technology which can reasonably be expected to be available in the early 1990's. Author

A91-38933*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

SP-100 NUCLEAR SPACE POWER SYSTEMS WITH APPLICATION TO SPACE COMMERCIALIZATION

J. M. SMITH (NASA, Lewis Research Center, Cleveland, OH) IN: Space commercialization: Launch vehicles and programs; Symposium on Space Commercialization: Roles of Developing Countries, Nashville, TN, Mar. 5-10, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 106-120. refs

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The technology of the SP-100 space nuclear power system program is compared to that of more familiar solar-power systems. The SP-100 program develops, validates, and demonstrates the technology for space nuclear power systems in the range of 10 to 1000 kilowatts electric for use in future military and civilian space missions. Mission applications, including earth orbiting platforms and lunar/Mars surface power, are enhanced or made possible by SP-100 technology. Attention is given to the SP-100 reference flight system design, the SP-100 nuclear reactor and nuclear-reactor shield, the platform-mounted, tethered, and free-flying reactors, and installation, operation, and disposal options, as well as lunar-Mars surface applications. The SP-100 is presented as one of the nuclear energy sources needed for long-life, compact, lightweight, continuous high power independent of solar orientation, specific orbits, or missions. P.D.

A91-39772

ENERGY MANAGEMENT ONBOARD THE SPACE STATION - A RULE-BASED APPROACH

MOUNIR BOUZGUENDA and SAIFUR RAHMAN (Virginia Polytechnic Institute and State University, Blacksburg) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. 27, March 1991, p. 302-310. refs

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The logic and the schedule for a rule-based optimization technique useful for energy management onboard the space station are presented. A diverse array of experiments is scheduled within the constraints of limited solar energy and battery storage availability, taking into account the uneven energy supply between the sunshine and eclipse periods and the occasional need to serve a peak load and the full battery charging load simultaneously. In addition, the noninterruptible and nonrestartable nature of many experiments has to be accounted for in the schedule. These factors have been accounted for by using various time intervals and priority weighting factors. Supply/demand windows of various durations are tested for the typical load profile. This shows under what circumstances fewer scheduling tasks are needed and how a closer match between the supply and demand can be obtained. The optimal supply/demand is expressed in terms of the excess and shortage of electricity, the peak load, and the time displacement of the individual payloads. This technique is implemented using PROLOG and FORTRAN. I.E.

A91-39823

ALLOCATING POWER TO SCHEDULE LOADS AND CHARGE BATTERIES ON THE SPACE STATION

T. J. SHESKIN (Cleveland State University, OH) British Interplanetary Society, Journal (ISSN 0007-094X), vol. 44, June 1991, p. 262-268. refs

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Research intended to allocate electric power for scheduling loads and charging batteries on the International Space Station is discussed, and a simplified model of power flow is presented. The model forms the basis for a binary integer programing formulation which allocates power to user loads scheduled to operate during an orbit. Batteries on the Space Station, charged by photovoltaic arrays during the solar portion of an orbit, will supply power during the eclipse portion. A computational procedure is developed for distributing surplus power to charge the batteries after power has been allocated to the loads. An example problem solution using a commercial integer programing code is given. O.G.

A91-41876

IEEE PHOTOVOLTAIC SPECIALISTS CONFERENCE, 21ST, KISSIMMEE, FL, MAY 21-25, 1990, CONFERENCE RECORD. VOLS. 1 & 2

New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. Vol. 1, 861 p.; vol. 2, 889 p. For individual items see A91-41877 to A91-41881, A91-41883 to A91-42029.

Copyright

Various papers on photovoltaics are presented. The general topics discussed include: recent photovoltaic developments, III-V single and multijunction cells, high-efficiency III-V cells, high-efficiency solar cells, silicon solar cells, high-efficiency silicon solar cells, modeling and characterization of single crystal solar cells, thin film compound semiconductors, polycrystalline solar cells, polycrystalline silicon, polycrystalline materials and device characterization, utility PV systems and concentration technology, utility applications and testing, terrestrial systems and array technology, applications and technology of terrestrial systems. Also discussed are: PV module performance and testing, PV system performance and measurement, stand-alone systems and concentrator modules/arrays, space flight experiments and results, space environmental effects, space systems and technology, space solar arrays and components, advanced array technology, amorphous silicon solar cells and modules, amorphous silicon-based cells, amorphous silicon, modeling and stability of amorphous silicon arrays, materials and processing of amorphous silicon, modeling and stability of amorphous silicon. C.D.

A91-41878*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PHOTOVOLTAIC POWER FOR SPACE STATION FREEDOM
COSMO R. BARAONA (NASA, Lewis Research Center, Cleveland, OH) IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 30-35. Previously announced in STAR as N90-21812. refs

Space Station Freedom is described with special attention to its electric power system. The photovoltaic arrays, the battery energy storage system, and the power management and distribution system are also discussed. The current design of Freedom's power system and the system requirements, trade studies, and competing factors which lead to system selections are referenced. This will be the largest power system ever flown in space. This system represents the culmination of many developments that have improved system performance, reduced cost, and improved reliability. Key developments and their evolution into the current space station solar array design are briefly described. The features of the solar cell and the array including the development, design, test, and flight hardware production status are given. Author

A91-41971*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
RECENT RESULTS FROM THE INP HOMOJUNCTION CELL MODULE ON THE LIPS III SPACECRAFT
DAVID J. BRINKER and IRVING WEINBERG (NASA, Lewis Research Center, Cleveland, OH) IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1167-1171. refs

The flight performance of the NASA Lewis Research Center's indium phosphide homojunction cell module on the LIPs III spacecraft is presented. Four n+-p diffused junction cells, an early product of an InP development program, were flown. The voltage range of the data prohibits determination of the open-circuit voltage or the maximum power point. However, analysis of the 32 months of short-circuit current data reveals a slight increase, not the 4 percent decrease expected from radiation tolerance studies. This increase may be due to continual cleaning of possible prelaunch dust contamination or changes in data acquisition system calibration. For all cells, the average short-circuit current remains below prelaunch values. I.E.

A91-41975
THE DESIGN AND PERFORMANCE OF THE HUGHES HS-39C SATELLITE SOLAR ARRAYS FEATURING LARGE AREA SOLAR CELLS
JAY S. FODOR, STEVEN W. GELB, LELAND J. GOLDHAMMER, and DAVID W. MOFFETT (Hughes Aircraft Co., Space and Communications Group, El Segundo, CA) IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1188-1192. refs
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The successful construction of the Hughes HS-393C solar arrays has demonstrated that large-area silicon solar cells are a viable design option for large space solar panels. The solar arrays used on the HS-393C satellite consist of two cylindrical solar panels. Each panel is approximately 12 ft in diameter and over 9 ft tall. The total array power is 1800 W at summer solstice after ten years in geosynchronous orbit. HS-393C is the first commercial satellite to utilize large-area silicon solar cells as the primary power source. These cells offer a significant cost advantage over more conventionally sized solar cells. Analysis after one year in orbit on the first HS-393C indicates that the arrays manufactured from these large-area cells are performing better than expected. I.E.

A91-41977
FIRST SPACE FLIGHT OF INP SOLAR CELLS
M. YAMAGUCHI (NTT, Opto-Electronics Laboratories, Tokai, Japan), T. HAYASHI, A. USHIROKAWA, Y. TAKAHASHI, M. KOUBATA (Institute of Space and Astronautical Science, Sagamihara, Japan) et al. IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1198-1202. refs
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A large-scale, commercial process to produce high-efficiency diffused-junction InP solar cells is developed. Proton-irradiation effects on InP solar cells are also studied. Superior proton-resistance of InP cells is confirmed by defect analysis. 1300 pieces of InP solar cells, with efficiencies of 16-17 percent, were used as the power source for the lunar orbiter of the Japanese scientific satellite MUSES-A, launched in January 1990. The InP solar cells have been demonstrated to be stable in space. I.E.

A91-41980* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PRELIMINARY RESULTS FROM THE ADVANCED PHOTOVOLTAIC EXPERIMENT FLIGHT TEST
DAVID J. BRINKER, RUSSELL E. HART, JR. (NASA, Lewis Research Center, Cleveland, OH), and JOHN R. HICKEY (Eppley Laboratory, Inc., Newport, RI) IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1213-1218.
Copyright

The Advanced Phototovoltaic Experiment is a space flight test designed to provide reference cell standards for photovoltaic measurements and to investigate the solar spectrum and the effect of the space environment on solar cells. After a flight of 69 months in low earth orbit as part of the Long Duration Exposure Facility set of experiments, it was retrieved in January 1990. The electronic data acquisition system functioned as designed, measuring and recording cell performance data over the first 358 days of flight, limited by battery lifetime. Significant physical changes are also readily apparent, including erosion of front surface paint, micrometeoroid and debris cratering, and contamination. I.E.

A91-41981
SPACE PROVEN GAAS SOLAR CELLS - MAIN POWER GENERATION FOR CS-3
N. TAKATA, H. KURAKATA (NASDA, Tsukuba, Japan), S. MATSUDA (High Reliability Component Corp., Japan), T. OKUNO (Telecommunications Satellite Corporation of Japan, Kimitsu), S. YOSHIDA (Mitsubishi Electric Corp., Kita-Itami Works, Itami, Japan) et al. IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1219-1225. refs
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GaAs solar cells were used for the main solar array to satisfy the power requirement for the Japanese domestic communications satellite-3 (CS-3). The authors review the GaAs solar cell performance, reliability, and array assembly for CS-3 and present the on-orbit performance of CS-3 after launch in 1988. The annual radiation degradation rate of the CS03 GaAs solar array was found to be one fourth or one fifth that of the ETS-V and BS-2b Si solar arrays. It was clear from the flight data that the radiation hardness of GaAs solar cells was excellent in comparison with that of Si solar cells. I.E.

A91-41982

IN-FLIGHT PERFORMANCE OF THE SBS-1A SOLAR ARRAY FEATURING ULTRATHIN, HIGH EFFICIENCY SOLAR CELLS

R. D. WILLIAMS, S. W. GELB, and J. S. FODOR (Hughes Aircraft Co., Space and Communications Group, Los Angeles, CA) IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1226-1230. refs

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Ultrathin (0.0025-in) solar cells were selected for use on the Satellite Business System (SBS) 1A solar array to achieve minimum solar array weight and maximum end-of-life solar array power. The design of the ultrathin cell was predicted to produce an improved resistance to radiation degradation and superior current collection efficiency, thus increasing the power per unit area at end of life compared to conventional-thickness silicon solar cells. The ultrathin solar cells were qualified for flight and characterized prior to fabrication of the SBS-1A array. Performance predictions in the mission environment were based on these characteristics and on the measured photovoltaic output of the flight solar cells. The predicted solar array performance has been validated to date within 2 percent by in-flight test data. I.E.

A91-41985

RECENT SOLAR FLARE ACTIVITY AND ITS EFFECT ON IN-ORBIT SOLAR ARRAYS

L. J. GOLDHAMMER (Hughes Aircraft Co., El Segundo, CA) IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1241-1248. refs

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Three major solar proton events (August 12, September 29, and October 19, 1989) have occurred thus far in the 22nd solar cycle. The in-orbit solar array performance of 11 geosynchronous spacecraft was analyzed to determine the effects from these events. The observed degradation was compared to predicted degradations using the flux energy spectra given by the GOES 7 detectors. The observed in-orbit performance degradation to the solar array varied from 2 to 5 percent for current at a given voltage, depending on the type of solar cell, cover-glass thickness, and length of time in orbit. I.E.

A91-41989* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

THE MINI-DOME FRESNEL LENS PHOTOVOLTAIC CONCENTRATOR ARRAY - CURRENT STATUS OF COMPONENT AND PROTOTYPE PANEL TESTING

M. F. PISZCZOR, C. K. SWARTZ (NASA, Lewis Research Center, Cleveland, OH), M. J. O'NEILL, A. J. MCDANAL (Entech, Inc., Dallas, TX), and L. M. FRAAS (Boeing High Technology Center, Seattle, WA) IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1271-1276. refs

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NASA Lewis and ENTECH have been developing a high-efficiency, lightweight space photovoltaic concentrator array. The emphasis of the program has shifted to fabrication and testing of the minidome Fresnel lens and other array components. Prototype lenses have been tested for optical efficiency, with results around 90 percent, and tracking error performance. The results of these tests have been very consistent with the predicted analytical performance. Work has also progressed in the fabrication of the array support structure. Recent advances in 30 percent efficient stacked cell technology will have a significant effect on the array performance. It is concluded that near-term array performance goals of 300 W/sq m and 100 W/kg are feasible. I.E.

A91-41990* Boeing Co., Seattle, WA.

LIGHTWEIGHT CONCENTRATOR MODULE WITH 30 PERCENT AM0 EFFICIENT GAAS/GASB TANDEM CELLS

J. E. AVERY, L. M. FRAAS, V. S. SUNDARAM, N. MANSOORI, J. W. YERKES (Boeing High Technology Center, Seattle, WA), D. J. BRINKER, H. B. CURTIS (NASA, Lewis Research Center, Cleveland, OH), and M. J. O'NEILL (Entech, Inc., Dallas, TX) IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1277-1281. refs

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A concept is presented for an aerospace concentrator module with lightweight domed lenses and 30 percent AM0 efficient GaAs/GaSb tandem solar cell circuits. The performance of transparent GaAs cells is reviewed. NASA's high-altitude jet flight calibration data for recent GaSb cells assembled with bulk GaAs filters are reported, along with subsequent Boeing and NASA measurements of GaSb I-V performance at various light levels and temperatures. The expected performance of a basic two-terminal tandem concentrator circuit with three-to-one voltage matching is discussed. All of the necessary components being developed to assemble complete flight test coupons are shown. Straightforward interconnect and assembly techniques yield voltage matched circuits with near-optimum performance over a wide temperature range. I.E.

A91-41991

INVESTIGATION OF THE REVERSE BIASING OF SOLAR CELLS IN A SPACE ARRAY

R. KIMBER (British Aerospace /Space Systems/, Ltd., Stevenage, England), R. HILL, and N. M. PEARSALL (Newcastle upon Tyne Polytechnic, England) IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1282-1287.

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The investigation of the reverse bias tolerance of a solar cell in a string is performed for cell types used on current designs of British Aerospace satellites. The test schedules used were chosen to represent worst-case reverse bias conditions due to shadowing, array switching, or fracturing of cells. Certain cells showed variations in magnitude of reverse current during the course of the test period. Some cells also showed a history effect, leading to difficulties in the long-term predictability of cell behavior. It is concluded that it is not satisfactory to base estimates of the effects of reverse biasing on cell characteristics measured over the very short time periods normal for automatic measurement systems. Some cell designs appear to have inherent instability in reverse bias, which shows itself only in measurements carried out over time periods of minutes or longer. I.E.

A91-41996

HUBBLE SPACE TELESCOPE SOLAR GENERATOR DESIGN FOR A DECADE IN ORBIT

L. GERLACH, A. FOURNIER-SICRE (ESTEC, Noordwijk, Netherlands), A. FROMBERG (British Aerospace, PLC, Bristol, England), and S. KROEHNERT (Telefunken Systemtechnik GmbH, Wedel, Federal Republic of Germany) IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1308-1313.

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The Space Telescope Solar Array (STSA), which is supplying the power for the Hubble Space Telescope (HST), is the largest flexible solar array built to date, carrying 48,760 back surface field with reflector (BSFR) silicon cells. STSA is designed to survive at least five years in low earth orbit (30,000 thermal cycles) and will supply at least 4400 W at 34 V after four years. STSA had to be designed to survive the aggressive atomic oxygen (ATOX) environment. This was achieved by the development of an ATOX-resistant carrier substrate and of two different types of ATOX-resistant interconnectors. A 10-ohm-cm BSFR solar cell with an extremely smooth surface was developed to ensure a high-quality interconnector weld. The array is protected against shadowing and hot spots by solar cell shunt diodes. Thermal cycling was performed up to 65,000 cycles, which demonstrated that the lifetime of the array should be on the order of ten years. I.E.

A91-41997

STABILITY OF GAAS/GE SOLAR CELLS WITH STANDARD FRONT CONTACTS AFTER LONG-TERM, HIGH-TEMPERATURE EXPOSURE

STEVEN GASNER, GEORGE PACK, MARK GATES, and RON GIVEN (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1314-1319. refs

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A series of accelerated high-temperature soak tests has been performed on GaAs/Ge solar cells with standard front contacts in order to determine their ability to operate on space missions that require the solar array to operate at temperatures up to 250 C for long periods of time. Four soak tests were performed: one at 300 C for 1000 h, one at 300 C for 500 h, and two at temperatures up to 370 C for up to 260 h. The tests used GaAs/Ge solar cells with etch-through front contacts and GaAs/Ge solar cells with a GaAs cap front contact structure. The solar cells in the 300 C soak tests showed no significant degradation. In the other tests, the solar cells showed severe degradation in open-circuit voltage and maximum power. Results of these tests show that these solar cells should be able to operate in temperatures up to 180 C for long periods of time (eight years). If the solar cells are required to operate above 180 C for long periods of time, new contact systems must be developed. I.E.

A91-42000

ELECTRICAL AND THERMAL BEHAVIOUR OF GSR3 TYPE SOLAR ARRAY

J. P. DAVID, J. DUVEAU, J. GUERIN (Aix-Marseille III, Universite, Marseille, France), L. PELENC (Aerospatiale, Cannes-la-Bocca, France), A. MICHEL (CNES, Toulouse, France) et al. IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1334-1339. refs

(Contract CNES-89-5845; CNES-89-5715)

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The authors compare the results obtained for coupled electrical and thermal characteristics of a solar generator in the experimentation done on a representative piece of a GSR3-type solar array in simulated space environment conditions and the corresponding modeling of these characteristics. This work was done in order to study the hot spot phenomenon in solar arrays with silicon BSFR (back surface field with reflector) solar cells when a cell is partially shadowed. Correlations between the electrical and thermal behavior of such cell assemblies observed by infrared thermography are shown and discussed. Local temperatures higher than 200 C have been observed for cells in hot spot situations and for applied electrical power limited to 8.5 W. Large temperature gradients in the structure have also been measured and calculated. No visible damage (under magnification 10x) was detected on the solar cells and the coupon after this test. Good agreement is observed between experimental and theoretical results obtained for different shadowing ratios on two cells of the coupon selected according to their reverse characteristics and for different values of the power supplied to the shadowed cell. I.E.

A91-42001

PERFORMANCE EVALUATION OF CLEFT GAAS/CUINSE2 TANDEM CELL CIRCUITS THROUGH SOLAR SIMULATOR TESTING AND COMPUTER MODELING

R. BURGESS, C. FLORA, and M. SCHNEIDER (Boeing Aerospace and Electronics, Seattle, WA) IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1340-1345. refs

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CLEFT GaAs/CuInSe2 (CIS) tandem cell development has proceeded to circuit fabrication and testing. Solar simulator tests have been conducted to characterize tandem cell circuits under various environments and configurations. Three test panels were fabricated, each containing up to 30 tandem cell modules. These panels contained circuits with the ratio of CIS cells in series to each series GaAs cell from 2:1 to 3:1 (defined as a series ratio), and circuits with 0 percent to 6 percent Imp mismatch between two substrings in series, where each substring consisted of three CIS cells in series to three GaAs cells in parallel. One panel contained a single circuit of ten closely matched 3:1 substrings in series. The electrical performance of these circuits was measured over 18 C to 55 C. Electrical performance test results demonstrated that a 3:1 series ratio maximizes circuit output at 28 C and that current mismatch between substring circuits must be tightly controlled to prevent reverse voltage bias operation. The large circuit measured 21.9 percent efficiency (AM0, 28 C) and demonstrated that, with careful circuit design optimization and cell selection, high efficiency achieved at the individual cell layer can be translated to the string level. I.E.

A91-42002* Kopin Corp., Taunton, MA.

23.5 PERCENT THIN-FILM SPACE CONCENTRATOR CELLS

B. D. DINGLE, R. P. GALE, R. W. MCCLELLAND, M. B. SPITZER (Kopin Corp., Taunton, MA), H. B. CURTIS, and D. J. BRINKER (NASA, Lewis Research Center, Cleveland, OH) IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1346-1349.

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Thin-film AlGaAs-GaAs double-heterostructure concentrator cells were fabricated which exhibit total-area conversion efficiencies as high as 23.5 percent AM0 at 100 suns, 25 C. This is one of the best space concentrators measured to date at NASA and is designed for a thin-film cell without a prismatic coverglass. This solar cell structure consists of a GaAs/AlGaAs film less than 5 micron thick mounted to a glass cover/superstrate, with coplanar back-side contacts. The coverglass is not prismatic. The CLEFT process, a method for mechanically separating epitaxial layers from their substrate, is used to process these cells into thin films. The advantages of single-crystal GaAs are thereby retained, while reducing weight and cutting cost by allowing for substrate reuse. Thin-film cells also have better thermal management capabilities and can be stacked for use in tandem structures. Cell fabrication and performance are described, and directions for further improvements are identified. I.E.

A91-42004*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

PHOTOVOLTAIC SUPERIORITY FOR SPACE STATION FREEDOM POWER IN THE 21ST CENTURY

SHEILA G. BAILEY (NASA, Lewis Research Center, Cleveland, OH), GEOFFREY A. LANDIS (Sverdrup Technology, Inc., Brook Park, OH), and MARIA A. PERINO (Aeritalia S.p.A., Turin, Italy) IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1356-1361. refs

Complete power systems capable of delivering 75 kW of continuous power in low earth orbit have been compared. Performance, liabilities, and advantages are discussed for a shielded nuclear system, a solar dynamic system, and photovoltaic systems, both current Freedom Si design and near-term GaAs/Ge with NaS storage. System components include power generation, storage (if required), heat rejection, power conversion and distribution, structural support, and shielding (if required). Performance parameters indicate the substantial advantage of the GaAs/Ge photovoltaic system, which does not require altering the support structure of the current Freedom design. I.E.

A91-42005* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

MISSION APPLICATIONS FOR ADVANCED PHOTOVOLTAIC SOLAR ARRAYS

PAUL M. STELLA, JOHN L. WEST, ROBERT G. CHAVE, DAVID P. MCGEE, and ALBERT S. YEN (JPL, Pasadena, CA) IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1362-1368.
Copyright

The suitability of the Advanced Photovoltaic Solar Array (APSA) for future space missions was examined by considering the impact on the spacecraft system in general. The lightweight flexible blanket array system was compared to rigid arrays and a radio-isotope thermoelectric generator (RTG) static power source for a wide range of assumed future earth orbiting and interplanetary mission applications. The study approach was to establish assessment criteria and a rating scheme, identify a reference mission set, perform the power system assessment for each mission, and develop conclusions and recommendations to guide future APSA technology development. The authors discuss the three selected power sources, the assessment criteria and rating definitions, and the reference missions. They present the assessment results in a convenient tabular format. It is concluded that the three power sources examined, APSA, conventional solar arrays, and RTGs, can be considered to complement each other. Each power technology has its own range of preferred applications. I.E.

A91-42006

RETRACTABLE PLANAR SPACE PHOTOVOLTAIC ARRAY

E. L. RALPH (Hughes Aircraft Co., Los Angeles, CA), MICHAEL A. CHUNG, and KITT C. REINHARDT (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1369-1373.
(Contract F33615-89-C-2900)
Copyright

An advanced array design based on the recently developed HS-601 oriented flatplate array is described. The advanced design incorporates the use of high-efficiency gallium arsenide on germanium dual-junction solar cells that have BOL (beginning-of-life) efficiencies of greater than 22 percent. Reflections off deployable flatplate shutters increase the sunlight concentration on the planar solar cell panels, resulting in a 30 percent increase in power from the solar cells. Each solar cell panel, 2.16 x 2.54 sq m in size, has a BOL output power of 1667 W at the operating temperature of 81 C. The full-size array, consisting of two wings with three panels/wing, has a BOL output of 10.0 kW and a projected end-of-life output of about 7.7 kW. This advanced solar power structure provides a novel approach for utilizing high-efficiency multibandgap solar cells in a retractable array configuration, thus providing higher efficiency and a more versatile operational design. I.E.

A91-42007

LARGE AREA SPACE SOLAR CELLS - SI OR GAAS

S. KHEMTHONG, H. YOO, N. HANSEN, C. CHU, P. ILES (Applied Solar Energy Corp., City of Industry, CA) et al. IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1374-1377. refs
Copyright

The authors review the status of both large-area silicon and GaAs cells and discuss how GaAs cells may be competitive with silicon cells. It is noted that significant advances have been made in producing silicon solar cells with good efficiencies and large areas. Development cells have shown even higher efficiencies. GaAs solar cells have been in continuous production since 1984. Metalorganic chemical vapor deposition (MOCVD)-grown GaAs on Ge substrates have been in production since mid-1989, and the efficiency has been improving steadily. Large-area GaAs/Ge cells with thicknesses down to 3.5 mil are available in limited quantity. The thin GaAs/Ge cell process is being scaled-up for higher productivity. Current work is directed towards larger cells, possibly with wraparound or wrapthrough contacts. It is pointed out that production experience with GaAs/Ge solar cells is accumulating and cell costs are decreasing steadily. At system levels, GaAs/Ge cells can compare favorably with silicon cells in cost and performance. I.E.

A91-43398*# Sverdrup Technology, Inc., Brook Park, OH.

MOLFLUX ANALYSIS OF THE SSF ELECTRICAL POWER SYSTEM CONTAMINATION

RITA L. COGNION (Sverdrup Technology, Inc., Brook Park, OH) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 6 p. refs
(Contract NAS3-25266)
(AIAA PAPER 91-1328)

The external induced contamination of Space Station Freedom's electrical power system surfaces is assessed using a molecular flow evaluation code, MOLFLUX. Outgassing rates are compared to available experimental data, and deposition to the midregion of both the solar array and the photovoltaic power module thermal control system radiator is calculated using a constant sticking coefficient. An estimate of annual deposition to the solar array due to outgassing is found to be 10 percent of the Space Station Freedom program requirement for maximum allowable deposition, while annual deposition to the radiator is approximately equal to the requirement. Author

A91-43400#

COMPUTATION OF SOLAR ARRAY POWER LOSS FROM MMH/N2O4 ROCKET MOTOR PLUME CONTAMINATION

PAUL T. MA (Lockheed Missiles and Space Co., Inc., Space Systems Div., Sunnyvale, CA) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 8 p. refs
(AIAA PAPER 91-1330) Copyright

Computation of solar array power loss resulting from plume contamination can be accurately and quickly calculated using a derived power law model. The model predictions agree well with test data. The solution model uses spectral transmittance data from measurements with monomethylhydrazinium nitrate (MMH-HNO3). MMH-HNO3 is the key contaminant formed from bipropellant plume impingement. Since solar cell power output is influenced by cell operating temperature and radiation transmission through the contaminant deposit, both of these effects are included in the model. Contamination by other molecular contaminants can also be analyzed with this methodology. Author

A91-44550#

SOLAR DYNAMIC CBC POWER FOR SPACE STATION FREEDOM

WILLIAM B. HARPER, JR., ROBERT V. BOYLE (Allied-Signal Aerospace Co., Garrett Fluid Systems Div., Tempe, AZ), and CHARLES T. KUDIJA (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 35th, Brussels, Belgium, June 11-14, 1990. 6 p. refs
(ASME PAPER 90-GT-70)

NASA has selected a closed-Brayton-cycle (CBC) solar-dynamic-power-conversion system to provide electric power for the growth phase of Space Station Freedom. This selction was based in part on the comparative reduction in solar radiation collection made possible by the high efficiency closed-Brayton-cycle system when compared to the efficiency of static conversion systems. The smaller required collector area results in a significant reduction in drag in the low earth orbit which is planned for the Space Station. Recently under development is the Solar Dynamic Power Generating Subsystem (PGS), which consists of a solar receiver, which accepts sunlight from the multifaceted collector mirror (the concentrator), and a CBC heat engine that converts the solar heat into electricity. This paper reviews the design requirements for the Space Station Solar Dynamic Power Module and presents results of the PGS cycle analysis and preliminary design. Author

A91-44599#
FLEXIBILITY AND ADAPTABILITY OF CLOSED BRAYTON CYCLES ASSOCIATED WITH LOW POWER LEVEL SPACE NUCLEAR HEAT SOURCES
Z. P. TILLIETTE, F. O. CARRE, and E. PROUST (CEA, Centre d'Etudes Nucleaires de Saclay, Gif-sur-Yvette, France) ASME, International Gas Turbine and Aeroengine Congress and Exposition, 35th, Brussels, Belgium, June 11-14, 1990. 8 p. Research sponsored by CNES and CEA. refs
(ASME PAPER 90-GT-164)
The adaptation of the closed Brayton cycle (CBC) in French preliminary studies of space nuclear power systems is discussed. It is shown how CBC arrangements make it possible to limit thermodynamical penalties related to adequate temperature conditions for the ZrH moderator and a sufficiently low reactor inlet temperature. Mass estimates regarding the thermal management subsystem are given. C.D.

A91-45671
ORGANIC WORKING FLUID OPTIMIZATION FOR SPACE POWER CYCLES
G. ANGELINO, E. MACCHI (Milano, Politecnico, Milan, Italy), and C. INVERNIZZI (Brescia, Universita, Italy) IN: Modern research topics in aerospace propulsion - In honor of Corrado Casci. New York, Springer-Verlag, 1991, p. 297-326. refs
Copyright
The advantages of organic fluid space power cycles are studied and compared with alternate options. The principal characteristics of organic power cycles are shown to be predictable with a good level of accuracy through a general methodology, which requires the knowledge of limited information concerning the fluid properties, i.e., specific heat in the ideal gas state, the critical parameters, and a portion of the saturation curve. Based on this theory, the adoption of fluids with a relatively complex molecular structure and condensation at the lowest practically admissable reduced temperature allow a better efficiency than attainable with the use of toluene, which is employed as a reference fluid. It is shown that only the combined optimization of fluid and thermal dynamic variables leads to the definition of an optimum working fluid and power cycle. R.E.P.

A91-50545* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
DEVELOPMENT OF A FUEL CELL FOR THE EMU
PAULA BECKSTROM (NASA, Johnson Space Center, Houston, TX), MATTHEW J. ROSSO, JR., and OTTO J. ADLHART (Ergenics Power Systems, Inc., Wyckoff, NJ) IN: Space Station and advanced EVA technologies; Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990, Technical Papers. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 11-18. refs
(Contract NAS9-17775)
(SAE PAPER 901318) Copyright
The fuel cell technology for the advanced portable life support system is reviewed, using the breadboard test data, and the design concepts are presented for the development of the improved preprototype fuel cell. Subscale test results confirm the suitability of the solid polymer electrolyte fuel cell fueled by hydride stored hydrogen and oxygen for extravehicular mobility unit (EMU) power generation. Issues verified include passive, zero-G product water removal, nonventing operation in the EMU duty cycle, and complete recovery of product water in potable form. The long cycle life and quick rechargeability are confirmed in 600 h of testing including 150 deep discharge cycles. O.G.

A91-52368#
AN AIR FORCE TECHNOLOGISTS' PERSPECTIVE ON THE MILITARY UTILITY OF SPACE NUCLEAR POWER
MICHAEL SCHULLER and DAN MULDER (USAF, Phillips Laboratory, Kirtland AFB, NM) AIAA, NASA, and OAI, Conference on Advanced SEI Technologies, Cleveland, OH, Sept. 4-6, 1991. 7 p. refs
(AIAA PAPER 91-3458)
Air Force technologists at the Phillips Laboratory have studied the integration and use of space nuclear power (SNP) with DoD missions. The missions studied include tactical warning and attack assessment, space based radar, space surveillance, and electric orbit transfer. Based on the results and conclusions of these studies, the AF, DOE, and SDIO initiated a joint program aimed at developing thermionic technology in parallel to the SP-100 program. The goal of this joint program is to develop compact, survivable SNP as a cost effective power system option for mission applications in the early 21st century. Key elements of the program include developing a baseline thermionic SNP system design, assessing Soviet thermionic technology, demonstrating critical technologies, and developing the infrastructure for a viable flight demonstration program, should such an option be pursued. Author

A91-52391#
SPACE EXPLORATION INITIATIVE MISSION ARCHITECTURES UTILIZING SPACE POWER GENERATION AND DISTRIBUTION
JUDITH A. BAMBERGER, EDMUND P. COOMES, and JEFFERY E. DAGLE (Battelle Pacific Northwest Laboratory, Richland, WA) AIAA, NASA, and OAI, Conference on Advanced SEI Technologies, Cleveland, OH, Sept. 4-6, 1991. 9 p. Research supported by SDIO. refs
(Contract DE-AC06-76RL-01830)
(AIAA PAPER 91-3492) Copyright
The power-beaming approach to power generation and distribution in space is presented. Power-beaming technology provides a viable power infrastructure that can be developed sequentially as it is applied to power satellite constellations in earth orbit and to power electric orbital transport vehicles transferring satellites and cargos to geosynchronous orbit and beyond. This approach makes it possible to reduce the initial mass in LEO and thereby significantly lowers launch costs. Coupled with nuclear electric propulsion systems for cargo transport, the technology can be used to provide global power coverage on the lunar surface and on the Mars surface. O.G.

A91-52454*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OVERVIEW OF THE SP-100 PROGRAM
JACK F. MONDT (JPL, Pasadena, CA) AIAA, NASA, and OAI, Conference on Advanced SEI Technologies, Cleveland, OH, Sept. 4-6, 1991. 10 p. refs
(AIAA PAPER 91-3585) Copyright
Technical progress made by the SP-100 Program over the past five years is reviewed. The following advances are discussed: (1) development of the fuel pin which is the thermal power producing component in the system; (2) development of the conductively coupled multi-couple thermoelectric cell components; (3) verification of the predicted structural and electrical performance of the thermoelectric cells; (4) development of fabricating and welding niobium alloy, NbIZr and NbIZr.1C to verify the containment of lithium in space vacuum with no leakage, (5) the containment of nitrogen in the fuel with accurate stoichiometric control and bonded rhenium liners, (6) system mass reduction of 15 percent; and (7) the development of high-temperature, low-cost, low-mass heat pipes for heat rejection to space. O.G.

A91-52455#
PROGRESS IN THE SP-100 FSQ REACTOR DEVELOPMENT
MONTE B. PARKER (Los Alamos National Laboratory, NM) AIAA, NASA, and OAI, Conference on Advanced SEI Technologies, Cleveland, OH, Sept. 4-6, 1991. 6 p.
(AIAA PAPER 91-3586) Copyright
The reactor for the SP-100 Space Power Supply System is described in this paper. The various components that make up the reactor are discussed and the testing programs to assure that the design will meet the SP-100 requirements are described. Author

A91-52457#
SP-100 PROGRESS
J. S. ARMIJO, A. T. JOSLOFF, H. S. BAILEY, and D. N. MATTEO (General Electric Co., Astro-Space Div., Philadelphia, PA) AIAA, NASA, and OAI, Conference on Advanced SEI Technologies, Cleveland, OH, Sept. 4-6, 1991. 9 p. refs
(Contract DE-AC03-86SF-16006)
(AIAA PAPER 91-3588) Copyright

SP-100 technology satisfies the emerging high power requirements that will enable future space missions and is readily adaptable to provide base power for lunar and Martian surface applications. The SP-100 nuclear power reactor can also be coupled to various static and dynamic power conversion systems as they achieve technology readiness. This unique capability expands SP-100's applicability into the range needed for advanced Nuclear Electric Propulsion missions. Major progress has been made in fabricating and testing the technology features that are essential to meeting SP-100's stringent safety, performance, life, and reliability requirements for both civil and defense missions. Author

A91-53282
THE SPACE POWER PROGRAMME OF THE EUROPEAN SPACE AGENCY
K. P. BOGUS, G. DUDLEY, J. HAINES, D. KASSING, and D. O'SULLIVAN (ESTEC, Noordwijk, Netherlands) Space Power - Resources, Manufacturing and Development (ISSN 0883-6272), vol. 10, no. 1, 1991, p. 23-42.
Copyright

The main development activities required in the ESA Space Power Program for missions in LEO, GEO, and various scientific missions are examined. A 120-volt multiple power bus system incorporating failure-tolerant, single-error control loops and new power distribution and protection concepts with improved flexibility for payload reconfigurations for Columbus elements is addressed. Failure-tolerant end-to-end optimized power system architectures for telecommunications missions, advanced silicon and GaAs solar cells, interconnection technologies for 10-yr life in LEO, and high-voltage array concepts with better protection against atomic oxygen, micrometeoroids, and plasma interactions are described. The development of nickel-hydrogen batteries for secondary storage and fuel cells for the Hermes primary storage system is discussed. C.D.

A91-53284
OVERVIEW OF CNES-CEA JOINT PROGRAMME ON SPACE NUCLEAR BRAYTON SYSTEMS
F. CARRE, E. PROUST, S. CHAUDOURNE, P. KEIRLE, Z. TILLIETTE, and B. VRILLON (CEA, Centre d'Etudes Nucleaires de Saclay, Gif-sur-Yvette, France) Space Power - Resources, Manufacturing and Development (ISSN 0883-6272), vol. 10, no. 1, 1991, p. 79-102. refs
Copyright

An overview is given of the present phase of the CNES-CEA Joint Programme on Space Nuclear Brayton Systems. Emphasis is given to three reference design concepts of 20 kWe turboelectric power system covering a wide range of reactor temperatures and relevant technologies. All candidate systems appear to show about equivalent mass performances of 1900 to 2350 kg. No significant advantage is found for the advanced technology very high temperature UN/Li/MoRe-1125 C system at the 20 kWe power level. Differences between the LMFBR and GTGR derivative system relating to operating constraints, launch safety, reliability, extrapolation potential, and development risk are identified. C.D.

N91-21240*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
POWER TECHNOLOGIES AND THE SPACE FUTURE
KARL A. FAYMON, J. STUART FORDYCE, and HENRY W. BRANDHORST, JR. Apr. 1991 24 p Submitted for publication
(Contract RTOP 506-49-21)
(NASA-TM-103649; E-5835; NAS 1.15:103649) Avail: CASI HC A03/MF A01 CSCL 21H

Advancements in space power and energy technologies are critical to serve space development needs and help solve problems on Earth. The availability of low cost power and energy in space will be the hallmark of this advance. Space power will undergo a dramatic change for future space missions. The power systems which have served the U.S. space program so well in the past will not suffice for the missions of the future. This is especially true if the space commercialization is to become a reality. New technologies, and new and different space power architectures and topologies will replace the lower power, low-voltage systems of the past. Efficiencies will be markedly improved, specific powers will be greatly increased, and system lifetimes will be markedly extended. Space power technology is discussed - its past, its current status, and predictions about where it will go in the future. A key problem for power and energy is its cost of affordability. Power must be affordable or it will not serve future needs adequately. This aspect is also specifically addressed. Author

N91-21581*# Analytical Mechanics Associates, Inc., Hampton, VA.
POWER OPTIMAL SINGLE-AXIS ARTICULATING STRATEGIES
RENJITH R. KUMAR and MICHAEL L. HECK Feb. 1991 36 p
(Contract NAS1-18935; RTOP 476-14-15-01)
(NASA-CR-187510; REPT-91-1; NAS 1.26:187510) Avail: CASI HC A03/MF A01 CSCL 20K

Power optimal single axis articulating PV array motion for Space Station Freedom is investigated. The motivation is to eliminate one of the articular joints to reduce Station costs. Optimal (maximum power) Beta tracking is addressed for local vertical local horizontal (LVLH) and non-LVLH attitudes. Effects of intra-array shadowing are also presented. Maximum power availability while Beta tracking is compared to full sun tracking and optimal alpha tracking. The results are quantified in orbital and yearly minimum, maximum, and average values of power availability. Author

N91-22370*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FINDINGS OF THE JOINT WORKSHOP ON EVALUATION OF IMPACTS OF SPACE STATION FREEDOM GROUND CONFIGURATIONS
DALE C. FERGUSON, DAVID B. SNYDER, and RALPH CARRUTH (National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.) 1990 9 p Presented at the Space Environment Analysis Workshop, Noordwijk, Netherlands, 9-12 Oct. 1990; sponsored by ESA
(Contract RTOP 506-41-41)
(NASA-TM-103717; E-5950; NAS 1.15:103717) Avail: CASI HC A02/MF A01 CSCL 22B

A workshop to consider the effects of various proposed Space Station Freedom (SSF) grounding schemes was held. Expert from the plasma interactions community evaluated the impacts of environmental interactions on SSF under each of three proposed grounding schemes. The choice of the grounding scheme for the SSF power system was found to have important implications for SSF design. Interactions of the SSF power system and structure with the low earth orbit (LEO) plasma differ significantly between different grounding schemes. Environmental constraints will require modification of current SSF designs under any grounding scheme. Maintaining the present negative ground scheme may compromise SSF safety, structural integrity, and electromagnetic compatibility, and will increase contamination rates over alternate schemes. Positive grounding of the array requires redesign of the primary power system. Floating the array reduces the number of circuit changes in the primary power system but adds new hardware. Maintaining the present design will affect all parts of SSF. However, no impacts were identified on SSF systems outside of the electrical power system by positively grounding or floating the array. Author

N91-22371*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

FUTURE MISSION OPPORTUNITIES AND REQUIREMENTS FOR ADVANCED SPACE PHOTOVOLTAIC ENERGY CONVERSION TECHNOLOGY

DENNIS J. FLOOD 1990 12 p Presented at the 5th International Photovoltaic Science and Engineering Conference, Kyoto, Japan, 26-30 Nov. 1990; sponsored in part by The Japan Society of Applied Physics, The Inst. of Electrical Engineers of Japan, and Foundation for the Advancement of International Science, Kyoto, Japan, 26-30 November 1990
(Contract RTOP 506-41-11)
(NASA-TM-103661; E-5857; NAS 1.15:103661) Avail: CASI HC A03/MF A01 CSCL 10A

The variety of potential future missions under consideration by NASA will impose a broad range of requirements on space solar arrays, and mandates the development of new solar cells which can offer a wide range of capabilities to mission planners. Major advances in performance have recently been achieved at several laboratories in a variety of solar cell types. Many of those recent advances are reviewed, the areas are examined where possible improvements are yet to be made, and the requirements are discussed that must be met by advanced solar cell if they are to be used in space. The solar cells of interest include single and multiple junction cells which are fabricated from single crystal, polycrystalline and amorphous materials. Single crystal cells on foreign substrates, thin film single crystal cells on superstrates, and multiple junction cells which are either mechanically stacked, monolithically grown, or hybrid structures incorporating both techniques are discussed. Advanced concentrator array technology for space applications is described, and the status of thin film, flexible solar array blanket technology is reported. Author

N91-22781*# Sverdrup Technology, Inc., Brook Park, OH.

AUTONOMOUS POWER SYSTEM INTELLIGENT DIAGNOSIS AND CONTROL

MARK J. RINGER, TODD M. QUINN, and ANTHONY MEROLLA *In* NASA. Goddard Space Flight Center, The 1991 Goddard Conference on Space Applications of Artificial Intelligence p 153-167 May 1991
Avail: CASI HC A03/MF A03 CSCL 09B

The Autonomous Power System (APS) project at NASA Lewis Research Center is designed to demonstrate the abilities of integrated intelligent diagnosis, control, and scheduling techniques to space power distribution hardware. Knowledge-based software provides a robust method of control for highly complex space-based power systems that conventional methods do not allow. The project consists of three elements: the Autonomous Power Expert System (APEX) for fault diagnosis and control, the Autonomous Intelligent Power Scheduler (AIPS) to determine system configuration, and power hardware (Brassboard) to simulate a space based power system. The operation of the Autonomous Power System as a whole is described and the responsibilities of the three elements - APEX, AIPS, and Brassboard - are characterized. A discussion of the methodologies used in each element is provided. Future plans are discussed for the growth of the Autonomous Power System. Author

N91-23054*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

SOLAR POWERED STIRLING CYCLE ELECTRICAL GENERATOR

RICHARD K. SHALTENS *In* National Aeronautics and Space Administration, Technology 2000, Volume 1 p 269-278 Mar. 1991
Avail: CASI HC A02/MF A04 CSCL 10B

Under NASA's Civil Space Technology Initiative (CSTI), the NASA Lewis Research Center is developing the technology needed for free-piston Stirling engines as a candidate power source for space systems in the late 1990's and into the next century. Space power requirements include high efficiency, very long life, high reliability, and low vibration. Furthermore, system weight and operating temperature are important. The free-piston Stirling engine has the potential for a highly reliable engine with long life because it has only a few moving parts, non-contacting gas bearings, and can be hermetically sealed. These attributes of the free-piston Stirling engine also make it a viable candidate for terrestrial applications. In cooperation with the Department of Energy, system designs are currently being completed that feature the free-piston Stirling engine for terrestrial applications. Industry teams were assembled and are currently completing designs for two Advanced Stirling Conversion Systems utilizing technology being developed under the NASA CSTI Program. These systems, when coupled with a parabolic mirror to collect the solar energy, are capable of producing about 25 kW of electricity to a utility grid. Industry has identified a niche market for dish Stirling systems for worldwide remote power application. They believe that these niche markets may play a major role in the introduction of Stirling products into the commercial market. Author

N91-23072*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

RESEARCH AND TECHNOLOGY

1990 149 p
(NASA-TM-103759; NAS 1.15:103759) Avail: CASI HC A07/MF A02 CSCL 05B

A brief but comprehensive review is given of the technical accomplishments of the NASA Lewis Research Center during the past year. Topics covered include instrumentation and controls technology; internal fluid dynamics; aerospace materials, structures, propulsion, and electronics; space flight systems; cryogenic fluids; Space Station Freedom systems engineering, photovoltaic power module, electrical systems, and operations; and engineering and computational support. Author

N91-23231# Ben Gurion Univ. of the Negev, Beersheva (Israel). Center for MHD Studies.

LIQUID-METAL MHD POWER CONVERSION FOR SPACE ELECTRIC SYSTEMS

L. BLUMENAU, HERMAN BRANOVER, A. EL-BOHER, E. SPERO, SEMION SUKORIANSKY, and E. GREENSPAN (Israel Atomic Energy Commission, Beersheba.) 1987 6 p Presented at the 4th Symposium on Space Nuclear Power Systems, Albuquerque, NM, 12-16 Jan. 1987 Sponsored by SOLMECS Corp. N.V. and Chief Scientists Office of the Israel Ministry of Industry and Trade
(SER-S/27; ITN-88-85008) Avail: CASI HC A02/MF A01

A number of LMMHD (Liquid Metal Magneto-Hydro-Dynamic) Power Conversion Systems (PCS) were conceived for SES (Space Electric Systems) applications. Variations of a single-stage PCS operating on the Wet Vapor Cycle can meet demands of most continuous mode applications. A two-stage version and an Ericsson Cycle PCS are also presented. ISA

N91-23234*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

COMPONENT TECHNOLOGY FOR STIRLING POWER CONVERTERS

LANNY G. THIEME 1991 10 p Presented at the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, 4-9 Aug. 1991; sponsored by American Nuclear Society, SAE, American Chemical Society, AIAA, ASME, IEEE, and American Inst. of Chemical Engineers
(Contract RTOP 590-13-11)
(NASA-TM-104387; E-6175; NAS 1.15:104387) Avail: CASI HC A02/MF A01 CSCL 10B

NASA Lewis Research Center has organized a component technology program as part of the efforts to develop Stirling converter technology for space power applications. The Stirling Space Power Program is part of the NASA High Capacity Power Project of the Civil Space Technology Initiative (CSTI). NASA Lewis is also providing technical management for the DOE/Sandia program to develop Stirling converters for solar terrestrial power producing electricity for the utility grid. The primary contractors for the space power and solar terrestrial programs develop component technologies directly related to their goals. This Lewis component technology effort, while coordinated with the main programs, aims at longer term issues, advanced technologies, and independent assessments. An overview of work on linear alternators, engine/alternator/load interactions and controls, heat exchangers, materials, life and reliability, and bearings is presented. Author

N91-24225*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

ENVIRONMENTAL INTERACTIONS OF THE SPACE STATION FREEDOM ELECTRIC POWER SYSTEM

HENRY K. NAHRA and CHENG-YI LU (Rockwell International Corp., Canoga Park, CA.) 1991 8 p Presented at the European Space Power Conference, Florence, Italy, 2-6 Sep. 1991; sponsored by ESA, the Politecnico di Milana, the Italian Space Agency, and the European Power Electronics

(Contract RTOP 474-12-10)

(NASA-TM-104373; E-6177; NAS 1.15:104373) Avail: CASI HC A02/MF A01 CSCL 10B

The Space Station Freedom operates in a low earth orbit (LEO) environment. Such operation results in different potential interactions with the Space Station systems including the Electric Power System (EPS). These potential interactions result in environmental effects which include neutral species effects such as atomic oxygen erosion, effects of micrometeoroid and orbital debris impacts, plasma effects, ionizing radiation, and induced contamination degradation effects. The EPS design and its interactions with the LEO environment are briefly described and the results of analyses and testing programs planned and performed thus far to resolve environmental concerns related to the EPS and its function in LEO environment. Author

N91-24226*# Sverdrup Technology, Inc., Brook Park, OH.

TROUBLE 3: A FAULT DIAGNOSTIC EXPERT SYSTEM FOR SPACE STATION FREEDOM'S POWER SYSTEM Final Report

DAVID B. MANNER Cleveland, OH NASA 1990 54 p

(Contract NAS3-25266; RTOP 488-51-03)

(NASA-CR-187113; E-6188; NAS 1.26:187113) Avail: CASI HC A04/MF A01 CSCL 10B

Designing Space Station Freedom has given NASA many opportunities to develop expert systems that automate onboard operations of space based systems. One such development, TROUBLE 3, an expert system that was designed to automate the fault diagnostics of Space Station Freedom's electric power system is described. TROUBLE 3's design is complicated by the fact that Space Station Freedom's power system is evolving and changing. TROUBLE 3 has to be made flexible enough to handle changes with minimal changes to the program. Three types of expert systems were studied: rule-based, set-covering, and model-based. A set-covering approach was selected for TROUBLE 3 because if offered the needed flexibility that was missing from the other approaches. With this flexibility, TROUBLE 3 is not limited to Space Station Freedom applications, it can easily be adapted to handle any diagnostic system. Author

N91-24227*# Boeing Co., Seattle, WA. Defense and Space Group.

ADVANCED DEVELOPMENT RECEIVER THERMAL VACUUM TESTS WITH COLD WALL Final Report

LEIGH M. SEDGWICK Jun. 1991 282 p

(Contract NAS3-25716; RTOP 474-52-10)

(NASA-CR-187092; NAS 1.26:187092; D180-32816-1) Avail: CASI HC A13/MF A03 CSCL 22B

The first ever testing of a full size solar dynamic heat receiver using high temperature thermal energy storage was completed. The heat receiver was designed to meet the requirements for operation on the Space Station Freedom. The purpose of the test program was to quantify the receiver thermodynamic performance, its operating temperatures, and thermal response to changes in environmental and power module interface boundary conditions. The heat receiver was tested in a vacuum chamber with liquid nitrogen cold shrouds and an aperture cold plate to partially simulate a low Earth orbit environment. The cavity of the receiver was heated by an infrared quartz lamp heater with 30 independently controllable zones to produce flux distributions typical of candidate concentrators. A closed Brayton cycle engine simulator conditioned a helium xenon gas mixture to specific interface conditions to simulate various operational modes of the solar dynamic power module. Inlet gas temperature, pressure, and flow rate were independently varied. A total of 58 simulated orbital cycles were completed during the test conduct period. The test hardware, execution of testing, test data, and post test inspections are described. Author

N91-24232*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

DESIGN OF MULTIHUNDREDWATT DIPS FOR ROBOTIC SPACE MISSIONS

D. J. BENTS, S. M. GENG, J. G. SCHREIBER, C. A. WITHROW, P. C. SCHMITZ, and THOMAS J. MCCOMAS (Florida Univ., Gainesville.) 1991 8 p Proposed for presentation at the 26th Intersociety Energy Conversion Conference, Boston, MA, 4-9 Aug. 1991; cosponsored by ANS, SAE, ACS, AIAA, ASME, IEEE, and AIChE

(Contract NAS3-25266; RTOP 590-13-11)

(NASA-TM-104401; E-6216; NAS 1.15:104401) Avail: CASI HC A02/MF A01 CSCL 21H

Design of a dynamic isotope power system (DIPS) general purpose heat source (GPHS) and small free piston Stirling engine (FPSE) is being pursued as a potential lower cost alternative to radioisotope thermoelectric generators (RTG's). The design is targeted at the power needs of future unmanned deep space and planetary surface exploration missions ranging from scientific probes to SEI precursor missions. These are multihundredwatt missions. The incentive for any dynamic system is that it can save fuel which reduces cost and radiological hazard. However, unlike a conventional DIPS based on turbomachinery converions, the small Stirling DIPS can be advantageously scaled to multihundred watt unit size while preserving size and weight competitiveness with RTG's. Stirling conversion extends the range where dynamic systems are competitive to hundreds of watts (a power range not previously considered for dynamic systems). The challenge of course is to demonstrate reliability similar to RTG experience. Since the competative potential of FPSE as an isotope converter was first identified, work has focused on the feasibility of directly integrating GPHS with the Stirling heater head. Extensive thermal modeling of various radiatively coupled heat source/heater head geometries were performed using data furnished by the developers of FPSE and GPHS. The analysis indicates that, for the 1050 K heater head configurations considered, GPHS fuel clad temperatures remain within safe operating limits under all conditions including shutdown of one engine. Based on these results, preliminary characterizations of multihundred watt units were established. Author

N91-24875# Sandia National Labs., Albuquerque, NM.

MASS AND PERFORMANCE ESTIMATES FOR 5 TO 1000 KW(E) NUCLEAR REACTOR POWER SYSTEMS FOR SPACE APPLICATIONS

L. O. CROPP, D. R. GALLUP, and A. C. MARSHALL Mar. 1991 54 p

(Contract DE-AC04-76DP-00789)

(DE91-010319; SAND-90-0312) Avail: CASI HC A04/MF A01

Masses and radiator areas of typical space nuclear power concepts are estimated as a function of the continuous electrical power required during a ten-year mission. Results are presented as a function of power level in the range of 5 to 1000 kW electrical. Three general reactor types will be discussed: (1) the radiatively cooled Star-C reactor technology with thermionic conversion external to the core; (2) liquid metal cooled technology with pin-type thermionic fuel element conversion in the core; and (3) the liquid metal cooled SP-100 reactor technology with thermoelectric, Brayton, Stirling, and Rankine conversion systems. Mass estimates include all satellite subsystems except the payload itself. Area estimates include radiators to dump waste heat from the power conversion and power conditioning subsystems but not the payload. All system components utilize near-term technology with the exception of the Sp-100 Rankine and refractory Stirling concepts. DOE

N91-25173*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

SENSIBLE HEAT RECEIVER FOR SOLAR DYNAMIC SPACE POWER SYSTEM

MARLA E. PEREZ-DAVIS, JAMES R. GAIER, and CHRIS PETREFSKI (Cleveland State Univ., OH.) 1991 6 p Presented at the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, 4-9 Aug. 1991; sponsored by the American Nuclear Society, SAE, the American Chemical Society, AIAA, ASME, IEEE, and the American Inst. of Chemical Engineers
(Contract RTOP 506-41-41)
(NASA-TM-104393; E-6208; NAS 1.15:104393) Avail: CASI HC A02/MF A01 CSCL 10B

A sensible heat receiver considered in this study uses a vapor grown carbon fiber-carbon (VGCF/C) composite as the thermal storage media and was designed for a 7 kW Brayton engine. The proposed heat receiver stores the required energy to power the system during eclipse in the VGCF/C composite. The heat receiver thermal analysis was conducted through the Systems Improved Numerical Differencing Analyzer and Fluid Integrator (SINDA) software package. The sensible heat receiver compares well with other latent and advanced sensible heat receivers analyzed in other studies while avoiding the problems associated with latent heat storage salts and liquid metal heat pipes. The concept also satisfies the design requirements for a 7 kW Brayton engine system. The weight and size of the system can be optimized by changes in geometry and technology advances for this new material. Author

N91-25184*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

FULL-SIZE SOLAR DYNAMIC HEAT RECEIVER THERMAL-VACUUM TESTS

L. M. SEDGWICK, K. J. KAUFMANN (Boeing Aerospace and Electronics Co., Seattle, WA.), K. L. MCLALLIN, and THOMAS W. KERSLAKE 1991 8 p Presented at the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, 4-9 Aug. 1991; sponsored by the American Nuclear Society, SAE, the American Chemical Society, AIAA, ASME, IEEE, and the American Inst. of Chemical Engineers
(Contract RTOP 474-52-10)
(NASA-TM-104486; E-6332; NAS 1.15:104486) Avail: CASI HC A02/MF A01 CSCL 10B

The testing of a full-size, 120 kW, solar dynamic heat receiver utilizing high-temperature thermal energy storage is described. The purpose of the test program was to quantify receiver thermodynamic performance, operating temperatures, and thermal response to changes in environmental and power module interface boundary conditions. The heat receiver was tested in a vacuum chamber with liquid nitrogen cold shrouds and an aperture cold plate to partly simulate a low-Earth-orbit environment. The cavity of the receiver was heated by an infrared quartz lamp heater with 30 independently controllable zones to allow axially and circumferentially varied flux distributions. A closed-Brayton cycle engine simulator conditioned a helium-xenon gas mixture to specific interface conditions to simulate the various operational modes of the solar dynamic power module on the Space Station Freedom. Inlet gas temperature, pressure, and flow rate were independently varied. A total of 58 simulated orbital cycles, each 94 minutes in duration, was completed during the test conduct period. Author

N91-25680*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

AN AUTONOMOUS FAULT DETECTION, ISOLATION, AND RECOVERY SYSTEM FOR A 20-KHZ ELECTRIC POWER DISTRIBUTION TEST BED

TODD M. QUINN (Sverdrup Technology, Inc., Brook Park, OH.) and JERRY L. WALTERS Jun. 1991 18 p
(Contract NAS3-25266; RTOP 505-12-33)
(NASA-TM-104344; E-6118; NAS 1.15:104344) Avail: CASI HC A03/MF A01 CSCL 09B

Future space explorations will require long term human presence in space. Space environments that provide working and living quarters for manned missions are becoming increasingly larger and more sophisticated. Monitor and control of the space environment subsystems by expert system software, which emulate human reasoning processes, could maintain the health of the subsystems and help reduce the human workload. The autonomous power expert (APEX) system was developed to emulate a human expert's reasoning processes used to diagnose fault conditions in the domain of space power distribution. APEX is a fault detection, isolation, and recovery (FDIR) system, capable of autonomous monitoring and control of the power distribution system. APEX consists of a knowledge base, a data base, an inference engine, and various support and interface software. APEX provides the user with an easy-to-use interactive interface. When a fault is detected, APEX will inform the user of the detection. The user can direct APEX to isolate the probable cause of the fault. Once a fault has been isolated, the user can ask APEX to justify its fault isolation and to recommend actions to correct the fault. APEX implementation and capabilities are discussed. Author

N91-25749*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

DEVELOPMENT OF AN ANALYTICAL TOOL TO STUDY POWER QUALITY OF AC POWER SYSTEMS FOR LARGE SPACECRAFT

L. ALAN KRAFT (Valparaiso Univ., IN.) and M. DAVID KANKAM 1991 7 p Presented at the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, 4-9 Aug. 1991; sponsored by the American Nuclear Society, SAE, the American Chemical Society, AIAA, ASME, IEEE, and American Inst. of Chemical Engineers
(Contract RTOP 506-41-41)
(NASA-TM-104451; E-6292; NAS 1.15:104451) Avail: CASI HC A02/MF A01 CSCL 12B

A harmonic power flow program applicable to space power systems with sources of harmonic distortion is described. The algorithm is a modification of the Electric Power Research Institute's HARMFLO program which assumes a three phase, balanced, AC system with loads of harmonic distortion. The modified power flow program can be used with single phase, AC systems. Early results indicate that the required modifications and the models developed are quite adequate for the analysis of a 20 kHz testbed built by General Dynamics Corporation. This is demonstrated by the acceptable correlation of present results with published data. Although the results are not exact, the discrepancies are relatively small. Author

N91-26202*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

DEVELOPMENT AND TESTING OF A SOURCE SUBSYSTEM FOR THE SUPPORTING DEVELOPMENT PMAD DC TEST BED

ROBERT M. BUTTON 1991 8 p Presented at the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, 4-9 Aug. 1991; sponsored by ANS, SAE, ACS, AIAA, ASME, IEE, and AIChe
(Contract RTOP 474-42-10)
(NASA-TM-104510; E-6378; NAS 1.15:104510) Avail: CASI HC A02/MF A01 CSCL 10B

The supporting Development Power Management and Distribution (PMAD) DC Test Bed is described. Its benefits to the Space Station Freedom Electrical Power System design are discussed along with a short description of how the PMAD DC Test Bed was systematically integrated. The Source Subsystem of the PMAD DC Test Bed consisting of a Sequential Shunt Unit (SSU) and a Battery Charge/Discharge Unit (BCDU) is introduced. The SSU is described in detail and component level test data is presented. Next, the BCDU's operation and design is given along with component level test data. The Source Subsystem is then presented and early data given to demonstrate an effective subsystem design. Author

N91-26204*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Electrical Engineering.
SPACE PLATFORM POWER SYSTEM HARDWARE TESTBED Final Report, Sep. 1990 - Apr. 1991
D. SABLE, A. PATIL, T. SIZEMORE, S. DEUTY, J. NOON, B. H. CHO, and F. C. LEE 21 Jun. 1991 410 p
(Contract NAG5-1232)
(NASA-CR-185839; NAS 1.26:185839) Avail: CASI HC A18/MF A04 CSCL 10B

The scope of the work on the NASA Space Platform includes the design of a multi-module, multi-phase boost regulator, and a voltage-fed, push-pull autotransformer converter for the battery discharger. A buck converter was designed for the charge regulator. Also included is the associated mode control electronics for the charger and discharger, as well as continued development of a comprehensive modeling and simulation tool for the system. The design of the multi-module boost converter is discussed for use as a battery discharger. An alternative battery discharger design is discussed using a voltage-fed, push-pull autotransformer converter. The design of the charge regulator is explained using a simple buck converter. The design of the mode controller and effects of locating the bus filter capacitor bank 20 feet away from the power ORU are discussed. A brief discussion of some alternative topologies for battery charging and discharging is included. The power system modeling is described. Author

N91-27105*# Florida Inst. of Tech., Melbourne. Dept. of Computer Science.
A DESIGN FOR AN INTELLIGENT MONITOR AND CONTROLLER FOR SPACE STATION ELECTRICAL POWER USING PARALLEL DISTRIBUTED PROBLEM SOLVING Final Report
ROBERT A. MORRIS *In* Houston Univ., NASA/ASEE Summer Faculty Fellowship Program, 1990, Volume 2 15 p Dec. 1990
(Contract NGT-44-005-803)
Avail: CASI HC A03/MF A02 CSCL 09C

The emphasis is on defining a set of communicating processes for intelligent spacecraft secondary power distribution and control. The computer hardware and software implementation platform for this work is that of the ADEPTS project at the Johnson Space Center (JSC). The electrical power system design which was used as the basis for this research is that of Space Station Freedom, although the functionality of the processes defined here generalize to any permanent manned space power control application. First, the Space Station Electrical Power Subsystem (EPS) hardware to be monitored is described, followed by a set of scenarios describing typical monitor and control activity. Then, the parallel distributed problem solving approach to knowledge engineering is introduced. There follows a two-step presentation of the intelligent software design for secondary power control. The first step decomposes the problem of monitoring and control into three primary functions. Each of the primary functions is described in detail. Suggestions for refinements and embelishments in design specifications are given. Author

N91-27204*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CONCENTRATOR TESTING USING PROJECTED IMAGES
KENT S. JEFFERIES 1991 16 p Presented at the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, 4-9 Aug. 1991; sponsored by ANS, AIChE, SAE, ACS, AIAA, ASME, and IEEE
(Contract RTOP 474-12-10)
(NASA-TM-104349; E-6129; NAS 1.15:104349) Avail: CASI HC A03/MF A01 CSCL 10B

The projected image system can be used to evaluate concentrator optical properties by comparing images reflected onto the ceiling of the test facility to theoretical facet outlines. This system was tested by comparing ceiling images to facet outlines computed using facet characteristics measured by the digital image radiometer (DIR) optical measuring system. The agreement was good, confirming the accuracy of both optical systems. Six facets were mounted in the centers of the pie sectors of one hexagonal panel. Differences between the facets and facet nonsymmetries were observed in photographs of the ceiling images of these facets. Author

N91-27206*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AN EMTP SYSTEM LEVEL MODEL OF THE PMAD DC TEST BED
NARAYAN V. DRAVID, THOMAS J. KACPURA, and KWA-SUR TAM (Virginia Polytechnic Inst. and State Univ., Blacksburg.) 1991 9 p Presented at the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, 4-9 Aug. 1991; sponsored by ANS, SAE, ACS, AIAA, ASME, IEEE, and AIChE
(Contract RTOP 474-42-10)
(NASA-TM-104515; E-6384; NAS 1.15:104515) Avail: CASI HC A02/MF A01 CSCL 10B

A power management and distribution direct current (PMAD DC) test bed was set up at the NASA Lewis Research Center to investigate Space Station Freedom Electric Power Systems issues. Efficiency of test bed operation significantly improves with a computer simulation model of the test bed as an adjunct tool of investigation. Such a model is developed using the Electromagnetic Transients Program (EMTP) and is available to the test bed developers and experimenters. The computer model is assembled on a modular basis. Device models of different types can be incorporated into the system model with only a few lines of code. A library of the various model types is created for this purpose. Simulation results and corresponding test bed results are presented to demonstrate model validity. Author

N91-27207*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE DEVELOPMENT OF TEST BEDS TO SUPPORT THE DEFINITION AND EVOLUTION OF THE SPACE STATION FREEDOM POWER SYSTEM
JAMES F. SOEDER, ROBERT J. FRYE, and RUDY L. PHILLIPS (Rockwell International Corp., Canoga Park, CA.) 1991 9 p Presented at the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, 4-9 Aug. 1991; sponsored by ANS, SAE, ACS, AIAA, ASME, IEEE, and AIChE
(Contract RTOP 474-42-10)
(NASA-TM-104504; E-6365; NAS 1.15:104504) Avail: CASI HC A02/MF A01 CSCL 10B

Since the beginning of the Space Station Freedom Program (SSFP), the Lewis Research Center (LeRC) and the Rocketdyne Division of Rockwell International have had extensive efforts underway to develop test beds to support the definition of the detailed electrical power system design. Because of the extensive redirections that have taken place in the Space Station Freedom Program in the past several years, the test bed effort was forced to accommodate a large number of changes. A short history of these program changes and their impact on the LeRC test beds is presented to understand how the current test bed configuration has evolved. The current test objectives and the development approach for the current DC Test Bed are discussed. A description of the test bed configuration, along with its power and controller hardware and its software components, is presented. Next, the uses of the test bed during the mature design and verification phase of SSFP are examined. Finally, the uses of the test bed in operation and evolution of the SSF are addressed. Author

N91-27208*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
UPDATE ON RESULTS OF SPRE TESTING AT NASA LEWIS
JAMES E. CAIRELLI, DIANE M. SWEC, WAYNE A. WONG, THOMAS J. DOEBERLING, and FRANK J. MADI (Sverdrup Technology, Inc., Brook Park, OH.) 1991 8 p Presented at the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, 4-9 Aug. 1991; sponsored by ANS, SAE, ACS, AIAA, ASME, IEEE, and AIChE
(Contract RTOP 590-13-11)
(NASA-TM-104425; E-6258; NAS 1.15:104425) Avail: CASI HC A02/MF A01 CSCL 10B

The Space Power Research Engine (SPRE), a free-piston Stirling engine with a linear alternator, is being tested at NASA Lewis Research Center as part of the Civilian Space Technology Initiative (CSTI) as a candidate for high capacity space power. Results are presented from recent SPRE tests designed to investigate the effects of variation in the displacer seal clearance and piston centering port area on engine performance and dynamics. The impact of these variations on PV power and efficiency are presented. Comparisons of the displacer seal clearance tests results with HFAST code predictions show good agreement for PV power, but show poor agreement for PV efficiency. Correlations are presented relating the piston midstroke position to the dynamic Delta P across the piston and the centering port area. Test results indicate that a modest improvement in PV power and efficiency may be realized with a reduction in piston centering port area. Author

N91-27209*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

GROUND TEST PROGRAM FOR A FULL-SIZE SOLAR DYNAMIC HEAT RECEIVER

L. M. SEDGWICK, K. J. KAUFMANN (Boeing Aerospace and Electronics Co., Seattle, WA.), K. L. MCLALLIN, and T. W. KERSLAKE 1991 8 p Presented at the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, 4-9 Aug. 1991; sponsored by ANS, SAE, ACS, AIAA, ASME, IEEE, and AIChE
(Contract RTOP 474-52-10)
(NASA-TM-104485; E-6331; NAS 1.15:104485) Avail: CASI HC A02/MF A01 CSCL 10A

Test hardware, facilities, and procedures were developed to conduct ground testing of a full size, solar dynamic heat receiver in a partially simulated, low Earth orbit environment. The heat receiver was designed to supply 102 kW of thermal energy to a helium and xenon gas mixture continuously over a 94 minute orbit, including up to 36 minutes of eclipse. The purpose of the test program was to quantify the receiver thermodynamic performance, its operating temperatures, and thermal response to changes in environmental and power module interface boundary conditions. The heat receiver was tested in a vacuum chamber using liquid nitrogen cold shrouds and an aperture cold plate. Special test equipment were designed to provide the required ranges in interface boundary conditions that typify those expected or required for operation as part of the solar dynamic power module on the Space Station Freedom. The support hardware includes an infrared quartz lamp heater with 30 independently controllable zones and a closed Brayton cycle engine simulator to circulate and condition the helium xenon gas mixture. The test article, test support hardware, facilities, and instrumentation developed to conduct the ground test program are all described. Author

N91-27210*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

PHOTOVOLTAIC ARRAY SPACE POWER PLUS DIAGNOSTICS EXPERIMENT Final Report, May 1985 - Oct. 1990

D. R. BURGER Nov. 1990 300 p
(Contract NAS7-918; AF PROJ. 2822)
(NASA-CR-188672; NAS 1.26:188672; AD-A235585; PL-TR-91-2002) Avail: CASI HC A13/MF A03 CSCL 10B

The objective is to summarize the five years of hardware development and fabrication represented by the Photovoltaic Array Space Power Plus Diagnostics (PASP Plus) Instrument. The original PASP Experiment requirements and background is presented along with the modifications which were requested to transform the PASP Experiment into the PASP Plus Instrument. The PASP Plus hardware and software is described. Test results for components and subsystems are given as well as final system tests. Also included are appendices which describe the major subsystems and present supporting documentation such as block diagrams, schematics, circuit board artwork, drawings, test procedures and test reports. GRA

N91-27214*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

SOLAR DYNAMIC POWER FOR EARTH ORBITAL AND LUNAR APPLICATIONS

JAMES E. CALOGERAS, MILES O. DUSTIN, and RICHARD R. SECUNDE 1991 12 p Presented at the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, 4-9 Aug. 1991; sponsored by ANS, SAE, ACS, AIAA, ASME, IEEE, and AIChE
(Contract RTOP 506-41-31)
(NASA-TM-104511; E-6379; NAS 1.15:104511) Avail: CASI HC A03/MF A01 CSCL 10B

Development of solar dynamic (SD) technologies for space over the past 25 years by NASA Lewis Research Center brought SD power to the point where it was selected in the design phase of Space Station Freedom Program as the power source for evolutionary growth. More recent studies showed that large cost savings are possible in establishing manufacturing processes at a Lunar Base if SD is considered as a power source. Technology efforts over the past 5 years have made possible lighter, more durable, SD components for these applications. A review of these efforts and respective benefits is presented. Author

N91-27940*# National Aeronautics and Space Administration, Washington, DC.

FUSION ENERGY FOR SPACE MISSIONS IN THE 21ST CENTURY: EXECUTIVE SUMMARY

NORMAN R. SCHULZE Washington Aug. 1991 54 p
(NASA-TM-4297; NAS 1.15:4297) Avail: CASI HC A04/MF A01 CSCL 20H

Future space missions were hypothesized and analyzed, and the energy source of their accomplishment investigated. The missions included manned Mars, scientific outposts to and robotic sample return missions from the outer planets and asteroids, as well as fly-by and rendezvous missions with the Oort Cloud and the nearest star, Alpha Centauri. Space system parametric requirements and operational features were established. The energy means for accomplishing missions where delta v requirements range from 90 km/sec to 30,000 km/sec (High Energy Space Mission) were investigated. The need to develop a power space of this magnitude is a key issue to address if the U.S. civil space program is to continue to advance as mandated by the National Space Policy. Potential energy options which could provide the propulsion and electrical power system and operational requirements were reviewed and evaluated. Fusion energy was considered to be the preferred option and was analyzed in depth. Candidate fusion fuels were evaluated based upon the energy output and neutron flux. Additionally, fusion energy can offer significant safety, environmental, economic, and operational advantages. Reactors exhibiting a highly efficient use of magnetic fields for space use while at the same time offering efficient coupling to an exhaust propellant or to a direct energy convertor for efficient electrical production were examined. Near term approaches were identified. A strategy that will produce fusion powered vehicles as part of the space transportation infrastructure was developed. Space program resources must be directed toward this issue as a matter of the top policy priority. Author

N91-28276# Pacific Northwest Lab., Richland, WA.

SPGD: A CENTRAL POWER SYSTEM FOR SPACE

R. D. WIDRIG 1991 5 p Presented at the SEE/AIAA Meeting: Power From Space, Paris, France, 1-13 Apr. 1991
(Contract DE-AC06-76RL-01830)
(DE91-012610; PNL-SA-18750; CONF-910456-1) Avail: CASI HC A01/MF A01

The Space Power Generation and Distribution (SPGD) concept for providing power to any satellite in earth orbit via power beaming is described. Other applications such as providing power for terrestrial or space exploration purposes are identified. An assessment of SPGD versus conventional space power is summarized concluding SPGD appears extremely attractive for the space future. DOE

N91-28279# Edgerton, Germeshausen and Grier, Inc., Idaho Falls, ID.
SMALL EX-CORE HEAT PIPE THERMIONIC REACTOR CONCEPT (SEHPTR)
M. G. JACOX, R. G. BENNETT, L. B. LUNDBERG, B. G. MILLER, and R. L. DREXLER 1991 6 p Presented at the 26th Intersociety Energy Conversion Engineering (IECE) Conference, Boston, 3-9 Aug. 1991
(Contract DE-AC07-76ID-01570)
(DE91-014073; EGG-M-91251; CONF-910801-6) Avail: CASI HC A02/MF A01

The Idaho National Engineering Laboratory (INEL) has developed an innovative space nuclear power concept with unique features and significant advantages for both Defense and Civilian space missions. The Small Ex-core Heat Pipe Thermionic Reactor (SEHPTR) concept was developed in response to Air Force needs for space nuclear power in the range of 10 to 40 kilowatts. This paper describes the SEHPTR concept and discusses the key technical issues and advantages of such a system. DOE

N91-28776*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DESCRIPTION OF REAL-TIME ADA SOFTWARE IMPLEMENTATION OF A POWER SYSTEM MONITOR FOR THE SPACE STATION FREEDOM PMAD DC TESTBED
KIMBERLY LUDWIG (Sverdrup Technology, Inc., Brook Park, OH.), MICHAEL MACKIN, and THEODORE WRIGHT 1991 8 p Presented at the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, 4-9 Aug. 1991; cosponsored by ANS, SAE, ACS, AIAA, ASME, IEEE, and AIChE
(Contract RTOP 474-42-10)
(NASA-TM-105157; E-6444; NAS 1.15:105157) Avail: CASI HC A02/MF A01 CSCL 09B

The Ada language software development to perform the electrical system monitoring functions for the NASA Lewis Research Center's Power Management and Distribution (PMAD) DC testbed is described. The results of the effort to implement this monitor are presented. The PMAD DC testbed is a reduced-scale prototype of the electrical power system to be used in the Space Station Freedom. The power is controlled by smart switches known as power control components (or switchgear). The power control components are currently coordinated by five Compaq 382/20e computers connected through an 802.4 local area network. One of these computers is designated as the control node with the other four acting as subsidiary controllers. The subsidiary controllers are connected to the power control components with a Mil-Std-1553 network. An operator interface is supplied by adding a sixth computer. The power system monitor algorithm is comprised of several functions including: periodic data acquisition, data smoothing, system performance analysis, and status reporting. Data is collected from the switchgear sensors every 100 milliseconds, then passed through a 2 Hz digital filter. System performance analysis includes power interruption and overcurrent detection. The reporting mechanism notifies an operator of any abnormalities in the system. Once per second, the system monitor provides data to the control node for further processing, such as state estimation. The system monitor required a hardware time interrupt to activate the data acquisition function. The execution time of the code was optimized using an assembly language routine. The routine allows direct vectoring of the processor to Ada language procedures that perform periodic control activities. A summary of the advantages and side effects of this technique are discussed. Author

N91-30186*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
POWER SYSTEMS TESTING
Aug. 1991 17 p *Original contains color illustrations*
(Contract RTOP 474-74-10)
(NASA-TM-104513; E-6383; NAS 1.15:104513) Avail: CASI HC A03/MF A01; 11 functional color pages CSCL 14B

The Space Station Freedom (SSF) will give the U.S. a permanent manned presence in space in 1999. The SSF underwent its final design concept in 1991. Launches of hardware will begin in late 1995, and the SSF will become operational in the man tended configuration in 1997. Additional Space Shuttle flights between 1997 and 1999 will complete the SSF. Along with international partners, a crew of four astronauts will conduct long-term experimentation in the microgravity environment of the orbiting spacecraft. Lewis Research Center, along with its prime contractor, will provide the electrical power system (EPS) for SSF. Two major testing facilities at the Lewis Research Center will support the Lewis EPS. The Power Systems Facility provides test beds for life testing the station batteries and the power management distribution system testbed. This testbed simulates two channels of the EPS. The Space Power Facility at the Lewis Plum Brook Station is the largest vacuum chamber in the world. Within this chamber, a simulated space environment, testing of full-size EPS components will occur. Author

N91-30195*# Martin Marietta Aerospace, Denver, CO. Astronautics Group.
SPACE STATION AUTOMATION OF COMMON MODULE POWER MANAGEMENT AND DISTRIBUTION Interim Final Report
W. MILLER, E. JONES, B. ASHWORTH, J. RIEDESEL, C. MYERS, K. FREEMAN, D. STEELE, R. PALMER, R. WALSH, J. GOHRING et al. Washington NASA Nov. 1989 550 p
(Contract NAS8-36433)
(NASA-CR-4260; NAS 1.26:4260; MCR-89-516) Avail: CASI HC A23/MF A04 CSCL 22B

The purpose is to automate a breadboard level Power Management and Distribution (PMAD) system which possesses many functional characteristics of a specified Space Station power system. The automation system was built upon 20 kHz ac source with redundancy of the power buses. There are two power distribution control units which furnish power to six load centers which in turn enable load circuits based upon a system generated schedule. The progress in building this specified autonomous system is described. Automation of Space Station Module PMAD was accomplished by segmenting the complete task in the following four independent tasks: (1) develop a detailed approach for PMAD automation; (2) define the software and hardware elements of automation; (3) develop the automation system for the PMAD breadboard; and (4) select an appropriate host processing environment. Author

N91-30203*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SPACE PHOTOVOLTAIC RESEARCH AND TECHNOLOGY CONFERENCE
Aug. 1991 471 p The 11th Conference was held in Cleveland, OH, 7-9 May 1991
(Contract RTOP 506-41-11)
(NASA-CP-3121; E-6161; NAS 1.55:3121) Avail: CASI HC A20/MF A04 CSCL 10B

The Eleventh Space Photovoltaic Research and Technology conference was held at NASA Lewis Research Center from May 7 to 9, 1991. The papers and workshop summaries presented here report remarkable progress on a wide variety of approaches in space photovoltaics, both near and far term applications. Papers were presented in a variety of technical areas, including multijunction cell technology, GaAs and InP cells, system studies, cell and array development, and photovoltaics for conversion of laser radiation. Three workshops were held to discuss thin film cell development, III-V cell development, and space environmental effects.

N91-30227*# Sverdrup Technology, Inc., Cleveland, OH.
SPACE POWER BY LASER ILLUMINATION OF PV ARRAYS
GEOFFREY A. LANDIS *In* NASA. Lewis Research Center, Space Photovoltaic Research and Technology Conference 5 p Aug. 1991
Avail: CASI HC A01/MF A04 CSCL 10B

There has recently been a resurgence of interest in the use of beamed power to support space exploration activities. The utility is examined of photovoltaics and problem and research areas are identified for photovoltaics in two beamed-power applications: to convert incident laser radiation to power at a remote receiving station, and as a primary power source on space based power station transmitting power to a remote user. A particular application of recent interest is to use a ground-based free electron laser as a power source for space applications. Specific applications include: night power for a moonbase by laser illumination of the moonbase solar arrays; use of a laser to provide power for satellites in medium and geosynchronous Earth orbit, and a laser powered system for an electrical propulsion orbital transfer vehicle. These and other applications are currently being investigated at NASA Lewis as part of a new program to demonstrate the feasibility of laser transmission of power for space. Author

N91-30228*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

POTENTIAL CONVERTER FOR LASER-POWER BEAMING

GILBERT H. WALKER, MICHAEL D. WILLIAMS, GREGORY L. SCHUSTER, and PETER A. ILES (Applied Solar Energy Corp., City of Industry, CA.) *In* NASA. Lewis Research Center, Space Photovoltaic Research and Technology Conference 5 p Aug. 1991

Avail: CASI HC A01/MF A04 CSCL 10B

Future space missions, such as those associated with the Space Exploration Initiative (SEI), will require large amounts of power for operation of bases, rovers, and orbit transfer vehicles. One method for supplying this power is to beam power from a spaced based or Earth based laser power station to a receiver where laser photons can be converted to electricity. Previous research has described such laser power stations orbiting the Moon and beaming power to a receiver on the surface of the Moon by using arrays of diode lasers. Photovoltaic converters that can be efficiently used with these diode lasers are described. Author

N91-30236*# Air Force Geophysics Lab., Hanscom AFB, MA.

MEASUREMENT OF HIGH-VOLTAGE AND RADIATION-DAMAGE LIMITATIONS TO ADVANCED SOLAR ARRAY PERFORMANCE

D. A. GUIDICE, P. S. SEVERANCE, and K. C. KEINHARDT (Aeronautical Systems Div., Wright-Patterson AFB, OH.) *In* NASA. Lewis Research Center, Space Photovoltaic Research and Technology Conference 10 p Aug. 1991

Avail: CASI HC A02/MF A04 CSCL 10B

A description is given of the reconfigured Photovoltaic Array Space Power (PASP) Plus experiment: its objectives, solar-array complement, and diagnostic sensors. Results from a successful spaceflight will lead to a better understanding of high-voltage and radiation-damage limitations in the operation of new-technology solar arrays. Author

N91-30239*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

RAPID THERMAL CYCLING OF SOLAR ARRAY BLANKET COUPONS FOR SPACE STATION FREEDOM

DAVID A. SCHEIMAN (Sverdrup Technology, Inc., Brook Park, OH.) and BRYAN K. SMITH *In its* Space Photovoltaic Research and Technology Conference 9 p Aug. 1991

(Contract NAS3-25266)

Avail: CASI HC A02/MF A04 CSCL 10B

The NASA Lewis Research Center has been conducting rapid thermal cycling on blanket coupons for Space Station Freedom. This testing includes two designs (8 coupons total) of the solar array. Four coupons were fabricated as part of the Photovoltaic Array Environmental Protection Program (PAEP), NAS3-25079, at Lockheed Missiles and Space Company. These coupons began cycling in early 1989 and have completed 172,000 thermal cycles. Four other coupons were fabricated a year later and included several design changes; cycling of these began in early 1990 and has reached 90,000 cycles. The objective of this testing is to demonstrate the durability or operational lifetime (15 yrs.) of the welded interconnects within a low earth orbit (LEO) thermal cycling environment. The blanket coupons, design changes, test description, status to date including performance and observed anomalies, and any insights related to the testing of these coupons are described. The description of a third design is included. Author

N91-30241*# Johns Hopkins Univ., Laurel, MD. Applied Physics Lab.

GALLIUM ARSENIDE SOLAR CELL RADIATION DAMAGE EXPERIMENT

R. H. MAURER, J. D. KINNISON, G. A. HERBERT, and A. MEULENBERG (Communications Satellite Corp., Clarksburg, MD.) *In* NASA. Lewis Research Center, Space Photovoltaic Research and Technology Conference 11 p Aug. 1991

Avail: CASI HC A03/MF A04 CSCL 10B

Gallium arsenide (GaAs) solar cells for space applications from three different manufactures were irradiated with 10 MeV protons or 1 MeV electrons. The electrical performance of the cells was measured at several fluence levels and compared. Silicon cells were included for reference and comparison. All the GaAs cell types performed similarly throughout the testing and showed a 36 to 56 percent power areal density advantage over the silicon cells. Thinner (8-mil versus 12-mil) GaAs cells provide a significant weight reduction. The use of germanium (Ge) substrates to improve mechanical integrity can be implemented with little impact on end of life performance in a radiation environment. Author

N91-30248*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

LOW EARTH ORBITAL ATOMIC OXYGEN MICROMETEOROID, AND DEBRIS INTERACTIONS WITH PHOTOVOLTAIC ARRAYS

BRUCE A. BANKS, SHARON K. RUTLEDGE, and KIM K. DEGROH *In its* Space Photovoltaic Research and Technology Conference 10 p Aug. 1991

Avail: CASI HC A02/MF A04 CSCL 10B

Polyimide Kapton solar array blankets can be protected from atomic oxygen in low earth orbit if SiO sub x thin film coatings are applied to their surfaces. The useful lifetime of a blanket protected in this manner strongly depends on the number and size of defects in the protective coatings. Atomic oxygen degradation is dominated by undercutting at defects in protective coatings caused by substrate roughness and processing rather than micrometeoroid or debris impacts. Recent findings from the Long Duration Exposure Facility (LDEF) and ground based studies show that interactions between atomic oxygen and silicones may cause grazing and contamination problems which may lead to solar array degradation. Author

N91-30249*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

LEO SPACE PLASMA INTERACTIONS

DALE C. FERGUSON *In its* Space Photovoltaic Research and Technology Conference 11 p Aug. 1991

Avail: CASI HC A03/MF A04 CSCL 10B

Photovoltaic arrays interact with the low earth orbit (LEO) space plasma in two fundamentally different ways. One way is the steady collection of current from the plasma onto exposed conductors and semiconductors. The relative currents collected by different parts of the array will then determine the floating potential of the spacecraft. In addition, these steady state collected currents may lead to sputtering or heating of the array by the ions or electrons collected, respectively. The second kind of interaction is the short time scale arc into the space plasma, which may deplete the array and/or spacecraft of stored charge, damage solar cells, and produce EMI. Such arcs only occur at high negative potentials relative to the space plasma potential, and depend on the steady state ion currents being collected. New high voltage solar arrays being incorporated into advanced spacecraft and space platforms may be endangered by these plasma interactions. Recent advances in laboratory testing and current collection modeling promise the capability of controlling, and perhaps even using, these space plasma interactions to enable design of reliable high voltage space power systems. Some of the new results may have an impact on solar cell spacing and/or coverslide design. Planned space flight experiments are necessary to confirm the models of high voltage solar array plasma interactions. Finally, computerized, integrated plasma interactions design tools are being constructed to place plasma interactions models into the hands of the spacecraft designer. Author

N91-30250*# Wayne State Univ., Detroit, MI. Dept. of Electrical and Computer Engineering.

THIN FILM CELL DEVELOPMENT WORKSHOP REPORT

JAMES R. WOODYARD *In* NASA. Lewis Research Center, Space Photovoltaic Research and Technology Conference 12 p Aug. 1991

Avail: CASI HC A03/MF A04 CSCL 10B

The Thin Film Development Workshop provided an opportunity for those interested in space applications of thin film cells to debate several topics. The unique characteristics of thin film cells as well as a number of other issues were covered during the discussions. The potential of thin film cells, key research and development issues, manufacturing issues, radiation damage, substrates, and space qualification of thin film cells were discussed. Author

N91-30265*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

ON PROTECTION OF FREEDOM'S SOLAR DYNAMIC RADIATOR FROM THE ORBITAL DEBRIS ENVIRONMENT. PART 2: FURTHER TESTING AND ANALYSES

JENNIFER L. RHATIGAN, ERIC L. CHRISTIANSEN, and MICHAEL L. FLEMING (LTV Missiles and Electronics Group, Dallas, TX.) 1991 11 p Proposed for presentation at the International Solar Energy Conference, Lahaina, Maui, HI, 4-8 Apr. 1992; sponsored by ASME

(Contract RTOP 474-52-10)

(NASA-TM-104514; E-6335; NAS 1.15:104514) Avail: CASI HC A03/MF A01 CSCL 21H

Presented here are results of a test program undertaken to further define the response of the solar dynamic radiator to hypervelocity impact (HVI). Tests were conducted on representative radiator panels (under ambient, nonoperating conditions) over a range of velocity. Target parameters are also varied. Data indicate that analytical penetration predictions are conservative (i.e., pessimistic) for the specific configuration of the solar dynamic radiator. Test results are used to define the solar dynamic radiator reliability with respect to HVI more rigorously than previous studies. Test data, reliability, and survivability results are presented. Author

N91-30266*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

DESCRIPTION OF THE CONTROL SYSTEM DESIGN FOR THE SSF PMAD DC TESTBED

ANASTACIO N. BAEZ and GREG L. KIMNACH 1991 10 p Presented at the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, 4-9 Aug. 1991; sponsored by ANS, SAE, ACS, AIAA, ASME, IEEE, and AIChE

(Contract RTOP 474-42-10)

(NASA-TM-105202; E-6505; NAS 1.15:105202) Avail: CASI HC A02/MF A01 CSCL 21H

The Power Management and Distribution (PMAD) DC Testbed Control System for Space Station Freedom was developed using a top down approach based on classical control system and conventional terrestrial power utilities design techniques. The design methodology includes the development of a testbed operating concept. This operating concept describes the operation of the testbed under all possible scenarios. A unique set of operating states was identified and a description of each state, along with state transitions, was generated. Each state is represented by a unique set of attributes and constraints, and its description reflects the degree of system security within which the power system is operating. Using the testbed operating states description, a functional design for the control system was developed. This functional design consists of a functional outline, a text description, and a logical flowchart for all the major control system functions. Described here are the control system design techniques, various control system functions, and the status of the design and implementation. Author

N91-30267*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

TEST AND EVALUATION OF LOAD CONVERTER TOPOLOGIES USED IN THE SPACE STATION FREEDOM POWER MANAGEMENT AND DISTRIBUTION DC TEST BED

RAMON C. LEBRON, ANGELA C. OLIVER, and ROBERT F. BODI (Analytical Engineering Corp., North Olmsted, OH.) 1991 9 p Presented at the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, 4-9 Aug. 1991; cosponsored by the ANS, SAE, ACS, AIAA, ASME, IEEE, and AIChE

(Contract RTOP 474-42-10)

(NASA-TM-105217; E-6532; NAS 1.15:105217) Avail: CASI HC A02/MF A01 CSCL 21H

Power components hardware in support of the Space Station Freedom dc Electrical Power System were tested. One type of breadboard hardware tested is the dc Load Converter Unit, which constitutes the power interface between the electric power system and the actual load. These units are dc to dc converters that provide the final system regulation before power is delivered to the load. Three load converters were tested: a series resonant converter, a series inductor switchmode converter, and a switching full-bridge forward converter. The topology, operation principles, and tests results are described, in general. A comparative analysis of the three units is given with respect to efficiency, regulation, short circuit behavior (protection), and transient characteristics. Author

N91-31023*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

STATUS OF THE ADVANCED STIRLING CONVERSION SYSTEM PROJECT FOR 25 KW DISH STIRLING APPLICATIONS Final Report

RICHARD K. SHALTENS and JEFFREY G. SCHREIBER 1991 11 p Presented at the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, 4-9 Aug. 1991; cosponsored by ANS, SAE, ACS, AIAA, ASME, IEEE, and AIChE

(Contract DE-AI04-85AL-33408; RTOP 776-81-63)

(NASA-TM-104528; E-6404; DOE/NASA/33408-5; NAS 1.15:104528) Avail: CASI HC A03/MF A01 CSCL 10B

Heat engines were evaluated for terrestrial Solar Distributed Heat Receivers. The Stirling engine was identified as one of the most promising heat engines for terrestrial applications. Technology development is also conducted for Stirling convertors directed toward a dynamic power source for space applications. Space power requirements include high reliability with very long life, low vibration, and high system efficiency. The free-piston Stirling engine has the potential for future high power space conversion systems, either nuclear or solar powered. Although both applications appear to be quite different, their requirements complement each other. Author

N91-31217*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

ADVANCED POWER SYSTEMS FOR EOS

SHEILA G. BAILEY, IRVING WEINBERG, and DENNIS J. FLOOD 1991 8 p Presented at the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, 4-9 Aug. 1991; cosponsored by ANS, SAE, ACS, AIAA, ASME, IEEE, and AIChE

(Contract RTOP 506-41-11)

(NASA-TM-105222; E-6536; NAS 1.15:105222) Avail: CASI HC A02/MF A01 CSCL 21H

The Earth Observing System, which is part of the International Mission to Planet Earth, is NASA's main contribution to the Global Change Research Program. Five large platforms are to be launched into polar orbit: two by NASA, two by the European Space Agency, and one by the Japanese. In such an orbit the radiation resistance of indium phosphide solar cells combined with the potential of utilizing 5 micron cell structures yields an increase of 10 percent in the payload capability. If further combined with the Advanced Photovoltaic Solar Array, the total additional payload capability approaches 12 percent. Author

N91-31702# Sandia National Labs., Albuquerque, NM.
THE FEASIBILITY OF TESTING NASA'S SCAD CONCENTRATOR ON EARTH
T. R. MANCINI, C. P. CAMERON, and V. R. GOLDBERG (WG Associates, Dallas, TX.) Jul. 1991 113 p
(Contract DE-AC04-76DP-00789)
(DE91-016055; SAND-89-1724) Avail: CASI HC A06/MF A02

NASA has proposed that the solar concentrator for the manned space station, referred to as the Solar Concentrator Advanced Development (SCAD) dish, undergo terrestrial testing prior to being deployed in space. Because reliable flight concentrator performance is so important, independent tests of the SCAD concentrator are needed to demonstrate the offset parabolic concept and validate the computer codes needed for predicting concentrator flux profile and power generating capability. This report documents the first phase of a three-phase project to test the SCAD concentrator on sun. The three phases of the project are: (1) feasibility of on-sun testing; (2) detailed design and fabrication of test fixtures; and (3) testing and analysis of results. The objectives of Phase 1 are to evaluate the feasibility of testing the concentrator on sun in a terrestrial environment and to determine the potential for accurately predicting its performance in space. The feasibility study includes: an evaluation of terrestrial structures to support and track the concentrator; an assessment of methods for protecting the concentrator from the environment when it is not on test; the selection of the most feasible support structure and protection system; an evaluation of the effects of terrestrial solar power levels and sunshapes on the verification of computer codes for predicting the on-orbit performance of the concentrator; the development of a preliminary test plan complete with procedures and instrumentation; and the development of schedule and cost estimates for Phases 2 and 3 of the project. DOE

N91-31708*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NICKEL-HYDROGEN CELL LOW-EARTH LIFE TEST UPDATE
DAVID T. FRATE 1991 8 p Presented at the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, 4-9 Aug. 1991; cosponsored by ANS, SAE, ACS, AIAA, ASME, IEEE, and AIChE
(Contract RTOP 474-46-10)
(NASA-TM-105229; E-6552; NAS 1.15:105229) Avail: CASI HC A02/MF A01 CSCL 10A

When individual pressure vessel (IPV) nickel-hydrogen (Ni/H2) cells were selected as the energy storage system for the Space Station Freedom in March of 1986, a limited database existed on life and performance characteristics of these cells in a low earth orbit (LEO) regime. Therefore, NASA LeRC initiated a Ni/H2 cell test program with the primary objectives of building a test facility, procuring cells from existing NASA contracts, and screening several cell designs by life testing in a LEO 35 percent depth of discharge (DOD) scenario. A total of 40 cells incorporating 13 designs were purchased from Yardney, Hughes, and Eagle-Picher. Thirty-two of the cells purchased were 65 A-hr nameplate capacity and eight cells were 50 A-hr. Yardney and Eagle-Picher cells were built with both the Air Force recirculating and the advanced back-to-back electrode stack configurations and incorporated 31 and 26 percent KOH. Acceptance testing of the first delivered cells began in March of 1988, with life testing following in September of that year.Performance comparisons of these cells are made here while specifically addressing life test data relative to the design differences. Author

N91-32169# Pacific Northwest Lab., Richland, WA.
A POWER BEAMING BASED INFRASTRUCTURE FOR SPACE POWER
J. A. BAMBERGER Aug. 1991 7 p Presented at the 26th Intersociety Energy Conversion Engineering (IECE) Conference, Boston, MA, 3-9 Aug. 1991
(Contract DE-AC06-76RL-01830)
(DE91-017533; PNL-SA-18950; CONF-910801-21) Avail: CASI HC A02/MF A01

At present all space mission power requirements are met by integral, on-board, self-contained power systems. To provide needed flexibility for space exploration and colonization, an additional approach to on-board, self-contained power systems is needed. Power beaming, an alternative approach to providing power, has the potential to provide increased mission flexibility while reducing total mass launched into space. Laser-power beaming technology provides a viable power and communication infrastructure that can be developed sequentially as it is applied to power satellite constellations in Earth orbit and to orbital transport vehicles transferring satellites and cargos to geosynchronous orbit and beyond. Coupled with nuclear electric propulsion systems for cargo transport, the technology can be used to provide global power to the Lunar surface and to Mars' surface and moons. The technology can be developed sequentially as advances in power system and propulsion system technology occur. This paper presents stepwise development of an infrastructure based on power beaming that can support the space development and exploration goals of the Space Exploration Initiative. Power scenarios based on commonality of power systems hardware with cargo transport vehicles are described. Advantages of this infrastructure are described. DOE

N91-32292# Swiss Center for Electronics and Microtechnology, Inc., Neuchatel.
DEVELOPMENT OF SEMICONDUCTOR TEST STRUCTURES FOR RELIABILITY EVALUATION
P. WEISS and L. ADAMS (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA, ESA Electronic Components Conference p 15-19 Mar. 1991
Copyright Avail: CASI HC A01/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

A reliability test circuit including a full set of specific structures is described. Its patterns address the most significant failure mechanisms for Complementary Metal Oxide Semiconductor (CMOS) technology. The overall layout is specially adapted to reliability testing. Among the implemented structures are diodes, gate oxide capacitors, metal lines for electromigration and corrosion measurements. Paired transistors allow device degradation studies. Latchup patterns and surface ion detectors are included. Results related to electromigration, hot carrier effects and surface ion detection are presented. ESA

N91-32293# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
GAAS/GE SOLAR CELL FOR SPACE APPLICATIONS
JOSE ANTONIO GONZALEZDELAMO *In its* ESA Electronic Components Conference p 21-24 Mar. 1991
Copyright Avail: CASI HC A01/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

GaAs/Ge solar cells offer important advantages over silicon cells for space applications. The use of Ge rather than fragile, expensive GaAs substrates, provides the option of stronger, larger and thinner cells, with all the electrical advantages of GaAs cells. The properties of the interface between the Ge substrate and the GaAs buffer layer are of fundamental importance in order to obtain better GaAs on Ge devices. The properties of the GaAs/Ge interface are studied. The effect of misorientation in the Metal Organic Chemical Vapor Deposition (MOCVD) growth of GaAs epitaxial layers on Ge (100) substrates, and the growth conditions and the measurement problems that arise in the analysis of the GaAs/Ge interface are addressed. ESA

N91-32308# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).

SPACECRAFT POWER SYSTEM CONCERNS REGARDING FAILURE MODES WITHIN COMPLEX INTEGRATED CIRCUITS AND HYBRID PACKAGES

J. E. HAINES *In its* ESA Electronic Components Conference p 121-125 Mar. 1991

Copyright Avail: CASI HC A01/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

Failure modes associated with the utilization of complex integrated circuits and electronic hybrid packages within spacecraft power system designs are presented. With the purpose of highlighting these concerns, application of space qualified power controller integrated circuits and hybrid packaging concepts are considered. Basic rules to be considered when using such devices in spacecraft power systems are outlined. ESA

N91-32411 Virginia Polytechnic Inst. and State Univ., Blacksburg.

MODELING AND ANALYSIS OF SPACECRAFT BATTERY CHARGER SYSTEMS Ph.D. Thesis

SEONG JOONG KIM 1991 254 p

Avail: Univ. Microfilms Order No. DA9123736

Large signal analysis of various spacecraft power systems is performed to predict the bus dynamics in various modes of operation. The large-signal trajectories of the system's operating point are analyzed employing qualitative graphical representation. The analyses are verified through simulation using EASY5 software. Small-signal dynamic characteristics of spacecraft battery charge converter systems are analyzed to facilitate the design of a control loop for optimum performance and stability. Control-loop designs for the charge converters in bus voltage regulation mode, charge current regulation mode, and peak power tracking mode are discussed. Dissert. Abstr.

N91-32557*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

IMPEDANCES OF NICKEL ELECTRODES CYCLED IN VARIOUS KOH CONCENTRATIONS

MARGARET A. REID and PATRICIA L. LOYSELLE *In its* Space Electrochemical Research and Technology p 89-100 Sep. 1991

Avail: CASI HC A03/MF A03 CSCL 10B

Recent tests at Hughes have shown that Ni/H2 cells cycled in 26 percent KOH have much longer lives than those cycled in other concentrations. As part of an ongoing program to try to correlate the impedances of nickel electrodes with their life and performance, impedances were measured of a number of electrodes from these tests that had been cycled in concentrations from 21 to 36 percent KOH. These had ranged from about 1000 to 40,000 cycles. After cycling ten times to reduce possible changes due to storage, impedances were measured at five voltages corresponding to low states of charge. The results were analyzed using a standard circuit model including Warburg impedance term. Lower kinetic resistances and Warburg slopes were found for several electrodes which had been cycled in 26 percent KOH even though they had been cycled for a much longer time than the others. Interpretation of the data is complicated by the fact that the cycle lives, storage times, and failure mechanisms varied. Several other circuit models have also been examined, but the best correlations with life were found with parameters obtained from the simple model. Author

N91-32564*# Johnson Controls, Inc., Milwaukee, WI. Nickel Hydrogen Battery Div.

MULTIPLE CELL COMMON PRESSURE VESSEL NICKEL HYDROGEN BATTERY

JEFFREY P. ZAGRODNIK and KENNETH R. JONES *In* NASA. Lewis Research Center, Space Electrochemical Research and Technology p 209-220 Sep. 1991

Avail: CASI HC A03/MF A03 CSCL 10B

A multiple cell common pressure vessel (CPV) nickel hydrogen battery was developed that offers significant weight, volume, cost, and interfacing advantages over the conventional individual pressure vessel (IPV) nickel hydrogen configuration that is currently used for aerospace applications. The baseline CPV design was successfully demonstrated though the testing of a 26 cell prototype, which completed over 7,000 44 percent depth of discharge LEO cycles. Two-cell boilerplate batteries have now exceeded 12,500 LEO cycles in ongoing laboratory tests. CPV batteries using both nominal 5 and 10 inch diameter vessels are currently available. The flexibility of the design allows these diameters to provide a broad capability for a variety of space applications. Author

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ELECTRONIC SYSTEMS & EQUIPMENT

Design and operation of electrical equipment such as motors, switch gear, connectors and other fixtures.

A91-32350

A ROBUST APPROACH FOR HIGH RESOLUTION FREQUENCY ESTIMATION

SANG GEUN OH (Texas Instruments Computer Science Center, Dallas) and RANGASAMI L. KASHYAP (Purdue University, West Lafayette, IN) IEEE Transactions on Signal Processing (ISSN 1053-587X), vol. 39, March 1991, p. 627-643. SDIO-supported research. refs

(Contract N00014-85-K-0611; NSF CDR-88-03017)

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A robust estimation method for frequencies of received signals is considered. The influence function of a robust estimate is derived for the sinuosidal signals. The variance of the robust estimate is also derived using the influence function. It is found that the robust estimate attains the Cramer-Rao lower bound (CRLB) for the contaminated Gaussian distribution. It is of order O(N-3) and is close to the CRLB for the perfect Gaussian distribution. The authors introduce some basic definitions for the high-resolution frequency estimation method and prove that the robust estimate has the high-resolution property. This property is also confirmed by numerical simulations. I.E.

A91-32351

ON THE FAMILY OF ML SPECTRAL ESTIMATES FOR MIXED SPECTRUM IDENTIFICATION

PETER J. SHERMAN and KANG-NING LOU (Purdue University, West Lafayette, IN) IEEE Transactions on Signal Processing (ISSN 1053-587X), vol. 39, March 1991, p. 644-655. refs

(Contract N00014-89-J-1747)

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A recently developed point spectrum estimation procedure is utilized to arrive at procedures for estimating point spectrum. One procedure is designed for a white continuous spectrum and utilizes only the number of identified point masses, their frequencies, and their maximum likelihood (ML) n values, where n is the ML model order. Another technique, utilizing the autoregressive (AR) spectrum, is useful for an unknown colored continuous spectrum and estimates this spectrum to arrive at local white noise values needed for improved point spectrum estimates. The continuous spectrum is estimated by removing the point spectrum influence from the highest-order AR(n) spectrum available. This influence is characterized, detailing a number of useful properties of the AR(n) and Ml(n) spectra as a function of n. Both point spectrum procedures utilize a root test to detect the presence of point spectrum. Even though this test is asymptotically inconclusive, the monotone convergence properties (from above for point spectrum and from below for continuous spectrum) were sufficient to detect point spectrum at component signal-to-noise ratios of less than 0 dB. For highly colored noise, falsely identified point spectrum is observed. I.E.

A91-32352
MAXIMUM LIKELIHOOD BASED SENSOR ARRAY SIGNAL PROCESSING IN THE BEAMSPACE DOMAIN FOR LOW ANGLE RADAR TRACKING
MICHAEL D. ZOLTOWSKI and TA-SUNG LEE (Purdue University, West Lafayette, IN) IEEE Transactions on Signal Processing (ISSN 1053-587X), vol. 39, March 1991, p. 656-671. General Electric Co.-supported research. refs
(Contract NSF ECS-87-07681)
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A three-dimensional beamspace domain, maximum likelihood (3-D BDML) bearing estimation scheme for low-angle radar tracking is developed for exploitation of the fact that the respective beams associated with any three classical beam-forming vectors which are mutually orthogonal have M-3 nulls in common, where M is the number of elements comprising a uniformly spaced, linear array. Exploitation of this property yields an estimation scheme that is nearly as computationally simplistic as the two-dimensional beamspace bearing estimation technique. To provide robustness to the severe signal cancellation occurring across the array when the direct and specular path signals arrive 180 deg out of phase at the aperture center with roughly equal amplitude, frequency diversity is incorporated into 3-D BDML. The coherent signal subspace concept of Wang and Kaveh (1985) is invoked as a means of retaining the computational simplicity of single-frequency 3-D BDML. It is shown that if the auxiliary frequencies are chosen from a restricted set of special values, the 3 x 3 beamspace-domain-based focusing matrices necessary for coherently combining the target energy at each transmission frequency do not depend on the bearings of the direct and specular signals and are known a priori. Under these conditions, perfect focusing may be achieved at the outset, i.e., without iterating, such that the computational complexity is essentially that associated with single-frequency operation. I.E.

A91-32353
AN EXPERIMENTAL DEMONSTRATION OF IMPROVED DOPPLER PROCESSING PERFORMANCE
RUSSELL D. BROWN (USAF, Rome Air Development Center, Griffiss AFB, NY) and HONG WANG (Syracuse University, NY) IEEE Transactions on Signal Processing (ISSN 1053-587X), vol. 39, March 1991, p. 718-721. refs
(Contract F30602-88-D-0027)
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The authors present the experimental results of applying the wideband modified forward-backward linear prediction (MFBLP) algorithm to radar data obtained in a real target-clutter environment for detection improvement in the Doppler frequency domain. The system used for data acquisition is an L-band radar. The system parameters and specifications relevant to this experiment are given. This experimental demonstration shows that through the application of an appropriate spectral estimation method, Doppler domain processing performance improvements can be achieved with ordinary equipment. Significant signal detection improvement is obtained. Further research topics are suggested. I.E.

A91-32354
NEW ALGORITHM FOR SOLVING BLOCK MATRIX EQUATIONS WITH APPLICATIONS IN 2-D AR SPECTRAL ESTIMATION
MURALI TUMMALA (U.S. Naval Postgraduate School, Monterey, CA) IEEE Transactions on Signal Processing (ISSN 1053-587X), vol. 39, March 1991, p. 759-764. U.S. Navy-supported research. refs
Copyright

The author presents an iterative algorithm to solve Toeplitz and non-Toeplitz block matrix equations. The development is based upon some well-known matrix iterative techniques. The algorithm is developed for the ideal case where the individual blocks in the autocorrelation matrix are Toeplitz, and it is then extended to a more general least squares data formulation case. It is shown that the algorithm requires fewer computations than the direct matrix inversion methods and is very simple to implement. The algorithm is applied to compute the spectral estimates of two-dimensional data of very small size based on the least squares data formulation with a quarter plane support. I.E.

A91-32355
NONPARAMETRIC BISPECTRUM-BASED TIME-DELAY ESTIMATORS FOR MULTIPLE SENSOR DATA
WEIXIN ZHANG (Shanghai University of Technology, People's Republic of China) and MYSORE RAGHUVEER (Rochester Institute of Technology, NY) IEEE Transactions on Signal Processing (ISSN 1053-587X), vol. 39, March 1991, p. 770-774.
(Contract NSF MIP-89-09701)
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When estimating time-delays of signals from sensor outputs, the bispectrum has advantages when the signal has a skewed distribution. The authors provide nonparametric time-delay estimation approaches which exploit the two-dimensional nature of the bispectrum. When dealing with observations from more than a pair of sensors, the new algorithms have computational advantages and, in some cases, show improved performance compared to the nonparametric, bispectrum-based time-delay estimation approach. I.E.

A91-32356
PHOTOSENSITIVE STRUCTURE BASED ON THE HIGH-TEMPERATURE SUPERCONDUCTING CERAMIC YBA2CU3O7 [FOTOCHUVSTVITEL'NAIA STRUKTURA NA OSNOVE VTSP KERAMIKI YBA2CU3O7]
S. S. GASPARIAN and T. A. MNATSAKANIAN (AN ASSR, Institut Fizicheskikh Issledovanii, Ashtarak, Armenian SSR) Pis'ma v Zhurnal Tekhnicheskoi Fiziki (ISSN 0320-0116), vol. 17, Jan. 12, 1991, p. 3-7. In Russian. refs
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The design of a photodetector operating at a wavelength of 0.63 micron based on the high-temperature superconducting ceramic YBa2Cu3O7 is described. The photodetector of this type has a sensitivity of the order of 10 to the -10th W/sq rt Hz at a temperature 84.3 K for a bias current of 25 ma. It is noted that the photodetector design proposed here is far from optimal from the standpoint of heat transfer. Therefore, the sensitivity of such photodetector structures can be increased by using the methods commonly used in the development of classical superconducting bolometers. V.L.

A91-32357
GAS COOLING IN PLASMA BY SOUND [OKHLAZHDENIE GAZA V PLAZME ZVUKOM]
A. R. ARAMIAN, G. A. GALECHIAN, and A. R. MKRTCHIAN (AN ASSR, Institut Prikladnykh Problem Fiziki, Yerevan, Armenian SSR) Pis'ma v Zhurnal Tekhnicheskoi Fiziki (ISSN 0320-0116), vol. 17, Jan. 12, 1991, p. 12-14. In Russian.
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The interaction of acoustic waves with plasma was investigated experimentally using a 100-cm-long discharge tube with an internal diameter of 60 mm. It is found that, as the sound intensity in the discharge increases, the gas temperature at the discharge axis decreases from 433 to 390 K for a current of 90 mA and from 402 to 360 K for a current of 60 mA; the temperature gradient between the discharge axis and the wall decreases from 128 to 55 K and from 94 to 40 K, respectively. The mechanisms of the effect of sound on the gas temperature in the discharge are examined. V.L.

A91-32358
MICRO-, MESO-, AND MACROKINETICS OF SELF-SIMILAR CRACK GROWTH [MIKRO-, MEZO- I MAKROKINETIKA SAMOPODOBNOGO ROSTA TRESHCHIN]
A. S. BALANKIN and V. S. IVANOVA Pis'ma v Zhurnal Tekhnicheskoi Fiziki (ISSN 0320-0116), vol. 17, Jan. 12, 1991, p. 32-36. In Russian. refs
Copyright

An analysis of processes controlling fracture kinetics with allowance for long-range forces leads to a power law dependence of the correlation fluctuation, which is characteristic of fractal structures. The fractal dimension of the wave functions is determined at the mesoscopic level. It is shown that the only self-similarity criterion controlling self-similar crack growth in the case of self-similar fracture is the Poisson coefficient in the elastic region and that the fractal dimension changes periodically within certain limits, which are defined numerically. This conclusion is in good agreement with fractographic data. V.L.

A91-32361
AN ENGINEERING MODEL OF THE MARS ATMOSPHERE FOR THE MARS-94 PROJECT (MA-90) [INZHENERNAIA MODEL' ATMOSFERY MARSA DLIA PROEKTA MARS-94 /MA-90/]
B. I. MOROZ, V. V. KERZHANOVICH, and V. A. KRASNOPOL'SKII Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, Jan.-Feb. 1991, p. 3-84. In Russian. refs
Copyright
The MA-90 engineering model for the Mars-94 project, the Soviet mission to Mars planned for 1994, is described. The project includes an orbiter and a set of descent modules (balloon, small stations, penetrators, and a small rover). The balloon has been shown to be the module that would be the most sensitive to the atmosphere below 10 km. Diverse data pertaining to the development of the Mars-93 project and the MA-90 model are presented. L.M.

A91-32363
CHARACTER OF THE RELATION OF ELECTRON AND PROTON FLUXES OF SOLAR COSMIC RAYS TO MICROWAVE-BURST PARAMETERS [KHARAKTER SVIAZI POTOKOV ELEKTRONOV I PROTONOV SOLNECHNYKH KOSMICHESKIKH LUCHEI S PARAMETRAMI MIKROVOLNOVYKH VSPLESKOV]
V. F. MEL'NIKOV, T. S. PODSTRIGACH, E. I. DAIBOG, and V. G. STOLPOVSKII Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, Jan.-Feb. 1991, p. 95-103. In Russian. refs
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The correlation between solar electron and proton fluxes and microwave bursts increases significantly if the frequency of the spectral maximum and the effective duration of the burst are included in the radio index. It is shown that the connection between SCR protons and the effective burst duration is stronger than between the electrons and the burst duration. It is suggested that this is due to differences in the dynamics of accelerated electrons and protons in flare loops of different sizes. It is concluded that the results obtained can be used for the diagnostics of high-energy particles and the conditions of their escape into interplanetary space according to flare radio emission in the microwave and meter-decameter ranges. L.M.

A91-32366
DUAL ALGORITHMS FOR THE MINIMAX ESTIMATION OF MOTION PARAMETERS IN THE CONTINUOUS FORMULATION [DVOISTVENNYE ALGORITMY MINIMAKSNOGO OTSENIVANIIA PARAMETROV DVIZHENIIA V NEPRERYVNOI POSTANOVKE]
V. N. SOLOV'EV Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, Jan.-Feb. 1991, p. 127-132. In Russian. refs
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The paper examines the problem of estimating trajectory parameters according to observations containing white noise and a process with an unknown correlation function but a known variance. The problem of determining the linear unbiased estimation algorithm, minimizing the guaranteed variance of the estimate, is reduced to the unconstrained minimization of a smooth convex function of the state vector of the estimated system. Some examples of this approach are considered. L.M.

A91-32367
EVOLUTION OF THE SPECIAL ELLIPTICAL ORBITS OF SYNCHRONOUS ARTIFICIAL EARTH SATELLITES [OB EVOLIUTSII OSOBYKH ELLIPTICHESKIKH ORBIT SINKHRONNYKH ISZ]
M. A. VASHKOV'IAK Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, Jan.-Feb. 1991, p. 133-144. In Russian. refs
Copyright
A class of elliptical orbits of artificial earth satellites is studied. The parameters of these orbits are: period of revolution, 1 day, inclination, 60 deg eccentricity 0.5-0.8, argument of the perigee +/- 90 deg. The dependences of the orbital elements on time are obtained from set of linear differential equations in the vicinity of a special solution of the averaged Hill's problem, taking into account the planetary oblateness. These dependences describe satisfactorily the variation of the orbital elements during 5 years. Author

A91-32368
EFFECT OF THE GEOMAGNETIC FIELD ON THE PERIODIC MOTIONS OF A SATELLITE WITH RESPECT TO THE CENTER OF MASS [O VLIIANII GEOMAGNITNOGO POLIA NA PERIODICHESKIE DVIZHENIIA SPUTNIKA OTNOSITEL'NO TSENTRA MASS]
I. M. AKSENENKOVA Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, Jan.-Feb. 1991, p. 145-148. In Russian.
Copyright
The perturbation problem of a Lagrangian top in the case of small potential perturbations is shown to be analogous to the problem of the rotation of a satellite whose center of mass moves in circular orbit in the equatorial plane under the effect of the geomagnetic field, modeled by a dipole field whose axis coincides with the earth's rotation axis. The perturbing factors in this problem are magnetization of the satellite shell and the deviation of its magnetic moment from the dynamic-symmetry axis of the satellite. An analysis is made of the resonance tori of the unperturbed problem in the vicinity of which periodic solutions of the perturbed problem exist. L.M.

A91-32369
EFFECT OF THE NONUNIFORM DENSITY OF CHARGE FORMED ON A SPACECRAFT SURFACE [VLIIANIE NERAVNOMERNOI PLOTNOSTI ZARIADOV, OBRAZUIUSHCHIKHSIA NA POVERKHNOSTI KOSMICHESKOGO APPARATA]
R. M. ZAIDEL' Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, Jan.-Feb. 1991, p. 149, 150. In Russian.
Copyright
The work of Rich and Stringer (1980) concerning the accumulation of charge on a spacecraft surface is extended. It is considered that the spacecraft is charged due to charged particles from the surrounding space as well as due to the emission of photoelectrons from the spacecraft surface under the effect of solar UV radiation. The present work shows that the nonuniform (over the spacecraft surface) emission of charged particles can lead to the generation of a much stronger electric field parallel to the surface than in the case of uniform emission. L.M.

A91-32370
THE POSSIBILITY OF COSMIC RAY GENERATION IN PLASMA PINCHES [O VOZMOZHNOSTI GENERATSII KOSMICHESKIKH LUCHEI V PLAZMENNYKH PINCHAKH]
V. P. VLASOV, S. K. ZHDANOV, and B. A. TRUBNIKOV (Institut Atomnoi Energii; Moskovskii Inzhenerno-Fizicheskii Institut, Moscow, USSR) Fizika Plazmy (ISSN 0367-2921), vol. 16, Dec. 1990, p. 1457-1468. In Russian. refs
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The problem of nonlinear constrictions on a relativistic z-pinch is solved in the narrow channel approximation, and the spectrum of particles accelerated during the expulsion of the plasma jet from the constriction is calculated. The spectrum has a power law form and is close to the observed spectrum of galactic cosmic rays. This is consistent with the well-known hypothesis concerning the generation of cosmic rays in cosmic plasma pinches. V.L.

A91-32372

RELATIVISTIC THEORY OF SEMICYCLOTRON RESONANCES IN A COLLISIONLESS PLASMA [RELIATIVISTSKAIA TEORIIA POLUTSIKLOTRONNYKH RESONANSOV V BESSTOLKNOVITEL'NOI PLAZME]

A. V. GONCHAROV and V. P. MILANT'EV (Universitet Druzhby Narodov, Moscow, USSR) Fizika Plazmy (ISSN 0367-2921), vol. 17, Jan. 1991, p. 47-54. In Russian. refs

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A relativistic kinetic theory is presented for the interaction of magnetized plasma particles with high-frequency wave packets in the semicyclotron resonance region. The theory allows for plasma and electromagnetic field inhomogeneity and nonstationarity effects and also for the effects of nonlinear wave interaction. The problem of semicyclotron absorption of an ordinary wave propagating normal to the external magnetic field is examined as an example. It is shown that semicyclotron absorption of an ordinary wave is a strictly relativistic effect. V.L.

A91-32373

TWO-DIMENSIONAL NONLINEAR LONG-WAVE PERTURBATIONS OF THE ELECTRON FLUX IN A STRIP LINE WITH MAGNETIC INSULATION [DVUMERNYE NELINEINYE DLINNOVOLNOVYE VOZMUSHCHENIIA ELEKTRONNOGO POTOKA V POLOSKOVOI LINII S MAGNITNOI IZOLIATSIEI]

O. I. VASILENKO (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR) Fizika Plazmy (ISSN 0367-2921), vol. 17, Jan. 1991, p. 78-84. In Russian. refs

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The perturbations of the stationary regimes of magnetic insulation of a strip line in the electrode plane, that are dependent on all the coordinates and time, are investigated in the context of cold single-velocity hydrodynamics. In the approximation of perturbation quasi-homogeneity and quasi-stationarity, a series expansion in the small parameter is carried out up to terms allowing for the effect of nonlinearity and dispersion on the linear amplitude behavior. For these, a Kadomtsev-Petviashvili equation is obtained which permits soliton solutions. Field distributions are determined. V.L.

A91-32374

MICROWAVE DISCHARGES IN THE STRATOSPHERE AND THEIR EFFECT ON THE CONDITION OF THE OZONE LAYER [MIKROVOLNOVYE RAZRIADY V STRATOSFERE I IKH VLIIANIE NA SOSTOIANIE OZONNOGO SLOIA]

G. A. ASKAR'IAN, G. M. BATANOV, I. A. KOSSYI, and A. IU. KOSTINSKII (AN SSSR, Institut Obshchei Fiziki, Moscow, USSR) Fizika Plazmy (ISSN 0367-2921), vol. 17, Jan. 1991, p. 85-96. In Russian. refs

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The theory of plasma-chemical processes in microwave discharges in air is presented, and an experiment, conducted over a wide range of pressures and temperatures, is described. The formation of large amounts of nitrogen oxides, associated with the formation of electron-excited nitrogen molecules, is demonstrated. Changes in the chemical composition and optical properties of air due to the release of nitrogen oxide are evaluated. Particular attention is given to the possible detrimental effects of microwave discharges in the stratosphere currently planned by a number of laboratories around the world. V.L.

A91-32376

THE CONDITION OF MICROCIRCULATION IN FLIGHT PERSONNEL DEPENDING ON THE AGE AND THE PRESENCE OF CARDIOVASCULAR DISORDERS [SOSTOIANIE MIKROTSIRKULIATSII U LITS LETNOGO SOSTAVA V ZAVISIMOSTI OT VOZRASTA I NEKOTORYKH ZABOLEVANII SERDECHNO-SOSUDISTOI SISTEMY]

O. K. VEKLICH and E. G. MUKHAMEDOV Voenno-Meditsinskii Zhurnal (ISSN 0026-9050), Dec. 1990, p. 46-48. In Russian. refs

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The use of conjunctival biomicroscopy in evaluating the condition of microcirculation was investigated in 105 subjects. Of these, 56 subjects were healthy, 16 were affected by atherosclerosis of aorta and cardiac veins without showing symptoms of coronary insufficiency, 21 had a latent form of chronic ischemic disease, and 12 had symptoms of first-stage hypertonia. It was shown that the conjunctival biomicroscopy method could identify the pathology of conjunctival microvessels at the early stages of cardiovascular disorders and could differentiate between ischemic heart disease, atherosclerosis, and hypertonia. It is noted that healthy subjects may display changes in venous microcirculation and that, in subjects at least 40 years old, there often occurred signs of erythrocyte aggregation in individual venulae. I.S.

A91-32377

CHARACTERISTICS OF CALCIUM AND PHOSPHORUS METABOLISM UNDER CONDITIONS WHEN THE ENVIRONMENT IS CHANGED [OSOBENNOSTI OBMENA KAL'TSIIA I FOSFORA V ORGANIZME V USLOVIIAKH IZMENENNOI SREDY OBITANIIA]

M. A. GREBENIK, A. A. MAKHNENKO, A. A. SHAPOVALOV, V. I. POPOV, and S. T. SERGEEV Voenno-Meditsinskii Zhurnal (ISSN 0026-9050), Dec. 1990, p. 48-52. In Russian.

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The effects of hypokinesia, insufficient UV irradiation, and the composition of inhaled gas on the characteristics of calcium and phosphorus metabolism of humans subjected to four months of residence in hermetically sealed quarters were investigated. Subjects were divided into three groups: (1) subjects who performed physical exercises and were daily subjected to UV irradiation at 0.15 'minimal erythema dose' (MED); (2) subjects who did not exercise and who received no UV irradiation; and (3) subjects who did not exercise but who received a daily UV dose of 0.05 MED. The composition of oxygen in the gas mixture varied from 21.3 to 26.3 kPa, while the CO_2 composition varied from 0.1 to 0.4 kPa. It was found that the parameters of Ca and P metabolism were negatively affected by all three factors (hypokinesia, insufficient UV, and the deviations from the atmospheric contents of O_2 and CO_2). I.S.

A91-32380

METHODS OF THE THEORY OF ABSOLUTE STABILITY APPLIED TO INVARIANCE PROBLEMS [METODY TEORII ABSOLIUTNOI USTOICHIVOSTI V ZADACHAKH INVARIANTNOSTI]

V. A. IAKUBOVICH (Leningradskii Gosudarstvennyi Universitet, Leningrad, USSR) Kibernetika i Vychislitel'naia Tekhnika (ISSN 0454-9910), no. 85, 1990, p. 1-13. In Russian. refs

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It is shown that invariance problems for nonlinear systems can be reduced to the problem of constructing a Liapunov function with properties analogous to those of the Liapunov function in stability problems. The use of a frequency theorem provides effective conditions for the existence of the required Liapunov function in certain multiparameter classes. Using this approach, criteria for the epsilon-invariance of nonlinear systems are obtained. In addition, methods for obtaining epsilon-invariance criteria for linear and nonlinear systems based on energy-norm estimates are examined. L.M.

A91-32387

THERMOELASTIC PROPERTIES OF THREE-DIMENSIONALLY REINFORCED MATERIALS [TERMOUPRUGIE SVOISTVA PROSTRANSTVENNO ARMIROVANNYKH MATERIALOV]

L. P. KHOROSHUN and E. N. SHIKULA (AN USSR, Institut Mekhaniki, Kiev, Ukrainian SSR) Prikladnaia Mekhanika (ISSN 0032-8243), vol. 27, Jan. 1991, p. 15-24. In Russian. refs

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Theoretical principles are presented for the prediction of the effective thermoelastic properties of three-dimensionally reinforced fiber composites with anisotropic components and a random structure. The three-dimensionally reinforced composite is treated as a multicomponent material, assuming that the fibers of each orientation constitute a separate component. The problem of effective thermoelastic properties is solved by the conditional moment method. Expressions are obtained which relate the effective thermoelastic constants to the component properties, their volume fraction, and three-dimensional fiber orientation. V.L.

A91-32391
COMPARISON OF ATMOSPHERIC AND OCEAN FRONTS [O SRAVNENII ATMOSFERNYKH I OKEANSKIKH FRONTOV]
A. S. MONIN (AN SSSR, Institut Okeanologii, Moscow, USSR) Akademiia Nauk SSSR, Izvestiia, Fizika Atmosfery i Okeana (ISSN 0002-3515), vol. 27, Jan. 1991, p. 3-15. In Russian. refs
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The concepts of the atmospheric and the oceanic fronts are defined, and their characteristics and differences are examined. It is shown that the difference consists in fact that the air mass is heated actively from below and the ocean-water mass is cooled or salted from above. In addition, the absence of westerlies in the world ocean results in the quasi-stationary nature of the oceanic fronts. The main difference, however, lies in the thermohaline character of the oceanic fronts, which causes the formation of six front types determined by temperature, salinity, and the density of the approaching water mass. I.S.

A91-32392
CONVECTION REGIMES ON DIFFERENT ROTATING GEOPHYSICAL AND ASTROPHYSICAL OBJECTS [REZHIMY KONVEKTSII NA RAZLICHNYKH VRASHCHAIUSHCHIKHSIA GEOFIZICHESKIKH I ASTROFIZICHESKIKH OB'EKTAKH]
G. S. GOLITSYN (AN SSSR, Institut Fiziki Atmosfery, Moscow, USSR) Akademiia Nauk SSSR, Izvestiia, Fizika Atmosfery i Okeana (ISSN 0002-3515), vol. 27, Jan. 1991, p. 20-31. In Russian. refs
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This paper presents theoretical and experimental results on convection in a horizontal plane fluid layer rotating along a vertical axis. The results are related to the origin of motions, their spatial scale, and the classification of the regimes of convective motions into regular or irregular motions; with the latter subdivided into geostrophic motions and common thermal turbulence motions. The motion regimes of the following objects were determined: the atmospheric boundary layer, the ocean, the magma chambers within the earth's mantle, the earth's liquid core, Jupiter's atmosphere and interior, the solar granulation, and the accretion disks and neutron stars (i.e., pulsars). Significant geostrophic convection was identified in the terrestrial and Jovian interiors, in fast rotating pulsars, and in accretion disks for which the velocity and the temperature scales are known. In objects other than these, the effect of rotation was found to be smaller. I.S.

A91-32393
THE ADEQUACY OF SIMULATIONS OF VORTICAL ASTROPHYSICAL STRUCTURES IN EXPERIMENTS WITH ROTATING SHALLOW WATER [OB ADEKVATNOSTI MODELIROVANIIA VIKHREVYKH ASTROFIZICHESKIKH STRUKTUR V OPYTAKH NA VRASHCHAIUSHCHEISIA MELKOI VODE]
M. V. NEZLIN (Institut Atomnoi Energii, Moscow, USSR) Akademiia Nauk SSSR, Izvestiia, Fizika Atmosfery i Okeana (ISSN 0002-3515), vol. 27, Jan. 1991, p. 32-44. In Russian. refs
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The three conditions necessary for adequate modeling of the atmospheric vortical structures of the Jupiter Red-Spot type are quasi-two-dimensionality, large scale, and cyclonic-anticyclonic asymmetry. It is shown that these conditions are satisfied only in the experiments of Nezlin (1986), Nezlin and Snezhkin (1990), and Antipov et al. (1988). Using the results of a simulation of spiral structures of gaseous galactic disks, it is hypothesized that the friction between these structures and stars is physically analogous to the Rayleigh friction between shallow water and the bottom of a vessel. Due to this analogy, data from experiments with rotating shallow water can be used to adequately model galactic spiral structures. I.S.

A91-37968
TRIPLE SYNCHRONIZED CONTROLLER FOR SPACECRAFT POWER SUBSYSTEMS
DENNY D. GUDEA and PAUL E. HACKAMACK (TRW, Inc., Redondo Beach, CA) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 257-262.
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The operation of a triple modular redundant microprocessor-based controller and the associated hardware and software are described. The controller uses a balanced mixture of radiation-hardened hardware and structured software redundancy. Each module on the triad is tightly synchronized with the other two, and voting is used to mask the effects of a failed module. The self-test features of the controller will detect any fault through an interaction of hardware and firmware. For a transient fault, the controller will recover and continue operation. If the fault is permanent, it will report the error, turn off the defective module, and reconfigure itself. The controller has been tested for both normal and failure (artificially induced faults) modes of operation to verify the integrity of the design. The objective of this research was to develop a radiation-hardened controller that is capable of meeting the autonomy requirements of an electrical power subsystem for a spacecraft. As part of development work, a study of different fault tolerant techniques was done. The study concluded that a controller that is triple modular redundant (TMRC), tightly synchronized, and uses structured software redundance is the best solution. I.E.

A91-37984* Virginia Polytechnic Inst. and State Univ., Blacksburg.
DESIGN CONSIDERATIONS FOR A SOLAR ARRAY SWITCHING UNIT
A. R. PATIL, B. H. CHO, and F. C. LEE (Virginia Polytechnic Institute and State University, Blacksburg) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 373-379. Research supported by Fairchild Space, Washington Technical Support Center, and NASA. refs
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An analysis of the sequential switching shunt regulator unit (SSU) proposed for the space station and space platform is presented. The solar array and shunt regulator system is analyzed for ripple, output impedance, and stability. The performances of proportional gain and proportional integrator (PI) controllers are compared. A design example is provided, and an EASY5 simulation is presented for the regulation of the bus voltage by the SSU. It is shown that the bus ripple may be limited by the equivalent series resistor, in which case it cannot be reduced by increasing the capacitance or switching frequency. The proportional controller is shown to offer a faster response than the PI controller, but has a load-current-dependent steady state error. This error can be removed by the PI controller, but the bus impedance has a low-frequency pole which slows the response. I.E.

A91-38005* MICON Engineering, Inc., College Station, TX.
FUNCTIONAL REQUIREMENTS FOR AN INTELLIGENT RPC
B. M. AUCOIN and R. P. HELLER (MICON Engineering, College Station, TX) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 496-499. refs
(Contract NAS8-38442)
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An intelligent remote power controller (RPC) based on microcomputer technology can implement advanced functions for the accurate and secure detection of all types of faults on a spaceborne electrical distribution system. The intelligent RPC will implement conventional protection functions such as overcurrent, under-voltage, and ground fault protection. Advanced functions for the detection of soft faults, which cannot presently be detected, can also be implemented. Adaptive overcurrent protection changes overcurrent settings based on connected load. Incipient and high-impedance fault detection provides early detection of arcing conditions to prevent fires, and to clear and reconfigure circuits before soft faults progress to a hard-fault condition. Power electronics techniques can be used to implement fault current limiting to prevent voltage dips during hard faults. It is concluded that these techniques will enhance the overall safety and reliability of the distribution system. I.E.

A91-38161

SPACE POWER CONVERTER SELECTION METHODOLOGIES

WILLIAM E. JACKSON (Martin Marietta Astronautics Group, Denver, CO) and RENE THIBODEAUX (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: *IECEC-90; Proceedings of the 25th Intersociety Energy Conversion* Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 6. New York, American Institute of Chemical Engineers, 1990, p. 26-29.

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During baseload power system conceptual design phases, common, flexible power conversion equipment must be identified, characterized, compared and selected to meet all pertinent requirements between various spacecraft sources, distribution networks, and loads. The process used to perform the conceptual analyses must be structured to evaluate all known requirements and integrate them properly into the preliminary study format. An evaluation process is presented, as implemented in a 5-100-kW baseload space power system study, that provides an approach to matching and conceptually designing power converters to power system applications. I.E.

A91-41992

THE BYPASS DIODE ASSEMBLY - SOLAR CELL PROTECTION FOR SPACE STATION FREEDOM

T. W. WOIKE, S. C. STOTLAR (Advanced Optoelectronics, City of Industry, CA), and L. WOODS (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: IEEE Photovoltaic Specialists Conference, 21st, Kissimmee, FL, May 21-25, 1990, Conference Record. Vol. 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 1288-1293.

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When a shadow partially obscures a large solar array, the large power dissipated in the reverse direction can degrade the shadowed cell. A bypass diode, a diode connected in reverse polarity to the solar cell, can prevent damage to the solar cell and thus extend the operable life of the solar array. A single bypass diode for the Space Station Freedom (SSF) solar array protects eight cells. The custom diode housing required by the flexible array fits within the thin envelope and increases its mechanical stability and thermal capacity. The SSF solar arrays require the use of bypass diodes with minimal thickness (less than 20 mil). During the bypass diode assembly development phase, 11 different configurations were examined which utilized a number of candidate materials. Measurements and analyses were performed to eliminate unsuitable configurations, resulting in the parallel contact ceramic hybrid configuration as the final design selection. This configuration which has been shown to meet all requirements. I.E.

A91-49368* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

STATE-OF-THE ART OF DC COMPONENTS FOR SECONDARY POWER DISTRIBUTION OF SPACE STATION FREEDOM

STANLEY KRAUTHAMER, MUKUND GANGAL, and RADHE S. L. DAS (JPL, Pasadena, CA) IEEE Transactions on Power Electronics (ISSN 0885-8993), vol. 6, July 1991, p. 548-561. refs

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120-V dc secondary power distribution has been selected for Space Station Freedom. State-of-the art components and subsystems are examined in terms of performance, size, and topology. One of the objectives of this work is to inform Space Station users what is available in power supplies and power control devices. The other objective is to stimulate interest in the component industry so that more focused product development can be started. Based on results of this study, it is estimated that, with some redesign, modifications, and space qualification, may of these components may be applied to Space Station needs. I.E.

A91-54642

A METHOD TO QUANTITATIVELY JUSTIFY AND RELATE SHIELDING REQUIREMENTS AND DESIGN MARGINS TO HARDWARE REQUIREMENTS

C. F. GUENTHER (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: IEEE/AIAA/NASA Digital Avionics Systems Conference, 9th, Virginia Beach, VA, Oct. 15-18, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 425-429. refs

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A methodology was developed and utilized for justifying to management, in a quantifiable and understandable way, the need for shielding electronic parts and design margins. The approach related the probability of part failure due to radiation to an associated part reliability. The part reliability was then correlated to an overall subsystem reliability and assessed against the subsystems' requirements. The approach is applicable to any environment whose consequences are cumulative. Consequently, effects resulting from displacement damage can be treated in a similar manner. The results are of interest in connection with the consideration of total dose impacts on electronics in the analysis of a spacecrafts' response to the radiation environments encountered on orbit. The proposed approach is applicable to any environment whose consequences are cumulative. Consequently, effects resulting from displacement damage can be treated in a similar manner. I.E.

N91-22508*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

HIGH TEMPERATURE POWER ELECTRONICS FOR SPACE

AHMAD N. HAMMOUD (Sverdrup Technology, Inc., Brook Park, OH.), ERIC D. BAUMANN, IRA T. MYERS, and ERIC OVERTON 1991 8 p Presented at the First International High Temperature Electronics Conference, Albuquerque, NM, 16-20 Jun. 1991; sponsored by Sandia National Labs., AF Wright Research Development Center and New Mexico Univ.

(Contract NAS3-25266; RTOP 506-41-41)

(NASA-TM-104375; E-6181; NAS 1.15:104375) Avail: CASI HC A02/MF A01 CSCL 09C

A high temperature electronics program at NASA Lewis Research Center focuses on dielectric and insulating materials research, development and testing of high temperature power components, and integration of the developed components and devices into a demonstrable 200 C power system, such as inverter. An overview of the program and a description of the in-house high temperature facilities along with experimental data obtained on high temperature materials are presented. Author

N91-26461*# Maxwell Labs., Inc., San Diego, CA.

HIGH-POWER CONVERTERS FOR SPACE APPLICATIONS Final Report

J. N. PARK and RANDY COOPER Jun. 1991 133 p Prepared in cooperation with General Electric Co., Schenectady, NY

(Contract NAS3-25800; RTOP 506-41-3F)

(NASA-CR-187116; NAS 1.26:187116; REPT-90SRD008) Avail: CASI HC A07/MF A02 CSCL 10B

Phase 1 was a concept definition effort to extend space-type dc/dc converter technology to the megawatt level with a weight of less than 0.1 kg/kW (220 lb./MW). Two system designs were evaluated in Phase 1. Each design operates from a 5 kV stacked fuel cell source and provides a voltage step-up to 100 kV at 10 A for charging capacitors (100 pps at a duty cycle of 17 min on, 17 min off). Both designs use an MCT-based, full-bridge inverter, gaseous hydrogen cooling, and crowbar fault protection. The GE-CRD system uses an advanced high-voltage transformer/rectifier filter is series with a resonant tank circuit, driven by an inverter operating at 20 to 50 kHz. Output voltage is

controlled through frequency and phase shift control. Fast transient response and stability is ensured via optimal control. Super-resonant operation employing MCTs provides the advantages of lossless snubbing, no turn-on switching loss, use of medium-speed diodes, and intrinsic current limiting under load-fault conditions. Estimated weight of the GE-CRD system is 88 kg (1.5 cu ft.). Efficiency of 94.4 percent and total system loss is 55.711 kW operating at 1 MW load power. The Maxwell system is based on a resonance transformer approach using a cascade of five LC resonant sections at 100 kHz. The 5 kV bus is converted to a square wave, stepped-up to a 100 kV sine wave by the LC sections, rectified, and filtered. Output voltage is controlled with a special series regulator circuit. Estimated weight of the Maxwell system is 83.8 kg (4.0 cu ft.). Efficiency is 87.2 percent and total system loss is 146.411 kW operating at 1 MW load power.
Author

N91-27189# Sandia National Labs., Albuquerque, NM.
HARDNESS ASSURANCE FOR LOW-DOSE SPACE APPLICATIONS
D. M. FLEETWOOD, P. S. WINOKUR, and T. L. MEISENHEIMER 1991 5 p Presented at the IEEE Annual International Nuclear and Space Radiation Effects Conference, San Diego, 15-19 Jul. 1991
(Contract DE-AC04-76DP-00789)
(DE91-009179; SAND-91-0482C; CONF-910751-6) Avail: CASI HC A01/MF A01

A simple test method for hardness assurance testing of metal oxide semiconductor (MOS) devices for low dose rate applications is outlined. The method provides a conservative estimate of MOS hardness in space, but allows greater latitude in device selection than the present MIL-STD. DOE

N91-28486# Los Alamos National Lab., NM.
A HIGH POWER KLYSTRODE WITH POTENTIAL FOR SPACE APPLICATION
D. W. REID, D. H. PREIST, and M. B. SHRADER (Varian Associates, San Carlos, CA.) 1991 5 p Presented at the 1991 Institute of Electrical and Electronics Engineers (IEEE) Particle Accelerator Conference (PAC), San Francisco, 6-9 May 1991
(Contract W-7405-ENG-36)
(DE91-013046; LA-UR-91-1461; CONF-910505-150) Avail: CASI HC A01/MF A01

A 500 kW peak power, 50 kW average, 425 MHz Klystrode was designed and built. The high power Klystrode design evolved from earlier work on the new line of UHF TV Klystrodes. The 500 kW program was undertaken to determine experimentally if a Klystrode would be a viable device in space applications at this power level at 425 MHz. Testing has proceeded in three phases. The initial testing was done in a beam simulation device to determine the characteristics of the gridded gun. The second phase consisted of low duty cycle, full voltage, and current RF testing. The third phase involved full duty cycle and long pulses (11 ms).
DOE

N91-29465# Naval Postgraduate School, Monterey, CA.
INTRODUCTION OF A CURRENT WAVEFORM, WAVESHAPING TECHNIQUE TO LIMIT CONDUCTION LOSS IN HIGH-FREQUENCY DC-DC CONVERTERS SUITABLE FOR SPACE POWER M.S. Thesis
DOUGLAS P. MILLER Jun. 1990 160 p
(AD-A237903) Avail: CASI HC A08/MF A02 CSCL 10B

Space power supply manufacturers have tried to increase power density and construct smaller, highly efficient power supplies by increasing switching frequency. Incorporation of a power MOSFET as a switching element alleviates switching loss. However, values of R sub DS(on) (drain-to-source resistance in the on-state) for MOSFET's are of such magnitude to produce greater on-state losses than an equivalent BJT operated in saturation. This research serves to introduce a design concept, pertinent to low-voltage relatively-high-current applications, that minimizes the peak current through the switching element in order to reduce average power loss. Basic waveforms produced by different PWM and resonant mode topologies were examined. Theoretical analysis reveals that a ramp-sine current waveform could cut conduction power loss by at least 18 percent over a conventional Buck switching converter. A 14V, 14W combination quasi-resonant Buck/ZCS, Quasi-Resonant Buck dc-dc converter with an unregulated input voltage of 28 V was built for simplicity to demonstrate one particular waveshaping technique. This converter represents a useful example of an actual circuit which is capable of producing the desired ramp-sine switch-current waveform. Final results confirm improvement in conduction loss enhancing existing power MOSFET technology for use in dc-dc power conversion. GRA

N91-30393*# Clarkson Univ., Potsdam, NY. Dept. of Electrical and Computer Engineering.
ANALYSIS OF ELECTROMAGNETIC INTERFERENCE FROM POWER SYSTEM PROCESSING AND TRANSMISSION COMPONENTS FOR SPACE STATION FREEDOM Interim Progress Report, 1 Jan. - 31 Aug. 1991
PETER W. BARBER, NABEEL A. O. DEMERDASH, R. WANG, B. HURYSZ, and Z. LUO 1991 224 p
(Contract NAG3-1126)
(NASA-CR-186564; NAS 1.26:186564) Avail: CASI HC A10/MF A03 CSCL 20N

The goal is to analyze the potential effects of electromagnetic interference (EMI) originating from power system processing and transmission components for Space Station Freedom.The approach consists of four steps: (1) develop analytical tools (models and computer programs); (2) conduct parameterization studies; (3) predict the global space station EMI environment; and (4) provide a basis for modification of EMI standards. Author

N91-32291# European Space Agency, Paris (France).
ESA ELECTRONIC COMPONENTS CONFERENCE
BRIGITTE KALDEICH, ed. Mar. 1991 600 p In ENGLISH and FRENCH Conference held in Noordwijk, Netherlands, 12-16 Nov. 1990
(ESA-SP-313; ISBN-92-9092-094-7; ETN-91-99560) Copyright Avail: CASI HC A25/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

In this first ESA electronic components conference the electronic components needed for the Columbus, Hermes, Ariane 5, Horizon 2000 and other major ESA programs, are discussed. New component technologies, Application Specific Integrated Circuits (ASIC's) and Very Large Scale Integration (VLSI) are reviewed. Microwave and optoelectronics, hybrids and packaging, dosimetry and imaging charge coupled devices are discussed. Single event upset and latchup, and Silicon On Isolator (SOI) technology are considered. Data bases, procurement approaches and policy as well as assessment methodologies and component standardization are reviewed.
ESA

N91-32294# Societe d'Applications Generales d'Electricite et de Mecanique, Cergy-Pontoise (France).
NON VOLATILE SOLID STATE MAGNETIC MEMORY TECHNOLOGIES
MICHEL A. POIRIER *In* ESA, ESA Electronic Components Conference p 25-29 Mar. 1991
Copyright Avail: CASI HC A01/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

The basic properties of Vertical Block Line (VBL) technology are summarized. VBL memory has a potential density of one gigabit per square centimeter. Also discussed are the space qualified magnetic bubble components produced by SAGEM. The capacity of the components made by SAGEM so far are 8 Mbits and 16 Mbits in density. The upper limit possible using the older technology is 32 Mbits. By using VBL pairs, the density is only limited by the line width of the photolithographic process. ESA

N91-32295# Interuniversity Micro-Electronics Center, Leuven (Belgium).
NEW DEVELOPMENTS IN NON-VOLATILE SEMICONDUCTOR MEMORY TECHNOLOGIES AND DEVICES

H. E. MAES, G. GROESENEKEN, and J. WITTERS (MIETEC, Oudenaarde, Belgium) *In* ESA, ESA Electronic Components Conference p 31-42 Mar. 1991
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The state of the art and the new trends in reprogrammable nonvolatile memories are presented. The physical operation principles evolution, in technology, device concepts and new developments and trends for each class of nonvolatile memory are discussed. Erasable Programmable Read Only Memories (EPROM), full feature and flash Electrically Erasable Programmable Read Only Memories (EEPROM), nonvolatible RAM (Random Access Memory) and Ferroelectric RAM (FRAM) are described. Reliability and radiation related problems specific to the above mentioned memory types are discussed. ESA

N91-32297# Rockwell International Corp., Houston, TX. Rocketdyne Div.
DESIGN, DEVELOPMENT, AND QUALIFICATION OF SPECIAL SUPER N-CHANNEL MOSFET DIE FOR SPACE APPLICATIONS
HASKEL M. JOSEPH *In* ESA, ESA Electronic Components Conference p 49-53 Mar. 1991
Copyright Avail: CASI HC A01/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

The design, manufacture, processing and testing of special super Metal Oxide Semiconductor Field Effect Transistors (MOSFET) die sizers 9 and 10 (approx. 690 by 500 mils and 1022 by 772 mils respectively) are described. These sizes are developed specifically to meet the requirements of the Remote Power Controller (RPC), the Remote Bus Isolator (RBI) and the DC to DC converter of the Space Station Freedom power management and distribution system. The reliability goal is for a 15 year failure free operation in space. ESA

N91-32299# ABB Hafo A.B., Jaerfaella (Sweden).
DESIGN AND MANUFACTURE OF SPACE ASICS TODAY AND TOMORROW: PROMISES AND PROBLEMS
INGMAR HOEGLUND *In* ESA, ESA Electronic Components Conference p 63-66 Mar. 1991
Copyright Avail: CASI HC A01/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

A few important items limiting Application Specific Integrated Circuits (ASIC) use in space, such as visual inspection and testability, differences in ESA and MIL standards and the large number of hierarchical levels between the end user and the ASIC manufacturer are described. Although ASICs are the flagship of electronics due to their high speed, their functional complexity and reliability, and their low power dissipation, they are in many ways incompatible with the careful conservative approach required for success in space projects. The lack of experience with ASICs in space projects as compared to other more commercial projects is discussed. ESA

N91-32300# Alcatel Espace, Toulouse (France).
DIGITAL ASIC DESIGN FOR SPACE APPLICATIONS
L. BAGUENA, S. BENAMOR, and G. GREGORIS *In* ESA, ESA Electronic Components Conference p 67-70 Mar. 1991
Copyright Avail: CASI HC A01/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

A digital Application Specific Integrated Circuit (ASIC) design methodology for space applications is presented. Experience in ASIC design used in developing the methodology is described. The flowchart of ASIC development from the system specification level to Hirel part procurement is presented. Specific points such as the choice of technology and manufacture as well as worst case and test oriented simulations are described. The different reviews which are the backbone of the methodology are outlined. Close collaboration between quality and design teams throughout the development cycle is identified as being essential for success. A specific example of the impact of an early reliability analysis on a design architecture is described. The impact of new design tools on ASIC design is outlined. ESA

N91-32301# University Coll., Cork (Ireland). National Microelectronics Research Centre.
ASSESSMENT OF DFT STRATEGIES
C. T. HANNON, J. F. PAGE, and S. U. LIDHOLM *In* ESA, ESA Electronic Components Conference p 71-76 Mar. 1991
Copyright Avail: CASI HC A02/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

The Design For Testability (DFT) concept is motivated by the increasing difficulty to adequately test Very Large Scale Integration (VLSI) chips whose density has increased rapidly in the past decade. DFT strategies with respect to different logic architectures are presented. A test vehicle is designed and then utilized to implement these techniques. The results are presented and compared. Fault simulators, in their efforts to establish how well the test vectors used to verify a finished product will catch manufacturing defects, have continuously adopted the stuck at fault model as their only fault modeling criteria. Criticism of using this fault model in Complementary Metal Oxide Semiconductor (CMOS) VLSI design is presented. ESA

N91-32302# GEC-Plessey Semiconductors, Lincoln (England).
AN 8 BIT HIGH PERFORMANCE ADC IN SILICON ON SAPPHIRE
N. M. MALLINSON, M. LYSEJKO, and A. S. REPTON *In* ESA, ESA Electronic Components Conference p 77-81 Mar. 1991
Copyright Avail: CASI HC A01/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

The suitability of Complementary Metal Oxide Semiconductor (CMOS) Silicon On Sapphire (SOS) process technology for the implementation of monolithic high speed Analog to Digital Converters (ADC's) is investigated and the most appropriate converter architecture identified. A detailed design phase including extensive simulation of key circuit elements using the BSOS transistor model is described. Results indicate that 8 bit flash ADCs with conversion rates in excess of 50 M samples per second can be reliably manufactured. The potential radiation hard attributes of CMOS SOS contribute to an encouraging total dose radiation tolerance of up to 200 krads in initial tests on the MA6561 converter. Further work underway to correct minor problems in first iteration design and to subsequently enhance the radiation tolerance of the conveter is described. ESA

N91-32303# Plessey Research (Caswell) Ltd., Towcester (England).
AN EVALUATION PROGRAMME FOR THE CAPABILITY APPROVAL OF GAAS MMICS
R. F. B. CONLON, C. E. LINDSAY, G. M. BRYDON, and A. BENSOUSSAN (Alcatel Espace, Toulouse, France) *In* ESA, ESA Electronic Components Conference p 85-91 Mar. 1991
Copyright Avail: CASI HC A02/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

The evaluation phase of the ESA capability approval program (ESA/SCC 24390) for space qualification of the Plessey GaAs foundry is described. The requirements of microwave integrated circuits and in particular the need for bare die are discussed. Preliminary designs for tests vehicles are described and details of the step stress, accelerated temperature and radiation testing are presented. The active involvement of Alcatel Espace, a foundry customer and ESA subcontractor is seen as an important element to ensure that the needs of the system users are fully accounted for in the program. ESA

N91-32304# Centre National d'Etudes des Telecommunications, Lannion (France).
A SURVEY OF THE PARASITIC EFFECTS AND DEGRADATION MECHANISMS AFFECTING THE GAAS FET-BASED IC'S: THE FIRST STEP FOR A TECHNOLOGICAL EVALUATION
J. M. DUMAS *In* ESA, ESA Electronic Components Conference p 93-99 Mar. 1991
Copyright Avail: CASI HC A02/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

Several parasitic effects which influence GaAs IC performance

are reviewed. The main concerns include in bulk trap dependent parasitics such as back (side) gating, and surface induced parasitics such as gate-lag. How the basic understanding of these effects is taken into account in the design rules provided to designers is discussed. Major degradation mechanisms are briefly reviewed. Failure modes observed from high temperature lifetesting conditions are demonstrated to give optimistic median life values when compared with those obtained from low temperatures. Failure criteria are reviewed. In order to assess the effects penalizing the integration and lifetime for both analog and digital IC's, a first step qualification procedure is proposed. It is based on specific test vehicles, issued from Process Control Monitors (PCM) or from specially designed Technology Characterization Vehicles (TCV).
ESA

N91-32305# Philips Components, Caen (France).
RELIABILITY OF MICROWAVE BIPOLAR SILICON TRANSISTORS
G. BOBIN and J. M. LEMENAGER *In* ESA, ESA Electronic Components Conference p 101-106 Mar. 1991
Copyright Avail: CASI HC A02/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

Reliability of solid state technology in power amplifiers for space applications is discussed. Life curves and life goals for such amplifiers are presented. Failure mechanisms are discussed. Different types of screening are presented and discussed. The influence of development and processing of the transistors on one side, and the conditions of use, both electrical and mechanical, on the other side are reviewed. The phenomenon of end of life is presented. Test results from over 20,000 hours of real testing and more than 10 years of experience in the microwave field, for space application are used in this reliability analysis. ESA

N91-32306# ANT Nachrichtentechnik, Backnang (Germany, F.R.).
SELECTION STRATEGY AND RELIABILITY ASSESSMENT FOR SILEX-COMMUNICATION LASER DIODES
ROLAND LOEFFLER and BODO MENKE *In* ESA, ESA Electronic Components Conference p 107-112 Mar. 1991
Copyright Avail: CASI HC A02/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

Steps involved in the search for suitable laser diodes for Semiconductor laser Intersatellite Link EXperiment (SILEX) and evaluation of their capabilities in meeting qualification requirements are discussed. A baseline of the laser diode functional specifications is identified by synthesizing the SILEX system requirements and thereby predicting the desired diode characteristics. Samples of approximately 20 different laser diode types are submitted to comprehensive measurements of their characteristics, spectral widths, mode hopping behavior, far field patterns, wave front errors and astigmatisms under modulation. An evaluation program consisting of a conventional three temperature aging test and sensitivity and environmental tests is defined. ESA

N91-32309# MATRA Espace, Paris-Velizy (France). Microelectronics and Packaging Depts.
SURFACE MOUNT ON CERAMIC: HOW TO ACHIEVE A SPACE QUALITY LEVEL
MICHEL MASSENAT *In* ESA, ESA Electronic Components Conference p 127-132 Mar. 1991
Copyright Avail: CASI HC A02/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

Space qualification tests carried out on electrical components produced using surface mount on ceramic technology are described. The steps taken to develop the industrial procedure for this technology are described. The use of ceramic is considered a transient technology in preparation for development of surface mount on printed circuit boards. A process description is presented outlining the composition of the multilayer substrates and the steps involved in component assembly. The manufacturing equipment and qualification stages are described. ESA

N91-32310# Limburgs Univ., Diepenbeek (Belgium). Materials Research Inst.
A NEW APPROACH TO THE RELIABILITY OF ELECTRONIC MATERIAL SYSTEMS
L. DESCHEPPER, W. DECEUNINCK, B. VANHECKE, E. BEYNE, L. M. STALS, and J. ROGGEN (Interuniversity Micro-Electronics Center, Leuven, Belgium) *In* ESA, ESA Electronic Components Conference p 133-138 Mar. 1991
Copyright Avail: CASI HC A02/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

An experimental technique developed to study accelerated ageing of material systems used in microelectronics is described. The method is useful for material systems of which the aging can be characterized by the DC electrical resistance or the AC impedance. The main advantage of the in situ approach is the high measuring resolution that can be obtained. The resolution can be in the order of 1 to 5 ppm for a system with a temperature coefficient of resistance of 100 ppm/C whereas the comparable resolution with the conventional method is in the order of 500 ppm. The aging kinetics of a system can be studied in more detail, and on shorter time scales. Some typical applications of the in situ technique are outlined. Hybrid thick film resistor aging, diffusion and electromigration induced aging of gold aluminum contact, and oxidation/deoxidation behavior of superconducting YBaCuO are described. ESA

N91-32311# Plessey Research (Caswell) Ltd., Towcester (England).
HIGH PERFORMANCE PACKAGES FOR SPACE APPLICATIONS
K. BEASLEY and J. T. LYNCH *In* ESA, ESA Electronic Components Conference p 139-143 Mar. 1991
(Contract ESTEC-8058/88/NL/RE(SC))
Copyright Avail: CASI HC A01/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

A comprehensive review of packaging for high performance microelectronics is presented. A capability approval approach to package supply is predicted to ensure high performance packages suitable for space applications, and provide the range of special electrical and mechanical characteristics needed to exploit the latest semiconductor technology. Conventional chip and wire assemblies are deemed to be reaching their limits. Flip-chip bonding, which is inherently more reliable, is recommended to avoid wire bonding difficulties for 200 plus pins. Flip-chip bonding into Multi Chip Modules (MCMs), which provides a highly compact alternative to chip carrier to substrate assemblies, is discussed.
ESA

N91-32312# Alcatel Espace, Toulouse (France).
QUALIFICATION STRATEGY FOR MULTI-CHIP PACKAGING FOR SPACE APPLICATIONS
A. BENSOUSSAN, G. GREGORIS, and P. COVAL *In* ESA, ESA Electronic Components Conference p 145-148 Mar. 1991
Copyright Avail: CASI HC A01/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

A qualification strategy for the integration of Monolithic Microwave Integrated Circuits (MMIC) into real systems is described. An overview of the MMIC based predevelopment conducted at Alcatel Espace is presented. The methodology to be used for the implementation of packaged MMICs in these systems and the qualification approach taking into account multiprocurement chips, packages and several assembling subtechnologies are described. The main conclusion is that foundry services, equipment manufacturers and agencies need to work in close conjunction with one another. ESA

N91-32313# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Space Communications and Propulsion Systems Div.
WITHSTANDING VOLTAGE DEGRADATION OF EEE COMPONENTS DUE TO CAVITY PRESSURE LOSS
ROLF RIEGER, MICHAEL REGULA, and OLE PEDERSEN *In* ESA, ESA Electronic Components Conference p 149-156 Mar.

1991
Copyright Avail: CASI HC A02/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

Hermeticity problems of Electric, Electronic and Electromechanical (EEE) components are discussed. Ways of withstanding voltage degradation of components designed and qualified for operating voltages of greater than or equal to 50 volts are described. The underlying physical background of the problem is discussed. Experimental results are presented illustrating gas discharge phenomena, glow discharge, and arc discharge. Glow discharge of several representative two wire gaps (0.5 through 10 mm) are presented. Experimental set ups and results are shown in diagrammatic form. ESA

N91-32314# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
TEST ON OPTO COUPLERS IN THE LINEAR APPLICATION CONSIDERING TEMPERATURE, RADIATION AND VCE EFFECTS
H. SPRUIJT, K. BURROWS, J. ANDERSEN, S. MARSDEN, and J. TILMANT (Etudes Techniques et Constructions Aerospatiales, Charleroi, Belgium) *In its* ESA Electronic Components Conference p 159-164 Mar. 1991
Copyright Avail: CASI HC A02/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

The test result for four different types of opto couplers (20 devices each) operating at very low current levels (lower than the test condition for logic operation) considering temperature, radiation and absolute value of forward voltage (Vce) effects are presented. A galvanically isolated precision linear interface using a pair of opto couplers is introduced, which could be of interest in the areas of monitoring, control, control loops and linear interfaces for future space applications. ESA

N91-32315# Johns Hopkins Univ., Laurel, MD. Applied Physics Lab.
SPACE QUALIFICATION TEST AND EVALUATION OF JHU/APL DESIGNED ASICS
K. CHAO *In* ESA, ESA Electronic Components Conference p 165-169 Mar. 1991
Copyright Avail: CASI HC A01/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

The results of accelerated life tests on spectrum accumulators using MOSIS/HP three micron Complementary Metal Oxide Semiconductor (CMOS) technology are presented. Results of screening and 2000 hours of life tests are used to determine the reliability of the accumulators for spaceborne applications. The MOSIS/HP process is found to yield consistent circuit and transistor parameters equivalent to those obtained using HCMOS technologies. Careful precap and visual inspection and packaging are determined to be essential for this and other high reliability applications. ESA

N91-32317# ITT Sealectro (UK), Portsmoutyh (England).
MICROWAVE BLIND MATE COAXIAL CONNECTORS
M. WHITE, J. PIERCE, and G. CUNNINGHAM *In* ESA, ESA Electronic Components Conference p 173-174 Mar. 1991
Copyright Avail: CASI HC A01/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

A microwave blind mate intermodular connector is described. The connector offers the designer of satellite payloads benefits in weight and volume. This allows for either a smaller system or for more electronics within the original payload limits. Modular flush mounting construction of units is achieved by use of recessed plugs, which are coaxially interconnected using a specially designed slide on jack to jack adaptors. By virtue of this special design, synchronous multiple connections per box can be achieved without special attention to tolerances, while maintaining electrical and mechanical integrity. Weight and volume are reduced through elimination of cable assemblies and increased connector packing density opportunity. ESA

N91-32318# Plessey Research (Caswell) Ltd., Towcester (England).
HIGH PERFORMANCE PACKAGES FOR SPACE APPLICATIONS: REVIEW OF PACKAGING AND ASSEMBLY METHODS FOR LONG WAVELENGTH LASER DIODES
C. E. LINDSAY *In* ESA, ESA Electronic Components Conference p 175-178 Mar. 1991 Sponsored by ESA
Copyright Avail: CASI HC A01/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

Laser diode mounting and packaging techniques are discussed and the space compatibility of the materials and designs reviewed. Materials and designs are examined against the drive current, output power, temperature, and environmental and mechanical conditions specific to space applications. Low power laser diodes for optical databases and laser diodes operating at more than 20mW CW optical output power, suitable for free space links are considered. Particular areas of study are thermal effects at the chip/heat sink interface, package rigidity and hermiticity, chip bonding and coupling of the lasers optical output to either a telescope or a fiber. ESA

N91-32319# Souriau, Paray (France). Space Div.
MATING AND UNMATING OF MULTI-PIN CONNECTORS UNDER VACUUM
Y. DOHAN *In* ESA, ESA Electronic Components Conference p 179-180 Mar. 1991
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Future spacecraft designed for a long life in orbit require serviceable modules and reliable electrical connectors which can operate in space vacuum. Numerous applications are described, all relying on the same basic experimentation and development results. Results of tests simulating the life conditions expected for such equipment are presented. A dedicated test jig is used in these tests to accomodate mating and unmating sequences in a vacuum chamber. ESA

N91-32322# Compagnie d'Electronique et de Piezo-Electricite, Argenteuil (France).
QUALIFICATION STATUS OF HYBRID CRYSTAL OSCILLATORS STYLE OTO 16S FOR SPACE APPLICATION
E. GERARD and J. L. DEVILLER *In* ESA, ESA Electronic Components Conference p 193-199 Mar. 1991
Copyright Avail: CASI HC A02/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

The qualification status of a crystal clock oscillator, OTO 16S, is described. Specifically designed for the Telecom 2 and Intelsat 7 programs, the oscillator is available in frequencies between 3 and 25 MHz with Transistor Transistor Logic (TTL) compatible outputs. Qualification tests results are presented to demonstrate that all the OTO 16S performances are in compliance with space requirements. From a mechanical viewpoint, no degradation is seen from a vibration level of 50 g sinus 10 to 2000 Hz. From a life test viewpoint, no significant variations are observed after 2000 hours of testing. ESA

N91-32323# Texas Instruments France, Velizy-Villacoublay. Regional Technology Center.
AN ADVANCED TESTABILITY CONCEPT FOR SPACE APPLICATIONS
ODILE GRIMBERG *In* ESA, ESA Electronic Components Conference p 201-203 Mar. 1991
Copyright Avail: CASI HC A01/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

The contribution of Texas Instruments to the efforts of the Joint Tests Action Group in developing a structured test methodology for devices, boards, subsystems and systems, is described. The test methodology, designed to reduce test costs and test time over the lifecycle of the product, is outlined. The role of Texas Instruments in improving the ease and accuracy of fault detection and isolation is reviewed. Various aspects of the International Electric, Electronic and Electromechanical (IEEE) standard initiated by the Joint Tests Action Group are discussed. ESA

N91-32326# Alcatel Espace, Toulouse (France).
SURFACE MOUNT TECHNOLOGY ON PCBS AT ALCATEL ESPACE
F. BOUTON *In* ESA, ESA Electronic Components Conference p 215-219 Mar. 1991
Copyright Avail: CASI HC A01/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

Tests performed on Surface Mount Components (SMCs) on polyimide printed circuit boards are described. The SMCs are passive chips and leadless ceramic chip carriers. The boards range from double sided Printed Circuit Boards (PCBs) to complex multilayer PCBs with heat sinks and buried vias. The technology described is used on ERS 1, ERS 2, Telecom 2, Poseidon, Eutelsat 2, Eutelsat 7, SPOT 4 and HELIOS. ESA

N91-32327*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TEST CHIPS AND ASIC QUALIFICATION
M. G. BUEHLER, B. R. BLAES, Y.-S. LIN, N. ZAMANI, and U. LIENEWEG *In* ESA, ESA Electronic Components Conference p 221-226 Mar. 1991 Sponsored in part by DOD
Copyright Avail: CASI HC A02/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders CSCL 09C

A test chip set being developed to aid in the qualification of spaceborne Application Specific Integrated Circuits (ASICs) is described. The chip set consists of a process monitor for process parameter verification, a fault chip for yield analysis, a reliability chip for ASIC failure rate analysis, and total ionizing dose and single event upset chips for radiation effect analysis. The test structures contained in these chips are discussed along with representative test results. ESA

N91-32328# University Coll., Cork (Ireland). Microelectronics Technology Support Lab.
MTSL-005: RELIABILITY EVALUATION OF HIGH PINCOUNT HERMETIC CERAMIC PACKAGES FOR SPACE APPLICATIONS
J. BARRETT, T. HAYES, B. MILNER, G. OMALLEY, C. OMATHUNA, and T. YAMADA *In* ESA, ESA Electronic Components Conference p 227-233 Mar. 1991
Copyright Avail: CASI HC A02/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

Investigation of the reliability of high pincount (64 to 200 input/output) hermetic ceramic packages, concentrating on leaded surface mount packages and on pin grid arrays is discussed. The work program has a number of objectives, one of which is to determine the fundamental reliability, for space applications, of high pincount ceramic packages from manufacturers in Europe, Japan and the United States. Another objective is to measure the thermal resistances and electrical parameters of these packages and to compare these with theoretically derived values. Evaluating the reliability of different solder assembly techniques for high pincount, fine pitch, surface mount Integrated Circuit (IC) packages on printed circuit boards is another objective. Work of the generation of specification and standards for the selection and assembly of high pincount IC packages for space applications is described. ESA

N91-32331*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE NASA MICROELECTRONICS SPACE RADIATION EFFECTS PROGRAM (MSREP) AT THE JET PROPULSION LABORATORY
C. BARNES, J. COSS, D. NICHOLS, and D. SHAW *In* ESA, ESA Electronic Components Conference p 249-254 Mar. 1991
Copyright Avail: CASI HC A02/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders CSCL 09C

The primary objective of the Microelectronics Space Radiation Effects Program (MSREP) at the Jet Propulsion Laboratory (JPL) is to assist NASA in the selection of radiation hardened microelectronic parts for insertion in NASA space systems through radiation testing and research. Prior to presenting examples of the research and testing on Single Event Effects (SEE) and Total Ionizing Dose (TID) effects, the space radiation environment and radiation requirements for the CRAFT/Cassini program, a typical JPL space project, are discussed. ESA

N91-32333# Plessey Research (Caswell) Ltd., Towcester (England).
EFFECTS OF DESIGN ON TOTAL DOSE CHARACTERISTICS OF ASIC TECHNOLOGIES
D. R. PARKER *In* ESA, ESA Electronic Components Conference p 261-265 Mar. 1991 Sponsored by United Kingdom Ministry of Defence Procurement Executive
Copyright Avail: CASI HC A01/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

Circuits representing three separate silicon technologies are subjected to total dose environments to establish radiation tolerance levels for the respective technologies. In each case, results demonstrate a variation of tolerance relating to circuit design techniques. With the advent of gate arrays and application specific integrated circuits (ASIC), system designers often believe that all designs on a common technology have the same tolerance to radiation (total dose). Results however show considerable variation is possible and generalizations must be treated with caution. Technologies evaluated include a high performance one micron bipolar process, a digital twin well Complementary Metal Oxide Semiconductor (CMOS) process, and a mature analog CMOS process. ESA

N91-32335# MATRA Harris Semiconducteurs, Nantes (France).
RADIATION TOLERANT 1 MICRON CMOS TECHNOLOGY
P. CREVEL and K. RODDE *In* ESA, ESA Electronic Components Conference p 273-277 Mar. 1991
Copyright Avail: CASI HC A01/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

Starting from a standard one micron Complementary Metal Oxide Semiconductor (CMOS) for high density, low power memory applications, the degree of radiation tolerance of the baseline process is evaluated. Implemented process modifications to improve latchup sensitivity under heavy ion irradiation as well as total dose effects without changing layout rules are described. By changing doping profiles in Metal Nitride Oxide Semiconductors (MNOS) and P-channel MOS (PMOS) device regions, it is possible to guarantee data sheet specification of a 64 K low power static RAM for total gamma dose up to 35 krad (Si) (and even higher values for the gate array family) without latch up for Linear Energy Transfer LET up to 115 MeV/(mg/cm squared). ESA

N91-32339# Sira Inst. Ltd., Chislehurst (England).
SPACE RADIATION EFFECTS ON CCDS
GORDON R. HOPKINSON *In* ESA, ESA Electronic Components Conference p 301-306 Mar. 1991
Copyright Avail: CASI HC A02/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

The effects of the space radiation environment on Charge Coupled Devices (CCDs) are discussed. Data obtained from CCDs made by EEV Ltd and Thompson-CSF is presented. Two types of Thompson-CSF devices (the 288 by 385 pixel TH7863 and the 14 by 14 pixel THX31160-1) are irradiated with Co-60 gamma rays and protons (1.5 and 10 MeV). In both cases significant increases in dark current are observed which continue after irradiation has ceased with increased reverse annealing for regions of the CCD covered by an aluminum light shield, but reduced damage for proton rather than Co-60 irradiation. Threshold voltage shift of approximately 0.1 V/Krad are produced. Results of proton irradiation of EEV devices are considered. The majority of measurements on both manufacturers' devices are carried out at room temperature and no degradation of charge transfer efficiency is observed (though the measurement accuracy is limited to 0.99995 per pixel transfer). ESA

N91-32340# Leicester Univ. (England). X-Ray Astronomy Group.

FURTHER PROTON DAMAGE EFFECTS IN EEV CCDS

A. ABBEY, A. HOLLAND, D. LUMB, and K. MCCARTHY *In* ESA, ESA Electronic Components Conference p 307-318 Mar. 1991

(Contract ESTEC-8093/88/NL/SK)

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A large number of spaceborne observatories have been proposed for which the detecting systems rely on Charge Coupled Device (CCD) imagers for the sensing function. The orbits of these missions will have different radiation environments, but most will encounter highly ionizing protons which cause degradation of the charge tranfer performance, which is a critical parameter for X-ray spectroscopic applications. Measurements of the degradation as a function of incremental dose, temperature of irradiation and of proton energy are described for different device architectures, including structures designed to minimize the interaction between signal charge and trapping sites. Charge transfer degradation at doses of as little as 100 rads (6 MeV protons) is measured. The increase in dark current with proton dose is described. Implications for future astrophysics missions are discussed. ESA

N91-32341# Thomson-CSF, Bagneux (France).

TOTAL DOSE EFFECTS ON CHARGE COUPLED DEVICES (CCD) REVERSE ANNEALING PHENOMENA

J. C. BOUDENOT and P. AUGIER *In* ESA, ESA Electronic Components Conference p 319-324 Mar. 1991

Copyright Avail: CASI HC A02/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

Results concerning the total dose effect on CCDs are presented. The major effect is an increase of dark current which is observed even after termination of irradiation under all test conditions (sources, dose rate, polarization). It is a case of reverse annealing phenomena, like rebound or superrecovery. In this case the post irradiation effect affects the dark current rather than threshold voltage. An experimental means of testing for the origin of the reverse annealing is described. ESA

N91-32342# Saab Space A.B., Goeteborg (Sweden). Components Lab.

RADIATION ASSESSMENT OF COMPLEX TECHNOLOGIES

S. MATTSSON *In* ESA, ESA Electronic Components Conference p 327-332 Mar. 1991

Copyright Avail: CASI HC A02/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

Test strategies to guarantee adequate fault coverage and reliability of Very Large Scale Integration (VLSI) circuits in a radiation environment are more extensive and much more complicated than for less complex Integrated Circuits (ICs) such as Small Scale Integration (SSI) and Medium Scale Integration (MSI) devices. Several different approaches have been used in the past to assess the vulnerability of microprocessors to Single Event Upsets (SEU). Methods and strategies for radiation testing of microprocessors are discussed. Total dose and SEU results from tests of the microprocessors Motorola 68020 and Intel 80386 are presented. ESA

N91-32343# International Business Machines Corp., Manassas, VA.

SINGLE EVENT TEST METHOD AND TEST RESULTS ON THE INTEL 80386

THOMAS MARK SCOTT *In* ESA, ESA Electronic Components Conference p 333-338 Mar. 1991

Copyright Avail: CASI HC A02/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

The technique and results of radiation susceptibility testing performed on the Intel 80386 microprocessor are described. Latchup and upset sensitivities are evaluated using alpha particles, heavy ions and protons, as well as some total dose test results. Californium and heavy ion testing yield virtually identical results. No transients are discovered using californium or heavy ions, but the extended range of the heavy ion facility picked up a latchup mechanism. ESA

N91-32344# Centre National d'Etudes Spatiales, Toulouse (France).

RADIATION SENSITIVITY OF POWER MOSFETS

J. GARNIER and P. TASTET *In* ESA, ESA Electronic Components Conference p 339-343 Mar. 1991

Copyright Avail: CASI HC A01/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

Metal Oxide Semiconductor Field Effect Transistors (MOSFETS) are widely used in space applications. Their high speed switching capability and easy voltage gate control allow large gain in efficiency and mass of on board power supplies. However, these components are sensitive to radiation. In order to quantify this sensitivity, various tests (total dose and heavy ions) are performed on international rectifier MOSFETS. Two families are evaluated: the ESA/SSC qualified standard technology and radiation tolerant technology. It is concluded that in most cases a negative gate source bias is not necessary to ensure the blocking of the transistor. ESA

N91-32346# Commissariat a l'Energie Atomique, Bruyeres-le-Chatel (France).

SINGLE EVENT UPSET SENSITIVITY OF A SRAM: AN OVERVIEW FROM TESTING PROCEDURES TO DEVICE HARDENING (THEME 2)

O. MUSSEAU, J. L. LERAY, Y. M. COIC, and Y. PATIN *In* ESA, ESA Electronic Components Conference p 351-356 Mar. 1991

(Contract CNES-CEA-844/87/4757/00)

Copyright Avail: CASI HC A02/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

The single event upset sensitivity of Complementary Metal Oxide Semiconductors (CMOS) on epilayer 16 and 64 kbit Static RAM's (SRAMS) is studied. The device cross sections are measured using both a californium source and accelerator beams. The experimental results are complemented by numerical simulations of the transients in a memory cell under various conditions, and a simplified model of charge collection in CMOS on epilayer is proposed. Analysis of the topological sensitivity of memory cells suggests simple hardening techniques that do not modify the technological process. The data reveals an unexpected failure mode. Device testing validity with various accelerators is discussed. ESA

N91-32347# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

HEAVY-ION INDUCED SINGLE-EVENT UPSET IN INTEGRATED CIRCUITS

J. A. ZOUTENDYK *In* ESA, ESA Electronic Components Conference p 357-361 Mar. 1991 Sponsored by NASA Microelectronics Space Radiation Effects Program

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The cosmic ray environment in space can affect the operation of Integrated Circuit (IC) devices via the phenomenon of Single Event Upset (SEU). In particular, heavy ions passing through an IC can induce sufficient integrated current (charge) to alter the state of a bistable circuit, for example a memory cell. The SEU effect is studied in great detail in both static and dynamic memory devices, as well as microprocessors fabricated from bipolar, Complementary Metal Oxide Semiconductor (CMOS) and N channel Metal Oxide Semiconductor (NMOS) technologies. Each device/process reflects its individual characteristics (minimum scale geometry/process parameters) via a unique response to the direct ionization of electron hole pairs by heavy ion tracks. A summary of these analytical and experimental SEU investigations is presented. ESA

N91-32410*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

NEUTRON, GAMMA RAY AND POST-IRRADIATION THERMAL ANNEALING EFFECTS ON POWER SEMICONDUCTOR SWITCHES

G. E. SCHWARZE and A. J. FRASCA 1991 15 p Presented at the Conference on Advanced Space Exploration Initiative Technologies, Cleveland, OH, 4-6 Sep. 1991; cosponsored in part by AIAA, NASA, and OAI Previously announced in IAA as A91-52420
(Contract RTOP 590-13-31)
(NASA-TM-105248; E-6577; NAS 1.15:105248; AIAA PAPER 91-3525) Avail: CASI HC A03/MF A01 CSCL 09A

The effects of neutron and gamma rays on the electrical and switching characteristics of power semiconductor switches must be known and understood by the designer of the power conditioning, control, and transmission subsystem of space nuclear power systems. The SP-100 radiation requirements at 25 m from the nuclear source are a neutron fluence of 10(exp 13) n/sq cm and a gamma dose of 0.5 Mrads. Experimental data showing the effects of neutrons and gamma rays on the performance characteristics of power-type NPN Bipolar Junction Transistors (BJTs), Metal-Oxide-Semiconductor Field Effect Transistors (MOSFETs), and Static Induction Transistors (SITs) are presented. These three types of devices were tested at radiation levels which met or exceeded the SP-100 requirements. For the SP-100 radiation requirements, the BJTs were found to be most sensitive to neutrons, the MOSFETs were most sensitive to gamma rays, and the SITs were only slightly sensitive to neutrons. Post-irradiation thermal anneals at 300 K and up to 425 K were done on these devices and the effectiveness of these anneals are also discussed. Author

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DATA & COMMUNICATION SYSTEMS

Communication and data storage or retrieval systems. Includes control systems and also computer networks and software.

A91-32381

EQUILIBRIUM POSITIONS AND LOCAL STABILITY OF NONLINEAR DYNAMIC CONTROL SYSTEMS. I [POLOZHENIIA RAVNOVESIIA I LOKAL'NAIA USTOICHIVOST' NELINEINYKH DINAMICHESKIKH SISTEM UPRAVLENIIA. I]

V. E. NABIVACH (AN USSR, Institut Kibernetiki, Kiev, Ukrainian SSR) Kibernetika i Vychislitel'naia Tekhnika (ISSN 0454-9910), no. 85, 1990, p. 25-32. In Russian. refs
Copyright

Problems of the bifurcation of the equilibrium positions of dynamic systems which are reducible to a single differential equation are examined on the basis of a classification of cuspoid catastrophes. The local stability of such systems is analyzed together with possible cases of stability loss. L.M.

A91-33476

CONFERENCE ON ARTIFICIAL INTELLIGENCE APPLICATIONS, 6TH, SANTA BARBARA, CA, MAR. 5-9, 1990, PROCEEDINGS. VOL. 1

Conference sponsored by IEEE. Los Alamitos, CA, IEEE Computer Society Press, 1990, 352 p. For individual items see A91-33477 to A91-33486.
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The present conference on AI applications discusses diagnostic methods, inductive generalization, AI-related connectionism, AI scheduling, advanced rule systems, AI design methods, domain-independent tools, AI space applications, domain-specific tools, AI abstract models, and user interfaces. Attention is given to a minimal connection model for abductive diagnostic reasoning, the application of statistical knowledge to knowledge-base construction, modeling diagnostic problem-solving at multiple levels of abstraction, neural nets vs expert systems, and distributed constraint-directed factory scheduling. Also discussed are AI scheduling for NASA's Hubble Space Telescope, real-time reasoning for spacecraft, feedback-directed design modification, and three quantitative simulation extensions for supporting economics models. O.C.

A91-33483* Lockheed Engineering and Sciences Co., Houston, TX.

DEMONSTRATING ARTIFICIAL INTELLIGENCE FOR SPACE SYSTEMS - INTEGRATION AND PROJECT MANAGEMENT ISSUES

EDMUND C. HACK and DENISE M. DIFILIPPO (Lockheed Engineering and Sciences Co., Houston, TX) IN: Conference on Artificial Intelligence Applications, 6th, Santa Barbara, CA, Mar. 5-9, 1990, Proceedings. Vol. 1. Los Alamitos, CA, IEEE Computer Society Press, 1990, p. 191-197. refs
(Contract NAS9-15800; NAS9-17900)
Copyright

As part of its Systems Autonomy Demonstration Project (SADP), NASA has recently demonstrated the Thermal Expert System (TEXSYS). Advanced real-time expert system and human interface technology was successfully developed and integrated with conventional controllers of prototype space hardware to provide intelligent fault detection, isolation, and recovery capability. Many specialized skills were required, and responsibility for the various phases of the project therefore spanned multiple NASA centers, internal departments and contractor organizations. The test environment required communication among many types of hardware and software as well as between many people. The integration, testing, and configuration management tools and methodologies which were applied to the TEXSYS project to assure its safe and successful completion are detailed. The project demonstrated that artificial intelligence technology, including model-based reasoning, is capable of the monitoring and control of a large, complex system in real time. I.E.

A91-34636#

INTERFERENCE PROBLEMS IN SATELLITE SPREAD SPECTRUM CDMA SYSTEMS

FULVIO ANANASSO (Roma II, Universita, Rome, Italy), ANTONIO ARCIDIACONO (ESA, Paris, France), and RICCARDO GIUBILEI (Selenia Spazio S.p.A., Rome, Italy) IN: ICDSC-8; Proceedings of the 8th International Conference on Digital Satellite Communications, Pointe-a-Pitre, Guadeloupe, Apr. 24-28, 1989. Paris, France Cables et Radio, 1989, p. 165-172. refs

The present paper expands upon some peculiarities of code division multiple access (CDMA) to mitigate the effects of interference in multiple-user satellite systems. It is shown how some specific satellite applications - data relay satellites, Space Station, mobile satellite systems, VSATs, may take advantage of CDMA features offered by spread spectrum modulations. Author

A91-39049#

PC SIMULATIONS FOR DATA RECORDING AND STORAGE CONTROL DEVICES IN A MICRO-GRAVITY SPACE ENVIRONMENT

VINCENT J. RIZZO (Lockheed Sanders, Inc., Nashua, NH) IEEE, ACM, Amateur Computer Group of New Jersey, et al., Trenton Computer Festival, 16th, Mercer County Community College, NJ, Apr. 20, 21, 1991, Paper. 17 p.

The disturbances that devices such as optical disk and tape recorder data storage drives transmit to a satellite are discussed. The microgravity specifications for the European Polar Platform and the Space Station are given, and the role of angular momentum and torque disturbances are addressed along with control techniques for meeting these specifications. The computing power of the PC is used to solve the complex microgravity problem via real-time simulations, and the results are presented, along with some measured data, with the emphasis on controls for optical disk and tape recorder systems. The performance criteria are optical positioning, track acquiring, and single- and multiple-track seeking. The results can be expanded to include finite-element and three-dimensional analysis. P.D.

A91-39240* General Electric Co., Camden, NJ.
HIGH-PERFORMANCE OPTICAL DISK MASS STORAGE FOR AEROSPACE IMAGING SYSTEMS
STEPHEN M. RAVNER (GE Aerospace, Camden, NJ) and THOMAS A. SHULL (NASA, Langley Research Center, Hampton, VA) IN: Storage and retrieval systems and applications; Proceedings of the Meeting, Santa Clara, CA, Feb. 13-15, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 170-175. refs
Copyright

The specifications and techniques related to the development of the NASA Spaceflight Optical Disk Recorder (SODR) are presented. The system is being developed for the temporary storage of high-resolution sensor data that will be collected at high data rates by future space programs. Typical spaceflight recording requirements are given for the Space Station Freedom, the Earth Observing System, and some planetary missions. SODR module characteristics are listed, emphasizing the two independent optical disk recorders and the random access to 5 gigabytes of data on each side of the disks. The modular design includes two I/O ports providing 150 Mbits/sec user data rate each, and multimodule reconfigurable architecture permitting the synchronization of up to 16 modules with a maximum data rate of 4.8 gigabits/sec. C.C.S.

A91-39820
SPACECRAFT COMMAND AND CONTROL USING ARTIFICIAL INTELLIGENCE TECHNIQUES
BRIAN DRABBLE (Edinburgh, University, Scotland) British Interplanetary Society, Journal (ISSN 0007-094X), vol. 44, June 1991, p. 251-254. refs
(Contract SERC-GR/E/98058; F49620-89-C-0081)
Copyright

The major artificial intelligence (AI) techniques for spacecraft command and control (SCC) associated with mission operation and resource schedualing are described. The AI techniques which have been successfully applied to SCC include Deviser, Marvel, Sharp, and T-SCHED and involve knowledge-based planning and scheduling. Attention is also given to future research projects such as the Hubble Space Telescope Scheduler and O-Plan 2. O.G.

A91-41757#
THE INFLUENCE OF AN ELECTRIC THRUSTER PLASMA PLUME ON DOWNLINK COMMUNICATIONS IN SPACE EXPERIMENTS
B. S. BORISOV, V. I. GARKUSHA, N. V. KOZYREV, A. G. KORSUN, L. IU. SOKOLOV (Tsentral'nyi Nauchno-Issledovatel'skii Institut Mashinostroeniia, Kaliningrad, USSR) et al. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 12 p. refs
(AIAA PAPER 91-2349) Copyright

The effects of ejections of plasma on downlink communications is investigated by means of experiments utilizing the Cosmos satellite. Relatively dense plasma jets are provided by 50 firings of a cesium propellant to simulate the electron concentrations of high-power electric thruster plumes. An analytical model of plasma jets in space that considers geomagnetic effects is presented. The model predicts that a petal-shaped radio shield would create a shadow which affects on-board antenna radiation and therefore the communication. The experimental investigation qualitatively confirmed the theoretical predictions. Plots of the radio shadow contour made with amplitude measurements appear to be asymmetric relative to the theoretical satellite route. The plasma source designed for the experiment is an effective mechanism for investigating plasmadynamic phenomena and spacecraft charge control. C.C.S.

A91-42861
CCSDS - IMPLICATIONS FOR THE UK
S. MARA (Marcol Group, Ltd., Avonicom Div., Bristol, England) British Interplanetary Society, Journal (ISSN 0007-094X), vol. 44, July 1991, p. 291-296.
Copyright

The activities of the Consultative Committee for Space Data Systems (CCSDS), formed in 1982 to consider space data standards for the forthcoming space missions including SSF, are reviewed, and its impact on the British involvement in future space programs is discussed. The main goals of CCSDS activities include cross-support between agencies; more flexible spacecraft operation by standardizing interfaces, hardware, and software; development of a standard method of enveloping and describing data; and development of a standardized sequence of procedures to be followed to obtain a CCSDS service. The European Space Agency Standard issued on the basis of CCSDS recommendations is briefly discussed. O.G.

A91-45842
PACKET COMMUNICATIONS SERVICES FOR THE SPACE STATION FREEDOM
J. F. SMITH (McDonnell Douglas Space Systems Co., Huntington Beach, CA) IN: 1990 IEEE Aerospace Applications Conference, Vail, CO, Feb. 4-9, 1990, Digest. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 193-200. refs
Copyright

The preliminary design of the space-to-ground packet communications services that have been recommended for the Space Station Freedom Manned Base (SSFMB) is discussed. The packet communications services between the Space Station Freedom and the ground control centers are considered. The packet communications services described include path service for the unacknowledged and unconfirmed delivery of classical spacecraft telemetry, and internet service, which is to be used for the general computer-to-computer communications between the SSFMB and the ground control centers. The concepts of the virtual channel as it relates to delivery of the described packet services are introduced, and other data delivery services that will be provided by the Space Station Information System are briefly reviewed. I.E.

A91-45843
COMMUNICATIONS PROTOCOL STACKS FOR THE SPACE STATION FREEDOM
D. QUINCEY and J. F. SMITH (McDonnell Douglas Space Systems Co., Huntington Beach, CA) IN: 1990 IEEE Aerospace Applications Conference, Vail, CO, Feb. 4-9, 1990, Digest. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 201-207. refs
Copyright

Some of the aspects of the communications protocol stacks that have been recommended for the packet communications services for the Space Station Freedom Program are discussed. Particular attention is given to the protocol stacks that support the two space-to-ground packet communications services, the path and internet services. Then, the protocol stacks of the subnetworks and gateways that connect onboard and ground user applications are discussed. Standards developed by the Consultative Committee for Space Data Systems are used to implement the data link and physical layer function for the protocol stacks of the space link subnet which joins the onboard and ground networks. I.E.

A91-47753
SOFTWARE INTEGRATION, VERIFICATION AND QUALIFICATION FOR MANNED SPACE LABORATORIES - STRATEGIES AND TECHNIQUES
NICHOLAS INNES and LORENZO SARLO (Aeritalia S.p.A., Turin, Italy) IN: The management of large software projects in the space industry; Colloquium, Toulouse, France, Oct. 16-18, 1990, Proceedings. Toulouse, France, Cepadues-Editions, 1991, p. 33-45. refs
Copyright

Some strategies for and approaches to the management and implementation of the software integration, verification, and qualification (SIVQ) process for manned space labs are examined. The strategic allocation of IVQ resources throughout the software development life-cycle is discussed, and the role of SIVQ activities in relation to other system level and subcontractor activities is examined. Recommendations are made on how these relationships can be made more effective for the implementation of a comprehensive IVQ program. L.M.

A91-47755
INTEGRATION AND VALIDATION OF ONBOARD SPACE SOFTWARE [INTEGRATION ET VALIDATION DES LOGICIELS EMBARQUES SPATIAUX]
HERVE COSTARD (Matra Espace, Toulouse, France) IN: The management of large software projects in the space industry; Colloquium, Toulouse, France, Oct. 16-18, 1990, Proceedings. Toulouse, France, Cepadues-Editions, 1991, p. 59-66. In French.
Copyright
The integration and validation philosophy for the central flight software of the SPOT 4 satellite is presented. The initial phase of the life cycle is described, and the software test methodology is discussed. The close relationship between this methodology and the general philosophy for the integration of the satellite and the complete space system is explained. Finally, problems raised by the validation of future European space systems (e.g., Columbus, Hermes, AR5) are considered. L.M.

A91-47757
ON EXPERIENCE IN MODELLING OF SYSTEM'S OPERATIONAL BEHAVIOUR
RAINER GERLICH (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) IN: The management of large software projects in the space industry; Colloquium, Toulouse, France, Oct. 16-18, 1990, Proceedings. Toulouse, France, Cepadues-Editions, 1991, p. 79-89.
Copyright
A description is given to a software system modeling or prototyping approach, by which a very early prediction of what a system's behavior will be can be obtained. Prototyping is considered from a management point of view, with attention given to conceptualization, the implementation approach, and optimization. An implementation of operational modeling/prototyping is described which is intended to be used in the Columbus project. L.M.

A91-47760
PETRI NETS FOR MODELLING DYNAMIC CHARACTERISTICS IN HOOD
H. VAN BEIRENDONCK, J. BEAUFAYS, S. VAN BAELEN, and K. DE VLAMINCK (TRASYS Space; Leuven, Katholieke Universiteit, Louvain, Belgium) IN: The management of large software projects in the space industry; Colloquium, Toulouse, France, Oct. 16-18, 1990, Proceedings. Toulouse, France, Cepadues-Editions, 1991, p. 121-129. refs
Copyright
The possibility of complementing HOOD (hierarchical object-oriented design), which has been chosen for the Hermes and Columbus projects, with Petri nets is discussed. A possible practical integration strategy for HOOD and Petri nets is proposed. It is pointed out that integrating HOOD and Petri nets would alleviate the lack of modularity typical of Petri net structures and would provide HOOD with a formal method to express dynamic characteristics. L.M.

A91-47762
DEVELOPMENT OF A CONFIGURABLE INFRASTRUCTURE FOR THE CONTROL OF A LARGE VARIETY OF SPACECRAFT - THE SCOS
B. MULLET (ESA, European Space Operations Centre, Darmstadt, Federal Republic of Germany) IN: The management of large software projects in the space industry; Colloquium, Toulouse, France, Oct. 16-18, 1990, Proceedings. Toulouse, France, Cepadues-Editions, 1991, p. 155-165. refs
Copyright
The paper analyzes several aspects specific to the development of infrastructure software systems and proposes several guidelines and recommendations in connection with the SCOS (Spacecraft Control and Operation System). It is pointed out that the SCOS example demonstrates that the initial cost overhead implied by the increased project complexity is largely compensated by the advantage of reusing and maintaining a single large system kernel for three or more missions. L.M.

A91-47763
THE INTEGRATION AND TEST OF MODERN SPACECRAFT CONTROL SYSTEMS
N. HEAD and M. JONES (ESA, European Space Operations Centre, Darmstadt, Federal Republic of Germany) IN: The management of large software projects in the space industry; Colloquium, Toulouse, France, Oct. 16-18, 1990, Proceedings. Toulouse, France, Cepadues-Editions, 1991, p. 167-174.
Copyright
Various issues connected with the integration and testing of modern spacecraft control systems are examined. The discussion is limited to system level testing, and particular attention is given to the object of testing, the reason for testing, test philosophy and tools, and the needed improvements. L.M.

A91-47768
MANAGEMENT OF SOFTWARE DEVELOPMENTS FROM MULTIPLE SOURCES - EXPERIENCES GAINED FROM THE ERS-1 PROGRAM
FRANZ SASSE (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) IN: The management of large software projects in the space industry; Colloquium, Toulouse, France, Oct. 16-18, 1990, Proceedings. Toulouse, France, Cepadues-Editions, 1991, p. 215-226.
Copyright
The present study examines management aspects of the development of the onboard software for the European Remote Sensing satellite 1 (ERS-1). Consideration is given to the complete software life-cycle (design, development and operation phase, and maintenance phase). Emphasis is placed on the difficulties and constraints that appeared during the different software life-cycle phases and are mainly caused by the 'individual' approach of software development applied to each part of the ERS-1 onboard software. The advantages and disadvantages of the selected individual approach to software development are evaluated on the basis of experienced difficulties and constraints. An outline is presented of future projects in which the development approach to 'common' software planned for the Columbus and Hermes programs is discussed and compared with the 'individual' ERS-1 approach. P.D.

A91-47772
SOFTWARE MANAGEMENT STRATEGIES AND PRACTICES FOR SPACE SYSTEMS DEVELOPMENT
LORENZO SARLO (Aeritalia S.p.A., Turin, Italy) IN: The management of large software projects in the space industry; Colloquium, Toulouse, France, Oct. 16-18, 1990, Proceedings. Toulouse, France, Cepadues-Editions, 1991, p. 263-270. refs
Copyright
Work breakdown and software industrial structures are defined and the relationships between the software and the other system disciplines are evaluated. Emphasis is placed on the experience gained from the Columbus Attached Laboratory Flight and Ground Infrastructures programs and studies. Examples of scenarios are presented for: prime software management organization; software management, development planning, and maintenance; and software versioning and incremental development/integration.
P.D.

A91-47779* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
LESSONS LEARNED IN THE DEVELOPMENT OF THE HUBBLE SPACE TELESCOPE SOFTWARE
MICHAEL HARRINGTON (NASA, Marshall Space Flight Center, Huntsville, AL), FRANK VANLANDINGHAM (Computer Sciences Corp., Silver Spring, MD), and WILLIAM C. SCHNEIDER (Space Software Italia, Italy) IN: The management of large software projects in the space industry; Colloquium, Toulouse, France, Oct.

16-18, 1990, Proceedings. Toulouse, France, Cepadues-Editions, 1991, p. 335-343.
Copyright

An effort is made to document what was successful in the HST software development, and to present a retrospective analysis indicating what could have been done more efficiently. Consideration is given to systems engineering and design definition, standards and tools, system architecture and design, operational considerations, and reuse and adaptation of existing resources. R.E.P.

A91-47783

AGILE, AN EXPERT SYSTEM FOR ASSISTING IN THE MANAGEMENT OF LARGE SPACE PROJECTS [AGILE, UN SYSTE L'EXPLOITATION DES GRANDS PROJETS SPATIAUX]

ELISABETH LAUTIER, BERNARD ROMEO (CNES, Paris, France), and PATRICK LESUEUR (TECHLOG, France) IN: The management of large software projects in the space industry; Colloquium, Toulouse, France, Oct. 16-18, 1990, Proceedings. Toulouse, France, Cepadues-Editions, 1991, p. 383-390. In French.
Copyright

Activitites at the Software Management Service (SGL) of CNES are discussed. Particular attention is given to the characteristics of the AGILE expert system, which offers an original solution to one of the typical problems of space-project management: namely, the problem of centralizing knowledge and preserving acquired experience. L.M.

A91-47785

COLUMBUS SOFTWARE - TRANSITION FROM SOFTWARE DEVELOPMENT TO SYSTEM OPERATIONS

VITTORIO CIAMPOLINI, DAVID R. HARRIS, NICHOLAS INNES, and CARLO PACCAGNINI (Aeritalia S.p.A., Turin, Italy) IN: The management of large software projects in the space industry; Colloquium, Toulouse, France, Oct. 16-18, 1990, Proceedings. Toulouse, France, Cepadues-Editions, 1991, p. 395-403. refs
Copyright

The Aeritalia approach for the Columbus Attached Laboratory is presented, focusing on the integrated utilization of the software development environment, mission preparation tools, and system verification facilities. Attention is given to the integration of software components into the system mission database, generation of the onboard software 'objects' to support system test campaigns, and generation of the onboard software 'objects' for a given system mission. R.E.P.

A91-47786

SOFTWARE MAINTENANCE FOR GROUND SYSTEMS [MAINTENANCE DES LOGICIELS DES SYSTEMES SOL]

JEAN L. DUCUING, JEAN P. DENIER, OLIVIER PASERO (Matra Espace, Toulouse, France), and AMAURY SIMON (Durham, University, England) IN: The management of large software projects in the space industry; Colloquium, Toulouse, France, Oct. 16-18, 1990, Proceedings. Toulouse, France, Cepadues-Editions, 1991, p. 405-417. In French. refs
Copyright

Various aspects of ground-system software maintenace are presented for current operational space systems, and related problems and solutions are described. The needs of future space systems are then identified, and it is suggested that future software maintenance will require a global approach, refined throughout the lifetime of the system. L.M.

A91-47788

WHY IS SPACE SOFTWARE SPECIAL?

P. NORRIS (Logica, London, England) IN: The management of large software projects in the space industry; Colloquium, Toulouse, France, Oct. 16-18, 1990, Proceedings. Toulouse, France, Cepadues-Editions, 1991, p. 435-441.
Copyright

Consideration is given to the extent to which onboard space software differs from other software applications. The implications of those differences are examined for various aspects of space programs including software to support integration and test activities, software to control the satellite from the ground, and software in the computers onboard the satellite. R.E.P.

A91-47789

THE ELECTRONIC COPILOT - A FRUITFUL EXPERIENCE TOWARD COMPLEX PROJECT MANAGEMENT USING ARTIFICIAL INTELLIGENCE IN THE SPACE DOMAIN

YANN RENAULT and GILLES CHAMPIGNEUX (Dassault Aviation, Saint-Cloud, France) IN: The management of large software projects in the space industry; Colloquium, Toulouse, France, Oct. 16-18, 1990, Proceedings. Toulouse, France, Cepadues-Editions, 1991, p. 443-462. refs
Copyright

Current experience is presented of how knowledge engineering methods should be employed for expertise initial design and then supplemented by extensive knowledge evaluation and refinement in a simulator, and in some cases by automatic knowledge generation tools. It is shown that the concept described of an electronic copilot, could be usefully applied to space projects. Three examples of potential applications are been identified and developed: an electronic assistant for the astronaut in IVA for combined EVA/robotics activities during in-orbit servicing operations, an electronic assistant flight controller for real-time telemetry data evaluation during manned space flights, and an electronic assistant for the 'smart evaluation' of the crew during intensive operations training. R.E.P.

A91-51227* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

OBJECT-ORIENTED FAULT TREE MODELS APPLIED TO SYSTEM DIAGNOSIS

DAVID L. IVERSON and F. A. PATTERSON-HINE (NASA, Ames Research Center, Moffett Field, CA) IN: Applications of artificial intelligence VIII; Proceedings of the Meeting, Orlando, FL, Apr. 17-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 1013-1023. refs
Copyright

When a diagnosis system is used in a dynamic environment, such as the distributed computer system planned for use on Space Station Freedom, it must execute quickly and its knowledge base must be easily updated. Representing system knowledge as object-oriented augmented fault trees provides both features. The diagnosis system described here is based on the failure cause identification process of the diagnostic system described by Narayanan and Viswanadham. Their system has been enhanced in this implementation by replacing the knowledge base of if-then rules with an object-oriented fault tree representation. This allows the system to perform its task much faster and facilitates dynamic updating of the knowledge base in a changing diagnosis environment. Accessing the information contained in the objects is more efficient than performing a lookup operation on an indexed rule base. Additionally, the object-oriented fault trees can be easily updated to represent current system status. This paper describes the fault tree representation, the diagnosis algorithm extensions, and an example application of this system. Comparisons are made between the object-oriented fault tree knowledge structure solution and one implementation of a rule-based solution. Plans for future work on this system are also discussed. Author

A91-53061* Lockheed Engineering and Sciences Co., Houston, TX.

INTERFERENCE EFFECTS ON SPACE STATION FREEDOM AND SPACE SHUTTLE ORBITER KU-BAND SINGLE ACCESS RETURN LINKS

HYUCK M. KWON, Y. C. LOH, KWEI TU, and WILLIAM C. GADD (Lockheed Engineering and Sciences Co., Houston, TX) IN: MILCOM '90 - IEEE Military Communications Conference, Monterey, CA, Sept. 30-Oct. 3, 1990, Conference Record. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 17-21. refs

(Contract NAS9-17900)
Copyright
In a Ku-band single access return (KSAR) communication link via the tracking and data relay satellite system (TDRSS), the interference between spacecraft can be discriminated by opposite antenna polarizations, pseudo-noise code, and by TDRSS antenna beam pointing. For the Space Station Freedom (SSF) KSAR and the Space Shuttle Orbiter (SSO) KSAR links, the pseudo-noise coding technique is not exploited. In addition, the two KSAR links use the same carrier frequency. Therefore, if the SSF and SSO are in close proximity, it is expected that mutual interference will be significant. Mutual interference effects on the SSO-KSAR I-channel and the SSF-KSAR links are analytically derived and compared to the simulation results. For the analysis, the channel is assumed ideally bandlimited and linear. It is demonstrated that a simplified (linear bandlimited channel) analytical approach yields results of adequate accuracy in an estimation of the signal degradation by interference. I.E.

A91-53071* Lockheed Engineering and Sciences Co., Houston, TX.
FRAME SYNCHRONIZATION FOR A CHANNEL WITH DIFFERENT DATA RATES
HYUCK M. KWON (Lockheed Engineering and Sciences Co., Houston, TX) IN: MILCOM '90 - IEEE Military Communications Conference, Monterey, CA, Sept. 30-Oct. 3, 1990, Conference Record. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 176-180. refs
(Contract NAS9-17900)
Copyright
In some communication links, different data rates are used at different times on the same channel and each is assigned a separate frame synchronization (sync) marker. The frame search is completed within a finite number of frame intervals once both phase-lock and bit-sync are achieved because the incoming data rate can change. The probability of failure to frame-lock, and an upper bound of probability of false frame-lock in a frame search mode are derived for a communication link with a 10 to the -5th bit error probability. The probability of failure to detect data-rate change and the probability of false detection of data-rate change in a frame-lock mode are discussed. In a frame-lock mode, the probability of failure to detect data-rate change and probability detection of data-rate change an equal to 4.96 x 10 to the -12th. A frame-lock device can be used for the Space Station Freedom Ku-band return link. I.E.

A91-53177* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MODELING OF THE SPACE STATION FREEDOM DATA MANAGEMENT SYSTEM
MARJORY J. JOHNSON (NASA, Ames Research Center, Moffett Field, CA) IN: GLOBECOM '90 - IEEE Global Telecommunications Conference and Exhibition, San Diego, CA, Dec. 2-5, 1990, Conference Record. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 572-578. refs
(Contract NCC2-387)
Copyright
The data management system (DMS) is the information and communications system onboard Space Station Freedom. Extensive modeling of the DMS is being conducted throughout NASA to aid in the design and development of this vital system. Activities to model the DMS network infrastructure are described, focusing on modeling of the fiber distributed data interface (FDDI) token-ring protocol and experimental testbedding of networking aspects of the DMS. I.E.

A91-54641
PERFORMANCE ANALYSIS OF SPACE STATION COMMUNICATIONS PROTOCOLS
KENT LOCKHART and SUSAN PALOCSAY (Mitre Corp., McLean, VA) IN: IEEE/AIAA/NASA Digital Avionics Systems Conference, 9th, Virginia Beach, VA, Oct. 15-18, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 419-424. refs
Copyright
The Space Station Freedom communications architecture, the Consultative Committee for Space Data Systems (CCSDS) advanced orbiting system (AOS) protocols, and the design of the protocol simulator prototype are discussed. The results from an initial performance analysis of the CCSDS AOS protocols based on processing time and throughput measurements from the protocol simulator are presented. These results illustrate how CCSDS AOS protocol processing is affected by packet size, CCSDS grades of service, and data type. It is demonstrated that neither procedure processing times nor throughput are noticeably affected by CCSDS grade of service. However, the inclusion of processing times for Reed-Solomon and CRC error coding and retransmission effects will change this result. It was found that the multiplexer procedure is the primary bottleneck point of the CCSDS procedures studied. Improved multiplexer performance can be achieved using packet sizes in which segmentation does not occur. It was also found that larger packet sizes provide a higher rate of throughput. However, when the effect of retransmission is considered, larger packet sizes may not provide the highest throughput. I.E.

A91-55829
JEM DATA MANAGEMENT SYSTEM SOFTWARE
T. YOKOYAMA (NASDA, Space Station Group, Tokyo, Japan), M. HATTORI, M. FUJIOKA, Y. IKI, A. ISOBE, and T. TAKASU (NEC Corp., Space Station Systems Div., Yokohama, Japan) IN: Space utilization and applications in the Pacific; Proceedings of the 3rd Pacific Basin International Symposium on Advances in Space Science Technology and its Applications, Los Angeles, CA, Nov. 6-8, 1989. San Diego, CA, Univelt, Inc., 1990, p. 345-351. refs
(AAS PAPER 89-632) Copyright
The Japanese Experiment Module Data Management System (JEM DMS) requirements and functions are described, and JEM DMS software architecture is briefly discussed. JEM DMS provides the onboard JEM Information System (JEMIS) with an integrated data processing, data storage and retrieval, and data communication environment as a functional part of the Space Station DMS. The JEM DMS software has a centralized architecture with the real-time kernel as the base of the operating system, although several appropriate parts of it are functionally distributed to network front-end processors and to a workstation. O.G.

N91-21966*# Research Inst. for Computing and Information Systems, Houston, TX.
XTP FOR THE NASA SPACE STATION
ALFRED C. WEAVER (Virginia Univ., Charlottesville.) Mar. 1990 15 p
(Contract NCC9-16)
(NASA-CR-188087; NAS 1.26:188087) Avail: CASI HC A03/MF A01 CSCL 05B
The NASA Space Station is a truly international effort; therefore, its communications systems must conform to established international standards. Thus, NASA is requiring that each network-interface unit implement a full suite of ISO protocols. However, NASA is understandably concerned that a full ISO stack will not deliver performance consistent with the real-time demands of Space Station control systems. Therefore, as a research project, the suitability of the Xpress transfer protocol (XTP) is investigated along side a full ISO stack. The initial plans for implementing XTP and comparing its performance to ISO TP4 are described.
Author

N91-22235# European Space Agency. European Space Operations Center, Darmstadt (Germany, F.R.).
GROUND SYSTEMS FOR HANDLING PACKET TELEMETRY AND COMMANDS: A CASE STUDY, THE EURECA MISSION
MICHAEL JONES, ERIK MOSE SOERENSEN, and CHRISTIAN MUELLER (Logica Ltd., London, England) *In its* Ground Data Systems for Spacecraft Control p 279-283 Oct. 1990
Copyright Avail: CASI HC A01/MF A06
The European Retrievable Carrier (Eureca) mission concept,

based upon reusable platform supplying services to a variety of independently operated payloads is discussed. Eureca is characterized by several new on board features, most notably packet telemetry, and a partial implementation of packet telecommanding. As a consequence of the satellite's short contact times with its ground station (3 contacts during the mission in 5 to 8 minute passes), it also has essential built in autonomy features and on board recording of telemetry. The effect of these features on the ground control system are discussed. Special attention is given to: systems requirements, overall design of the ground control system and computer loading and sizing. The processing of packet telemetry is shown to have a significant effect on the computer loading and sizing. The effect of the greater on board autonomy is shown to require quite complex support functions for the operations staff, both for preparing the autonomous operations and then monitoring them a-postiori. ESA

N91-22264# Compagnia Italiana Servizi Tecnici, Rome. Space Div.

THE REQUIREMENTS ON DATA SYSTEMS OF COLUMBUS LOGISTICS AND ENGINEERING SUPPORT

G. F. DELUCA, S. MASULLO, and S. RANDISI *In* ESA, Ground Data Systems for Spacecraft Control p 467-475 Oct. 1990

Copyright Avail: CASI HC A02/MF A06

The functions served by the Columbus Engineering Support Facilities (ESFs) are outlined. The support these can provide to the operations and control of flight elements during the overall life cycle is discussed. Starting from an analytical review of applicable set of requirements, the activities to be executed in the centers are derived. Subsequently the definition and analysis of the functional requirements of the centers are performed, mainly using the Structured Analysis and Design Technique (SADT) method. A sample operational scenario is taken out from the set of possible system configurations for analysis and discussions using the Petri nets method, in order to highlight the behavior of the ESF and its related transmission modes under contingency conditioning events. The requirements placed on the internal infrastructure concerning data handling aspects, are discussed and assessed providing a possible architecture. Programmatic recommendations are suggested for actual implementation, in compliance with the available and applicable constraints of the Columbus program. ESA

N91-22282*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.

DEVELOPING A USER-INTERFACE-EVALUATION TOOL FOR SPACE-STATION-ERA APPLICATIONS

SHARI A. BAHDER, ELIZABETH D. MURPHY (Computer Technology Associates, Inc., Rockville, MD.), SYLVIA B. SHEPPARD, and WALTER TRUSZKOWSKI *In* ESA, Ground Data Systems for Spacecraft Control p 583-587 Oct. 1990

(Contract NAS5-30680)

Copyright Avail: CASI HC A01/MF A06 CSCL 05H

The development of progressively more intelligent interface dsign aids is described. The first generation of the Computer Human Interaction Models (CHIMES) methodology and toolset identifies trouble spots in an existing or proposed design. The second generation, CHIMES-2, provides the designer with intelligent assistance in formulating modifications to correct identified problems. The approaches used in development of the CHIMES-2 capabilities and knowledge bases are outlined. Implementation of the phase 1 prototype is described. Future directions include integration with other design tools, implementation of a design library, and further theoretical work. The final objective of the research and development effort is a total workstation environment for the designer of computer human interfaces for spacecraft control. ESA

N91-22284# Marcol Computer Systems Ltd., Darmstadt (Germany, F.R.).

MSCC CONSOLE DEMONSTRATOR PROJECT

P. HALL and M. DREXLER (Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen, Germany, F.R.) *In* ESA, Ground Data Systems for Spacecraft Control p 597-600 Oct. 1990

Copyright Avail: CASI HC A01/MF A06

The Columbus ground data systems will employ a number of new technologies including advanced graphical user interfaces, networked workstations and Ada. Each of these new technologies present new challenges to engineers and managers. In order to reduce the technical risk and to control life cycle costs, a pilot project is proposed to develop a control room demonstration console. The Manned Space Laboratories Control Center (MSCC) console demonstrator is a prototype of the console to be used in the MSCC ground data system during Columbus. It has two-operator positions with access to the existing MSCC voice, video and timing facilities. The console workstations are networked to a simulator which will generate telemetry data for display at the Console demonstrator Man Machine Interface (MMI). Development of the MSCC console demonstrator provides important information about the MMI and networking design. It also serves as a testbed for new technologies. ESA

N91-22298# National Aeronautical Lab., Tokyo (Japan).

TELESCIENCE TESTBED RESULT FOR JAPANESE EXPERIMENT MODULE

K. MATSUMOTO, K. HIGUCHI, H. KIMURA, N. TAKEDA, S. MATSUBARA, M. IZUMITA, Y. TOYAMA, M. KATO, and H. KATO (Nippon Electric Co. Ltd., Tokyo, Japan) *In* ESA, Ground Data Systems for Spacecraft Control p 677-681 Oct. 1990

Copyright Avail: CASI HC A01/MF A06

The first telescience testbed experiments for the Japanese Experiment Module (JEM) of the Space Station Freedom, conducted after the three year studies of its system requirements, are described. Three experiment themes of the First Material Processing Test (FMPT) of the Japanese Spacelab Mission are chosen for estimating communications requirements between the JEM and a ground station. A paper folding experiment is used to examine instruction aspects of onboard manual processing and onboard coaching. More than 10 principal investigators partipated in the experiments and were requested to answer a rating questionnaire for data acquisition. The results extracted from the questionnaire are summarized. ESA

N91-22352*# Research Inst. for Computing and Information Systems, Houston, TX.

EVALUATION PLAN FOR SPACE STATION NETWORK INTERFACE UNITS

ALFRED C. WEAVER Mar. 1990 80 p

(Contract NCC9-16)

(NASA-CR-188088; NAS 1.26:188088) Avail: CASI HC A05/MF A01 CSCL 22B

Outlined here is a procedure for evaluating network interface units (NIUs) produced for the Space Station program. The procedures should be equally applicable to the data management system (DMS) testbed NIUs produced by Honeywell and IBM. The evaluation procedures are divided into four areas. Performance measurement tools are hardware and software that must be developed in order to evaluate NIU performance. Performance tests are a series of tests, each of which documents some specific characteristic of NIU and/or network performance. In general, these performance tests quantify the speed, capacity, latency, and reliability of message transmission under a wide variety of conditions. Functionality tests are a series of tests and code inspections that demonstrate the functionality of the particular subset of ISO protocols which have been implemented in a given NIU. Conformance tests are a series of tests which would expose whether or not selected features within the ISO protocols are present and interoperable. Author

N91-22779*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.

THE GENERIC SPACECRAFT ANALYST ASSISTANT (GENSAA): A TOOL FOR AUTOMATING SPACECRAFT MONITORING WITH EXPERT SYSTEMS

PETER M. HUGHES and EDWARD C. LUCZAK (Computer

Sciences Corp., Beltsville, MD.) *In its* The 1991 Goddard Conference on Space Applications of Artificial Intelligence p 129-139 May 1991
Avail: CASI HC A03/MF A03 CSCL 09B

Flight Operations Analysts (FOAs) in the Payload Operations Control Center (POCC) are responsible for monitoring a satellite's health and safety. As satellites become more complex and data rates increase, FOAs are quickly approaching a level of information saturation. The FOAs in the spacecraft control center for the COBE (Cosmic Background Explorer) satellite are currently using a fault isolation expert system named the Communications Link Expert Assistance Resource (CLEAR), to assist in isolating and correcting communications link faults. Due to the success of CLEAR and several other systems in the control center domain, many other monitoring and fault isolation expert systems will likely be developed to support control center operations during the early 1990s. To facilitate the development of these systems, a project was initiated to develop a domain specific tool, named the Generic Spacecraft Analyst Assistant (GenSAA). GenSAA will enable spacecraft analysts to easily build simple real-time expert systems that perform spacecraft monitoring and fault isolation functions. Lessons learned during the development of several expert systems at Goddard, thereby establishing the foundation of GenSAA's objectives and offering insights in how problems may be avoided in future project, are described. This is followed by a description of the capabilities, architecture, and usage of GenSAA along with a discussion of its application to future NASA missions. Author

N91-22782*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
A MACHINE INDEPENDENT EXPERT SYSTEM FOR DIAGNOSING ENVIRONMENTALLY INDUCED SPACECRAFT ANOMALIES
MARK J. ROLINCIK *In its* The 1991 Goddard Conference on Space Applications of Artificial Intelligence p 169-179 May 1991
Avail: CASI HC A03/MF A03 CSCL 09B

A new rule-based, machine independent analytical tool for diagnosing spacecraft anomalies, the EnviroNET expert system, was developed. Expert systems provide an effective method for storing knowledge, allow computers to sift through large amounts of data pinpointing significant parts, and most importantly, use heuristics in addition to algorithms which allow approximate reasoning and inference, and the ability to attack problems not rigidly defines. The EviroNET expert system knowledge base currently contains over two hundred rules, and links to databases which include past environmental data, satellite data, and previous known anomalies. The environmental causes considered are bulk charging, single event upsets (SEU), surface charging, and total radiation dose. Author

N91-22786*# Computer Resources International A/S (Denmark).
EXPERT OPERATOR'S ASSOCIATE: A KNOWLEDGE BASED SYSTEM FOR SPACECRAFT CONTROL
MOGENS NIELSEN, KLAUS GRUE, and FRANCOIS LECOUAT (MATRA Espace, Toulouse, France) *In* NASA. Goddard Space Flight Center, The 1991 Goddard Conference on Space Applications of Artificial Intelligence p 227-237 May 1991
(Contract ESA-7627/88/NL/DG)
Avail: CASI HC A03/MF A03 CSCL 09B

The Expert Operator's Associate (EOA) project is presented which studies the applicability of expert systems for day-to-day space operations. A prototype expert system is developed, which operates on-line with an existing spacecraft control system at the European Space Operations Centre, and functions as an 'operator's assistant' in controlling satellites. The prototype is demonstrated using an existing real-time simulation model of the MARECS-B2 telecommunication satellite. By developing a prototype system, the extent to which reliability and effectivens of operations can be enhanced by AI based support is examined. In addition the study examines the questions of acquisition and representation of the 'knowledge' for such systems, and the feasibility of 'migration' of some (currently) ground-based functions into future spaceborne autonomous systems. Author

N91-22797*# Boeing Computer Services Co., Seattle, WA. Advanced Technology Center.
KNOWLEDGE REPOSITORIES FOR MULTIPLE USES
KEITH WILLIAMSON and PATRICIA RIDDLE *In* NASA. Goddard Space Flight Center, The 1991 Goddard Conference on Space Applications of Artificial Intelligence p 353-367 May 1991
Avail: CASI HC A03/MF A03 CSCL 09B

In the life cycle of a complex physical device or part, for example, the docking bay door of the Space Station, there are many uses for knowledge about the device or part. The same piece of knowledge might serve several uses. Given the quantity and complexity of the knowledge that must be stored, it is critical to maintain the knowledge in one repository, in one form. At the same time, because of quantity and complexity of knowledge that must be used in life cycle applications such as cost estimation, re-design, and diagnosis, it is critical to automate such knowledge uses. For each specific use, a knowledge base must be available and must be in a from that promotes the efficient performance of that knowledge base. However, without a single source knowledge repository, the cost of maintaining consistent knowledge between multiple knowledge bases increases dramatically; as facts and descriptions change, they must be updated in each individual knowledge base. A use-neutral representation of a hydraulic system for the F-111 aircraft was developed. The ability to derive portions of four different knowledge bases is demonstrated from this use-neutral representation: one knowledge base is for re-design of the device using a model-based reasoning problem solver; two knowledge bases, at different levels of abstraction, are for diagnosis using a model-based reasoning solver; and one knowledge base is for diagnosis using an associational reasoning problem solver. It was shown how updates issued against the single source use-neutral knowledge repository can be propagated to the underlying knowledge bases. Author

N91-22939# Booz-Allen and Hamilton, Inc., Reston, VA.
NASA-SPACE STATION PROGRAM
STEPHEN J. RITZMAN *In* NIST, Proceedings of the Federal Information Processing Standards (FIPS) Workshop on Information Resource Dictionary System (IRDS) Applications p 142-152 Dec. 1988
Avail: CASI HC A03/MF A03

This talk concerns the Technical and Management Information System (TMIS) project and issues related to other systems within the Space Station Program (SSP) as well as the impact of the Information Resource Dictionary System (IRDS) on them. Some of the topics discussed include: (1) information management; (2) program management; (3) software development; (4) the Space Station Information System; (5) the TMIS; (6) information transfer systems; (7) the three characteristics of the information resources that are going to exist in the different system domains; and (8) interoperability, data transportability, and commonality. K.S.

N91-23586# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
HOW TO DESIGN EFFICIENT MMI FOR SPACE
MURIEL DIDIER *In its* Space and Sea p 173-177 Dec. 1990
Copyright Avail: CASI HC A01/MF A03

The difficulties met when trying to design an efficient Man Machine Interface (MMI) for space are addressed and a way that can be followed to turn the difficulties around is shown. The problems of designing MMI for space come mainly from the environment (microgravity environment) and not so much from the task and the operator that can be easily identified. The methodologies and tools usually used when designing for a 4 g environment have to be adapted to the 0 g environment. The experience gained on Columbus when designing restraints for the crew project gives an example of a way that can be followed. ESA

N91-24753*# General Digital Industries, Inc., Huntsville, AL.
SOFTWARE TECHNOLOGY TESTBED SOFTPANEL PROTOTYPE Final Report, May 1988 - Feb. 1991
19 Feb. 1991 70 p
(Contract NAS8-37680)
(NASA-CR-187913; NAS 1.26:187913) Avail: CASI HC A04/MF A01 CSCL 09B

The following subject areas are covered: analysis of using Ada for the development of real-time control systems for the Space Station; analysis of the functionality of the Application Generator; analysis of the User Support Environment criteria; analysis of the SSE tools and procedures which are to be used for the development of ground/flight software for the Space Station; analysis if the CBATS tutorial (an Ada tutorial package); analysis of Interleaf; analysis of the Integration, Test and Verification process of the Space Station; analysis of the DMS on-orbit flight architecture; analysis of the simulation architecture. Author

N91-24792*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
NETWORK INTERFACE UNIT DESIGN OPTIONS PERFORMANCE ANALYSIS
FRANK W. MILLER Jun. 1991 23 p
(NASA-TM-104735; S-635; NAS 1.15:104735) Avail: CASI HC A03/MF A01 CSCL 09B

An analysis is presented of three design options for the Space Station Freedom (SSF) onboard Data Management System (DMS) Network Interface Unit (NIU). The NIU provides the interface from the Fiber Distributed Data Interface (FDDI) local area network (LAN) to the DMS processing elements. The FDDI LAN provides the primary means for command and control and low and medium rate telemetry data transfers on board the SSF. The results of this analysis provide the basis for the implementation of the NIU. Author

N91-25687*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ANALYSIS OF THE INTEL 386 AND I486 MICROPROCESSORS FOR THE SPACE STATION FREEDOM DATA MANAGEMENT SYSTEM
YUAN-KWEI LIU May 1991 24 p
(Contract RTOP 488-51-01)
(NASA-TM-103862; A-91145; NAS 1.15:103862) Avail: CASI HC A03/MF A01 CSCL 09B

The feasibility is analyzed of upgrading the Intel 386 microprocessor, which has been proposed as the baseline processor for the Space Station Freedom (SSF) Data Management System (DMS), to the more advanced i486 microprocessors. The items compared between the two processors include the instruction set architecture, power consumption, the MIL-STD-883C Class S (Space) qualification schedule, and performance. The advantages of the i486 over the 386 are (1) lower power consumption; and (2) higher floating point performance. The i486 on-chip cache does not have parity check or error detection and correction circuitry. The i486 with on-chip cache disabled, however, has lower integer performance than the 386 without cache, which is the current DMS design choice. Adding cache to the 386/386 DX memory hierachy appears to be the most beneficial change to the current DMS design at this time. Author

N91-26796*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PARALLEL PROCESSING AND EXPERT SYSTEMS
SONIE LAU and JERRY C. YAN (Sterling Federal Systems, Inc., Palo Alto, CA.) May 1991 40 p
(Contract RTOP 505-64-54)
(NASA-TM-103886; A-91077; NAS 1.15:103886) Avail: CASI HC A03/MF A01 CSCL 09B

Whether it be monitoring the thermal subsystem of Space Station Freedom, or controlling the navigation of the autonomous rover on Mars, NASA missions in the 1990s cannot enjoy an increased level of autonomy without the efficient implementation of expert systems. Merely increasing the computational speed of uniprocessors may not be able to guarantee that real-time demands are met for larger systems. Speedup via parallel processing must be pursued alongside the optimization of sequential implementations. Prototypes of parallel expert systems have been built at universities and industrial laboratories in the U.S. and Japan. The state-of-the-art research in progress related to parallel execution of expert systems is surveyed. The survey discusses multiprocessors for expert systems, parallel languages for symbolic computations, and mapping expert systems to multiprocessors. Results to date indicate that the parallelism achieved for these systems is small. The main reasons are (1) the body of knowledge applicable in any given situation and the amount of computation executed by each rule firing are small, (2) dividing the problem solving process into relatively independent partitions is difficult, and (3) implementation decisions that enable expert systems to be incrementally refined hamper compile-time optimization. In order to obtain greater speedups, data parallelism and application parallelism must be exploited. Author

N91-27100*# Stevens Inst. of Tech., Hoboken, NJ. Dept. of Electrical Engineering.
APPLICATIONS OF FORMAL SIMULATION LANGUAGES IN THE CONTROL AND MONITORING SUBSYSTEMS OF SPACE STATION FREEDOM Final Report
R. C. LACOVARA *In* Houston Univ., NASA/ASEE Summer Faculty Fellowship Program, 1990, Volume 1 13 p Dec. 1990
(Contract NGT-44-005-803)
Avail: CASI HC A03/MF A03 CSCL 17B

The notions, benefits, and drawbacks of numeric simulation are introduced. Two formal simulation languages, Simpscript and Modsim are introduced. The capabilities of each are discussed briefly, and then the two programs are compared. The use of simulation in the process of design engineering for the Control and Monitoring System (CMS) for Space Station Freedom is discussed. The application of the formal simulation language to the CMS design is presented, and recommendations are made as to their use. Author

N91-30722# European Space Agency, Paris (France).
BENCHMARKING OF COMPILERS AND PROCESSORS FOR SPACE EMBEDDED REAL-TIME SYSTEMS
M. DEJONG, F. GOMEZ-MOLINERO (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands), and W. R. BURKE, ed. Apr. 1991 103 p
(ISSN 0379-4067)
(ESA-STR-233; ISBN-92-9092-160-9; ETN-91-99830) Copyright Avail: CASI HC A06/MF A02

The benchmarking activities carried out by ESTEC as a means of comparing several compiler/processor pairs for use in spacecraft are presented. An overview of the application area is presented. The benchmarking results are presented and discussed. Conclusions concerning the Ada compiler and processor selections are derived. Some ideas for further work are discussed. It is concluded that the performance that an application can demand from a processor depends very much on fine tuning by the programmer. ESA

N91-32329# LABEN Ferranti International, Vimodrone (Italy).
A SOLID STATE MASS MEMORY FOR SPACE APPLICATIONS: TECHNOLOGICAL AND SYSTEM ASPECTS
F. LONGONI, G. SIMONETTI, and A. ZAMBRA *In* ESA, ESA Electronic Components Conference p 235-241 Mar. 1991
Copyright Avail: CASI HC A02/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

A solid state mass memory for space applications is presented. High memory capability with fault tolerant design make it useful for scientific payload data storage. Technological implementation and reliability evaluation are analyzed. Advantages of Solid State Mass Memory (SSMM) over conventional sequential memory techniques are outlined. SSMM architectural aspects and technological implementation are discussed. ESA

N91-32837*# Research Inst. for Computing and Information Systems, Houston, TX.
ART-ADA: AN ADA-BASED EXPERT SYSTEM TOOL
S. DANIEL LEE and BRADLEY P. ALLEN (Inference Corp., El Segundo, CA.) Jun. 1990 12 p Previously announced in IAA as N91-20698 Submitted for publication
(Contract NCC9-16; RICIS PROJ. SE-19)
(NASA-CR-188930; NAS 1.26:188930) Avail: CASI HC A03/MF A01 CSCL 09B

The Department of Defense mandate to standardize on Ada as the language for software systems development has resulted in an increased interest in making expert systems technology readily available in Ada environments. NASA's Space Station Freedom is an example of the large Ada software development projects that will require expert systems in the 1990's. Another large scale application that can benefit from Ada based expert system tool technology is the Pilot's Associate (PA) expert system project for military combat aircraft. The Automated Reasoning Tool-Ada (ART-Ada), an Ada expert system tool, is explained. ART-Ada allows applications of a C-based expert system tool called ART-IM to be deployed in various Ada environments. ART-Ada is being used to implement several prototype expert systems for NASA's Space Station Freedom program and the U.S. Air Force. Author

N91-32838*# Research Inst. for Computing and Information Systems, Houston, TX.
ADA ISSUES IN IMPLEMENTING ART-ADA
S. DANIEL LEE (Inference Corp., El Segundo, CA.) Nov. 1990 18 p Presented at the 3d Annual NASA Ada User's Symposium, Houston, TX, Nov. 1990
(Contract NCC9-16; RICIS PROJ. SE-19)
(NASA-CR-188941; NAS 1.26:188941) Avail: CASI HC A03/MF A01 CSCL 09B

Due to the Ada mandate of a number of government agencies, interest in deploying expert systems such as Ada has increased. Recently, several Ada-based expert system tools have been developed. According to a recent benchmark report, these tools do not perform as well as similar tools written in C. While poorly implemented Ada compilers contribute to the poor benchmark result, some fundamental problems of the Ada language itself have been uncovered. Here, the authors describe Ada language issues encountered during the deployment of ART-Ada, an expert system tool for Ada deployment. ART-Ada is being used to implement several prototype expert systems for the Space Station Freedom and the U.S. Air Force. Author

N91-32839*# Research Inst. for Computing and Information Systems, Houston, TX.
TOWARD THE EFFICIENT IMPLEMENTATION OF EXPERT SYSTEMS IN ADA
S. DANIEL LEE (Inference Corp., El Segundo, CA.) Dec. 1990 15 p Submitted for publication
(Contract NCC9-16; RICIS PROJ. SE-19)
(NASA-CR-188942; NAS 1.26:188942) Avail: CASI HC A03/MF A01 CSCL 09B

Here, the authors describe Ada language issues encountered during the development of ART-Ada, an expert system tool for Ada deployment. ART-Ada is being used to implement several expert system applications for the Space Station Freedom and the U.S. Air Force. Additional information is given on dynamic memory allocation. Author

N91-33005*# Research Inst. for Advanced Computer Science, Moffett Field, CA.
COPING WITH DATA FROM SPACE STATION FREEDOM
MARJORY J. JOHNSON Jan. 1991 29 p Submitted for publication
(Contract NCC2-387)
(NASA-CR-188885; NAS 1.26:188885; RIACS-TR-91-05) Avail: CASI HC A03/MF A01 CSCL 05B

The volume of data from future NASA space missions will be phenomenal. Here, we examine the expected data flow from the Space Station Freedom and describe techniques that are being developed to transport and process that data. Networking in space, the Tracking and Data Relay Satellite System (TDRSS), recommendations of the Consultative Committee for Space Data systems (CCSDS), NASA institutional ground support, communications system architecture, and principal data types and formats are discussed. Author

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LIFE SCIENCES/HUMAN FACTORS/SAFETY

Studies, models, planning, analyses and simulations of habitability issues. Includes the performance and well-being of the crew and crew rescue.

A91-32349
ADAPTIVE RECOVERY OF A CHIRPED SINUSOID IN NOISE. I - PERFORMANCE OF THE RLS ALGORITHM. II - PERFORMANCE OF THE LMS ALGORITHM
ODILE M. MACCHI (CNRS, Laboratoire des Signaux et Systemes, Gif-sur-Yvette, France) and NEIL J. BERSHAD (California, University, Irvine) IEEE Transactions on Signal Processing (ISSN 1053-587X), vol. 39, March 1991, p. 583-602. Research supported by CNRS and Universite de Paris XI. refs
(Contract AF-AFOSR-86-0093; AF PROJECT 2304A6)
Copyright

A91-33609
INTEGRATED INERTIAL NAVIGATION SYSTEM/GLOBAL POSITIONING SYSTEM (INS/GPS) FOR MANNED RETURN VEHICLE AUTOLAND APPLICATION
KEVIN BRADEN, CLINT BROWNING, HENDRIK GELDERLOOS, FRED SMITH (Honeywell Space Systems Group, Clearwater, FL), CHUCK MARTTILA (Honeywell Systems Research Center, Minneapolis, MN) et al. IN: IEEE PLANS '90 - Position Location and Navigation Symposium, Las Vegas, NV, Mar. 20-23, 1990, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 74-82. refs
Copyright

It is noted that with the development of the International Space Station Freedom, people will permanently live in space and require routine access and an assured crew return capability in case of emergencies in space. The extended duration in space requires a manned return vehicle that is less demanding on the crew and provides an autonomous deorbit, entry, and autoland capability. The authors discuss an autoland capability with an integrated differential GPS/INS that provides the required position and velocity accuracies without the need for tactical aircraft navigation (TACAN) and Microwave Landing System (MLS) navigation aides. Simulation results are used to demonstrate the feasibility of autoland using differential GPS aided with a high-precision altimeter. This concept applies to several manned space applications, such as Assured Crew Return Vehicle (ACRV), Assured Shuttle Availability (ASA), Advanced Manned Launch System (AMLS), and National Aerospace Plane (NASP), and to unmanned return vehicles such as the Propulsion Avionics Module (P/AM). I.E.

A91-37457#
RESULTS OF STUDIES OF MOTOR FUNCTIONS IN LONG-TERM SPACE FLIGHTS
I. B. KOZLOVSKAIA, V. A. BARMIN, V. I. STEPANTSOV, and N. M. KHARITONOV (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) (International Union of Physiological Sciences Commission on Gravitational Physiology, Annual Meeting, 11th, Lyons, France, Sept. 25-27, 1989, Proceedings. A91-37456 15-51) Physiologist, Supplement (ISSN 0031-9376), vol. 33, Feb. 1990, p. S-1 to S-3.

The effect of physical exercise on the intensity and the duration of motor function disturbances in humans due to exposures to microgravity were assessed in 25 crew members who underwent long-term (from 60 to 366 days) flights aboard the Salyut-6,7 or Mir space stations. The protocol of tests of motor functions was identical to that used by Kozlovskaya et al. (1982, 1984) and included tests and methods that allowed quantitative evaluations of changes in different parts of the motor system. It is shown that the intensity of motor-function deterioration did not correlate with the duration of flight but depended on the volume of physical exercises and the characteristics of physical exercises used during flights as a countermeasure to microgravity. I.S.

A91-37573#

MEDICAL SUPPORT OF LONG-TERM MISSIONS ABOARD 'MIR' ORBITAL COMPLEX

A. I. GRIGORIEV, V. V. BOGOMOLOV, and A. D. EGOROV (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) IN: Space - Technology, commerce and communications; Proceedings of the 4th Annual Conference, Washington, DC, Jan. 8-10, 1991. Lexington, MA, T.F. Associates, Inc., 1991, p. 78-81.

Medical monitoring of cosmonauts aboard the Mir orbital complex is discussed. Countermeasures used to adapt the body to microgravity are outlined and a brief and general overview is given of strategies to maintain high performance and minimize pathologies. C.D.

A91-37952* National Aeronautics and Space Administration, Washington, DC.

SAFETY STATUS OF SPACE RADIOISOTOPE AND REACTOR POWER SOURCES

GARY L. BENNETT (NASA, Washington, DC) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 162-167. refs

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The current overall safety criterion for both radioisotope and reactor power sources is containment or immobilization in the case of a reentry accident. In addition, reactors are designed to remain subcritical under conditions of land impact or water immersion. A very extensive safety test and analysis program was completed on the radioisotope thermoelectric generators (RTGs) in use on the Galileo spacecraft and planned for use on the Ulysses spacecraft. The results of this work show that the RTGs will pose little or no risk for any credible accident. The SP-100 space nuclear reactor program has begun addressing its safety criteria, and the design is planned to be such as to ensure meeting the various safety criteria. Preliminary mission risk analyses on SP-100 show the expected value population dose from postulated accidents on the reference mission to be very small. It is concluded that the current US nuclear power sources are the safest flown. I.E.

A91-37959

SPACE NUCLEAR REACTOR SAFETY

DENNIS DAMON, MARK TEMME, and NEIL BROWN (General Electric Co., Astro-Space Div., San Jose, CA) IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 1. New York, American Institute of Chemical Engineers, 1990, p. 204-209. DOE-supported research.

Copyright

Definition of safety requirements and design features of the SP-100 space reactor power system has been guided by a mission risk analysis. The analysis quantifies risk from accidental radiological consequences for a reference mission. Results show that the radiological risk from a space reactor can be minimized. The total mission risk from radiological consequences for a shuttle-launched, earth-orbit SP-100 mission is estimated to be 0.05 person-rem (expected values) based on a mRem/yr de Minimis dose. Results are given for each mission phase. The safety benefits of specific design features are evaluated through risk sensitivity analyses. I.E.

A91-41142

PEDALLING IN SPACE AS A COUNTERMEASURE TO MICROGRAVITY DECONDITIONING

G. ANTONUTTO, C. CAPELLI, and P. E. DI PRAMPERO (Udine, Universita, Italy) Microgravity Quarterly (ISSN 0958-5036), vol. 1, no. 2, 1991, p. 93-101. refs

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A two-bicycle system for exercising during spaceflight in order to prevent deconditioning due to microgravity is proposed, in which two mechanically coupled counterrotating bicycles are moved on the inner wall of a cylindrical space module. The two pedaling subjects generate a centrifugal acceleration vector, a(c), simulating gravity, which depends on the peripheral velocity and on the radius of gyration. It is shown that, by selecting appropriate radial dimensions of the space module, it is possible to minimize vestibular disturbances and head-to-feet centrifugal acceleration gradients, and, thus, combine the exercise and simulate microgravity with no need for additional external power. I.S.

A91-42718* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SURFACE DEFINITION AND GRID GENERATION ABOUT AN ASSURED CREW RETURN VEHICLE (ACRV) FOR SPACE STATION FREEDOM

R. E. SMITH, E. L. EVERTON, K. J. WEILMUENSTER (NASA, Langley Research Center, Hampton, VA), M. R. WEISE, and N. FARR (Computer Sciences Corp., Hampton, VA) (Computational technology for flight vehicles; Proceedings of the Symposium on Computational Technology on Flight Vehicles, Washington, DC, Nov. 5-7, 1990. A91-42703 18-59) Computing Systems in Engineering (ISSN 0956-0521), vol. 1, no. 2-4, 1990, p. 313-323. refs

Copyright

The surface definition and grid generation about an Assured Crew Return Vehicle (ACRV) for the Space Station Freedom are described. The purpose of the surface definition and grid generation is to provide the necessary geometry information for CFD calculations about the vehicle. There are two salient features in this description. The first is that the numerical model representing the ACRV configuration is obtained from the measurement of an existing wind tunnel model. The method for smoothing the measured data and obtaining the numerical model is described. The second feature is the description of the algebraic grid generation method and software to compute volume grids about the ACRV. The methods and software allow rapid computation of volume grids for a wide range of flow conditions. Author

A91-43250* Georgetown Univ., Washington, DC.

MICROGRAVITY TESTING A SURGICAL ISOLATION CONTAINMENT SYSTEM FOR SPACE STATION USE

SANFORD M. MARKHAM (Georgetown University, Washington, DC) and JOHN A. ROCK (Johns Hopkins Hospital, Baltimore, MD) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 62, July 1991, p. 691-693. NASA-supported research. refs

Copyright

Anticipated hazards for crewmembers in future long term space flights may result in a variety of injuries including trauma and burns. Management of these injuries will require special techniques because of the lack of gravity, limitations of space and environmental restrictions. A small surgical isolation containment system was developed and tested in microgravity. The chamber provided both protection of the injury and of the cabin environment and is felt to be the most effective means of trauma and burn care in future Health Maintenance Facilities planned for prolonged space exposure. Author

A91-45869

TEST OF EXERCISE EXPERIMENTS PROPOSED FOR THE MIR '92 MISSION

DIETER ESSFELD, KLAUS BAUM, and UWE HOFFMANN (Koeln, Deutsche Sporthochschule, Cologne, Federal Republic of

Germany) Microgravity Science and Technology (ISSN 0938-0108), vol. 4, June 1991, p. 48-51. refs
Copyright

During exercise, heart rate and blood pressure drives can be elicited by receptors situated in the interstitial space of the muscle. It was recently shown that these receptors are sensitive to the local state of hydration. Weightlessness could affect these receptor mechanisms through the redistribution of body fluids and through secondary changes in the interstitial structure. To investigate such effects, an experiment was carried out to determine heart rate and blood pressure responses to light isometric calf exercise at different calf volumes during the Mir '92 mission (experiment ISX). The First North Sea Parabolic Flight campaign provided an opportunity to test the setup and some operational aspects of this experiment. The experience of this campaign led to some modifications of the original setup. Author

A91-46770* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INTERPLANETARY CREW EXPOSURE ESTIMATES FOR THE AUGUST 1972 AND OCTOBER 1989 SOLAR PARTICLE EVENTS
LAWRENCE W. TOWNSEND, JUDY L. SHINN, and JOHN W. WILSON (NASA, Langley Research Center, Hampton, VA) Radiation Research (ISSN 0033-7587), vol. 126, 1991, p. 108-110. refs
Copyright

Detailed exposure estimates for the bone marrow, ocular lens, and skin of astronauts on manned missions beyond the earth's magnetosphere have been made for the large solar particle events (SPE) of August 1972 and October 1989. The estimates were made using the coupled neutron-proton space radiation transport computer code BRYNTRN and the CAM model for the human body. It is found that at least 10 g/sq cm aluminum shielding is needed to keep estimated dose equivalent values below current space radiation exposure guidelines recommended for LEO missions. Space suits currently being designed will not provide adequate crew protection and may not even ensure crew survival in the event of exposure to a large SPE during extravehicular activity. O.G.

A91-48938
THE FLOATING WORLD AT ZERO G
DOUG STEWART Air and Space (ISSN 0886-2257), vol. 6, Aug.-Sept. 1991, p. 38-44.
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The relevance of astronauts' experience of prolonged weightlessness while living aboard Skylab to the prospective NASA Space Station is discussed. Stays of as many as 84 days allowed the final Skylab crew to explore the long-term effects of zero-G on working and social habits, and sharpened skills for daily life in such an environment. These lessons are also pertinent to Mars missions currently in the planning stage. O.C.

A91-50527
ADVANCED ENVIRONMENTAL/THERMAL CONTROL AND LIFE SUPPORT SYSTEMS; INTERSOCIETY CONFERENCE ON ENVIRONMENTAL SYSTEMS, 20TH, WILLIAMSBURG, VA, JULY 9-12, 1990, TECHNICAL PAPERS
Conference sponsored by SAE. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-831), 1990, 260 p. For individual items see A91-50528 to A91-50542.
(SAE SP-831) Copyright

The present conference on advanced environmental/thermal control and life-support systems encompasses ongoing research and development activities pertinent to life-support requirements and technologies for future planetary exploration missions, with special attention given to energy efficient systems with recycling capabilities for air, water, and waste. Specific issues addressed include low-temperature thermal control for a lunar base, long-term life support for space exploration, a test facility for crop research in space, the conversion of lignocellulosics to fermentable sugars, and CO-removal and waste-collection systems for the Extended Duration Orbiter. Also addressed are a phase-change water-recovery system, an air revitalization system, the electrooxidation of organics in waste water, salt nucleation and growth during waste-water oxidation, closed-loop water recycling, and a conceptual design for a lunar-base CELSS. C.C.S.

A91-50528* National Aeronautics and Space Administration, Washington, DC.
LONG TERM LIFE SUPPORT FOR SPACE EXPLORATION
JOHN D. RUMMEL (NASA, Life Sciences Div., Washington, DC) IN: Advanced environmental/thermal control and life support systems; Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990, Technical Papers. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 67-73. refs
(SAE PAPER 901277) Copyright

A general strategy for the development of life-support systems is discussed in terms of present and future requirements for NASA exploration missions. A general life-support strategy is delineated for both intravehicular activity (IVA) and extravehicular activity (EVA) for lunar and Mars transfer vehicles, Mars habitats, and pressurized rovers. The baseline capability presented corresponds to the systems needs for the Space Station Freedom permanently manned capability and the Shuttle Extended Duration Orbiter. Design guidelines and system design goals are given for IVA life support with an emphasis on closed-loop systems, and the design prerogatives for EVA include a minimum time to transition between IVA and EVA, and minimum resitriction for human activity. C.C.S.

A91-50529* Bionetics Corp., Moffett Field, CA.
THE CELSS TEST FACILITY - A FOUNDATION FOR CROP RESEARCH IN SPACE
C. L. STRAIGHT (Bionetics Corp., Moffett Field, CA) and R. D. MACELROY (NASA, Ames Research Center, Moffett Field, CA) IN: Advanced environmental/thermal control and life support systems; Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990, Technical Papers. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 75-80. refs
(SAE PAPER 901279) Copyright

Under the NASA Space Biology Initiative, a CELSS Test Facility (CTF) is being planned for installation on Space Station Freedom. The CTF will be used to study the productivity of typical CELSS higher plant crops under the microgravity conditions of the Space Station Freedom (SSF). Such science studies will be supported under the CELSS Space Research Project. The CTF will be used to evaluate fundamental issues of crop productivity, such as the production rates of O2, food and transpired water, and CO2 uptake. A series of precursor tests that are essential to the development of the CTF will be flown on Space Shuttle flights. The tests will be used to validate and qualify technology concepts and to answer specific questions regarding seed germination, root/shoot orientation, water condensation and recycling, nutrient delivery, and liquid/gas phase interactions. Author

A91-50530* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SALAD MACHINE - A VEGETABLE PRODUCTION UNIT FOR LONG DURATION SPACE MISSIONS
M. KLISS and R. D. MACELROY (NASA, Ames Research Center, Moffett Field, CA) IN: Advanced environmental/thermal control and life support systems; Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990, Technical Papers. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 81-88. refs
(SAE PAPER 901280) Copyright

A review of NASA CELSS development specific to vegetable cultivation during space missions is presented in terms of enhancing the quality of life for space crews. A cultivation unit is being developed to permit the production of 600 grams of edible salad vegetables per week, thereby allowing one salad per crew member three times weekly. Plant-growth requirements are set forth for the specific vegetables, and environmental subsystems are listed. Several preprototype systems are discussed, and one particular integrated-systems design concept is presented in detail with views of the proposed rack configuration. The Salad Machine is developed exclusively from CELSS-derived technology, and the major challenge is the mitigation of the effects of plant-growth requirements on other space-mission facility operations. C.C.S.

A91-50531* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE CONVERSION OF LIGNOCELLULOSICS TO FERMENTABLE SUGARS - A SURVEY OF CURRENT RESEARCH AND APPLICATIONS TO CELSS
GENE R. PETERSEN and LARRY BARESI (JPL, Pasadena, CA) IN: Advanced environmental/thermal control and life support systems; Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990, Technical Papers. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 89-100. refs
(SAE PAPER 901282) Copyright

This report provides an overview options for converting lignocellulosics into fermentable sugars in CELSS. A requirement for pretreatment is shown. Physical-chemical and enzymatic hydrolysis processes for producing fermentable sugars are discussed. At present physical-chemical methods are the simplest and best characterized options, but enzymatic processes will be the likely method of choice in the future. The use of pentose sugars by microorganisms to produce edibles is possible. The use of mycelial food production on pretreated but not hydrolyzed lignocellulosics is also possible. Simple trade-off analyses to regenerate waste lignocellulosics for two pathways are made, one of which is compared to complete oxidation. Author

A91-50535
SUMMARY OF STATIC FEED WATER ELECTROLYSIS TECHNOLOGY DEVELOPMENTS AND APPLICATIONS FOR THE SPACE STATION AND BEYOND
DAVID J. GRIGGER, B.-J. CHANG, and ANDREW J. KOVACH (Life Systems, Inc., Cleveland, OH) IN: Advanced environmental/thermal control and life support systems; Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990, Technical Papers. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 133-144. refs
(SAE PAPER 901293) Copyright

The development and application possibilities of the alkaline-based Static Feed Electrolyzer (SFE) are described with specific reference to NASA and NASA space missions. Fundamental advances in technology leading to the SFE are listed including those related to electrode performance, cell design, module construction, integrated ancillary mechanical components, and control/monitor instrumentation. Electrode catalyzation, unitized cell cores, and injection molding are important improvements for the static-feed water-electrolysis process. The SFE technology provides the efficient generation of O_2 and H_2 and can be applied to a variety of advanced space-mission technologies. Specific applications include environmental control and life-support systems, energy storage, propulsion, and extravehicular activities. C.C.S.

A91-50536
PHASE CHANGE WATER RECOVERY FOR THE SPACE STATION FREEDOM AND FUTURE EXPLORATION MISSIONS
LARRY D. NOBLE, FRANZ H. SCHUBERT, RICK J. PUDOKA (Life Systems, Inc., Cleveland, OH), and JANIE H. MIERNIK (Boeing Aerospace Co., Huntsville, AL) IN: Advanced environmental/thermal control and life support systems; Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990, Technical Papers. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 145-158. refs
(SAE PAPER 901294) Copyright

The recovery of water from waste water on advanced missions is discussed in terms of the Vapor Compression Distillation (VCD) technology with attention given to the development and application of the phase-change system to the Space Station Freedom. The VCD process and VCD subsystems are described, and general operating characteristics are given including specific energy, still-motor power, compressor speed, water-recovery percentages, and solids concentrations. Specific technological advances are described that affect water-production rates, water quality, specific energy, pretreatment concepts, and pump designs. VCD technology can be applied to urine processing, ultrapure and hygiene water processing, and centrifuge facilities, and these applications are found to be important for space stations such as the Space Station Freedom. C.C.S.

A91-50537* Bend Research, Inc., OR.
PRELIMINARY EVALUATION OF A MEMBRANE-BASED SYSTEM FOR REMOVING CO2 FROM AIR
SCOTT B. MCCRAY, RANDI W. WYTCHERLEY, DWAYNE T. FRIESEN, and ROD J. RAY (Bend Research Inc., OR) IN: Advanced environmental/thermal control and life support systems; Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990, Technical Papers. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 159-166. refs
(Contract NAS9-18085)
(SAE PAPER 901295) Copyright

Processes to remove and/or recover CO_2 from air are essential to the long-term success of the U.S. space program. The results of a preliminary investigation of the use of a novel membrane-based system for removal of CO_2 from air are presented. Features of this technology that make it attractive include the following: (1) it is lightweight; (2) it requires no consumables or expendables; (3) it is relatively simple; and (4) it does not rely directly on other subsystems. Preliminary designs of systems for removing CO_2 from spacecraft cabin atmospheres and from the extravehicular mobility unit are presented. Author

A91-50540* Texas A&M Univ., College Station.
ELECTROOXIDATION OF ORGANICS IN WASTE WATER
G. D. HITCHENS, OLIVER J. MURPHY, LAMINE KABA (Texas A & M University, College Station), and CHARLES E. VEROSTKO (NASA, Johnson Space Center, Houston, TX) IN: Advanced environmental/thermal control and life support systems; Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990, Technical Papers. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 179-188. refs
(Contract NAG9-350)
(SAE PAPER 901312) Copyright

Electrooxidation is a means of removing organic solutes directly from waste waters without the use of chemical expendables. Research sponsored by NASA is currently being pursued to demonstrate the feasibility of the concept for oxidation of organic impurities common to urine, shower waters and space-habitat humidity condensates. Electrooxidation of urine and waste water ersatz was experimentally demonstrated. This paper discusses the electrooxidation principle, reaction kinetics, efficiency, power, size, experimental test results and water-reclamation applications. Process operating potentials and the use of anodic oxidation potentials that are sufficiently low to avoid oxygen formation and chloride oxidation are described. The design of an electrochemical system that incorporates a membrane-based electrolyte based on parametric test data and current fuel-cell technology is presented. Author

A91-50542* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PHYSICAL/CHEMICAL CLOSED-LOOP WATER-RECYCLING FOR LONG-DURATION MISSIONS
CAL C. HERRMANN (NASA, Ames Research Center; Bionetics Corp., Moffett Field, CA) and TED WYDEVEN (NASA, Ames Research Center, Moffett Field, CA) IN: Advanced environmental/thermal control and life support systems; Intersociety Conference on Environmental Systems, 20th, Williamsburg, VA, July 9-12, 1990, Technical Papers. Warrendale,

PA, Society of Automotive Engineers, Inc., 1990, p. 233-246. Previously announced in STAR as N91-24052. refs
(SAE PAPER 901446) Copyright

Water needs, water sources, and means for recycling water are examined in terms appropriate to the water quality requirements of a small crew and spacecraft intended for long duration exploration missions. Inorganic, organic, and biological hazards are estimated for waste water sources. Sensitivities to these hazards for human uses are estimated. The water recycling processes considered are humidity condensation, carbon dioxide reduction, waste oxidation, distillation, reverse osmosis, pervaporation, electrodialysis, ion exchange, carbon sorption, and electrochemical oxidation. Limitations and applications of these processes are evaluated in terms of water quality objectives. Computerized simulation of some of these chemical processes is examined. Recommendations are made for development of new water recycling technology and improvement of existing technology for near term application to life support systems for humans in space. The technological developments are equally applicable to water needs on earth, in regions where extensive water eycling is needed or where advanced water treatment is essential to meet EPA health standards. Author

A91-51356

SPACE STATION ENVIRONMENTAL/THERMAL CONTROL AND LIFE SUPPORT SYSTEMS; PROCEEDINGS OF THE 20TH INTERSOCIETY CONFERENCE ON ENVIRONMENTAL SYSTEMS, WILLIAMSBURG, VA, JULY 9-12, 1990

Conference sponsored by SAE. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-829), 1990, 191 p. For individual items see A91-51357 to A91-51369.
(SAE SP-829) Copyright

The present conference on Space Station environmental/thermal control and life-support systems encompasses design issues for systems pertinent to the Space Station Freedom, such as thermal technologies for microgravity environments ranging from insulation blankets to two-phase fluid-transport systems, heat exchangers, resource-allocation processes, and life-support technologies. Specific issues addressed include water recovery and management-test support modeling, a contaminant removal system, the testing of a CO2 removal assembly, the containment of solid human waste, an analysis of a passive thermal control system, the electrodeionization of water, and the survival and selectivity of bacteria in water systems. Also addressed are water-treatment systems for reagent-grade water, the development of a water-quality monitor, the fatigue testing of corrugated and Teflon hoses, a method for thermal modeling, and thermal-resource allocation for Space Station Freedom and future planetary missions. C.C.S.

A91-51357

SMOKE AND CONTAMINANT REMOVAL SYSTEM FOR SPACE STATION

FREDERICK SRIBNIK, PHILIP J. BIRBARA, JEFFREY J. FASZCZA, and TIMOTHY A. NALETTE (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) IN: Space Station environmental/thermal control and life support systems; Proceedings of the 20th Intersociety Conference on Environmental Systems, Williamsburg, VA, July 9-12, 1990. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 41-49. refs
(SAE PAPER 901391) Copyright

A design for a self-contained smoke and contaminant removal system (SCRS) and its capabilities in removing airborne particulates and toxic gases generated from a Space Station fire are presented. Based on potential fire scenarios, an SCRS has been sized to weigh 52 lbs, consume 50 watts and occupy less than 3 cu ft. The replaceable filter/sorbent beds provide the SCRS with the capability of handling multiple contaminant challenges. The SCRS will reduce the necessity to compromise mission objectives by changing out Space Station air. The SCRS option provides the crew with the added flexibility of restoring and maintaining the quality of the habitable environment. Author

A91-51358

SPACE STATION FREEDOM PREDEVELOPMENT OPERATIONAL SYSTEM TEST (POST) CARBON DIOXIDE REMOVAL ASSEMBLY

LORI WOODWARD and ROBERT KAY (Allied-Signal Aerospace Co., Torrance, CA) IN: Space Station environmental/thermal control and life support systems; Proceedings of the 20th Intersociety Conference on Environmental Systems, Williamsburg, VA, July 9-12, 1990. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 51-56.
(SAE PAPER 901392) Copyright

The predevelopment operational system test (POST) assembly of a CO2-removal system is reported in which closed-loop operation is demonstrated with hardware that is similar to the system for the Space Station Freedom. The goals of the regenerative system include removing CO2 from the air-supply stream, preventing the accumulation of CO2 within the cabin, concentrating CO2 for downstream processing, and recovering oxygen. The POST apparatus is a four-bed system that meets the requirements of the Freedom flight system, and detailed descriptions of component integration and specific components are given. Schematic diagrams are delineated for normal operation and the residual-air pump-down mode, and elements are described, such as the desiccant bed, precooler, CO2-removal bed, and check valves. The regenerative system offers the advantages of minimizing logistics support and closing the cabin oxygen loop. C.C.S.

A91-51359

COLLECTION AND CONTAINMENT OF SOLID HUMAN WASTE FOR SPACE STATION

D. W. RETHKE and J. W. STEELE (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) IN: Space Station environmental/thermal control and life support systems; Proceedings of the 20th Intersociety Conference on Environmental Systems, Williamsburg, VA, July 9-12, 1990. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 57-67. refs
(SAE PAPER 901393) Copyright

Test data and general considerations are presented with respect to the development of a subsystem for handling solid human waste on the Space Station Freedom. Convenience, safety, and efficiency are primary considerations for the proposed commode, and attention is given to minimizing the power requirement and avoiding overboard venting. The proposed system employs individual disposable collection bags, mechanized compaction, and natural biodegradation of the solid waste during the flight. Evaluation techniques are described for the collection bags, the fecal compaction technique, microbial control, the toilet-seat configuration, nonventilation, and the stabilization method. The resulting prototype commode is found to be an effective subsystem for long-duration space-flight missions. Natural biodegradation of human wastes is an effective storage technique and can lead to the ultimate regenerative use of solid human waste. C.C.S.

A91-51360* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.

ECLS RESUPPLY FOR SPACE STATION FREEDOM

KEITH HIGGINBOTHAM, KATHI OGLE, and GREG SCHUNK (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Space Station environmental/thermal control and life support systems; Proceedings of the 20th Intersociety Conference on Environmental Systems, Williamsburg, VA, July 9-12, 1990. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 69-75. refs
(SAE PAPER 901394) Copyright

The design of logistics carriers is presented emphasizing the use of cost-effective pressurized and nonpressurized versions to resupply consumable fluids and provide on-orbit support for the Space Station Freedom. The requirements for the Environmental Control and Life Support (ECLS) system include high-pressure oxygen and nitrogen as well as consumables that do not require pressurization. The nominal and contingency requirements are given for logistics carriers designed to support various mission scenarios by resupplying and servicing fluid systems on-orbit. The resulting design overview for the logistics carriers describes the cryogenic-nitrogen storage during launch and operation of the unpressurized version and the flexible payload-support capacity of the pressurized version. The carriers are characterized as lightweight and versatile, and the resupply of cryogenic nitrogen is a flight-proven capability. C.C.S.

A91-51362
WATER QUALITY AFTER ELECTRODEIONIZATION
ANITA K. HIGHSMITH, BILL M. KAYLOR, CAROL J. REED, and EDWIN W. ADES (Centers for Disease Control, Water Quality Laboratory, Atlanta, GA) IN: Space Station environmental/thermal control and life support systems; Proceedings of the 20th Intersociety Conference on Environmental Systems, Williamsburg, VA, July 9-12, 1990. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 93-96. refs
(SAE PAPER 901421) Copyright

Municipal water was purified by an electrodeionization (ED) process for use in the research and diagnostic laboratory. Except for elevated silica levels electrodeionization product water met NCCLS Type II water specifications. An extensive battery of physical, microbiologic, and chemical tests were performed to determine the effect of this technology on water quality and to demonstrate the interaction with the other components of a typical water purification system. Author

A91-51363
SURVIVAL OF MYCOPLASMAS AND UREAPLASMAS IN WATER AND AT ELEVATED TEMPERATURES
RUTH B. KUNDSIN (Brigham and Women's Hospital; Harvard University, Boston, MA) and ROBERT E. PERKINS (Brigham and Women's Hospital, Boston, MA) IN: Space Station environmental/thermal control and life support systems; Proceedings of the 20th Intersociety Conference on Environmental Systems, Williamsburg, VA, July 9-12, 1990. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 97-100. refs
(SAE PAPER 901422) Copyright

The survival of Mycoplasma hominis, Mycoplasma salivarium, Mycoplasma pneumoniae, and Ureaplasma urealyticum in water and at elevated temperatures is a cause for concern. These microorganisms are pathogens. Some are implicated in serious genitourinary tract infections in men and women resulting in significant perinatal mortality and morbility; others can cause respiratory tract infections. M. hominis has been implicated in wound infections, osteomyelitis, and infections of the heart valve. Because these microorganisms are pathogens, their survival in a closed water system has relevance to the well-being of crew members in an enclosed space. Consideration must be given to the elimination of these bacteria during recycling of water. Author

A91-51364
BACTERIAL SELECTIVITY IN THE COLONIZATION OF SURFACE MATERIALS FROM GROUNDWATER AND PURIFIED WATER SYSTEMS
W. BLOOM, S. POPE (Ionic Atlanta, Inc., GA), J. C. RICHARDSON, and A. T. MIKELL, JR. (Alabama, University; Consortium for the Space Life Sciences, Huntsville) IN: Space Station environmental/thermal control and life support systems; Proceedings of the 20th Intersociety Conference on Environmental Systems, Williamsburg, VA, July 9-12, 1990. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 101-111. refs
(SAE PAPER 901423) Copyright

A variety of metals and surface modification techniques were evaluated for corrosion and biofilm resistivity. Coupons in a modified Robbins' Spool device contacted water in a parallel-flow manifold test bed. System water was obtained from a water well with a chronic history of fouling and corrosion. Several surface types resisted corrosion; however, no metal or surface modification prevented attachment of bacteria as revealed by epifluorescence microscopy or classical culturing techniques. Different surfaces did result in modified bacterial consortia. In a separate series of experiments, stainless steel coupons and Teflon in laminar flow cells were exposed to multi-cartridge purified water exceeding 17 megohms resistivity. These coupons were heavily colonized with bacteria in 30 days. However, coupons in static stirred reactors charged with the same water demonstrated little colonization. Author

A91-51365
EVALUATION OF WATER TREATMENT SYSTEMS PRODUCING REAGENT GRADE WATER
ANITA HIGHSMITH, BILL M. KAYLOR, CAROL J. REED, and EDWIN W. ADES (Centers for Disease Control, Atlanta, GA) IN: Space Station environmental/thermal control and life support systems; Proceedings of the 20th Intersociety Conference on Environmental Systems, Williamsburg, VA, July 9-12, 1990. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 113-117. refs
(SAE PAPER 901424) Copyright

General considerations are set forth with respect to water treatment, and prototype water-treatment systems are evaluated with respect to design, operation, and resulting water quality. The specifications for high-purity water are discussed, and the major classes of contaminants are listed. High-purity reagent water is defined as water that is free of organic contaminants, and water-purification systems are discussed in terms of the grades of water that are available by means of the systems. Four water-treatment systems - three prototypes and one existing system - are evaluated in detail in terms of the production of reagent-grade water. Inconsistent results are reported for systems including prefilter, reverse osmosis, carbon absorption, deionization, ultrafiltration, and membrane filtration. It is found that it is possible and cost-beneficial to produce a grade of water for both general and specific uses by carefully selecting an appropriate treatment system. C.C.S.

A91-51366
DEVELOPMENT OF A WATER QUALITY MONITOR FOR SPACE STATION FREEDOM LIFE SUPPORT SYSTEM
WILLIAM NIU, DAVID BURCHFIELD, GORDON SNYDER (Perkin-Elmer Corp., Norwalk, CT), and KEITH CONKLIN (Boeing Aerospace and Electronics, Seattle, WA; Arthur D. Little, Inc., Cambridge, MA) IN: Space Station environmental/thermal control and life support systems; Proceedings of the 20th Intersociety Conference on Environmental Systems, Williamsburg, VA, July 9-12, 1990. Warrendale, PA, Society of Automotive Engineers, Inc., 1990, p. 127-136. Research supported by Boeing Aerospace and Electronics. refs
(SAE PAPER 901426) Copyright

Specifications, design considerations, and preliminary results are presented for a water-quality monitor (WQM) intended for use with the Environmental Control and Life Support System (ECLSS) on the Space Station Freedom. The WQM comprises 8 water-parameter monitor mechanisms, and is intended to monitor impurities in both potable and hygiene water samples. The WQM includes a chromatograph to measure inorganics, a UV/VIS spectrometer to measure color, a mercury detector, a carbon analyzer, a sensor to monitor pH, conductivity, and temperature, and a sampling system. The use of the monitor subsystems under the microgravitational conditions of space is considered. The conceptual design (under development) calls for a single rack and allows for automated operation, and the components are based on existing technologies except where gas/liquid separation is required. C.C.S.

A91-51449* San Diego State Univ., CA.
HEAT TRANSFER TO A THIN SOLID COMBUSTIBLE IN FLAME SPREADING AT MICROGRAVITY
S. BHATTACHARJEE (San Diego State University, CA), R. A. ALTENKIRCH (Mississippi State University, Mississippi State), S. L. OLSON, and R. G. SOTOS (NASA, Lewis Research Center, Cleveland, OH) ASME, Transactions, Journal of Heat Transfer (ISSN 0022-1481), vol. 113, Aug. 1991, p. 670-676. refs
(Contract NAS3-23901)
Copyright

The heat transfer rate to a thin solid combustible from an attached diffusion flame, spreading across the surface of the combustible in a quiescent, microgravity environment, was determined from measurements made in the drop tower facility at NASA-Lewis Research Center. With first-order Arrhenius pyrolysis kinetics, the solid-phase mass and energy equations along with the measured spread rate and surface temperature profiles were used to calculate the net heat flux to the surface. Results of the measurements are compared to the numerical solution of the complete set of coupled differential equations that describes the temperature, species, and velocity fields in the gas and solid phases. The theory and experiment agree on the major qualitative features of the heat transfer. Some fundamental differences are attributed to the neglect of radiation in the theoretical model.

Author

A91-51473
ON-LINE SPECTROSCOPIC MONITORING OF METAL IONS FOR ENVIRONMENTAL AND SPACE APPLICATIONS USING PHOTODIODE ARRAY SPECTROMETRY
KENNETH G. SCHLAGER (Biotronics Technologies, Inc., Wauwatosa, WI) IN: Optical spectroscopic instrumentation and techniques for the 1990s - Applications in astronomy, chemistry, and physics; Proceedings of the Meeting, Las Cruces, NM, June 4-6, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 220-233.
Copyright

A photodiode-array spectrometry characterized by fast data acquisition, simultaneous readings at multiple wavelengths, reproducibility, a wide dynamic range, and enhanced accuracy due to a low instrument drift is considered for on-line real-time monitoring of the trace levels of metal ions in water solutions for environmental, power plant, and space applications. An experimental application for NASA's Controlled Ecological Life Support System is outlined along with nuclear-plant monitoring applications. Steps involved in the developing of an algorithm for on-line multicomponent analyses in absorption spectrometry are presented, and a photodiode-array spectrometer used in the described experimental investigations is detailed. V.T.

A91-53752*# Sverdrup Technology, Inc., Huntsville, AL.
SPACE STATION RESOURCE NODE FLOW FIELD ANALYSIS
LEE KANIA, GANESH KUMAR (Sverdrup Technology, Inc., Huntsville, AL), and PAUL MCCONNAUGHEY (NASA, Marshall Space Flight Center, Huntsville, AL) IN: AIAA Applied Aerodynamics Conference, 9th, Baltimore, MD, Sept. 23-25, 1991, Technical Papers. Vol. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 279-287. refs
(AIAA PAPER 91-3235)

An analysis of the flow field within the Space Station Freedom resource node with operational intermodule ventilation and temperature/humidity control ventilation systems has been conducted. The INS3D code, an incompressible, steady-state Navier-Stokes solver has been used to assess the design of the ventilation system via quantification of the level of fluid mixing and identification of 'dead air' regions and short-circuit ventilation. Numerical results indicate significant short-circuit ventilation in the forward and midsections of the node and insufficient fluid mixing is found to exist in the aft node section. These results as well as results from a solution grid dependence study are presented.

Author

A91-53986
CONTAMINATION CONTROL PROGRAM FOR THE SPACE STATION HABITABLE MODULES
NIKKI M. ABRAMOV (Boeing Aerospace and Electronics, Huntsville, AL) IN: Institute of Environmental Sciences, Annual Technical Meeting, 36th, New Orleans, LA, Apr. 23-27, 1990, Proceedings. Mount Prospect, IL, Institute of Environmental Sciences, 1990, p. 206-211. refs
Copyright

The goals and the challenges of the contamination control program for the Space Shuttle Freedom habitable modules are briefly reviewed. The program includes rigorous screening of designs and materials, analytical modeling of the internal and external contamination sources and effects, assembly and testing in clean room facilities, cleaning processes, on-orbit maintenance operations, and potentially contaminating contingency operations. Some of the technologies required are routine cleaning and disinfection techniques and materials that are safe for use in microgravity and in a closed environment, rapid automated contaminant detection methods, and crew and hardware decontamination techniques that are effective in microgravity.

V.L.

A91-54048*# University of Central Florida, Orlando.
POST LANDING DESIGN AND TESTING OF AN ACRV MODEL
KENNETH C. HOSTERMAN and LOREN A. ANDERSON (Central Florida, University, Orlando, FL) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Baltimore, MD, Sept. 23-25, 1991. 8 p. Research sponsored by NASA, Universities Space Research Association, and Rockwell International Corp. refs
(AIAA PAPER 91-3129) Copyright

Consideration is given to a 1990-1991 program concentrated on the design, building, and testing of a one-fifth scale model of the egress and stabilization systems for an Apollo Command Module (ACM)-based assured crew return vehicle (ACRV). The program is aimed at determining the feasibility of 1) stabilizing the ACRV out of the range of motions which cause space sickness and 2) the safe and rapid removaling of a sick or injured crewmember from the ACRV. Research have been conducted in the following areas: ACRV model construction, water test facility identification, and stabilization control systems. The fidelity of the model has been established from geometric and dynamic characteristic tests performed on the model. O.G.

A91-54141
MAN IN SPACE - A EUROPEAN CHALLENGE IN BIOLOGICAL LIFE SUPPORT
C. TAMPONNET, R. BINOT, C. LASSEUR, and C. SAVAGE (ESTEC, Thermal Control and Life Support Div., Noordwijk, Netherlands) ESA Bulletin (ISSN 0376-4265), no. 67, Aug. 1991, p. 39-49.
Copyright

The requirements and potential applications of life-support technologies are reviewed in terms of the objectives and capacities of the ESA. Basic concepts of human life support and the regeneration of life-support materials are discussed with reference given to specific space-program logistics. Biological life-support techniques developed by ESA programs include the Biological Air Filter (BAF) and the Micro-Ecological Life-Support System Alternative (MELISSA). Principles of the BAF are at a high level of development, and the MELISSA concept is being examined theoretically to model the mass balance of the loop and identify potential technological difficulties. The report concludes that the ESA plans to continue development of the two programs and initiate programs regarding plant cultivation in space and biological waste and water treatment. C.C.S.

A91-54640
AN ANALYSIS OF THE CREW'S ROLE IN A HIGHLY AUTOMATED SPACE STATION CREW REENTRY VEHICLE
VICTOR RILEY and LEILA JOHANNESEN (Honeywell Systems and Research Center, Minneapolis, MN) IN: IEEE/AIAA/NASA Digital Avionics Systems Conference, 9th, Virginia Beach, VA, Oct. 15-18, 1990, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 415-418. refs
Copyright

An analysis of potential crew involvement in a highly automated vehicle for returning crew members from an orbiting space station is presented. The purpose of the analysis is to define a systematic process by which the various constraints of crew deconditioning, crew training, and operational environment could be balanced in designing the crew's response to automation failures. The results of the analysis include an automation taxonomy in which crew involvement in a given situation is bounded at one end by mission requirements and level of automation failure and at the other by crew capabilities, and a list of crew functions at each level of potential crew involvement. I.E.

A91-55824
STUDY OF MAN-SYSTEM FOR JAPANESE EXPERIMENT MODULE (JEM)
HIDETAKA TANAKA (Mitsubishi Heavy Industries, Ltd., Nagoya Aerospace Systems Work, Tobishima, Japan), TAKANOBU SHIMODA, and TAKAO YAMAGUCHI (NASDA, Tokyo, Japan) IN: Space utilization and applications in the Pacific; Proceedings of the 3rd Pacific Basin International Symposium on Advances in Space Science Technology and its Applications, Los Angeles, CA, Nov. 6-8, 1989. San Diego, CA, Univelt, Inc., 1990, p. 273-282. (AAS PAPER 89-627) Copyright

The JEM Man-Systems design concept is presented with particular attention given to major man-machine interface equipment configurations. The JEM Man System is aimed at supporting distributed system and element design, operations and training, flight crew, project management, and product assurance in the enforcement of human engineering and architectural continuity. It is based upon the SSF Man-Systems Integration standards. Specific functions of the system include mock-up production and test, study of accessibility and equipment layout, O-G simulator test, task analysis, and computer simulation. O.G.

N91-21182*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FIRE SUPPRESSION IN HUMAN-CREW SPACECRAFT
ROBERT FRIEDMAN and DANIEL L. DIETRICH (Sverdrup Technology, Inc., Brook Park, OH.) May 1991 14 p Presented at the Halon Alternatives Technical Working Conference, Albuquerque, NM, 30 Apr. - 1 May 1991; sponsored in part by New Mexico Univ.; and by The Center for Global Environmental Technologies
(Contract NAS3-25266; RTOP 323-53-62)
(NASA-TM-104334; E-6100; NAS 1.15:104334) Avail: CASI HC A03/MF A01 CSCL 06K

Fire extinguishment agents range from water and foam in early-design spacecraft (Halon 1301 in the present Shuttle) to carbon dioxide proposed for the Space Station Freedom. The major challenge to spacecraft fire extinguishment design and operations is from the micro-gravity environment, which minimizes natural convection and profoundly influences combustion and extinguishing agent effectiveness, dispersal, and post-fire cleanup. Discussed here are extinguishment in microgravity, fire-suppression problems anticipated in future spacecraft, and research needs and opportunities. Author

N91-21696*# National Aeronautics and Space Administration, Washington, DC.
EXPLORING THE LIVING UNIVERSE: A STRATEGY FOR SPACE LIFE SCIENCES
Jun. 1988 21 p Original contains color illustrations
(NASA-TM-103399; NAS 1.15:103399) Avail: CASI HC A03/MF A01; 2 functional color pages CSCL 06C

The knowledge obtained by space life sciences will play a pivotal role as humankind reaches out to explore the solar system. Information is needed concerning the existence of life beyond the Earth, the potential interactions between planets and living organisms, and the possibilities for humans to inhabit space safely and productively. Programs in the involved disciplines are an integral part of NASA's current and future missions. To realize their objectives, the development and operation of diverse ground and flight facilities and clost coordination with numerous scientific and governmental organizations in the U.S. and abroad are required. The status and goals of the life sciences programs are examined. Ways and means for attaining these goals are suggested. B.G.

N91-22173*# Fielder (Judith), Reston, VA.
A HYDROPONIC DESIGN FOR MICROGRAVITY AND GRAVITY INSTALLATIONS
JUDITH FIELDER and NICKOLAUS LEGGETT (Leggett, Nickolaus, Reston, VA) *In* NASA. Lewis Research Center, Vision-21: Space Travel for the Next Millennium p 436-439 Apr. 1990
Avail: CASI HC A01/MF A06 CSCL 06C

A hydroponic system is presented that is designed for use in microgravity or gravity experiments. The system uses a sponge-like growing medium installed in tubular modules. The modules contain the plant roots and manage the flow of the nutrient solution. The physical design and materials considerations are discussed, as are modifications of the basic design for use in microgravity or gravity experiments. The major external environmental requirements are also presented. Author

N91-22885# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Cologne (Germany, F.R.).
ASTRONAUT TRAINING [ASTRONAUTENTRAINING]
RENATE BRUEMMER *In its* Fourth Summer School on Microgravity: Conference Summaries and Forum Lectures p 13-20 Aug. 1990 In ENGLISH and GERMAN
Avail: CASI HC A02/MF A03

The training concept is defined. The astronauts should perfectly understand the experiments performed during spaceflight and they should be familiar with the payload onboard the Spacelab. The aim of the training is to give the required knowledge to astronauts and to foster the formation of a team. As a D2 mission is being prepared and further Spacelab flights are envisaged, training phases, basic training, lectures, operational training, simulation, and orbiter crew training are described. ESA

N91-23071*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
MONITORING AND CONTROL OF ATMOSPHERE IN A CLOSED ENVIRONMENT
R. HUMPHRIES and J. PERRY *In* National Aeronautics and Space Administration, Technology 2000, Volume 1 p 413-420 Mar. 1991
Avail: CASI HC A02/MF A04 CSCL 13B

Applications requiring new technologies for atmosphere monitoring and control in the closed environment and their principal functions aboard the Space Station Freedom are described. Oxygen loop closure, involving the conversion of carbon dioxide to oxygen; carbon dioxide reduction and removal; and monitoring of atmospheric contamination are discussed. The Trace Contaminant Monitor, the Major Constituent Analyzer, the Carbon Dioxide Monitor, and the Particulate Counter Monitor are discussed. Author

N91-23563# European Space Agency, Paris (France).
SPACE AND SEA
JOCELYNE LANDEAU, ed. Dec. 1990 296 p In ENGLISH and FRENCH Colloquium held in Paris, France, 24-26 Sep. 1990
(ESA-SP-312; ETN-91-99115) Copyright Avail: CASI HC A13/MF A03

Programs, opinions, experimentation, and discussions covering subjects as wide as life and work in confined environments, the evolution of present assisting equipment and the application of satellite technology to the marine environment are presented. These include ways in which the sea/deep water can be used to train astronauts and evaluate space equipment.

N91-23564# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Cologne (Germany, F.R.). Inst. for Aerospace Medicine.
THE DIVING LABORATORY AS A SIMULATION ENVIRONMENT FOR MANNED SPACEFLIGHT
J. WENZEL, L. VOGT, and R. D. FISCHER *In* ESA, Space and Sea p 11-13 Dec. 1990
Copyright Avail: CASI HC A01/MF A03

The underwater environment presents an interesting laboratory condition for the simulation and validation of manned space operations. Similarities between sea and space include both internal and external strains for the person under consideration. Some of the arguments are illustrated by video sequences comparing astronauts' activities during underwater training, parabola flight, and space mission. It is concluded that both basic training and mission specific simulation underwater is a valuable tool for the preparation of actual manned space projects. ESA

N91-23565# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Hamburg (Germany, F.R.). Dept. of Aviation and Space Psychology.
PSYCHOLOGICAL SELECTION OF ASTRONAUTS: RECENT DEVELOPMENTS AT THE DLR TESTING CENTRE IN HAMBURG (FED. REPUBLIC OF GERMANY)
C. FASSBENDER, K. M. GOETERS, and D. MANZEY *In* ESA, Space and Sea p 15-19 Dec. 1990
Copyright Avail: CASI HC A01/MF A03

Since 1977 the Department of Aviation and Space Psychology of the DLR has been regularly involved in astronaut (payload specialist) selection on a European as well as on a national level. For several of these selection campaigns the DLR has devised and applied its own test system consisting of a combination of paper pencil tests, apparatus tests, and personal interview. The DLR selection procedures incorporate diverse factors of performance (e.g., perception, memory, multiple task performance) as well as of personality (e.g., social capability, motivation, stress resistance). With the plan for a European participation in the Space Station Freedom new challenges are posed for the selection of all kinds of astronauts because of the specific demands of long duration space flights. These new challenges are discussed with regard to the problems of astronauts and recent developments at the DLR testing center concerning feasible psychological selection criteria and test methods for astronaut selection are presented. ESA

N91-23567# JCLP Hyperbarie, Paris (France).
SUBSEA HABITATS AND SPACE SIMULATION
JEAN CLAUDE LEPECHON *In* ESA, Space and Sea p 25-30 Dec. 1990 Sponsored in part by Atelier d'Architecture Aquatique, France
Copyright Avail: CASI HC A02/MF A03

Saturation diving was developed in the 1960's with subsea habitats and then used in the 1970's with deep diving systems and hyperbaric centers. Simulation of confinement can be carried out in saturation while simulation and training to extravehicular activity (EVA) must be performed in a pool. An integrated underwater safe center project which combines hyperbaric confinement and EVA sorties in a pool is presented. This center can also be used to train ground base team and payload specialists in communication techniques and procedures, during confinement and EVA exercices. ESA

N91-23569# OHB-System G.m.b.H., Bremen (Germany, F.R.). Space and Environmental Technology.
PAYLOAD RELATED CREW OPERATIONS: FROM PAST MISSIONS TO COLUMBUS
JAMES R. KASS, ERICH SCHAFHAUSER, and CARLO VIBERTI (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA, Space and Sea p 37-41 Dec. 1990
Copyright Avail: CASI HC A01/MF A03

Manned operations in an orbiting laboratory for extended periods of time have many characteristics in common with work in the deep sea, and are accompanied by a number of similar problems. The scenario of manned payload operations in space are addressed: some aspects with their parallel in deep sea work become evident. The analysis results from a study carried out with the ESA/ESTEC in preparation for the Columbus program, and uses as a baseline the lessons learned from past manned missions. Some highlights of these results are presented. ESA

N91-23573# Societe d'Architectures en Milieux Extremes, Paris (France).
EUROPEAN STAKES AND MEASURES PERMITTING THE MANAGEMENT OF GEOMETRIC DIMENSIONS [ENJEUX EUROPEENS ET MESURES PERMETTANT DE GERER LES DIMENSIONS GEOMETRIQUES]
M. FABRE *In* ESA, Space and Sea p 75-80 Dec. 1990 In FRENCH
Copyright Avail: CASI HC A02/MF A03

Within the Columbus program, the studies defining and optimizing the pressurized spaces must be based on extremely rigorous and highly performant modular and repetitive geometric dimensions, in compliance with ergonomic data inherent to the indispensable presence of man. These studies must also satisfy the following demands: they must comply, at all levels, with the geometric dimensional concepts of the decimal metric system and the international norms inherent to this system; they must be compatible, as much for the Columbus Attached Laboratory and the Columbus autonomous laboratory or Free Flyer as for the Hermes hold and pressurized airlock and the dynamic envelope of the cylindrical portion of the Ariane cap, with the most highly performant industrial geometric dimension norms and rules of international level, whether or not they come from the U.S. or are in use in Japan, USSR, etc.; they must generate a unique base denominator of geometric measurement in compliance with the international metric system. ESA

N91-23574# Compagnie Maritime d'Expertises, Marseille (France). Diving and Safety Dept.
COMPARISONS BETWEEN UNDERWATER AND SPACE WORKING ENVIRONMENTS FOR ON BOARD ACTIVITIES OPTIMIZATION (COLUMBUS SPACE PROGRAMME)
JEAN-PIERRE IMBERT and CARLO VIBERTI (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA, Space and Sea p 85-88 Dec. 1990
Copyright Avail: CASI HC A01/MF A03

The design of the standard racks for the Columbus laboratories, along with the rack transfer scenario, needs to be evaluated for the definition and optimization of crew on board tasks. In water tests seem to be the best way to conduct intravehicular activity (IVA) simulation and the problem of such tests definition is addressed. The method of intervention is reviewed under the light of the commercial diving experience: it seems that closed circuit breathing apparatus could be used which would make IVA simulation more realistic. The water physical properties are expected to induce differences but adequate arrangement of the rack mock up could minimize these biases. Obviously, underwater simulation is best to study operational problems, including supervision and monitoring. ESA

N91-23588# Direction des Constructions et Armes Navales, Toulon (France).
A KO2 REBREATHER FOR EVA DENITROGENATION PROCEDURE
E. RADZISZEWSKI and JEAN CLAUDE LEPECHON (JCLP Hyperbarie, Paris, France) *In* ESA, Space and Sea p 187-190 Dec. 1990
Copyright Avail: CASI HC A01/MF A03

In order to test the use of a KO_2 rebreather for space denitrogenation, the performances of a standard KO_2 unit were evaluated and thermal comfort discussed. After pure O_2 rinsing out of the lungs and of the counter lung nitrogen, the experimental protocol includes periods of rest and exercise. Nitrogen excretion is then evaluated, as well as oxygen contamination of the cabin atmosphere. The equipment tested proved to be acceptable for denitrogenation, some minor improvements are recommended and feasibility and advantages of the method for Extra Vehicular Activity (EVA) and emergency O_2 breathing are reviewed. ESA

N91-23694*# National Aeronautics and Space Administration, Washington, DC.
SPACE LIFE SCIENCES: A STATUS REPORT

Feb. 1990 60 p Original contains color illustrations
(NASA-NP-120; NAS 1.83:120) Avail: CASI HC A04/MF A01; 41 functional color pages CSCL 06B

The scientific research and supporting technology development conducted in the Space Life Sciences Program is described. Accomplishments of the past year are highlighted. Plans for future activities are outlined. Some specific areas of study include the following: Crew health and safety; What happens to humans in space; Gravity, life, and space; Sustenance in space; Life and planet Earth; Life in the Universe; Promoting good science and good will; Building a future for the space life sciences; and Benefits of space life sciences research. E.R.

N91-25576*# California Univ., San Diego, La Jolla.
HEART-LUNG INTERACTIONS IN AEROSPACE MEDICINE
HAROLD J. B. GUY and GORDON KIM PRISK *In* NASA. Lyndon B. Johnson Space Center, Spacelab Life Sciences 1: Reprints of Background Life Sciences Publications p 149-193 May 1991
Avail: CASI HC A03/MF A04 CSCL 06E

Few of the heart-lung interactions that are discussed have been studied in any detail in the aerospace environment, but is seems that many such interactions must occur in the setting of altered accelerative loadings and pressure breathing. That few investigations are in progress suggests that clinical and academic laboratory investigators and aerospace organizations are further apart than during the pioneering work on pressure breathing and acceleration tolerance in the 1940s. The purpose is to reintroduce some of the perennial problems of aviation physiology as well as some newer aerospace concerns that may be of interest. Many possible heart-lung interactions are pondered, by necessity often drawing on data from within the aviation field, collected before the modern understanding of these interactions developed, or on recent laboratory data that may not be strictly applicable. In the field of zero-gravity effects, speculation inevitably outruns the sparse available data. Author

N91-26107*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RADIATION RISK PREDICTIONS FOR SPACE STATION FREEDOM ORBITS
FRANCIS A. CUCINOTTA, WILLIAM ATWELL, MARK WEYLAND, ALVA C. HARDY, JOHN W. WILSON, LAWRENCE W. TOWNSEND, JUDY L. SHINN, and ROBERT KATZ (Nebraska Univ., Lincoln.) Washington Jun. 1991 22 p
(Contract RTOP 199-04-16-11)
(NASA-TP-3098; L-16903; NAS 1.60:3098) Avail: CASI HC A03/MF A01 CSCL 03B

Risk assessment calculations are presented for the preliminary proposed solar minimum and solar maximum orbits for Space Station Freedom (SSF). Integral linear energy transfer (LET) fluence spectra are calculated for the trapped proton and GCR environments. Organ dose calculations are discussed using the computerized anatomical man model. The cellular track model of Katz is applied to calculate cell survival, transformation, and mutation rates for various aluminum shields. Comparisons between relative biological effectiveness (RBE) and quality factor (QF) values for SSF orbits are made. Author

N91-26178# Joint Publications Research Service, Arlington, VA.
REVIEW OF PRIMARY MEDICAL RESULTS OF YEAR-LONG FLIGHT ON MIR STATION
A. I. GRIGORYEV, S. A. BUGROV, V. V. BOGOMOLOV, A. D. YEGOROV, I. B. KOZLOVSKAYA, I. D. PESTOV, and I. K. TARASOV *In its* JPRS Report: Science and Technology. USSR: Space p 42-49 16 Apr. 1991 Transl. into ENGLISH from Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina (USSR), v. 24, no. 5, Sep.-Oct. 1990 p 3-10
Avail: CASI HC A02/MF A02

The objective of medical investigations during and after the 366 day manned mission was to accumulate information about human responses to long-term effects of microgravity. To do this, cardiovascular and other systems were examined in detail during and after exposure. The results gave evidence that the crewmembers well adapted to the long-term flight effects. Their good health and high work capacity were supported by adequate medical procedures. Postflight readaptation developed similarly to what was seen after previous flights of shorter duration (6 to 11 months). No qualitatively new changes in the physiological systems were detected during or after this mission. Author

N91-26193*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
ILLUMINANCE AND LUMINANCE DISTRIBUTIONS OF A PROTOTYPE AMBIENT ILLUMINATION SYSTEM FOR SPACE STATION FREEDOM
R. C. MULLICAN (McGown-Mullican-Dunn, Architects, Nashville, TN.) and B. C. HAYES Jun. 1991 33 p
(NASA-TM-103541; NAS 1.15:103541) Avail: CASI HC A03/MF A01 CSCL 22B

Preliminary results of research conducted in the late 1970's indicate that perceptual qualities of an enclosure can be influenced by the distribution of illumination within the enclosure. Subjective impressions such as spaciousness, perceptual clarity, and relaxation or tenseness, among others, appear to be related to different combinations of surface luminance. A prototype indirect ambient illumination system was developed which will allow crew members to alter surface luminance distributions within an enclosed module, thus modifying perceptual cues to match crew preferences. A traditional lensed direct lighting system was compared to the prototype utilizing the full-scale mockup of Space Station Freedom developed by Marshall Space Flight Center. The direct lensed system was installed in the habitation module with the indirect prototype deployed in the U.S. laboratory module. Analysis centered on the illuminance and luminance distributions resultant from these systems and the implications of various luminaire spacing options. All test configurations were evaluated for compliance with NASA Standard 3000, Man-System Integration Standards. Author

N91-27088*# Houston Univ., TX.
NASA/ASEE SUMMER FACULTY FELLOWSHIP PROGRAM, 1990, VOLUME 1
RICHARD B. BANNEROT, ed. and STANLEY H. GOLDSTEIN, ed. (National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.) Dec. 1990 207 p Program held in Houston, TX, 1990
(Contract NGT-44-005-803)
(NASA-CR-185637-VOL-1; NAS 1.26:185637-VOL-1) Avail: CASI HC A10/MF A03 CSCL 05B

The 1990 Johnson Space Center (JSC) NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program was conducted by the University of Houston-University Park and JSC. A compilation of the final reports on the research projects are presented. The topics covered include: the Space Station; the Space Shuttle; exobiology; cell biology; culture techniques; control systems design; laser induced fluorescence; spacecraft reliability analysis; reduced gravity; biotechnology; microgravity applications; regenerative life support systems; imaging techniques; cardiovascular system; physiological effects; extravehicular mobility units; mathematical models; bioreactors; computerized simulation; microgravity simulation; and dynamic structural analysis.

N91-27093*# Mary Hardin-Baylor Univ., Belton, TX. Dept. of Mathematics and Physics.
AN AIR REVITALIZATION MODEL (ARM) FOR REGENERATIVE LIFE SUPPORT SYSTEMS (RLSS) Final Report
MAXWELL M. HART *In* Houston Univ., NASA/ASEE Summer Faculty Fellowship Program, 1990, Volume 1 15 p Dec. 1990
(Contract NGT-44-005-803)
Avail: CASI HC A03/MF A03 CSCL 06K

The primary objective of the air revitalization model (ARM) is to determine the minimum buffer capacities that would be necessary for long duration space missions. Several observations are supported by the current configuration sizes: the baseline values for each gas and the day to day or month to month fluctuations that are allowed. The baseline values depend on the minimum safety tolerances and the quantities of life support consumables necessary to survive the worst case scenarios within those tolerances. Most, it not all, of these quantities can easily be determined by ARM once these tolerances are set. The day to day fluctuations also require a command decision. It is already apparent from the current configuration of ARM that the tighter these fluctuations are controlled, the more energy used, the more nonregenerable hydrazine consumed, and the larger the required capacities for the various gas generators. All of these relationships could clearly be quantified by one operational ARM. Author

N91-27112*# Texas Lutheran Coll., Seguin. Dept. of Biology.
MECHANICS, IMPACT LOADS AND EMG ON THE SPACE SHUTTLE TREADMILL Final Report
WILLIAM G. SQUIRES *In* Houston Univ., NASA/ASEE Summer Faculty Fellowship Program, 1990, Volume 2 3 p Dec. 1990
(Contract NGT-44-005-803)
Avail: CASI HC A01/MF A02 CSCL 06E

The ability of astronauts to egress the Shuttle, particularly during emergency conditions, is likely to be reduced following physiological adaptation in space. It is well established that effective application of exercise counter measures requires the exercise to be applied specifically. The problem is that objective scientific evidence is not available to validate the Space Shuttle treadmill with respect to in its role in diminishing the deleterious effects of a prolonged exposure to the microgravity environment. Author

N91-27765*# Alabama Univ., Huntsville.
ECLSS ADVANCED AUTOMATION PRELIMINARY REQUIREMENTS Final Report
BRENDA D. LUKEFAHR, DANIEL M. ROCHOWIAK, BRIAN L. BENSON, JOHN S. ROGERS, and JAMES W. MCKEE Nov. 1989 168 p
(Contract NAS8-36955)
(NASA-CR-186115; NAS 1.26:186115; UAH-RR-823) Copyright
Avail: CASI HC A08/MF A02 CSCL 06K

A description of the total Environmental Control and Life Support System (ECLSS) is presented. The description of the hardware is given in a top down format, the lowest level of which is a functional description of each candidate implementation. For each candidate implementation, both its advantages and disadvantages are presented. From this knowledge, it was suggested where expert systems could be used in the diagnosis and control of specific portions of the ECLSS. A process to determine if expert systems are applicable and how to select the expert system is also presented. The consideration of possible problems or inconsistencies in the knowledge or workings in the subsystems is described. Author

N91-27766*# Alabama Univ., Huntsville.
A DIAGNOSTIC PROTOTYPE OF THE POTABLE WATER SUBSYSTEM OF THE SPACE STATION FREEDOM ECLSS Final Report
BRENDA D. LUKEFAHR, DANIEL M. ROCHOWIAK, BRIAN L. BENSON, JOHN S. ROGERS, and JAMES W. MCKEE Nov. 1989 49 p
(Contract NAS8-36955)
(NASA-CR-186111; NAS 1.26:186111; UAH-RR-824) Copyright
Avail: CASI HC A03/MF A01 CSCL 06K

In analyzing the baseline Environmental Control and Life Support System (ECLSS) command and control architecture, various processes are found which would be enhanced by the use of knowledge based system methods of implementation. The most suitable process for prototyping using rule based methods are documented, while domain knowledge resources and other practical considerations are examined. Requirements for a prototype rule based software system are documented. These requirements reflect Space Station Freedom ECLSS software and hardware development efforts, and knowledge based system requirements. A quick prototype knowledge based system environment is researched and developed. Author

N91-27769# Joint Publications Research Service, Arlington, VA.
HABITABILITY AND BIOLOGICAL LIFE SUPPORT SYSTEMS
O. G. GAZENKO, A. I. GRIGORYEV, G. I. MELESHKO, and YE. YA. SHEPELEV *In its* JPRS Report: Science and Technology. USSR: Life Sciences p 1-6 20 Mar. 1991 Transl. into ENGLISH from Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina, Moscow (USSR), v. 24, no. 3, May-Jun. 1990 p 12-17
Avail: CASI HC A02/MF A01

Problems about man's attitude toward biological life support systems (BLSS's) are discussed. Man's understanding of the purpose and role of BLSS's in the future of cosmonautics depends on an understanding of the problem of habitability. If the concept of habitability is based on the satisfaction of a familiar list of individual physiological and hygiene requirements, then the task of life support systems (LSS's) can be understood purely from the viewpoint of a consumer: as one of ensuring the parameters required of the environment and the amount of its required components (oxygen, water, and food). If the problem is based on the ecological concept of the habitat in the broad sense, then ecological, not consumer, requirements must be imposed on the LSS as a system for total development of a biologically complete habitat adequate for man's biological needs and meeting, in principle, the basic criteria of the natural environment on Earth. This is the reason for the different approaches to evaluating the prospects of BLSS's used by designers on the one hand and doctors studying human living conditions in space facilities on the other. The importance of defining relations between the concept of habitability and the role of the means that ensure it are discussed. Author

N91-29737*# Alabama Univ., Huntsville. Coll. of Science.
CHEMICAL WASTE DISPOSAL IN SPACE BY PLASMA DISCHARGE Final Report
JAMES K. BAIRD 31 Mar. 1991 68 p
(Contract NAS8-37195)
(NASA-CR-184169; NAS 1.26:184169) Avail: CASI HC A04/MF A01 CSCL 06K

An inductively coupled plasma discharge apparatus operating at 13.56 MHz and with electrical power up to 2.5 kW was constructed. The efficiency of this device to destroy various gases expected to be carried aboard the Space Station was tested. By expressing the efficiency of the device in terms of G-value (the number of molecules decomposed per 100 eV of energy absorbed), the results are compared with known efficiencies of ionizing radiation to destroy these same gases. In the case of ammonia, it was found that in the inductively coupled device, the destruction efficiency, G(-NH3) varied from 6.0 to 32.0 molecules/100 eV, depending on conditions. It was also found that capacitatively coupled discharges were less efficient in destroying NH2 than the inductively coupled discharge. In the case NH2 destruction, it was found that the G(-NH3) was a qualitative guide to the efficiencies of plasmas. The plasma device was also used to destroy nitrous oxide and methane. It is shown how the G-value for the destruction of any gas can be computed theoretically from a knowledge of the electron velocity distribution, the various electron molecule scattering cross sections, and the rate constants for the reactions of secondary species. Author

N91-30198# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Materials and Processes Div.
THE CONTROL OF LIMITED-LIFE MATERIALS
Dec. 1990 14 p
(ISSN 0379-4059)
(ESA-PSS-01-722-ISSUE-2; ETN-91-99828) Copyright Avail: CASI HC A03/MF A01

The procedure to be used for the control of limited life materials employed in the fabrication of ESA spacecraft and associated equipment is specified. The areas covered are hazards and safety precautions, material control, procurement documents, identification, storage and handling. Control of material life includes assessment of shelf life, extension of shelf life and disposal of non certifiable materials. Acceptance criteria and recertification testing are outlined. Quality control criteria concerning data nonconformance, calibration and traceability are discussed. ESA

N91-31061*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ANALYSES OF RISKS ASSOCIATED WITH RADIATION EXPOSURE FROM PAST MAJOR SOLAR PARTICLE EVENTS
MARK D. WEYLAND, WILLIAM ATWELL, FRANCIS A. CUCINOTTA, JOHN W. WILSON (National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.), and ALVA C. HARDY Aug. 1991 37 p
(NASA-TP-3137; S-639; NAS 1.60:3137) Avail: CASI HC A03/MF A01 CSCL 03B

Radiation exposures and cancer induction/mortality risks were investigated for several major solar particle events (SPE's). The SPE's included are: February 1956, November 1960, August 1972, October 1989, and the September, August, and October 1989 events combined. The three 1989 events were treated as one since all three could affect a single lunar or Mars mission. A baryon transport code was used to propagate particles through aluminum and tissue shield materials. A free space environment was utilized for all calculations. Results show the 30-day blood forming organs (BFO) limit of 25 rem was surpassed by all five events using 10 g/sq cm of shielding. The BFO limit is based on a depth dose of 5 cm of tissue, while a more detailed shield distribution of the BFO's was utilized. A comparison between the 5 cm depth dose and the dose found using the BFO shield distribution shows that the 5 cm depth value slightly higher than the BFO dose. The annual limit of 50 rem was exceeded by the August 1972, October 1989, and the three combined 1989 events with 5 g/sq cm of shielding. Cancer mortality risks ranged from 1.5 to 17 percent at 1 g/sq cm and 0.5 to 1.1 percent behind 10 g/sq cm of shielding for five events. These ranges correspond to those for a 45 year old male. It is shown that secondary particles comprise about 1/3 of the total risk at 10 g/sq cm of shielding. Utilizing a computerized Space Shuttle shielding model to represent a typical spacecraft configuration in free space at the August 1972 SPE, average crew doses exceeded the BFO dose limit. Author

N91-31775*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEMS: CELSS '89 WORKSHOP
ROBERT D. MACELROY, ed. Mar. 1990 433 p Workshop held in Orlando, FL, Feb. 1989
(Contract RTOP 199-61-12)
(NASA-TM-102277; A-90059; NAS 1.15:102277) Avail: CASI HC A19/MF A04 CSCL 06K

Topics discussed at NASA's Controlled Ecological Life Support Systems (CELSS) workshop concerned the production of edible biomass. Specific areas of interest ranged from the efficiency of plant growth, to the conversion of inedible plant material to edible food, to the use of plant culture techniques. Models of plant growth and whole CELSS systems are included. The use of algae to supplement and improve dietary requirements is addressed. Flight experimentation is covered in topics ranging from a Salad Machine for use on the Space Station Freedom to conceptual designs for a lunar base CELSS.

N91-31788*# New Mexico State Univ., Las Cruces. Dept. of Civil Engineering.
PRELIMINARY EVALUATION OF WASTE PROCESSING IN A CELSS
RICARDO B. JACQUEZ *In* NASA. Ames Research Center, Controlled Ecological Life Support Systems: CELSS '89 Workshop p 245-263 Mar. 1990
Avail: CASI HC A03/MF A04 CSCL 06K

Physical/chemical, biological, and hybrid methods can be used in a space environment for processing wastes generated by a Closed Ecological Life Support System (CELSS). Two recycling scenarios are presented. They reflect differing emphases on and responses to the waste system formation rates and their composition, as well as indicate the required products from waste treatment that are needed in a life support system. Author

N91-32552*# Hamilton Standard, Windsor Locks, CT.
SPE (TM) WATER ELECTROLYZERS IN SUPPORT OF MISSION FROM PLANET EARTH
J. F. MCELROY *In* NASA. Lewis Research Center, Space Electrochemical Research and Technology p 23-35 Sep. 1991
Avail: CASI HC A03/MF A03 CSCL 10B

During the 1970's, the Solid Polymer Electrolyte (SPE) water electrolyzer, which uses ion exchange membranes as its sole electrolyte, was developed for nuclear submarine metabolic oxygen production. SPE water electrolyzer developments included operation at up to 3,000 psia and at current densities in excess of 1,000 amps per square foot. The SPE water electrolyzer system has accumulated tens of thousands of system hours with the Navies of both the United States and the United Kingdom. During the 1980's, the basic SPE water electrolyzer cell structure developed for the Navies was incorporated into several demonstrators for NASA's Space Station Program. Among these were: (1) the SPE regenerative fuel cell for electrical energy storage; (2) the SPE water electrolyzer for metabolic oxygen production; and (3) the high pressure SPE water electrolyzer for reboost propellant production. In the 1990's, emphasis will be the development of SPE water electrolyzers for Mission from Planet Earth. Currently defined potential applications for the SPE water electrolyzer include: (1) SPE water electrolyzers operating at high pressure as part of a regenerative fuel cell extraterrestrial surface energy storage system; (2) SPE water electrolyzers for propellant production from extraterrestrial indigenous materials; and (3) SPE water electrolyzers for metabolic oxygen and potable water production from reclaimed water. Author

N91-32553*# Life Systems, Inc., Cleveland, OH.
SPACE WATER ELECTROLYSIS: SPACE STATION THROUGH ADVANCE MISSIONS
RONALD J. DAVENPORT, FRANZ H. SCHUBERT, and DAVID J. GRIGGER *In* NASA. Lewis Research Center, Space Electrochemical Research and Technology p 37-56 Sep. 1991
Avail: CASI HC A03/MF A03 CSCL 10B

Static Feed Electrolyzer (SFE) technology can satisfy the need for oxygen (O_2) and Hydrogen (H_2) in the Space Station Freedom and future advanced missions. The efficiency with which the SFE technology can be used to generate O_2 and H_2 is one of its major advantages. In fact, the SFE is baselined for the Oxygen Generation Assembly within the Space Station Freedom's Environmental Control and Life Support System (ECLSS). In the conventional SFE process an alkaline electrolyte is contained within the matrix and is sandwiched between two porous electrodes. The electrodes and matrix make up a unitized cell core. The electrolyte provides the necessary path for the transport of water and ions between the electrodes, and forms a barrier to the diffusion of O_2 and H_2. A hydrophobic, microporous membrane permits water vapor to diffuse from the feed water to the cell core. This membrane separates the liquid feed water from the product H_2, and, therefore, avoids direct contact of the electrodes by the feed water. The feed water is also circulated through an external heat exchanger to control the temperature of the cell. Author

N91-32776*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
MEDICAL EVALUATIONS ON THE KC-135 1990 FLIGHT REPORT SUMMARY
CHARLES W. LLOYD, TERRELL M. GUESS, CHARLES W. WHITING, and CHARLES R. DOARN (Krug Life Sciences, Inc., Houston, TX.) Sep. 1991 243 p
(Contract NAS9-18492)
(NASA-TM-104740; S-646; NAS 1.15:104740) Avail: CASI HC A11/MF A03 CSCL 05H

The medical investigations completed on the KC-135 during FY 1990 in support of the development of the Health Maintenance Facility and Medical Operations are discussed. The experiments are comprised of engineering evaluations of medical hardware and medical procedures. The investigating teams are made up of both medical and engineering personnel responsible for the development of medical hardware and medical operations. The hardware evaluated includes dental equipment, a coagulation analyzer, selected pharmaceutical aerosol devices, a prototype air/fluid separator, a prototype packaging and stowage system for medical supplies, a microliter metering system, and a workstation for minor surgical procedures. The results of these engineering evaluations will be used in the design of fleet hardware as well as to identify hardware specific training requirements.

N91-32777*# Texas Univ. Health Science Center, San Antonio.
HEALTH MAINTENANCE FACILITY: DENTAL EQUIPMENT REQUIREMENTS
JOHN YOUNG, JOHN GOSBEE, and ROGER BILLICA (Krug International, Houston, TX.) *In* NASA. Lyndon B. Johnson Space Center, Medical Evaluations on the KC-135 1990 Flight Report Summary p 1-4 Sep. 1991
Avail: CASI HC A01/MF A03 CSCL 06E

The objectives were to test the effectiveness of the Health Maintenance Facility (HMF) dental suction/particle containment system, which controls fluids and debris generated during simulated dental treatment, in microgravity; to test the effectiveness of fiber optic intraoral lighting systems in microgravity, while simulating dental treatment; and to evaluate the operation and function of off-the-shelf dental handheld instruments, namely a portable dental hand drill and temporary filling material, in microgravity. A description of test procedures, including test set-up, flight equipment, and the data acquisition system, is given. Author

N91-32778*# Texas Univ. Health Science Center, San Antonio.
DENTAL EQUIPMENT TEST DURING ZERO-GRAVITY FLIGHT
JOHN YOUNG, JOHN GOSBEE, and ROGER BILLICA (Krug International, Houston, TX.) *In* NASA. Lyndon B. Johnson Space Center, Medical Evaluations on the KC-135 1990 Flight Report Summary p 5-19 Sep. 1991
Avail: CASI HC A03/MF A03 CSCL 06E

The overall objectives of this program were to establish performance criteria and develop prototype equipment for use in the Health Maintenance Facility (HMF) in meeting the needs of dental emergencies during space missions. The primary efforts during this flight test were to test patient-operator relationships, patent (manikin) restraint and positioning, task lighting systems, use and operation of dental rotary instruments, suction and particle containment system, dental hand instrument delivery and control procedures, and the use of dental treatment materials. The initial efforts during the flight focused on verification of the efficiency of the particle containment system. An absorptive barrier was also tested in lieu of the suction collector. To test the instrument delivery system, teeth in the manikin were prepared with the dental drill to receive restorations, some with temporary filling materials and another with definitive filling material (composite resin). The best particle containment came from the combination use of the laminar-air/suction collector in concert with immediate area suction from a surgical high-volume suction tip. Lighting in the treatment area was provided by a flexible fiberoptic probe. This system is quite effective for small areas, but for general tasks ambient illumination is required. The instrument containment system (elastic cord network) was extremely effective and easy to use. The most serious problem with instrument delivey and actual treatment was lack of time during the microgravity sequences. The restorative materials handled and finished well. Author

N91-32779*# Krug International, Houston, TX.
MINI-RACK TESTBED EVALUATION
JOHN GOSBEE, BARBARA STEGMANN, and TERRELL M. GUESS (Krug Life Sciences, Inc., Houston, TX.) *In* NASA. Lyndon B. Johnson Space Center, Medical Evaluations on the KC-135 1990 Flight Report Summary p 21-40 Sep. 1991
Avail: CASI HC A03/MF A03 CSCL 05H

The goal was to characterize the Health Maintenance Facility (HMF)-like mini-racks and drawers onboard the KC-135 as a test bed for the Space Station Freedom HMF racks. An additional goal was to evaluate the attachments, mounting points, and inner drawer assemblies of the mini-racks for various medical equipment and supplies. Results and recommendations are given. Author

N91-32780*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
OPERATION AND PERFORMANCE OF THE CIBA-CORNING 512 COAGULATION MONITOR DURING PARABOLIC FLIGHT
ROBYN GOCKE, CHARLES W. LLOYD, and NANCY K. GREENTHANER (Krug Life Sciences, Inc., Houston, TX.) *In its* Medical Evaluations on the KC-135 1990 Flight Report Summary p 41-58 Sep. 1991
Avail: CASI HC A03/MF A03 CSCL 06E

The goal was to assess the functionality and evaluate the procedures and operations required to operate the Ciba-Corning 512 Coagulation Monitor during parabolic flight. This monitor determines the clotting characteristics of blood. The analyzer operates by laser detection of the cessation of blood flow in a capillary channel within a test cartridge. Test simulator results were excellent for both pre-and post-flight. In-flight results were not obtained due to the warm-up time required for the simulator. Since this is an electronic function only, the expected results on the simulator would be the same in zero-g. Author

N91-32784*# Krug International, Houston, TX.
TRANSPORT SUCTION APPARATUS AND ABSORPTION MATERIALS EVALUATION
DEBRA T. KRUPA and JOHN GOSBEE *In* NASA. Lyndon B. Johnson Space Center, Medical Evaluations on the KC-135 1990 Flight Report Summary p 97-108 Sep. 1991
Avail: CASI HC A03/MF A03 CSCL 05H

The specific objectives were as follows. The effectiveness and function was evaluated of the hand held, manually powered v-vac for suction during microgravity. The function was evaluated of the battery powered laerdal suction unit in microgravity. The two units in control of various types of simulated bodily fluids were compared. Various types of tubing and attachments were evaluated which are required to control the collection of bodily fluids during transport. Various materials were evaluated for absorption of simulated bodily fluids. And potential problems were identified for waste management and containment of secretions and fluids during transport. Test procedures, results, and conclusions are briefly discussed. Author

N91-32785*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ATLS-STOWAGE AND DEPLOYMENT TESTING OF MEDICAL SUPPLIES AND PHARMACEUTICALS
JOHN GOSBEE, DARREN BENZ, CHARLES W. LLOYD, RICHARD BUEKER, and DEBRA ORSAK (McDonnell-Douglas Space Systems Co., Houston, TX.) *In its* Medical Evaluations on the KC-135 1990 Flight Report Summary p 109-119 Sep. 1991
Avail: CASI HC A03/MF A03 CSCL 05H

The objective is to evaluate stowage and deployment methods for the Health Maintenance Facility (HMF) during microgravity. The specific objectives of this experiment are: (1) to evaluate the stowage and deployment mechanisms for the medical supplies; and (2) to evaluate the procedures for performing medical scenarios. To accomplish these objectives, the HMF test mini-racks will contain medical equipment mounted in the racks; and self-contained drawers with various mechanisms for stowing and deploying items. The medical supplies and pharmaceuticals will be destowed, handled, and restowed. The in-flight test procedures and other aspects of the KC-135 parabolic flight test to simulate weightlessness are presented. Author

N91-32786*# Krug International, Houston, TX.
MINOR SURGERY IN MICROGRAVITY
ROGER BILLICA, DEBRA T. KRUPA, ROBERT STONESTREET, and VICTOR D. KIZZEE *In* NASA. Lyndon B. Johnson Space Center, Medical Evaluations on the KC-135 1990 Flight Report

Summary p 121-130 Sep. 1991
Avail: CASI HC A02/MF A03 CSCL 06E

The purpose is to investigate and demonstrate equipment and techniques proposed for minor surgery on Space Station Freedom (SSF). The objectives are: (1) to test and evaluate methods of surgical instrument packaging and deployment; (2) to test and evaluate methods of surgical site preparation and draping; (3) to evaluate techniques of sterile procedure and maintaining sterile field; (4) to evaluate methods of trash management during medical/surgical procedures; and (4) to gain experience in techniques for performing surgery in microgravity. A KC-135 parabolic flight test was performed on March 30, 1990 with the goal of investigating and demonstrating surgical equipment and techniques under consideration for use on SSF. The flight followed the standard 40 parabola profile with 20 to 25 seconds of near-zero gravity in each parabola. Author

N91-32787*# Krug International, Houston, TX.
EVALUATION OF PROTOTYPE ADVANCED LIFE SUPPORT (ALS) PACK FOR USE BY THE HEALTH MAINTENANCE FACILITY (HMF) ON SPACE STATION FREEDOM (SSF)
DEBRA T. KRUPA, JOHN GOSBEE, LINDA MURPHY, and VICTOR D. KIZZEE *In* NASA. Lyndon B. Johnson Space Center, Medical Evaluations on the KC-135 1990 Flight Report Summary p 131-143 Sep. 1991
Avail: CASI HC A03/MF A03 CSCL 05H

The purpose is to evaluate the prototype Advanced Life Support (ALS) Pack which was developed for the Health Maintenance Facility (HMF). This pack will enable the Crew Medical Officer (CMO) to have ready access to advanced life support supplies and equipment for time critical responses to any situation within the Space Station Freedom. The objectives are: (1) to evaluate the design of the pack; and (2) to collect comments for revision to the design of the pack. The in-flight test procedures and other aspects of the KC-135 parabolic test flight to simulate weightlessness are presented. Author

N91-32788*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
VENIPUNCTURE AND INTRAVENOUS INFUSION ACCESS DURING ZERO-GRAVITY FLIGHT
DEBRA T. KRUPA, JOHN GOSBEE, ROGER BILLICA, PERRY BECHTLE, GERALD J. CREAGER (Krug International, Houston, TX.), and JOEY B. BOYCE *In its* Medical Evaluations on the KC-135 1990 Flight Report Summary p 145-162 Sep. 1991
Avail: CASI HC A03/MF A03 CSCL 06E

The purpose of this experiment is to establish the difficulty associated with securing an intravenous (IV) catheter in place in microgravity flight and the techniques applicable in training the Crew Medical Officer (CMO) for Space Station Freedom, as well as aiding in the selection of appropriate hardware and supplies for the Health Maintenance Facility (HMF). The objectives are the following: (1) to determine the difficulties associated with venipuncture in a microgravity environment; (2) to evaluate the various methods of securing an IV catheter and attached tubing for infusion with regard to the unique environment; (3) to evaluate the various materials available for securing an intravenous catheter in place; and (4) to evaluate the fluid therapy administration system when functioning in a complete system. The inflight test procedures and other aspects of the KC-135 parabolic flight test to simulate microgravity are presented. Author

N91-32789*# Krug International, Houston, TX.
EVALUATION OF CARDIOPULMONARY RESUSCITATION TECHNIQUES IN MICROGRAVITY
ROGER BILLICA, JOHN GOSBEE, and DEBRA T. KRUPA *In* NASA. Lyndon B. Johnson Space Center, Medical Evaluations on the KC-135 1990 Flight Report Summary p 163-183 Sep. 1991
Avail: CASI HC A03/MF A03 CSCL 06E

Cardiopulmonary resuscitation (CPR) techniques were investigated in microgravity with specific application to planned medical capabilities for Space Station Freedom (SSF). A KC-135 parabolic flight test was performed with the goal of evaluating and quantifying the efficacy of different types of microgravity CPR techniques. The flight followed the standard 40 parabola profile with 20 to 25 seconds of near-zero gravity in each parabola. Three experiments were involved chosen for their clinical background, certification, and practical experience in prior KC-135 parabolic flight. The CPR evaluation was performed using a standard training mannequin (recording resusci-Annie) which was used in practice prior to the actual flight. Aboard the KC-135, the prototype medical restraint system (MRS) for the SSF Health Maintenance Facility (HMF) was used for part of the study. Standard patient and crew restraints were used for interface with the MRS. During the portion of study where CPR was performed without MRS, a set of straps for crew restraint similar to those currently employed for the Space Shuttle program were used. The entire study was recorded via still camera and video. Author

N91-32790*# Krug International, Houston, TX.
FLUID HANDLING 2: SURGICAL APPLICATIONS
ROGER BILLICA, JOHN YOUNG (Texas Univ. Health Science Center, San Antonio.), DOUG RUSHING, and VICTOR D. KIZZEE *In* NASA. Lyndon B. Johnson Space Center, Medical Evaluations on the KC-135 1990 Flight Report Summary p 185-192 Sep. 1991
Avail: CASI HC A02/MF A03 CSCL 06E

The methods proposed for managing fluids and particulate debris during minor surgery on Space Station Freedom (SSF) were investigated and demonstrated. A KC-135 parabolic flight test was performed, in which the flight followed the standard 40 parabola profile with 20 to 25 seconds in near-zero gravity in each parabola. The equipment (suction and laminar flow device) was evaluated. While this equipment performed satisfactorily previously in the dental simulation, the purpose of the current flight was to reconfigure the equipment in support of a minor surgical situation in order to evaluate its efficacy and establish clear requirements for the actual flight hardware. To accomplish the study the Health Maintenance Facility medical restraint system was deployed as for surgical use and mannequin suture arm was restrained to its surface. The surgical area was established as for performing minor surgery with standard tray and suture instruments employed. Author

N91-32791*# Krug International, Houston, TX.
EVALUATION OF PROTOTYPE AIR/FLUID SEPARATOR FOR SPACE STATION FREEDOM HEALTH MAINTENANCE FACILITY
ROGER BILLICA, MAUREEN SMITH, LINDA MURPHY, and VICTOR D. KIZZEE *In* NASA. Lyndon B. Johnson Space Center, Medical Evaluations on the KC-135 1990 Flight Report Summary p 193-203 Sep. 1991
Avail: CASI HC A03/MF A03 CSCL 05H

A prototype air/fluid separator suction apparatus proposed as a possible design for use with the Health Maintenance Facility aboard Space Station Freedom (SSF) was evaluated. A KC-135 parabolic flight test was performed for this purpose. The flights followed the standard 40 parabola profile with 20 to 25 seconds of near-zero gravity in each parabola. A protocol was prepared to evaluate the prototype device in several regulator modes (or suction force), using three fluids of varying viscosity, and using either continuous or intermittent suction. It was felt that a matrixed approach would best approximate the range of utilization anticipated for medical suction on SSF. The protocols were performed in one-gravity in a lab setting to familiarize the team with procedures and techniques. Identical steps were performed aboard the KC-135 during parabolic flight. Author

N91-32794*# Georgetown Univ., Washington, DC.
DEPLOYMENT AND TESTING OF A SECOND PROTOTYPE EXPANDABLE SURGICAL CHAMBER IN MICROGRAVITY
SANFORD M. MARKHAM and JOHN A. ROCK (Johns Hopkins Univ., Baltimore, MD.) *In* NASA. Lyndon B. Johnson Space Center, Medical Evaluations on the KC-135 1990 Flight Report Summary p 237-239 Sep. 1991
Avail: CASI HC A01/MF A03 CSCL 05H

During microgravity exposure, two separate expandable surgical chambers were tested. Both chambers had been modified to fit the microgravity work station without extending over the sides of the table. Both chambers were attached to a portable laminar flow generator which served two purposes: to keep the chambers expanded during use; and to provide an operative area environment free of contamination. During the tests, the chambers were placed on various parts of a total body moulage to simulate management of several types of trauma. The tests consisted of cleansing contusions, debridement of burns, and suturing of lacerations. Also, indigo carmine dye was deliberately injected into the chamber during the tests to determine the ease of cleansing the chamber walls after contamination by escaping fluids. Upon completion of the tests, the expandable surgical chambers were deflated, folded, and placed in a flattened state back into their original containers for storage and later disposal. Results are briefly discussed.
Author

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ORBITS & ORBITAL TRANSFER

Maintenance of space station or other large structures in their orbits, as well as transfer between orbits. Includes docking with servicing or transfer vehicles.

A91-33229#

A COMPARISON OF A PREDICTIVE FUZZY CONTROL WITH AN OPTIMAL CONTROL FOR AUTOMATIC SPACECRAFT RENDEZVOUS

SHINJI ISHIMOTO and KANICHIRO KATO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 39, no. 444, 1991, p. 44-50. In Japanese, with abstract in English. refs

A study is described that compares the performance of a predictive fuzzy control law with that of an optimal feedback control law. The predictive fuzzy control scheme is a method which predicts the result and selects the most likely control rule based on a human's control strategy. Two methods are applied to automatic rendezvous maneuvers to bring a spacecraft toward a target vehicle (typically a Space Station). It is shown that the predictive fuzzy controller can provide better performance compared with the optimal regulator, in the sense that it can assure collision avoidance in case of RCS jet failure. Author

A91-33506

THE DYNAMICS OF SOLAR SAILS WITH A NON-POINT SOURCE OF RADIATION PRESSURE

COLIN R. MCINNES and JOHN C. BROWN (Glasgow, University, Scotland) Celestial Mechanics and Dynamical Astronomy (ISSN 0923-2958), vol. 49, no. 3, 1990, p. 249-264. refs

Copyright

The form of the solar radiation pressure on a heliocentric orbiting sail is obtained for a finite angular sized and limb darkened solar disk by the use of the radiation pressure tensor. It is found that the usual inverse square variation of the solar radiation pressure is modified by the finite angular size, and to a lesser extent by the solar limb darkening. The actual magnitude of the modification is in itself small, except at close heliocentric distances. However, its existence has implications for the dynamical stability of solar sails both in parked and circular orbital configurations and for the accuracy of trajectory calculations, particularly for sails in the inner solar system. Author

A91-38230#

A NOTE ON OPTIMAL SPACECRAFT RENDEZVOUS

SHINJI ISHIMOTO and KANICHIRO KATO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 39, no. 445, 1991, p. 91-96. In Japanese, with abstract in English. refs

This paper considers optimal rendezvous maneuvers to bring a spacecraft into close proximity of a target in circular orbit (typically a space station). The motion of the spacecraft relative to the target is described by linearized differential equations. Three optimal control problems are formulated using these equations. Optimal maneuvers minimizing energy, fuel, and time required for transfer are investigated and numerical solutions are shown employing the sequential gradient-restoration algorithm. Author

A91-39683

PROGRESS M-7 - CATASTROPHE AVOIDED

NEVILLE KIDGER Spaceflight (ISSN 0038-6340), vol. 33, June 1991, p. 192, 193.

Copyright

Attention is given to aversion of a catastrophe on the second of three attempts on March 23, 1991 to dock the Progress M-7 spacecraft to the Mir space station. A near-collision occurred due to a malfunction of one of the Kurs antennas. On March 28, 1991 Progress M-7 docked automatically to the front port of the Mir base block. Also discussed are scientific and maintainance work on the the spacecraft and the EVA undertaken to examine the Kurs antenna on the Kvant module. O.G.

A91-44207#

SYSTEMS ANALYSIS FOR AN OPERATIONAL EOTV

T. M. MILLER (McDonnell Douglas Space Systems Co., Huntington Beach, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p. refs

(AIAA PAPER 91-2351) Copyright

A study has been performed to parametrically determine optimum performance parameters of an operational solar electric orbital transfer vehicle (SEOTV) capable of initial operating capability in the year 2000. The SEOTV concept is to be capable of near-earth transfer of payloads from low earth orbit (LEO) to geosynchronous earth orbit and from LEO to global positioning system orbit. The objective was to search for the optimum specific impulse operating range that results in maximum vehicle payload fraction while minimizing vehicle life cycle costs with reasonable mission trip times. Results were used to aid in propulsion system selection for the SEOTV concept. A parametric expression was developed that accounts for all variables in the problem including the variation of power conditioning unit efficiency, thruster efficiency, tankage fraction, and specific power of the power system with specific impulse. The expression was solved for various performance parameters of interest including limit trip time, required power to initial mass ratio, thrust to mass ratio, payload mass to power mass ratio, and payload fraction. Results indicate that for all performance parameters of interest, thrusters in the 1000 s to 1300 s specific impulse operating range showed optimum characteristics. Thrusters in this range correspond to arcjets operating on hydrogen propellant. Author

A91-45090

SPACE FLIGHT MECHANICS [MEKHANIKA KOSMICHESKOGO POLETA]

MIKHAIL S. KONSTANTINOV, EVGENII F. KAMENKOV, BORIS P. PERELYGIN, and VITALII K. BEZVERBYI Moscow, Izdatel'stvo Mashinostroenie, 1989, 408 p. In Russian. refs

Copyright

The fundamental principles of the analysis and selection of spacecraft trajectories and characteristics of satellite orbits are presented. Attention is given to spacecraft maneuvering during the approach and docking; orbital system dynamics; and spacecraft descent in the earth and planet atmospheres for both elliptical and parabolic entry velocities. The design ballistic characteristics of interplanetary trajectories are analyzed. V.L.

A91-47644

ON THE USE OF ANALYTICAL ATMOSPHERIC MODELS FOR DETERMINATION OF SPACE STATIONS 'SALJUT' AND 'MIR' ORBITS

T. KASIMENKO and N. SOROKIN (AN SSSR, Astronomicheskii

Sovet, Moscow, USSR) of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A91-47626 20-12) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 6, 1991, p. 151-154. refs
Copyright

The present study explores the possibility of using simplified atmospheric models (DTM, TD-88, and S-89) for determining the orbits of the Salyut and Mir space stations. The differences between all combinations of the models were found to be of the same order. In terms of lower solar and geomagnetic activity, the differences between DTM and S-89 are smaller than between DTM and TD-88. P.D.

A91-49747# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

APPROXIMATE REASONING-BASED LEARNING AND CONTROL FOR PROXIMITY OPERATIONS AND DOCKING IN SPACE

HAMID R. BERENJI (NASA, Ames Research Center; Sterling Software, Inc., Moffett Field, CA), YASHVANT JANI (LinCom Corp., Houston, TX), and ROBERT N. LEA (NASA, Johnson Space Center, Houston, TX) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1703-1710. refs
(AIAA PAPER 91-2803) Copyright

A recently proposed hybrid-neutral-network and fuzzy-logic-control architecture is applied to a fuzzy logic controller developed for attitude control of the Space Shuttle. A model using reinforcement learning and learning from past experience for fine-tuning its knowledge base is proposed. Two main components of this approximate reasoning-based intelligent control (ARIC) model - an action-state evaluation network and action selection network are described as well as the Space Shuttle attitude controller. An ARIC model for the controller is presented, and it is noted that the input layer in each network includes three nodes representing the angle error, angle error rate, and bias node. Preliminary results indicate that the controller can hold the pitch rate within its desired deadband and starts to use the jets at about 500 sec in the run. V.T.

A91-49792#

INTERVENTION OF HUMAN OPERATORS IN AUTOMATED SPACECRAFT RENDEZVOUS AND DOCKING GNC

A. TOBIAS, W. FEHSE (ESTEC, Noordwijk, Netherlands), D. WILDE (MBB-ERNO, Bremen, Federal Republic of Germany), J. M. PAIROT (Matra Espace, Toulouse, France), and F. PAOLI (Aerospatiale, Cannes, France) AIAA, Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991. 8 p. refs
(Contract ESA-8369/89)
(AIAA PAPER 91-2791) Copyright

The Hermes Space Vehicle and the Columbus Free Flyer (CFF) will be the key elements in the immediate European scenario in low earth orbit. Hermes is a ground-based manned Space Shuttle that carries crew and goods to the CFF and has also the capability to visit other Space Stations as Freedom and Mir. The CFF is a space-based unmanned laboratory serviced by Hermes and for which also the visit to the Station Freedom for servicing has been considered. Rendezvous and Docking is a key operational technique in this scenario. Human operators can be involved on board the chaser, the target or both spacecraft and on ground. Though both Hermes and CFF have a high degree of automation, the intervention of the operator could enhance safety and the probability of mission success. This paper presents candidate concepts for the role of the operators in Mission and Vehicle Management and in Guidance Navigation and Control tasks including an innovative concept in which the operator replaces or corrects the Rendezvous sensor measurements for estimation update. Author

A91-49937* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ORBITAL STATION-KEEPING FOR MULTIPLE SPACECRAFT INTERFEROMETRY

ANTHONY B. DECOU (JPL, Pasadena, CA; Northern Arizona University, Flagstaff, AZ) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 39, July-Sept. 1991, p. 283-297. refs
Copyright

This paper presents a three-satellite station-keeping strategy that is applicable to very long (1-100 km) baseline optical interferometry in space using the 'free-flyer' approach. The relative positions of the satellites in an arbitrarily oriented inertial coordinate system are described parametrically, and the continuous thrust vectors required to follow the paths are derived. The paths, which are constrained to be in the U-V plane of an astronomical source (a plane perpendicular to the direction of the source), are always chosen to maximize the use of gravity gradient forces and minimize the use of thrusting which can easily be provided by ion thrusters. Two different thrust programs are presented. One allows the interferometer to take data over an elliptic-shaped area of the U-V plane of arbitrary size for astronomical sources in any direction except close to the orbit plane of the system. The second thrust program reorients the U-V plane from one arbitrary source direction to another. Author

A91-50084

OPTIMAL IMPULSIVE SPACE TRAJECTORIES BASED ON LINEAR EQUATIONS

T. E. CARTER (Eastern Connecticut State University, Willimantic, CT) Journal of Optimization Theory and Applications (ISSN 0022-3239), vol. 70, Aug. 1991, p. 277-297. refs
Copyright

Consideration is given to a problem of minimizing the total characteristic velocity of a spacecraft based on linear equations of motion and finitely many instantaneous impulses that result in velocity jump discontinuities. This formulation is flexible enough to make it possible to specify some of the impulses a priori by the mission planner. A specified set of nonlinear equations is presented for solution of the two-point boundary-value problem. These equations are found to be at most quadratic if the times of the velocity increments are specified. Several practical examples of spacecraft maneuvers and rendezvous in which the equations of motion are linear are given, including the computation of the velocity increments of a spacecraft near a real or fictitious satellite or space station in a circular or Keplerian orbit and the computation of the maneuvers of a spcecraft near a libration point in the restricted three-body problem. O.G.

A91-51540

CCD RENDEZ-VOUS SENSOR PROPOSED FOR HERMES SPACEPLANE AND COLUMBUS MTFF PROVIDING NOMINAL PERFORMANCES WITH THE SUN IN ITS FIELD OF VIEW

THIERRY BOMER and MICHEL TULET (Matra Espace, S.A., Velizy-Villacoublay, France) IN: Signal and image processing systems performance evaluation; Proceedings of the Meeting, Orlando, FL, Apr. 19, 20, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 207-214. Research supported by CNES. refs
Copyright

Solid state imaging devices are now widely used in a lot of measurement applications and specifically in space applications (remote sensing star trackers). The development of Space Stations leads to a growing number of new in-orbit operations as the rendezvous, which consists in the approach, the docking or berthing of two space vehicles. This paper describes a new way to operate CCDs which allows identification of target patterns and performance of measurements in a severe optical environment (sun in the field of view). This new operating mode, combined with lighting by a high power pulsed laser diode, enables the design of an efficient system for relative position and attitude measurements of two spacecrafts. This system is proposed for the rendezvous phase between the Hermes spaceplane and the Columbus Free Flyer, and for the approach of the Columbus Free Flyer to the Space Station Freedom. Experimental results are presented and the first applications are described. Author

A91-52327#
DO REUSEABLE ORBITAL TRANSFER VEHICLES MAKE SENSE?
PATRICK J. MCDANIEL (USAF, Phillips Laboratory, Kirtland AFB; Sandia National Laboratories, Albuquerque, NM) AIAA, NASA, and OAI, Conference on Advanced SEI Technologies, Cleveland, OH, Sept. 4-6, 1991. 12 p. refs
(AIAA PAPER 91-3403) Copyright

Reuseable Orbital Transfer Vehicles are compared with one-way transfer vehicles. For trips to GEO and beyond, ROTVs are shown to make economic sense if they have a specific impulse of 800 seconds or above. Any ROTV should have a minimum weight to be efficient. Lightweight nuclear ROTVs appear possible. Parametric curves are presented giving increased specific impulse requirements to compensate for heavier than minimum weight ROTVs based on a nuclear thermal rocket. Author

A91-55834
LUNAR MASSES AS AN ENERGY SOURCE FOR SPACE TRANSPORTATION AND SPACE STATIONS
EDWARD F. MARWICK IN: Space utilization and applications in the Pacific; Proceedings of the 3rd Pacific Basin International Symposium on Advances in Space Science Technology and its Applications, Los Angeles, CA, Nov. 6-8, 1989. San Diego, CA, Univelt, Inc., 1990, p. 403-406. refs
(AAS PAPER 89-643) Copyright

It is pointed out that one kilogram of mass in very low earth orbit has about 28 MJ of kinetic energy and about 2 MJ of potential energy relative to the equatorial surface of the earth. The following scenario is proposed: as that kilogram is transported to an electrodynamic tethered very LEO constellated space station by three types of transportations (here called crashportation, edportation, and genportation) much of that lunar potential energy is converted into electrical energy and/or is used to give kinetic energy to mass which has been rocketed straight upward from the earth. Alternatively, much of that potential energy of the lunar mass can be used to transport that mass itself and large quantities of other cargoes from a LEO space station to a higher earth orbit by means of a crashload capturing orbital transfer vehicle. L.M.

A91-55840
GSV - A NEW OPPORTUNITY FOR ON-ORBIT SERVICE TECHNOLOGY
TETSUO YASAKA (NTT, Radio Communication Systems Laboratory, Yokosuka, Japan) IN: Space utilization and applications in the Pacific; Proceedings of the 3rd Pacific Basin International Symposium on Advances in Space Science Technology and its Applications, Los Angeles, CA, Nov. 6-8, 1989. San Diego, CA, Univelt, Inc., 1990, p. 495-505. refs
(AAS PAPER 89-651) Copyright

Geostationary Service Vehicle (GSV) was recently proposed to help enhancing operational economy of commercial geostationary satellites. This system is composed of basically ready-to-use technologies to achieve system economy and to enable quick deployment of the system. However, it aims at several maneuvers which may constitute basic technologies of future elaborate robotic services. The GSV system description is stated first, and associated technology requirements are reviewed. Author

N91-22188# Bristol Univ. (England). Dept. of Aerospace Engineering.
SPACE TUG: AN ORBITAL TRANSFER VEHICLE B.S. Thesis
J. L. MUIR and C. MURMANN Jun. 1990 73 p
(BU-513; ETN-91-99206) Avail: CASI HC A04/MF A01

The mission specification for this first order study of an Orbital Transfer Vehicle (OTV) was the capability to transport a two ton satellite (based on the Intelsat 4 design) between geostationary orbit and low Earth orbit. The OTV would rendezvous with the Space Transportation System (or equivalent) and with the Space Station. To minimize the mission cost, a low fuel requirement was a priority. Thus, orbital transfer was planned via the Hohmann minimum energy transfer ellipse, with an 'aerobraking maneuver' assist on the return journey. This was found to be the most fuel efficient. Apart from the new technologies involved with aerobreaking, design policy was conservative, using tried and tested materials and systems. The results outline a suggested format for an OTV and identify some of the main design problems faced, namely the saving of weight to reduce fuel requirements and the simulation of the complex flowfield during aerobraking. ESA

N91-24260# McDonnell-Douglas Space Systems Co., Huntington Beach, CA.
ORBIT TRANSFER VEHICLE PROPULSION DESIGN: TRADES AND COMPARISONS
V. E. HALOULAKOS and T. M. MILLER *In* Johns Hopkins Univ., The 1990 JANNAF Propulsion Meeting, Volume 2 p 291-298 Oct. 1990
(Contract IRAD-PD-189)
Avail: CASI HC A02/MF A04

In-space expendable orbital transfer vehicles (OTVs) capable of delivering 36,000 kg (79,366 lb) of payload from earth orbit (LEO) to geosynchronous orbit (GEO) including return missions to LEO both empty and with a retrieved payload were compared and evaluated. Chemical (LOX/LH2), nuclear thermal (NTR), and thermo-nuclear fusion propulsion systems were considered, vehicle mass breakdowns were calculated, and comparisons made. The chemical systems used performance and systems data typical of the RL-10 and J-2 engines while the nuclear systems used the solid-core ALPHA NTR (a NERVA derivative) performance parameters. The fusion propulsion systems represent new designs from a recently conducted study. PC-based computer program was written to automate the vehicle sizing process. The results indicate that the sizing software developed in this study correlates very well with mass property data from actual OTV designs. As expected, the study shows that as the propulsion system performance increases the total vehicle mass required in LEO decreases. A reusable nuclear OTV initial mass in LEO increases only slightly for empty return missions compared to an expendable, one-way trip OTV. The study also shows that fusion systems are limited to lower levels (approximately equal to 100 kN or 22.5 klbf) because of the size of the power generating equipment, and optimize (i.e., minimum initial mass) at a specific impulse of approximately 1000 to 3000 s. Author

N91-24272# Air Force Astronautics Lab., Edwards AFB, CA.
ANALYSIS OF EXPENDABLE SOLAR ELECTRIC ORBIT TRANSFER VEHICLES
W. M. SCHMIDT *In* Johns Hopkins Univ., The 1990 JANNAF Propulsion Meeting, Volume 2 p 417-421 Oct. 1990
Avail: CASI HC A01/MF A04

This analysis estimated the payload delivered to geosynchronous (GEO) and one-half GEO orbits from a 430 kilometer, 28.5 degree inclination low earth orbit (LEO). Four propulsion systems were examined based on the 900 second Specific Impulse (Isp) ammonia arcjet, 1500 second Isp hydrogen arcjet, 3000 second Isp ion engine, and 4400 second Isp ion engine. Each of these systems were analyzed at power levels of 10, 20, and 30 kilowatts. Delta 2 and Atlas 2 vehicles were used as launch systems. The results indicated that the 30 kilowatt, ammonia arcjet Orbit Transfer Vehicle (OTV) provided the best compromise between payload capability and trip time. In all cases, this 30 kWe arcjet system increased the payload capability of the launch system by 100 percent with transfer times as low as 99 days over a 444 second Isp chemical OTV. Hydrogen arcjets offered little advantage over ammonia arcjets. Both ion systems yielded payload increases of 200 percent over a 444 second Isp chemical OTV, but required trip times greater than 250 days. This analysis also indicated that power levels below 15 kilowatts resulted in trip times greater than 200 days for most payloads of interest, regardless of the propulsion system. Author

N91-27197# Naval Postgraduate School, Monterey, CA.
SATELLITE SERVICING USING THE ORBITAL MANEUVERING VEHICLE IN LOW EARTH ORBIT M.S. Thesis
ANTHONY D. CUTRI Jun. 1990 124 p
(AD-A236941) Avail: CASI HC A06/MF A02 CSCL 22A

The concept of servicing and repair of satellites in low earth orbit (LEO) using the Orbital Maneuvering Vehicle (OMV) is examined. It could be economically applied to any LEO in which sufficient numbers of satellites are located or where individual satellite cost/mission justify servicing. Increases in cost effectiveness and operational flexibility of in-space systems can be realized when the capability to replenish consumable fluids, propellants and Orbital Replacement Units (ORUs) are incorporated into satellite design. ORUs can be placed in orbit using expendable launch vehicles (ELV), specifically selected to satisfy the mission need. Several suitable small payload, low cost boosters are now under development, with attainment of operational status expected in the early 1990's. The concept calls for modular satellite design and deployment of a space based support platform. New technology could be applied in the form of upgrades and on orbit modifications much more efficiently than the current abandon/replace policy for most satellite systems. The first chapters provide background on the proposed concept, OMV and ELVs. Several polar orbiting satellite systems providing mass summary breakdowns and current cost information are described and then OMV payload servicing using the flight telerobotic servicer is discussed. Comparison of estimated OMV satellite servicing costs vs. satellite replacement for several missions is tabulated. GRA

N91-27200* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
STANDARD REMOTE MANIPULATOR SYSTEM DOCKING TARGET AUGMENTATION FOR AUTOMATED DOCKING Patent
RICHARD W. DABNEY, inventor (to NASA), RICHARD T. HOWARD, inventor (to NASA), and THOMAS C. BRYAN, inventor (to NASA) 4 Jun. 1991 12 p Filed 20 Feb. 1990
(NASA-CASE-MFS-28419-1; US-PATENT-5,020,876; US-PATENT-APPL-SN-431538; US-PATENT-CLASS-350-102; US-PATENT-CLASS-350-97; US-PATENT-CLASS-350-107; INT-PATENT-CLASS-G02B-5/122) Avail: US Patent and Trademark Office CSCL 22B

A docking target is provided for use in automated docking of a first vehicle on which the target is located. The target comprises a pair of laterally extending arm portions lying in substantially the same plane and a central post extending outwardly from the plane of the arm portions. At least three reflectors are located on the target. Two of the reflectors are located at the outboard ends of the arms portions and another reflector is located at the end of the central post. In an important embodiment, the reflectors comprise individual pieces of retroreflective tape. The reflectors, when viewed from the front of the target, are aligned along the longitudinal center line of the target, and can take a number of different shapes including circular or square.
Official Gazette of the U.S. Patent and Trademark Office

N91-27212*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EVOLVING THE SP-100 REACTOR IN ORDER TO BOOST LARGE PAYLOADS TO GEO AND TO LOW LUNAR ORBIT VIA NUCLEAR-ELECTRIC PROPULSION
ROBERT E. ENGLISH 1991 14 p Proposed for presentation at the Conference on Advanced Space Exploration Initiative Technologies, Cleveland, OH, 4-6 Sep. 1991; cosponsored by AIAA and OAI
(NASA-TM-104527; E-6401; NAS 1.15:104527; AIAA PAPER 91-3562) Avail: CASI HC A03/MF A01 CSCL 18N

In striving to reduce exploration cost and exploration risks, a crucial aspect of the plans is program continuity, i.e., the continuing application of a given technology over a long period so that experience will accumulate from extended testing here on Earth and from a diversity of applications in space. An integrated view needs to be formed of the missions SEI will carry out, near term as well as far, and of the ways in which these missions can mutually support one another. Near term programs should be so constituted as to provide for the long term missions both the enabling technologies and the accumulation of experience they need. In achieving this, missions in Earth orbit should both evolve and show the technologies crucial to long term missions on the lunar surface, and the program for the lunar labs should evolve and show the enabling technologies for exploration of the surface of Mars and for flights of human beings to Mars and return. In the near term, the program for the Space Station should be directed and funded to develop and demonstrate the solar Brayton power plant that will be most useful as the power generator for the SP-100 nuclear reactor. Author

N91-31203# Technische Univ., Munich (Germany, F.R.). Lehrstuhl fuer Raumfahrttechnik.
CONTRIBUTIONS TO A SPACE STATION FOR FLIGHTS IN THE NEAR FIELD AND TOWARDS GEOSTATIONARY EARTH ORBIT Ph.D. Thesis [BEITRAEGE ZUR RAUMSTATION ALS BAHNHOF FUER FLUEGE IN DEN NACHBEREICH UND NACH GEO]
MICHAEL KIRSCHNER 1990 130 p In GERMAN
(ETN-91-99744) Avail: CASI HC A07/MF A02

Missions and their boundary conditions were described. The Orbital Transfer Vehicle (OTV) carries out all orbital maneuvers with its rocket motors. Missions were executed, using a one stage and a two stage OTV. A mathematical coupling of disturbances by Earth gravitation and atmosphere was carried out. Parametric mission examinations are described for Low Earth Orbit (LO)/Geostationary Earth Orbit (GEO), OTV, Aeroassisted Orbital Transfer Vehicle (AOTV). Comparisons and discussions are reported on LEO/GEO and LEO/LEO missions. ESA

N91-32251*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PRECISE ORBIT DETERMINATION OF HIGH-EARTH ELLIPTICAL ORBITERS USING DIFFERENCED DOPPLER AND RANGE MEASUREMENTS
J. A. ESTEFAN *In its* The Telecommunications and Data Acquisition Report p 1-22 15 Aug. 1991
(Contract RTOP 310-10-63-90-01)
Avail: CASI HC A03/MF A04 CSCL 22A

Recent advances in Deep Space Network station calibration methods have led to renewed interest in the use of differenced Doppler and range data types for interplanetary navigation. Described here is an orbit determination error analysis of the performance of these differenced data types when used with conventional two-way Doppler for precise navigation of High-Earth Orbiters. Three highly elliptical Earth orbits are investigated, with apogee heights on the order of 20,000 km, 70,000 km, and 156,000 km. Results indicate that the most significant navigational accuracy improvements, relative to the performance obtained from two way Doppler alone, are achieved for the lowest altitude orbit by using differenced Doppler measurements with two way Doppler (assuming that spacecraft onboard downlink antennas have no ground footprint limitation in the near-apogee regime). In the case of the two higher altitude orbits, accuracy improvements over Doppler-only performance, although less dramatic, are also achieved when differenced range measurements are combined with two-way Doppler. Author

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PROPULSION SYSTEMS/FLUID MANAGEMENT

Descriptions, analyses, and subsystem requirements of propellant/fluid management, and propulsion systems for attitude control, orbital maintenance and transfer maneuvers for the station and supporting vehicles.

A91-34460
SAIL OF THE CENTURY
GRANT FJERMEDAL Final Frontier (ISSN 0899-4161), vol. 4, May-June 1991, p. 18-23.
Copyright

An overview is presented of the Columbus 500 Space Sail Cup that is scheduled to take place in 1992. Most of the vehicles in this regatta will carry video cameras in the aluminum-coated sails several hundred feet in size. A similar exploit, the Earth-to-Moon race to take place next year, is also described. In one project an Ariane launch vehicle will deliver a three-vehicle sail package into a highly elliptical orbit with an apogee of about 22,000 miles and a perigee of about 200 miles. Various design projects from a number of international organizations are described along with a variety of launch concepts. R.E.P.

A91-34927#
THE CANADIAN SOLAR SAIL PROJECT
ISTVAN HORVATH, KIERAN A. CARROLL, and ANDREW WILLIAMS (Prior Data Sciences, Ltd., Canada) IN: CASI Conference on Astronautics, 6th, Ottawa, Canada, Nov. 19-21, 1990, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1990, p. 11-16.

The Canadian Solar Sail Project has completed the design of a spacecraft structure capable of reaching Mars solely on the basis of light pressure, albeit with limited payload capacity; the basic configuration is, however, scalable to larger vehicles for more representative payloads. The primary virtues of the solar sail propulsion concept are its reusability and the ease with which it can undertake extended, multipurpose missions. The spacecraft will participate in a race to Mars that is being sponsored by the Christopher Columbus Quincentenary Jubilee Commission, whose purpose, apart from commemoration of the discovery of America, is the dramatization of solar sailing's capabilities. O.C.

A91-35541
DYNAMIC INVESTIGATIONS ON SATELLITE TANK STRUCTURES FILLED WITH LIQUID
E. HORNUNG, S. DIEKER, and H. WENZ (MBB-ERNO, Bremen, Federal Republic of Germany) IN: International Modal Analysis Conference, 8th, Kissimmee, FL, Jan. 29-Feb. 1, 1990, Proceedings. Vol. 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1990, p. 741-749. refs
Copyright

This paper presents tasks which had to be accomplished to perform dynamic investigations of a structure filled with liquid. The high mass ratio of 'fluid to structure' necessitates a more sophisticated approach for the investigation of loads due to the dynamic behavior of the fluid and the fluid-structure interactions. The fluid mass cannot be considered as 'frozen mass' as in previous calculations of the whole satellite. Thus, an analytical tool was found with the capability of representing the fluid behavior and of providing answers to questions concerning structures with fluids. R.E.P.

A91-38232#
GAS-LIQUID SEPARATION WITH MICROPOROUS HOLLOW FIBER MEMBRANE
HARUHIKO OHYA, MITSUO OGUTI, ATSUO HAKAMAYA, KANJI MATSUMOTO, and YOHICHI NEGISHI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 39, no. 446, 1991, p. 109-115. In Japanese, with abstract in English. refs

The separation of bubbles in the water/oil was attempted using a hydrophobic PTFE/hydrophilic PVA membrane modules. The PTFE membrane could effectively recover the bubbles flowing outside the fiber in the water into the fiber when the inside of the fiber was evacuated. The recovery rate, i.e. the gas permeation rate, depended on the gas flow rate, the length of fiber and the degree of vacuum. The recovery ratio which was defined by the recovery rate/gas flow rate had a good correlation with the gas hold up. On the other hand, the bubbles in the oil were flowing up outside the fiber without any contact with the fiber, and only the oil containing no bubbles was recovered inside the fiber for PTFE membranes. From the results mentioned above this recovery method of bubbles would be available in the nongravitational field of a space station. Author

A91-41141 Alabama Univ., Huntsville.
CRYOGENIC LIQUID HYDROGEN REORIENTATION ACTIVATED BY HIGH FREQUENCY IMPULSIVE REVERSE GRAVITY ACCELERATION OF GEYSER INITIATION
R. J. HUNG and K. L. SHYU (Alabama, University, Huntsville) Microgravity Quarterly (ISSN 0958-5036), vol. 1, no. 2, 1991, p. 81-92. refs
(Contract NAGW-812; NAS8-36955)
Copyright

The requirement to settle or to position liquid fluid over the outlet end of spacecraft propellant tank prior to main engine restart poses a microgravity fluid behavior problem. Resettlement or reorientation of liquid propellant can be accomplished by providing optimal acceleration to the spacecraft such that the propellant is reorientated over the tank outlet without any vapor entrainment, any excessive geysering, or any other undesirable fluid motion for the space fluid management under microgravity environment. The purpose of present study is to investigate most efficient technique for propellant resettling through the minimization of propellant usage and weight penalties. Comparison between the constant reverse gravity acceleration and impulsive reverse gravity acceleration to be used for the activation of propellant resettlement, it shows that impulsive reverse gravity thrust is superior to constant reverse gravity thrust for liquid reorientation in a reduced gravity environment. Author

A91-41627#
A HYBRID HIGH-THRUST HYDRAZINE/LOW-THRUST HYDROGEN-OXYGEN PROPULSION OPTION FOR SPACE STATION FREEDOM
FRANK S. ZIMMERMANN and CORY FRANCE (Loral AeroSys, Reston, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p. refs
(AIAA PAPER 91-1834)

Application of a high specific impulse low-thrust (0.4 lbf) hydrogen-oxygen propulsion system is proposed for aerodynamic drag compensation. It is suggested that the system can reduce hydrazine consumption by more than a factor of 10, reducing the requirement for dedicated hydrazine ground facilities and substantially reducing the STS resupply requirement. A low-thrust hydrogen-oxygen approach would eliminate the disadvantages of the previous 25 lbf system which had serious safety problems, associated with the high pressure storage of hydrogen and oxygen, and development risks, associated with the high pressure electrolyzer. The hybrid approach is suggested for using the baseline 'off-the-shelf' 25 lbf hydrazine propulsion system only during the early assembly sequence flights of the Space Station prior to the local vertical local horizontal flight attitude orientation. The hydrogen system may be also used for attitude control, collision avoidance, and other contingencies. O.G.

A91-41631*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CONCEPTUAL STUDY OF ON ORBIT PRODUCTION OF CRYOGENIC PROPELLANTS BY WATER ELECTROLYSIS
MATTHEW E. MORAN (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference,

27th, Sacramento, CA, June 24-26, 1991. 11 p. Previously announced in STAR as N91-19317. refs
(AIAA PAPER 91-1844) Copyright

The feasibility is assessed of producing cryogenic propellants on orbit by water electrolysis in support of NASA's proposed Space Exploration Initiative (SEI) missions. Using this method, water launched into low earth orbit (LEO) would be split into gaseous hydrogen and oxygen by electrolysis in an orbiting propellant processor spacecraft. The resulting gases would then be liquified and stored in cryogenic tanks. Supplying liquid hydrogen and oxygen fuel to space vehicles by this technique has some possible advantages over conventional methods. The potential benefits are derived from the characteristics of water as a payload, and include reduced ground handling and launch risk, denser packaging, and reduced tankage and piping requirements. A conceptual design of a water processor was generated based on related previous studies, and contemporary or near term technologies required. Extensive development efforts would be required to adapt the various subsystems needed for the propellant processor for use in space. Based on the cumulative results, propellant production by on orbit water electrolysis for support of SEI missions is not recommended. Author

A91-41632#
CENTRIFUGAL DEPOT
JOHN PORTER (General Dynamics Space Systems Div., San Diego, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p. refs
(AIAA PAPER 91-1845) Copyright

The Centrifugal Depot (CD) is a novel space propellant storage and transfer concept. In principle, it rotates torus-shaped tanks to provide artificial gravity which transfers stored propellants to and from future space transfer vehicles in the zero/near-zero gravity of space. Such a depot will be needed to service future reusable high earth orbit and space exploration vehicles. This paper assumes these vehicles will use cryogenic Hydrogen and Oxygen liquid propellants, and therefore concentrates on this application. Fill and drain times are comparable to earth transfers. A CD with a 15.24 meter (50 foot) mid torus radius, turning at 5.42 rpm could transfer 20,644 kg (45,500 lbs) of LH2/LOX propellant (5:1 mass ratio) to or from a space vehicle in approximately 2 hours. Other currently popular depot concepts would require 2-3 days for the same process, with pumps, and special liquid acquisition and gauging hardware not found on CD. Liquid and gas phase separation is automatic. CD employs low risk, currently available technology. Author

A91-41687*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
LONG LIFE MONOPROPELLANT HYDRAZINE THRUSTER EVALUATION FOR SPACE STATION FREEDOM APPLICATION
CHRISTOPHER G. POPP and JOHN B. HENDERSON (NASA, Johnson Space Center, Houston, TX) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 8 p.
(AIAA PAPER 91-2041) Copyright

In support of propulsion system thruster development activity for Space Station Freedom (SSF), NASA Johnson Space Center (JSC) is conducting a hydrazine thruster technology demonstration program. The goal of this program is to identify impulse life capability of state-of-the-art long life hydrazine thrusters nominally rated for 50 pounds thrust at 300 psia supply pressure. The SSF propulsion system requirement for impulse life of this thruster class is 1.5 million pound-seconds, corresponding to a throughput of approximately 6400 pounds of propellant, with a high performance (234 pound-seconds per propellant pound). Long life thrusters were procured from Hamilton Standard, The Marquardt Company, and Rocket Research Company. Testing has initiated on the thruster designs to identify life while simulating expected thruster firing duty cycles and durations for SSF using monopropellant grade hydrazine. This paper presents a review of the SSF propulsion system and requirements as applicable to hydrazine thrusters, the three long life thruster designs procured by JSC and the resultant acceptance test data for each thruster, and the JSC test plan and facility. Author

A91-41719#
PROPELLANT MANAGEMENT DEVICE CONCEPTUAL DESIGN AND ANALYSIS - VANES
D. E. JAEKLE, JR. (PMD Technology, Lafayette, IN) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 14 p. Research supported by TRW Pressure Systems, Inc. refs
(AIAA PAPER 91-2172) Copyright

The conceptual design process and the analytical methods used to verify the performance of surface-tension devices have been closely held by propellant management device (PMD) designers. With the proliferation of microcomputers, the sophistication of the analytical techniques has greatly advanced. This paper will address the process and the techniques developed and used by PMD technology to design and verify the simplest PMD component, the vane. All areas of concern inherent in vane design and implementation will be addressed, from the dictating requirements, proceeding into the design configuration choice, and ending with required performance analysis. The result is a cohesive process by which one may design and verify vane PMD components. Author

A91-43445#
AN ANALYTIC MODEL FOR LOW-GRAVITY TANK CHILLDOWN AND NO-VENT FILL - THE GENERAL DYNAMICS NO-VENT FILL PROGRAM (GDNVF)
S. C. HONKONEN, F. O. BENNETT, JR. (General Dynamics Corp., Space Systems Div., San Diego, CA), and H. K. HEPWORTH (Northern Arizona University, Flagstaff, AZ) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 9 p. refs
(AIAA PAPER 91-1380) Copyright

A computer program that models the chilldown and no-vent filling of a receiver tank in a low-g environment has been developed. The details of this program are described in this paper. Comparative analytical results are presented that indicate the trade-off that must be made between shortening the chilldown time and reducing the amount of liquid required for chilldown. No-vent fill results from the program are compared with 1-g LH2 test data from NASA Lewis Research Center. Author

A91-43481#
FREE-MOLECULE PRESSURE DISTRIBUTION WITHIN A FLUID LINE DUCT VENTED TO SPACE
D. K. EDWARDS, R. J. RADER, and A. R. AYOTTE (McDonnell Douglas Space Systems Co., Huntington Beach, CA) AIAA, Thermophysics Conference, 26th, Honolulu, HI, June 24-26, 1991. 11 p. refs
(AIAA PAPER 91-1422) Copyright

An analytical model was developed to predict the location and approximate magnitude of leaks from pressurized fluid lines in an enclosed duct venting to space through wall and joint cracks. The model is a one-dimensional treatment of diffuse re-emitting and scattering of adsorbed molecules. The model uses transfer factors from the solution of Hottel and Keller. In order to validate the model, tests were conducted in a vacuum chamber on a subscale mockup of the Space Station fluid distribution tray. In general, model predictions were found to be quite good, except in cases where cracks in the duct were made quite small and uncertainty in their dimensions arose. The model can be used to assist in designing the Space Station fluid distribution tray and a leak detection system. Author

A91-44031*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
DESIGN OF HIGH POWER ELECTROMECHANICAL ACTUATOR FOR THRUST VECTOR CONTROL
J. R. COWAN and W. N. MYERS (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, SAE, ASME, and ASEE, Joint

Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p.
(AIAA PAPER 91-1849) Copyright

NASA-Marshall has undertaken the development of electromechanical actuators (EMAs) for thrust vector control (TVC) augmentation system implementation. The TVC EMA presented has as its major components two three-phase brushless dc motors, a two-pass gear-reduction system, and a roller screw for rotary-to-linear motion conversion. System control is furnished by a solid-state electronic controller and power supply; a pair of resolvers deliver position feedback to the controller, such that precise positioning is achieved. Peformance comparisons have been conducted between the EMA and comparable-performance hydraulic systems applicable to TVCs. O.C.

A91-44043#
STATUS OF THE SPACE TESTING PROGRAMS OF THE RF-ION THRUSTER RIT 10
HELMUT F. BASSNER, H.-P. BERG, and R. KUKIES (MBB GmbH, Munich, Federal Republic of Germany) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p.
(AIAA PAPER 91-1889) Copyright

The Eureca-1 spacecraft and mission are reviewed and the RIT Assembly (RITA) design for Eureca is discussed. The RITA experimental arrangement and thermal concept are shown and discussed and RITA characteristic data are given. The application of ion propulsion to the ESA Artemis satellite is addressed, describing the RITA design for Artemis in detail. C.D.

A91-44063*# McDonnell-Douglas Space Systems Co., Huntington Beach, CA.
DESIGN AND OPERATION OF THE U.S. SPACE STATION FREEDOM PROPULSION SYSTEM
JOSEPH S. MORANO (McDonnell Douglas Space Systems Co., Space Station Div., Huntington Beach, CA) and REX A. DELVENTHAL (NASA, Johnson Space Center, Houston, TX) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p.
(AIAA PAPER 91-1929)

The propulsion functions for the U.S. Space Station Freedom (SSF) are accomplished by two separate systems, the Primary Propulsion System and the Supplemental Reboost System (SRS). The Primary Propulsion System includes self-contained hydrazine modules for station reboost, attitude control and contingency maneuvers. These Propulsion Modules contain reboost and attitude control thrusters, propellant storage, thermal conditioning and electronic controls. The modules are serviced on the ground and launched on the Space Shuttle as replacements for the on-orbit modules which have expended their propellant. The expended modules are returned to the ground for reservicing and subsequent reuse. The Supplemental Reboost System includes a Waste Gas Assembly and Resistojet Modules which are used for reboost maneuvers only. The Waste Gas Assembly contains waste gas storage, compressors and dryers and the Resistojet Modules contain multipropellant resistojet thrusters, electronic pressure regulators and power conditioning equipment. Author

A91-44161#
HYDRAZINE PROPULSION MODULE DESIGN CONSIDERATIONS FOR INTERFACING WITH THE U.S. SPACE STATION AND SPACE SHUTTLE
RICHARD J. DARROW, JR. (McDonnell Douglas Space Systems Co., Space Station Div., Huntington Beach, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 9 p.
(AIAA PAPER 91-2221) Copyright

Methods for interfacing the Hydrazine Propulsion Modules with the Space Shuttle and Space Station are examined with emphasis on the objective of minimizing the amount of interface equipment, module weight, and power consumption. In particular, three options are compared against the baseline design. The options include various combinations of valves, valve drivers, load converters, and flight support equipment. The analysis considers such factors as cost, reliability, maintainability, safety, ground support equipment, schedules, and test and qualification time. V.L.

A91-44163#
ONE KILOWATT HYDROGEN AND HELIUM ARCJET PERFORMANCE
RICHARD P. WELLE, JAMES E. POLLARD, SIEGFRIED W. JANSON, MARK W. CROFTON, and RONALD B. COHEN (Aerospace Corp., Los Angeles, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p. Research sponsored by Aerospace Corp. refs
(AIAA PAPER 91-2229) Copyright

Performance data for the NASA-Lewis 1 kW arcjet operating on hydrogen, helium, and ammonia propellants are presented. Nozzle efficiency for all propellants falls between 0.93 and 0.96, with some flow separation in the ammonia case. Thrust-balance data show hydrogen arcjet specific impulse in the 700 to 900 sec range, with efficiencies between 0.32 and 0.38. Helium arcjet performance was 550 to 600 sec at 0.5 to 0.62 efficiency. Theoretical efficiency for a 1200-sec helium arcjet should be 0.7 or greater. If this performance can be demonstrated, the helium arcjet should compete favorably with the hydrogen arcjet for EOTV missions. Storage of helium is found not to be an insurmountable problem. Author

A91-44198*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
GROUND TESTING OF THE NONVENTED FILL METHOD OF ORBITAL PROPELLANT TRANSFER - RESULTS OF INITIAL TEST SERIES
DAVID J. CHATO (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 32 p. Previously announced in STAR as N91-24547. refs
(AIAA PAPER 91-2326) Copyright

The results are presented of a series of no-vent fill experiments conducted on a 175 cu ft flightweight hydrogen tank. The experiments consisted of the nonvented fill of the tankage with liquid hydrogen using two different inlet systems (top spray, and bottom spray) at different tank initial conditions and inflow rates. Nine tests were completed of which six filled in exceess of 94 percent. The experiments demonstrated a consistent and repeatable ability to fill the tank in excess of 94 percent using the nonvented fill technique. Ninety-four percent was established as the high level cutoff due to requirements for some tank ullage to prevent rapid tank pressure rise which occurs in a tank filled entirely with liquid. The best fill was terminated at 94 percent full with a tank internal pressure less than 26 psia. Although the baseline initial tank wall temperature criteria was that all portions of the tank wall be less than 40 R, fills were achieved with initial wall temperatures as high as 227R. Author

A91-44206#
A LIGHTWEIGHT LIQUID HYDROGEN STORAGE SYSTEM FOR ELECTRIC ORBITAL TRANSFER VEHICLE APPLICATION
T. M. MILLER and E. C. CADY (McDonnell Douglas Space Systems Co., Huntington Beach, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 6 p. refs
(AIAA PAPER 91-2348) Copyright

This paper discusses problems of storage and supply of liquid hydrogen (LH2) for the Electric Orbit Transfer Vehicles (EOTVs), which are being designed on the basis of hydrogen arcjet propulsion, together with requirements of an LH2 storage system for EOTVs and the design of an LH2 storage and supply system. The LH2 system designed consists of a very thin low-weight-composite LH2 tank impermeable to H2, and a gaseous-N2-purged multilayer insolation system for ground-loading/ground-hold operations, integrated with a vapor-cooled thermodynamic vent system (TVS) for venting. An integral electric heater is used to compensate for heat leak uncertainties and provide precise TVS vent flow. A design diagram of the LH2 storage and supply system is included. I.S.

A91-44305#
THE USE OF MAGNETIC SAILS TO ESCAPE FROM LOW EARTH ORBIT
ROBERT M. ZUBRIN (Martin Marietta Astronautics Group, Denver, CO) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 11 p. refs
(AIAA PAPER 91-3352) Copyright
The concept of the magnetic sail (magsail) is modeled to examine its performance as a spacecraft propellant. A plasma particle model and a fluid model are employed to assess the performance of the magsail, which uses superconducting cable to generate a magnetic field and thereby deflect plasma winds. Orbital transfers by means of magsail propulsion are expressed by analytical calculations to evaluate the effectiveness of the technique. At a radius of one AU the magsail can achieve accelerations of 0.01 m/sq s, a net tangetial force is generated, and a lift/drag ratio of approximately 0.3 is possible. Flight times slightly greater than the Hohmann transfer ballistic flight times are required to effect orbit transfer maneuvers. The thrust/weight ratio of the magsail is found to be one or two orders of magnitude greater than the ballistic method and also offers a braking device which does not require propellant. C.C.S.

A91-47916
EARLY INTERSTELLAR PRECURSOR SOLAR SAIL PROBES
GREGORY L. MATLOFF (Long Island University, Brooklyn, NY) British Interplanetary Society, Journal (ISSN 0007-094X), vol. 44, Aug. 1991, p. 367-370. refs
Copyright
First solar sails will be capable of deploying small payloads on extra-solar trajectories with solar-system escape velocities considerably in excess of that of Voyager 1 and 2. A simplified mathematical formalism of probe kinematics is presented. Next, a thermal model for sails deployed near the sun is developed and the performance of extra-solar probes launched by first generation solar sails is investigated. Finally, a method of obtaining private funds for these probes is suggested. Author

A91-48843* Sverdrup Technology, Inc., Brook Park, OH.
PERFORMANCE AND FLOW CALCULATIONS FOR A GASEOUS H2/O2 THRUSTER
S. C. KIM (Sverdrup Technology, Inc., Brook Park, OH) and T. J. VANOVERBEKE (NASA, Lewis Research Center, Cleveland, OH) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, July-Aug. 1991, p. 433-438. Previously cited in issue 21, p. 3335, Accession no. A90-47224. refs
(Contract NAS3-25266)
Copyright

A91-52308 National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
SENSITIVITY OF PROPULSION SYSTEM SELECTION TO SPACE STATION FREEDOM PERFORMANCE REQUIREMENTS
GEORGE R. SCHMIDT (NASA, Marshall Space Flight Center, Huntsville, AL; Booz-Allen and Hamilton, Inc., Reston, VA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Sept.-Oct. 1991, p. 708-716. Previously cited in issue 20, p. 3126, Accession no. A89-47115. refs
(Contract NASW-4300)
Copyright

A91-52352*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HYDROGEN/OXYGEN AUXILIARY PROPULSION TECHNOLOGY
BRIAN D. REED and STEVEN J. SCHNEIDER (NASA, Lewis Research Center, Cleveland, OH) AIAA, NASA, and OAI, Conference on Advanced SEI Technologies, Cleveland, OH, Sept. 4-6, 1991. 37 p. refs
(AIAA PAPER 91-3440) Copyright
This paper provides a survey of hydrogen/oxygen (H/O) auxiliary propulsion system (APS) concepts and low thrust H/O rocket technology. A review of H/O APS studies performed for the Space Shuttle, Space Tug, Space Station Freedom, and Advanced Manned Launch System programs is given. The survey also includes a review of low thrust H/O rocket technology programs, covering liquid H/O and gaseous H/O thrusters, ranging from 6600 N to 440 mN thrust. Ignition concepts for H/O thrusters and high-temperature, oxidation-resistant chamber materials are also reviewed. Author

A91-52382*# McDonnell-Douglas Space Systems Co., Houston, TX.
CRYOGENIC PROPELLANT MANAGEMENT SYSTEM REQUIREMENTS FOR SPACE STATION FREEDOM
R. J. SAUCILLO (McDonnell Douglas Space Systems Co., Houston, TX), S. M. STEVENSON, and R. R. CORBAN (NASA, Lewis Research Center, Cleveland, OH) AIAA, NASA, and OAI, Conference on Advanced SEI Technologies, Cleveland, OH, Sept. 4-6, 1991. 9 p. refs
(AIAA PAPER 91-3476) Copyright
Specific propellant management system requirements have been identified for each facility category of SSF. Distributed systems have been analyzed to indentify momentum management, guidance, and traffic management requirements associated with the guidance, navigation, and control system; space-to-space communications and enhanced tracking requirements associated with the communications and tracking system; and propellant management system utility requirements associated with the electrical power system. Flight element analyses determined attach structure, utility distribution, and structural integrity requirements for the pre-integrated truss and high mass manipulation and translation requirements for the mobile base system. O.G.

A91-53712*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EVOLVING THE SP-100 REACTOR IN ORDER TO BOOST LARGE PAYLOADS TO GEO AND TO LOW LUNAR ORBIT VIA NUCLEAR-ELECTRIC PROPULSION
ROBERT E. ENGLISH (NASA, Lewis Research Center, Cleveland, OH) AIAA, NASA, and OAI, Conference on Advanced SEI Technologies, Cleveland, OH, Sept. 4-6, 1991. 13 p. Previously announced in STAR as N91-27212. refs
(AIAA PAPER 91-3562) Copyright
In striving to reduce exploration cost and exploration risks, a crucial aspect of the plans is program continuity, i.e., the continuing application of a given technology over a long period so that experience will accumulate from extended testing here on earth and from a diversity of applications in space. An integrated view needs to be formed of the missions SEI will carry out, near term as well as far, and of the ways in which these missions can mutually support one another. Near term programs should be so constituted as to provide for the long term missions both the enabling technologies and the accumulation of experience they need. In achieving this, missions in earth orbit should both evolve and show the technologies crucial to long term missions on the lunar surfaces, and the program for the lunar labs should evolve and show the enabling technologies for exploration of the surface of Mars and for flights of human beings to Mars and return. In the near term, the program for the Space Station should be directed and funded to develop and demonstrate the solar Brayton power plant that will be most useful as the power generator for the SP-100 nuclear reactor. Author

A91-54449
LIQUID SLOSHING RESPONSE IN SPIN-STABILIZED MISSILES OR SATELLITES DUE TO AXIAL EXCITATION
H. F. BAUER (Muenchen, Universitaet der Bundeswehr, Neubiberg, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 15, Aug. 1991, p.

252-256. refs
Copyright
The natural frequencies for a rotating liquid in a cylindrical container and for an immiscible liquid system are presented. The response to harmonic axial excitation is treated and the velocity distribution and interface displacement are determined. The response of the free liquid surface or interfacial surface is numerically evaluated for different diameter ratios. C.D.

N91-21236*# Cincinnati Univ., OH. Dept. of Aerospace Engineering and Engineering Mechanics.
SPACE VEHICLE PROPULSION SYSTEMS: ENVIRONMENTAL SPACE HAZARDS Final Report
P. J. DISIMILE and G. K. BAHR Sep. 1990 60 p
(Contract NAG3-948)
(NASA-CR-188094; NAS 1.26:188094) Avail: CASI HC A04/MF A01 CSCL 21H
The hazards that exist in geolunar space which may degrade, disrupt, or terminate the performance of space-based LOX/LH2 rocket engines are evaluated. Accordingly, a summary of the open literature pertaining to the geolunar space hazards is provided. Approximately 350 citations and about 200 documents and abstracts were reviewed; the documents selected give current and quantitative detail. The methodology was to categorize the various space hazards in relation to their importance in specified regions of geolunar space. Additionally, the effect of the various space hazards in relation to spacecraft and their systems were investigated. It was found that further investigation of the literature would be required to assess the effects of these hazards on propulsion systems per se; in particular, possible degrading effects on exterior nozzle structure, directional gimbals, and internal combustion chamber integrity and geometry. Author

N91-24300*# Aerojet-General Corp., Sacramento, CA. Propulsion Div.
SPACE STATION AUXILIARY THRUST CHAMBER TECHNOLOGY Final Report
PHILIP J. ROBINSON Jul. 1990 223 p
(Contract NAS3-24398; RTOP 506-42-31)
(NASA-CR-185296; NAS 1.26:185296; RPT-2210-90-FR; RPT/E0095.68; AD-A236556) Avail: CASI HC A10/MF A03 CSCL 21H
The objective was to establish a technical data base to support future development of GO2/GH2 flight thrusters for a Space Station Auxiliary Propulsion System. Specific issues of concern were thruster performance and cycle life. To address these issues, NASA funded Aerojet to design, fabricate, and altitude test two 25-lbf GO2/GH2 thrusters. The first thruster was designed to operate at a nominal mixture ratio (O/F) of 4.0 and expansion area ratio (epsilon) of 100:1. It was tested over a range of O/F from 2.0 to 8.0, achieving a range of specific impulse (Isp) from 440 to 310 lbf-sec/lbm. The second thruster was optimized for a nominal O/F of 8.0 at a lower nozzle expansion area ratio, epsilon, of 30:1. This second thruster was tested over an O/F range of 3.0 to 9.5, achieving an Isp range of 416 to 3323 lbf-sec/lbm, respectively. At O/F = 8.0, the Isp was 360 lbf-sec/lbm, as predicted. Author

N91-24566*# Ball Aerospace Systems Div., Muncie, IN.
FLUID QUANTITY GAGING Final Report
ALLAN J. MORD, HOWARD A. SNYDER, KATHLEEN A. KILPATRICK, LYNN A. HERMANSON, RICHARD A. HOPKINS, and DONALD A. VANGUNDY 5 Dec. 1988 235 p
(Contract NAS9-17616)
(NASA-CR-185516; NAS 1.26:185516; F88-06-102A) Avail: CASI HC A11/MF A03 CSCL 14B
A system for measuring the mass of liquid in a tank on orbit with 1 percent accuracy was developed and demonstrated. An extensive tradeoff identified adiabatic compression as the only gaging technique that is independent of gravity or its orientation, and of the size and distribution of bubbles in the tank. This technique is applicable to all Earth-storable and cryogenic liquids of interest for Space Station use, except superfluid helium, and can be applied to tanks of any size, shape, or internal structure. Accuracy of 0.2 percent was demonstrated in the laboratory, and a detailed analytical model was developed and verified by testing. A flight system architecture is presented that allows meeting the needs of a broad range of space fluid systems without custom development for each user. Author

N91-24594*# Southwest Research Inst., San Antonio, TX.
ON-ORBIT COMPRESSOR TECHNOLOGY PROGRAM Final Report
DANNY M. DEFFENBAUGH, STEVEN J. SVEDEMAN, EDGAR C. SCHROEDER, and C. RICHARD GERLACH Oct. 1990 188 p
(Contract NAS9-18051; SWRI PROJ. 04-2529)
(NASA-CR-185645; NAS 1.26:185645) Avail: CASI HC A09/MF A02 CSCL 13I
A synopsis of the On-Orbit Compressor Technology Program is presented. The objective is the exploration of compressor technology applicable for use by the Space Station Fluid Management System, Space Station Propulsion System, and related on-orbit fluid transfer systems. The approach is to extend the current state-of-the-art in natural gas compressor technology to the unique requirements of high-pressure, low-flow, small, light, and low-power devices for on-orbit applications. This technology is adapted to seven on-orbit conceptual designs and one prototype is developed and tested. Author

N91-25380* National Aeronautics and Space Administration. Pasadena Office, CA.
FLUID-LOOP REACTION SYSTEM Patent
BORIS J. LURIE, inventor (to NASA), J. ALAN SCHIER, inventor (to NASA) (Jet Propulsion Lab., California Inst. of Tech., Pasadena.), and THEODORE C. ISKENDERIAN, inventor (to NASA) 25 Jun. 1991 12 p Filed 31 Jan. 1990 Supersedes N90-26292 (28 - 20, p 2864)
(Contract NAS7-918)
(NASA-CASE-NPO-17204-1-CU; US-PATENT-5,026,008; US-PATENT-APPL-SN-473242; US-PATENT-CLASS-244-164; US-PATENT-CLASS-244-165; US-PATENT-CLASS-114-122; US-PATENT-CLASS-114-125; INT-PATENT-CLASS-B64G-1/28)
Avail: US Patent and Trademark Office CSCL 20D
An improved fluid actuating system for imparting motion to a body such as a spacecraft is disclosed. The fluid actuating system consists of a fluid mass that may be controllably accelerated through at least one fluid path whereby an opposite acceleration is experienced by the spacecraft. For full control of the spacecraft's orientation, the system would include a plurality of fluid paths. The fluid paths may be circular or irregular, and the fluid paths may be located on the interior or exterior of the spacecraft.
Official Gazette of the U.S. Patent and Trademark Office

N91-30253# Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil).
ANALYSIS OF ELECTROTHERMAL THRUSTERS M.S. Thesis [ANALISE DE PROPULSORES ELETROTERMICOS]
FERNANDO DESOUZACOSTA 1991 128 p In PORTUGUESE, ENGLISH summary
(INPE-5240-TDI/440) Avail: CASI HC A07/MF A02
The performance of electrothermal thrusters is discussed and, particularly, the performance of augmented hydrazine catalytic thrusters. The influence of the mass of the power system, the thrust level, and the propellant on the mass efficiency of the propulsion systems for a certain mission are investigated. The influence of the power and tank pressure on the performance of an augmented catalytic thruster is determined. A number of electrothermal systems, some of them under development, is analyzed. The materials and the problems found in the construction of such systems are studied. Author

N91-30494# National Aerospace Lab., Amsterdam (Netherlands). Space Div.
A SENSOR FOR HIGH-QUALITY TWO-PHASE FLOW
A. A. M. DELIL 15 Apr. 1988 14 p Presented at 16th International Symposium on Space Technology and Science

Thermophysics and Thermochemistry Session, Sapporo, Japan, 22-27 May 1988 Previously announced in IAA as A89-38154
(Contract NIVR-02502N)
(NLR-MP-88025-U; ETN-91-99649; AD-B153430L) Avail: CASI HC A03/MF A01

A review of the development work and test results of a dedicated quality sensor, used to monitor the two phase heat transport systems currently considered for thermal management of large power spacecraft is presented. This sensor is based on the axial capacitance principle. Its feasibility was theoretically demonstrated. Preliminary tests with liquid layer simulating plastic sheets and with annular air/liquid flow experimentally confirm the feasibility, not only as vapor quality sensor but also as wetting (liquid layer thickness) sensor, for freons, ammonia, water, toluene, etc. Experiments in a two phase freon test loop show the sensor to be such an accurate, fastly responding, sensitive instrument, that it recently was accepted for inclusion in the two phase heat transport system developed by ESA. Recommendations for future work and applications foreseen are indicated. ESA

N91-31212*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MASS COMPARISONS OF ELECTRIC PROPULSION SYSTEMS FOR NSSK OF GEOSYNCHRONOUS SPACECRAFT
VINCENT K. RAWLIN and GREGORY A. MAJCHER (Cleveland State Univ., OH.) 1991 48 p Presented at the 27th Joint Propulsion Conference, Sacramento, Ca, 24-27 Jun. 1991; sponsored by AIAA, SAE, ASME, and ASEE Previously Announced in IAA as A91-45808
(Contract RTOP 506-42-31)
(NASA-TM-105153; E-6438; NAS 1.15:105153; AIAA PAPER 91-2347) Avail: CASI HC A03/MF A01 CSCL 21H

A model was developed and exercised to allow wet mass comparisons of three axis stabilized communication satellites delivered to geosynchronous transfer orbit. The mass benefits of using advanced chemical propulsion for apogee injection and north-south stationkeeping (NSSK) functions or electric propulsion (hydrazine arcjets and xenon ion thrusters) for NSSK functions are documented. A large derated ion thrusters is proposed which minimizes thruster lifetime concerns and qualification test times when compared to those of smaller ion thrusters planned for NSSK applications. The mass benefits, which depend on the spacecraft mass and mission duration, increase dramatically with arcjet specific impulse in the 500 to 600 s range, but are nearly constant for the derated ion thruster operated in the 2300 to 3000 s range. For a given mission, the mass benefits with an ion system are typically double those of the arcjet system; however, the total thrusting time with arcjets is less than 1/3 that with ion thrusters for the same thruster power. The mass benefits may permit increases in revenue producing payload or reduce launch costs by allowing a move to a smaller launch vehicle. Author

N91-32161*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE NASA CRYOGENIC FLUID MANAGEMENT TECHNOLOGY PROGRAM PLAN
JAMES R. FADDOUL and STANLEY D. MCINTYRE (National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.) Sep. 1991 24 p Presented at the Conference on Advanced Space Exploration Initiative Technologies, Cleveland, OH, 4-6 Sep. 1991; sponsored by AIAA, NASA, and OAI Previously announced in IAA as A91-52436
(Contract RTOP 506-42-73)
(NASA-TM-105256; E-6586; NAS 1.15:105256; AIAA PAPER 91-3553) Avail: CASI HC A03/MF A01 CSCL 21H

During the past three decades, NASA has been designing and using large quantities of cryogenic fluids for propulsion system propellants, coolants for experiments, and for environmental control systems. As a consequence, an erroneous conclusion has been drawn that the technology exists for using large quantities of cryogens in space for long periods of time. The attempt here is to dispel that myth and to present the technology needs that require development in order to support the NASA programs of the future. A NASA program, developed through the impetus of the Marshall Space Flight Center and the Lewis Research Center and supported by all NASA centers is outlined. The current state of the art is discussed along with specific needs for near future missions. Then, using the Space Exploration Initiative mission set, cost/benefit projections are made for the development of advanced cryogenic fluid management techniques. Earth based and space based test programs are discussed relative to the technology requirements for liquid storage, supply, and transfer for fluid transfer and advanced instrumentation. Author

N91-32163*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FIBER-OPTIC APPLICATIONS FOR SPACE-BASED ENGINES
AMY L. SOVIE, DOUGLAS P. BEWLEY, and MARC G. MILLIS Sep. 1991 9 p Presented at the Conference on Advanced Space Exploration Initiative Technologies, Cleveland, OH, 4-6 Sep. 1991; cosponsored by AIAA, NASA, and OAI Previously announced in IAA as A91-52468
(Contract RTOP 590-21-41)
(NASA-TM-105235; E-6560; NAS 1.15:105235; AIAA PAPER 91-3602) Copyright Avail: CASI HC A02/MF A01 CSCL 21H

The use of fiber optic technology is discussed with respect to the instrumentation systems for space based rocket engines. Optical fiber technologies are reviewed with specific attention given to the reliability, light weight, small fiber diameter, and operating life of the components in the space environment. An optical system can facilitate the incorporation of an optical health monitoring system, increase the space available for necessary redundancy, and safe high bandwidth communications that are immune to the effects of electromagnetic radiation. Author

N91-32168# Pacific Northwest Lab., Richland, WA.
PERFORMANCE ENHANCEMENT USING POWER BEAMING FOR ELECTRIC PROPULSION EARTH ORBITAL TRANSPORTERS
J. E. DAGLE Aug. 1991 6 p Presented at the 26th Intersociety Energy Conversion Engineering (IECE) Conference, Boston, MA, 3-9 Aug. 1991
(Contract DE-AC06-76RL-01830)
(DE91-017287; PNL-SA-18894; CONF-910801-18) Avail: CASI HC A02/MF A01

An electric propulsion Earth orbital transport vehicle (EOTV) can effectively deliver large payloads using much less propellant than chemical transfer methods. By using an EOTV instead of a chemical upper stage, either a smaller launch vehicle can be used for the same satellite mass or larger satellite can be deployed using the same launch vehicle. However, the propellant mass savings from using the higher specific impulse of electric propulsion may not be enough to overcome the disadvantage of the added mass and cost of the electric propulsion power source. Power system limitations have been a major factor delaying the acceptance and use of electric propulsion. This paper outlines the power requirements of electric propulsion technology being developed today, including arcjets, magnetoplasmadynamic (MPD) thrusters, and ion engines. Power supply characteristics are discussed for nuclear, solar, and power-beaming systems. Operational characteristics are given for each, as are the impacts of the power supply alternative on the overall craft performance. Because of its modular nature, the power-beaming approach is able to meet the power requirements of all three electric propulsion types. Also, commonality of approach allows different electric propulsion approaches to be powered by a single power supply approach. Power beaming exhibits better flexibility and performance than on-board nuclear or solar power systems. DOE

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COMMERCIALIZATION

Use of space stations for large scale commercial operations.

A91-33325
SOVIETS PRESS SPACE PROCESSING WITH SECRET MANNED DESIGN
CRAIG COVAULT Aviation Week and Space Technology (ISSN 0005-2175), vol. 134, April 22, 1991, p. 20-23.
Copyright

A heretofore secret Soviet manned spacecraft design appears to be slated for conversion into an unmanned materials-processing facility, with the aim of leapfrogging the space-processing technology capabilities of the West. In all, as many as four or five different Soviet unmanned materials-processing spacecraft are under development. These include a large vehicle reminiscent of the U.S. Gemini manned spacecraft; the Nika-T spacecraft, scheduled for launch in 1993-1994; the Space Biological Complex, set for launch in 1993; and the Vostok-class 'Photon' spacecraft. The ultimate goal of these developments appears to be the capture of an international commercial market in which Western nations have a manifest interest. O.C.

A91-34926
CASI CONFERENCE ON ASTRONAUTICS, 6TH, OTTAWA, CANADA, NOV. 19-21, 1990, PROCEEDINGS
VICTOR A. WEHRLE, ED. (Canadian Space Agency, Ottawa, Canada) Ottawa, Canadian Aeronautics and Space Institute, 1990, 521 p. In English and French. For individual items see A91-34927 to A91-34969.

The present conference on the developing status and future prospects of astronautics technologies discusses space commercialization in the 1990s, the Canadian Solar Sail Project, cooperative control of multiple space manipulators, a neural-network paradigm for robotic control, in situ lunar oxygen extraction, photovoltaic power for a lunar base, Radarsat payload technologies, and the development of an educational infrastructure for the study of outer space. Also discussed are spacecraft thermal design and verification, noncontact modal measurement in large space structure testing, a robotic vision system for the evolutionary MSS, the Limb imaging spectrograph for airglow, the remote sensing of temperature and composition in the middle atmosphere, the LDEF satellite's results on composite materials in space, a large and flexible Radarsat SAR antenna, and a Ku-band antenna design for the M-Sat mission. O.C.

A91-37572
SPACE - TECHNOLOGY, COMMERCE AND COMMUNICATIONS; PROCEEDINGS OF THE 4TH ANNUAL CONFERENCE, WASHINGTON, DC, JAN. 8-10, 1991
Lexington, MA, T.F. Associates, Inc., 1991, 215 p. For individual items see A91-37573 to A91-37575.

Various papers on space technology, commerce, and communications are presented. Individual topics addressed include: small satellite launch services, space risk management in the 1990s, launching small satellites, commercial business perspective on remote sensing, new systems/business issues in small satellites, internationalization of space, Space Station Freedom as a precedent for the Space Exploration Initiative (SEI), physiology of manned spaceflight, NASA's commercial development of space, international issues in SEI, medical support of long-term missions aboard Mir orbital complex, medical and biological investigations in Soviet space program, commercial space perspectives. Also discussed are: competitiveness or ELV technologies, industry view of SEI, moon and Mars exploration, NASDA's activities in earth and solar system exploration, German and European perspective on space activities in the upcoming European market, U.S.-Japanese cooperation in civil space programs, BREM-SAT small university satellite, European regulation of satellite communications, and progress report on SEI studies. C.D.

A91-38926
SPACE COMMERCIALIZATION: LAUNCH VEHICLES AND PROGRAMS; SYMPOSIUM ON SPACE COMMERCIALIZATION: ROLES OF DEVELOPING COUNTRIES, NASHVILLE, TN, MAR. 5-10, 1989, TECHNICAL PAPERS
F. SHAHROKHI, ED. (Tennessee, University, Tullahoma), J. S. GREENBERG, ED. (Princeton Synergetics, Inc., NJ), and TURKI AL-SAUD, ED. (Ministry of Defense and Aviation, Riyadh, Saudi Arabia) Symposium sponsored by University of Tennessee, AIAA, UN, and IAA. Washington, DC, American Institute of Aeronautics and Astronautics, Inc. (Progress in Astronautics and Aeronautics. Vol. 126), 1990, 299 p. For individual items see A91-38927 to A91-38942.
Copyright

The present volume on progress in astronautics and aeronautics discusses the advent of commercial space, broad-based space education as a prerequisite for space commercialization, and obstacles to space commercialization in the developing world. Attention is given to NASA directions in space propulsion for the year 2000 and beyond, possible uses of the external tank in orbit, power from the space shuttle and from space for use on earth, Long-March Launch Vehicles in the 1990s, the establishment of a center for advanced space propulsion, Pegasus as a key to low-cost space applications, legal problems of developing countries' access to space launch vehicles, and international law of responsibility for remote sensing. Also discussed are low-cost satellites and satellite launch vehicles, satellite launch systems of China; Raumkurier, the German recovery program; and the Ariane transfer vehicle as logistic support to Space Station Freedom. P.D.

A91-38954*# National Aeronautics and Space Administration, Washington, DC.
USER ACCOMMODATIONS ON SPACE STATION FREEDOM
THOMAS L. MOSER (NASA, Washington, DC) IN: Space commercialization: Platforms and processing; Symposium on Space Commercialization: Roles of Developing Countries, Nashville, TN, Mar. 5-10, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 36-60. refs
Copyright

The historical background of the SSF is overviewed, and current developments in methodology used to accomodate specific user requirements and physically integrate payloads on the station are discussed. Particular attention is given to the science and technology opportunities provided to commercial and government-sponsored users. Evolution of the SSF design and utilization impacts on design philosophy are also considered. O.G.

A91-38974#
ORBITEC - ORBITAL TECHNOLOGY DEMONSTRATION PROGRAM
PETER W. SHARP (MBB-ERNO, Bremen, Federal Republic of Germany) and GERD GOELZ (DLR, Cologne, Federal Republic of Germany) IN: Space commercialization: Platforms and processing; Symposium on Space Commercialization: Roles of Developing Countries, Nashville, TN, Mar. 5-10, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 366-373. DLR-supported research.
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An ORBITEC program used to investigate, coordinate, and realize orbital technology demonsration/verification missions is discussed. The program covers five major areas of investigation: technology themes, mission analysis, mission profile, payload accomodation, and programmatics. The investigation of a Eureca/Amica-type free-flying platform application as a possible demonstration vehicle shows that various technology payloads can be accommodated for demonstration purposes. Results of the individual payload development/mission programs evaluation are presented. O.G.

A91-39824
THE COMMERCIAL DEMAND FOR SPACE STATIONS
D. M. ASHFORD British Interplanetary Society, Journal (ISSN 0007-094X), vol. 44, June 1991, p. 269-274. refs
Copyright

A perspective for space station demand is discussed, and a preliminary estimate of the cost of transportation to and from space stations is presented. On the basis of literature search and by analogy with terrestrial economic activities a demand curve has been derived for each of the likely of commercial uses of space, showing annual traffic plotted against cost per ton to orbit. The applications considered include manufacturing, mining, solar power, suborbital transport, colonization, and tourism. Space tourism is considered to be the first application of space stations to generate large revenues. It is concluded that the transportation costs achievable are likely to result in tens of thousands of tons per year of commercial payload to and from space. O.G.

N91-25165*# National Inst. of Standards and Technology, Gaithersburg, MD. Building and Fire Research Lab.
MATERIAL FLAMMABILITY TEST ASSESSMENT FOR SPACE STATION FREEDOM
T. J. OHLEMILLER and K. M. VILLA Jun. 1991 78 p Sponsored by NASA. Lewis Research Center
(NASA-CR-187115; NAS 1.26:187115; NISTIR-4591) Avail: CASI HC A05/MF A01 CSCL 22B

The NASA Upward Flame Propagation test, which measures response to a well-defined laminar flame at the bottom of a test sample, is currently used to screen for flammability all materials intended for use in the interior of manned spacecraft. The response of a series of materials was compared in this test and in the standard NIST flammability tests. A simplified upward flame spread model, which utilizes inputs derived from the NIST test, was employed in an attempt to predict the behavior in the modified NASA tests. Author

N91-30191*# National Aeronautics and Space Administration, Washington, DC.
SPACE STATION WORKSHOP COMMERCIAL MISSIONS AND USER REQUIREMENTS: ISSUES AND RECOMMENDATIONS
12 May 1988 64 p Workshop held in Nashville, TN, 3-5 Nov. 1987
(NASA-TM-105093; NAS 1.15:105093) Avail: CASI HC A04/MF A01 CSCL 22B

The issues and recommendations of a conference on the Space Station are presented. The subjects are organized under three headings of: materials and processing in space, earth and ocean observations, and industrial services. One hundred and two issues and recommendations which resulted from the workskop are categorized for each discipline subpanel. Responses to these issues and recommendations are based on more than twenty interviews with highly qualified NASA personnel and represent the best answers available at this time. M.G.

N91-30192*# National Aeronautics and Space Administration, Washington, DC.
SPACE STATION FREEDOM WORKSHOP OPPORTUNITIES FOR COMMERCIAL USERS AND PROVIDERS: ISSUES AND RECOMMENDATIONS
Jul. 1989 88 p Workshops held in Denver, CO, 25-28 Oct. 1988 and Nashville, TN, 3-5 Nov. 1987 Revised
(NASA-TM-105094; NAS 1.15:105094) Avail: CASI HC A05/MF A01 CSCL 22B

The responses to issues and questions raised at the Space Station Freedom Workshops are compiled. The findings are presented under broad divisions of general, materials processing in space, commercial earth and ocean observations, life sciences, infrastructure services, and infrastructure policy. The responses represent the best answers available at this time and future modifications may be expected. Contact names, telephone numbers, and organizations are included. M.G.

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EXPERIMENTS

Design and description of experiments to be performed or managed from the space station.

A91-32954*# Lockheed Missiles and Space Co., Sunnyvale, CA.
COMPATIBILITY OF THE SPACE STATION FREEDOM LIFE SCIENCES RESEARCH CENTRIFUGE WITH MICROGRAVITY REQUIREMENTS
MARTIN D. HASHA (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) ASME, Winter Annual Meeting, Dallas, TX, Nov. 25-30, 1990. 10 p. NASA-supported research. refs
(ASME PAPER 90-WA/AERO-6)

NASA is developing a Life Sciences Centrifuge Facility for Space Station Freedom. In includes a 2.5-meter artificial gravity Bioresearch Centrifuge (BC), which is perhaps the most critical single element in the life sciences space research program. It rotates continuously at precise selectable rates, and utilizes advanced reliable technologies to reduce vibrations. Three disturbance types are analyzed using a current Space Station Freedom dynamic model in the 0.0 to 5.0 Hz range: sinusoidal, random, and transient. Results show that with proper selection of proven design techniques, BC vibrations are compatible with requirements. Author

A91-34336
PROGRAMMATIC OVERVIEW OF THE ESA MICROGRAVITY PROGRAMME
GEORG SEIBERT (ESA, Paris, France) Postepy Astronautyki (ISSN 0373-5982), vol. 23, no. 1-2, 1991, p. 29-54. 26 p.
Copyright

European activities in the different microgravity research disciplines (i.e., the materials, fluid, and life sciences) are reviewed. Aspects of ESA's Microgravity Research Programme are outlined. After examining the Spacelab and Eureca programs, the paper examines the Columbus Attached and Free-Flying Laboratories program. It is pointed out that one of the objectives of the Microgravity Programme is to ensure that preparations for the Space Station era are placed on the firmest possible scientific foundations. B.J.

A91-34958#
LISA - A LIMB IMAGING SPECTROGRAPH FOR AIRGLOW
F. R. HARRIS, R. L. GATTINGER, F. CREUTZBERG, D. T. BRADLEY (National Research Council of Canada, Herzberg Institute of Astrophysics, Ottawa), I. P. POWELL (National Research Council of Canada, Ottawa) et al. IN: CASI Conference on Astronautics, 6th, Ottawa, Canada, Nov. 19-21, 1990, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1990, p. 345-355. Canadian Space Agency-supported research. refs

Limb imaging spectrographs for airglow scheduled to be launched on a sounding rocket with the objective of studying the chemistry of the lower nighttime thermosphere are discussed. The optical, mechanical, and detector designs are considered as well as the theoretical specifications for a prototype imager (255-328 nm). The basic design drivers for the LISA imagers are the spatial distributions of the airglow emissions, the nature of the spectra, the location of the imagers relative to those emissions during flight of the rocket, and the necessity to make the instruments light and compact. The optical design drivers are high resolution and as high a throughput as possible consistent with a compact package. It is pointed out that the LISA imagers will be applicable to other problems related to space science and can be also deployed on the Space Station and on the ground. V.T.

A91-36106
DESIGN OF AN OPPOSING PAIR MAGNET SYSTEM FOR ASTROMAG
P. G. MARSTON, J. R. HALE, R. F. VIEIRA, A. ZHUKOVSKY, P.

TITUS (MIT, Cambridge, MA) et al. (1990 Applied Superconductivity Conference, Snowmass, CO, Sept. 24-28, 1990, Proceedings. A91-36027 15-33) IEEE Transactions on Magnetics (ISSN 0018-9464), vol. 27, pt. 3, March 1991, p. 2264-2268. refs

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A magnet system comprising a pair of self-supporting disk-shaped coils has been designed for the ASTROMAG facility on the space station Freedom. The coils are connected in a quadrupole configuration in order to eliminate their dipole moment. One of the primary requirements of this design is that the magnet coils must have near-perfect structural integrity. To this end, each coil would be manufactured as a monolithic composite in which the superconducting wire is incorporated as one of the components. By utilizing a precision X-Y numerically controlled wiring machine, the coil can be built up in pancake layers by alternating prepreg sheets of fiber/epoxy (e.g., carbon or Kevlar fiber) with a layer of NbTi wire that spirals from OD to ID in one layer, from ID to OD in the next, and so on. Each disk magnet will have an ID of 0.4 m and an OD of 1.7 m. The peak field at the winding will be 7.2 T. The system is to operate at 1.8 K, and Iop/Ic = 0.5. Results of magnetic field and force calculations are presented, and the structural characteristics of the system are described. I.E.

A91-36610 Cambridge Research and Instrumentation, Inc., MA.
CRYOGENIC CAVITY RADIOMETERS AS DETECTORS AND CALIBRATION STANDARDS FOR REMOTE SENSING
P. FOUKAL, C. HOYT, H. KOECHLING, and P. MILLER (Cambridge Research and Instrumentation, Inc., MA) IN: Long-term monitoring of the earth's radiation budget; Proceedings of the Meeting, Orlando, FL, Apr. 17, 18, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 92-100. refs
(Contract NAS1-18475; NAS5-30631)

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The large decrease in specific heat of pure metals achieved at liquid helium temperatures can be used to greatly reduce the time constant and increase the sensitivity of spectrally nonselective electrical substitution radiometers used for satellite remote sensing o fhte earth's radiations. Single-element and array receivers with a natural time constant below 25 msec and a sensitivity below 10 nW have been constructed and servocontrolled to measure radiations from below 300 nm to beyond 40 microns, to better than 1 percent absolute accuracy. Flight of such an experiment on the Atlas pallet would provide an important proof of concept for future cryogenic radiometry at high accuracy, sensitivity and spatial resolution from the Space Station, from polar platforms and possibly from geosynchronous platforms, as flight qualified 2 K cryocoolers are developed in the next decade. The use of cryogenic radiometers in radiometric calibrations at NIST and elsewhere, and their possible applications for ground-based calibrations of the Eos remote sensing instrument are described. Author

A91-37495#
OPPORTUNITY AND CHALLENGE IN LIFE SCIENCES RESEARCH ON SPACE STATION FREEDOM
MILTON R. HEINRICH (Zerog Corp., Los Altos Hills, CA) (International Union of Physiological Sciences Commission on Gravitational Physiology, Annual Meeting, 11th, Lyons, France, Sept. 25-27, 1989, Proceedings. A91-37456 15-51) Physiologist, Supplement (ISSN 0031-9376), vol. 33, Feb. 1990, p. S-102, S-103.

The facilities provided by the Space Station Freedom for studying crew problems arising in space are discussed together with their possible countermeasures. Spacial attention is given to major facilities which will be used in all of the life-science activities, which include the Habitat Holding System, the Centrifuge, the Life Sciences Glovebox, and the Equipment Washer/Sanitizer. In addition, the life-science facilities will include specific items of generic equipment used in life sciences and materal sciences research, called the laboratory support equipment. I.S.

A91-38951
SPACE COMMERCIALIZATION: PLATFORMS AND PROCESSING; SYMPOSIUM ON SPACE COMMERCIALIZATION: ROLES OF DEVELOPING COUNTRIES, NASHVILLE, TN, MAR. 5-10, 1989, TECHNICAL PAPERS
F. SHAHROKHI, ED. (Tennessee, University, Tullahoma), G. HAZELRIGG, ED. (NSF, Washington, DC), and R. BAYUZICK, ED. (Vanderbilt University, Nashville, TN) Washington, DC, American Institute of Aeronautics and Astronautics, Inc. (Progress in Astronautics and Aeronautics. Vol. 127), 1990, 409 p. For individual items see A91-38952 to A91-38975.

Copyright

Space commercialization activities in the areas of telecommunication and earth observation are reviewed with a focus on platforms and processing. Topics discussed are an OUTPOST transportation and service platform in low-earth orbit, the evolution and current status of the Columbus polar platform, user accommodations on Space Station Freedom, low-gravity materials experiments in space, preparation of synthetic polymer membranes in a microgravity environment, a modular containerless processing facility, the design of drop-tube and drop-tower facilities, a low-cost low-volume carrier for biotechnology and fluids experiments in low gravity, cell preparation and electrofusion in space, glass preparation under microgravity, and acoustic levitation for high-temperature containerless processing in space. O.G.

A91-38957*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
LOW-GRAVITY MATERIALS EXPERIMENTS IN THE SPACE STATION FREEDOM
ROGER P. CHASSAY (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Space commercialization: Platforms and processing; Symposium on Space Commercialization: Roles of Developing Countries, Nashville, TN, Mar. 5-10, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 84-93.

Copyright

The science and hardware programs laying the science and technology framework for experiments to be conducted aboard SSF are described. Six microgravity facilities planned for the Laboratory Module encompass the Fluid Physics/Dynamics Facility, investigating fundamental fluid behavior; the Advanced Protein Crystal Growth Facility, growing high-quality crystals for pharmaceutical, medical, chemical, and biotechnology applications; the Biotechnology Facility, investigating microgravity effects on biological processes and living organisms at the cellular level and on the purification and production of biological materials; the Space Station Furnace Facility, conducting metal and alloy solidification experiments; the Modular Containerless Processing Facility, supporting experiments through levitation techniques; and the Modular Combustion Facility, performing studies of fundumental combustion processes. O.G.

A91-38959*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MODULAR CONTAINERLESS PROCESSING FACILITY
ANDREW D. MORRISON (JPL, Pasadena, CA) IN: Space commercialization: Platforms and processing; Symposium on Space Commercialization: Roles of Developing Countries, Nashville, TN, Mar. 5-10, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 112-123.

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The Modular Containerless Processing Facility (MCPF) of the Space Station Freedom, being developed by the Jet Propulsion Laboratory, is described. The MCPF will be capable of positioning, manipulating, and performing processing operations on samples completely free of container walls. It will be comprised of a host facility and a series of interchangeable plug-in modules. Initial iterations of MCPF modules will be flown on the U.S. Microgravity Laboratory (USML) series of Shuttle flights. The Drop Physics Module schedualed to fly on USML-1 in March 1992 is also considered. O.G.

A91-38963# Instrumentation Technology Associates, Inc., Malvern, PA.

LOW-COST LOW-VOLUME CARRIER (MINILAB) FOR BIOTECHNOLOGY AND FLUIDS EXPERIMENTS IN LOW GRAVITY

JOHN M. CASSANTO, WALTER HOLEMANS, TED MOLLER (Instrumentation Technology Associates, Malvern, PA), PAUL TODD, ROBIN M. STEWART (NIST, Boulder, CO) et al. IN: Space commercialization: Platforms and processing; Symposium on Space Commercialization: Roles of Developing Countries, Nashville, TN, Mar. 5-10, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 199-213. NIST-supported research. refs
(Contract NAGW-694; NAS9-17431)

The design of the Materials Dispersion Apparatus (MDA) is briefly described, and a series of tests for validation of the design concept is presented. The MDA was subjected to flight qualification tests and laboratory experiment tests on protein crystal growth, protein crystal stability, and diffusion of a dye. Emphasis is placed on experiments known as Pathfinder Payload Biotechnology Fluids Experiments on a low-gravity sounding rocket. These include the nucleation of organic crystals in aqueous solution, behavior of immiscible aqueous solutions, solid-liquid surface phenomena at high surface-tension gradients, and the formation of thin polymeric membranes. Results of the study indicate that MDA is suitable for spaceflight experiments involving diffusion, crystallization, and thin film formation. The apparatus interfaces pairs of solutions with minimum turbulent mixing, and each unit is capable of processing up to 140 samples simultaneously. O.G.

A91-38964*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

CELL SEPARATION AND ELECTROFUSION IN SPACE

D. R. MORRISON (NASA, Johnson Space Center, Houston, TX) and G. A. HOFMANN (BTX, Inc., San Diego, CA) IN: Space commercialization: Platforms and processing; Symposium on Space Commercialization: Roles of Developing Countries, Nashville, TN, Mar. 5-10, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 214-234. refs
Copyright

In microgravity, free-fluid electrophoretic methods for separating living cells and proteins are improved significantly by the absence of gravity-driven phenomena. Cell fusion, culture, and other bioprocessing steps are being investigated to understand the limits of earth-based processing. A multistep space bioprocess is described that includes electrophoretic separation of human target cells, single-cell manipulations using receptor-specific antibodies, electrofusion to produce immortal hybridomas, gentle suspension culture, and monoclonal antibody recovery using continuous-flow electrophoresis or recirculating isoelectric focusing. Improvements in several key steps already have been demonstrated by space experiments, and others will be studied on Space Station Freedom. Author

A91-38972# NASA Space Station Program Office, Reston, VA.

SPACE STATION FREEDOM - OPTIMIZED TO SUPPORT MICROGRAVITY RESEARCH AND EARTH OBSERVATIONS

VINCENT J. BILARDO, JR. (NASA, Reston, VA; NASA, Ames Research Center, Moffett Field, CA) and DANIEL J. HERMAN (NASA, Washington, DC) IN: Space commercialization: Platforms and processing; Symposium on Space Commercialization: Roles of Developing Countries, Nashville, TN, Mar. 5-10, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 336-352. refs
Copyright

The Space Station Freedom Program is reviewed, with particular attention given to the Space Station configuration, program elements description, and utilization accommodation. Since plans call for the assembly of the initial SSF configuration over a 3-year time span, it is NASA's intention to perform useful research on it during the assembly process. The research will include microgravity experiments and observational sciences. The specific attributes supporting these attempts are described, such as maintainance of a very low microgravity level and continuous orientation of the vehicle to maintain a stable, accurate local-vertical/local-horizontal attitude. O.G.

A91-39408*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.

NEW METHOD FOR SCANNING SPACECRAFT AND BALLOON-BORNE/SPACE-BASED EXPERIMENTS

MICHAEL E. POLITES (NASA, Marshall Space Flight Center, Huntsville, AL) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, May-June 1991, p. 548-553. Previously announced in STAR as N90-25255. refs
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A new method is presented for scanning balloon-borne experiments, free-flying spacecraft, and gimballed experiments mounted to the space shuttle or the space station. It uses rotating-unbalanced-mass (RUM) devices for generating circular, line, or raster scan patterns and an auxiliary control system for target acquisition, keeping the scan centered on the target, and producing complementary motion for raster scanning. It is ideal for applications where the only possible way to accomplish the required scan is to physically scan the entire experiment or spacecraft as in X-ray and gamma ray experiments. In such cases, this new method should have advantages over prior methods in terms of either power, weight, cost, performance, stability, or a combination of these. Author

A91-42641*# Virginia Univ., Charlottesville.

LIMITS ON THE ISOLATION OF STOCHASTIC VIBRATION FOR MICROGRAVITY SPACE EXPERIMENTS

C. R. KNOSPE and P. E. ALLAIRE (Virginia, University, Charlottesville) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Mar.-Apr. 1991, p. 229-237. NASA-supported research. refs
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The limitations on the isolation of stochastic vibrations for microgravity space experiments are explored. These limitations result from the restricted interior space available for vibration isolation. A one-degree-of-freedom representation of the experiment-spacecraft system is used, and an ideal vibration actuator is assumed. A kinematic representation results, and the problem becomes one of finding the minimum acceleration trajectory within a pair of stochastic walls. The wall motion is characterized by an ergodic, stationary, zero-mean, Gaussian random process with known power spectral density. The geometry of the wall trajectories is defined in terms of their significant extrema and zero crossings. This geomemtry is used in defining a composite trajectory that has a mean square acceleratiaon lower than that on the optimal path satisfying the stochastic wall inequality constraints. The optimal control problem is solved on a return path yielding the mean square acceleration in terms of the distributions of significant maxima and first-passage time of the wall process. The methodology is applied to a microgravity isolation problem to find the lower bounds on root-mean-square acceleration given the disturbance power spectral density. Author

A91-43104#

CONVECTION OF FLUIDS AND MICROGRAVITY EXPERIMENTS

IU. S. RIAZANTSEV (AN SSSR, Institut Problem Mekhaniki, Moscow, USSR) IN: Israel Annual Conference on Aviation and Astronautics, 31st, Tel Aviv, Israel, Feb. 21, 22, 1990, Supplement. Haifa, Israel, Technion - Israel Institute of Technology, 1990, p. 21-32. refs

Convection in fluids is discussed as well as space processing experiments. It is noted that space technology needs to account for the influence of interface capillary forces with a linear and nonlinear dependence of surface tension on temperature and concentration. Physical and mathematical modeling are addressed as well. K.K.

A91-45268* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

THE ASTROMETRIC TELESCOPE FACILITY

DAVID BLACK, JOHN DYER, KENJI NISHIOKA, JEFFREY SCARGLE, CHARLIE SOBECK (NASA, Ames Research Center, Moffett Field, CA) et al. Astrophysics and Space Science (ISSN 0004-640X), vol. 177, no. 1-2, March 1991, p. 307-313. refs

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The evolution of the Astrometric Telescope Facility (ATF) proposed for use on NASA's Space Station is traced and its design characteristics are presented. With a focal plane scale of 12.7 arcsec/mm, the strawman design has a field size of 10 sq arcmin and a limiting visual magnitude fainter than 16. Output from an observation includes the X and Y coordinates of each star and its relative brightness. P.D.

A91-45862

PROGRAMMATIC OVERVIEW OF THE ESA MICROGRAVITY PROGRAMME

GUENTHER SEIBERT (ESA, Paris, France) Microgravity Science and Technology (ISSN 0938-0108), vol. 4, June 1991, p. 2-11.

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This paper concentrates on European activities in the various 'microgravity' research disciplines: materials, fluid and life sciences. The paper describes the activities of ESA's ongoing microgravity program including the mission opportunities and the experimental equipment to be flown and presents the planning of its future continuation into the Space Station era. ESA has recently started to undertake major enterprises in manned activities in space, as typified by the Attached and Free-Flying Laboratories of Columbus. It is one of the objectives of the Microgravity Programme to ensure that the preparations for the Space Station era are placed on the firmest possible scientific foundations. Author

A91-47692

SOLAR PHYSICS AT ULTRAHIGH RESOLUTION FROM THE SPACE STATION WITH THE SOLAR ULTRAVIOLET NETWORK (SUN)

LUC DAME (ONERA, Chatillon; CNRS, Service d'Aeronomie, Verrieres-le-Buisson, France), L. ACTON, M. BRUNER (Lockheed Research Laboratories, Palo Alto, CA), P. CONNES (CNRS, Service d'Aeronomie, Verrieres-le-Buisson, France), T. CORNWELL (National Radio Astronomy Observatory, Socorro, NM) et al. (Opening frontiers in solar research; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission E (Meetings E6 and E9) of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A91-47654 20-92) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 5, 1991, p. 267-270. refs

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Attention is given to the objectives of the SUN experiment, namely, a detailed study of the solar atmosphere, with emphasis on the physics of coronal loops, plasma heating and thermal inputs of flares and microflares, fine magnetic field structures in the UV and in the visible prominences, and the dynamics of granulation. The concept of the SUN instrumentation is described, and its image reconstruction potential is illustrated. C.A.B.

A91-47993* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.

SPACE ASTROPHYSICS WITH LARGE STRUCTURES - CASES AND P/OF

HUGH S. HUDSON and J. M. DAVIS (NASA, Marshall Space Flight Center, Huntsville, AL) IN: High-energy astrophysics in the 21st century; Proceedings of the Workshop, Taos, NM, Dec. 11-14, 1989. New York, American Institute of Physics, 1990, p. 134-137; Discussion, p. 138. refs

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Space instruments for remote sensing, of the types used for astrophysics and solar-terrestrial physics among many disciplines, will grow to larger physical sizes in the future. The zero-g space environment does not inherently restrict such growth, because relatively lightweight structures can be used. Active servo control of the structures can greatly increase their size for a given mass. The Pinhole/Occulter Facility, a candidate Space Station attached payload, offers an example: it will achieve 0.2 arc s resolution by use of a 50-m baseline for coded-aperture telescopes for hard X-ray and gamma-ray imagers. Author

A91-48008

A TOTAL THROUGHPUT TRANSIENT SPECTROMETER FOR GAMMA RAY SOURCES

KEVIN HURLEY (California, University, Berkeley) IN: High-energy astrophysics in the 21st century; Proceedings of the Workshop, Taos, NM, Dec. 11-14, 1989. New York, American Institute of Physics, 1990, p. 234-238; Discussion, p. 239. refs

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The TTTS for a Space Station configuration is presented. Monte Carlo simulations were performed to analyze the expected background and the resulting sensitivity to transient events. Unlike many hard X-ray and gamma-ray instruments, TTTS does not operate in a background-limited mode due to the intensity of most bursts. The 3-sigma narrow line sensitivity is estimated to be between 0.01 and 0.1 photons/sq cm sec depending on the energy, and the 3-sigma continuum detection flux limit is estimated to be around 10 to the -7th erg/sq cm sec above 30 keV. For intense bursts, the present simulations indicate that TTTS is sensitive to 10- to 50-percent linear polarization, and that their detection rate should be about five per year. P.D.

A91-48018* Harvard-Smithsonian Center for Astrophysics, Cambridge, MA.

THE EXOSS MISSION FOR HARD X-RAY ASTRONOMY

JONATHAN E. GRINDLAY (Harvard-Smithsonian Center for Astrophysics, Cambridge, MA), THOMAS A. PRINCE (California Institute of Technology, Pasadena), M. WEISSKOPF (NASA, Marshall Space Flight Center, Huntsville, AL), and G. SKINNER (Birmingham, University, England) IN: High-energy astrophysics in the 21st century; Proceedings of the Workshop, Taos, NM, Dec. 11-14, 1989. New York, American Institute of Physics, 1990, p. 325-341; Discussion, p. 342. refs

Copyright

The basis for the Energetic X-ray Observatory on Space Station is described. Attention is given to the principal scientific objectives of EXOSS, namely, to study in detail AGN and quasars (some 10,000 should be detectable) as well as compact Galactic sources (accreting white dwarfs, neutron stars, and black holes), and to probe both nonthermal and high-temperature thermal phenomena and the fundamental nature of these objects. The principal technical characteristics of the EXOSS baseline instrument, which overlap in sensitivity in the approximately 40-to-60-keV band, are presented. EXOSS should facilitate efforts to determine: the central power source and the dominant emission mechanisms in AGN, the ways in which the various AGN classes differ as hard X-ray and soft gamma-ray emitters, and the contribution of AGN to the diffuse hard X-ray and soft gamma-ray background. P.D.

A91-49764*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

THE DYNAMIC EFFECTS OF INTERNAL ROBOTS ON SPACE STATION FREEDOM

JEFFREY H. MILLER (NASA, Lewis Research Center, Cleveland; Sverdrup Technology, Inc. Brook Park, OH), CHARLES LAWRENCE, and DOUGLAS A. ROHN (NASA, Lewis Research Center, Cleveland, OH) IN: AIAA Guidance, Navigation and Control Conference, New Orleans, LA, Aug. 12-14, 1991, Technical Papers. Vol. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1865-1878. Previously announced in STAR as N91-22604. refs

(AIAA PAPER 91-2822) Copyright

Many of the planned experiments of the Space Station Freedom (SSF) will require acceleration levels to be no greater than microgravity (10 exp -6 g) levels for long periods of time. Studies have demonstrated that without adequate control, routine operations may cause disturbances which are large enough to affect on-board experiments. One way to both minimize disturbances and make the SSF more autonomous is to utilize robots instead of astronauts for some operations. The present study addresses the feasibility of using robots for microgravity manipulation. Two methods for minimizing the dynamic disturbances resulting from the robot motions are evaluated. The first method is to use a robot with kinematic redundancy (redundant links). The second method involves the use of a vibration isolation device between the robot and the SSF laboratory module. The results from these methods are presented along with simulations of robots without disturbance control. Author

A91-51452
DEVELOPMENT OF STRUCTURES FOR RETRIEVED SPACE ENVIRONMENT UTILIZATION EXPERIMENT SYSTEMS
TAKANE WATANABE, KENJI SAKANO, TOMOYUKI IKAMI, MUTSUMI ASAHI, TAKESHI TOKUMURA, and KANJI SEO Ishikawajima-Harima Engineering Review (ISSN 0578-7904), vol. 31, May 1991, p. 145-151. In Japanese. Research sponsored by NASDA. refs

Three structures being developed by NASDA are described: the Microgravity Experiments System, the Exposed Facility Flyer Unit, and the Exposed Facility, comprising the Japanese Experiment Module of the Space Station. These structures are designed to maintain equipment and to withstand lift-off, on-orbit, and landing environments without any failure that could damage the systems or vehicles. Y.P.Q.

A91-51453
ACTIVE VIBRATION CONTROL SYSTEM FOR IMPROVEMENT OF MICROGRAVITY ENVIRONMENT
KOJI TANIDA, KOICHI OKUBO, MITSURU MUTO, SEIKO HOSHI, and MUNETAKA KURIBAYASHI Ishikawajima-Harima Engineering Review (ISSN 0578-7904), vol. 31, May 1991, p. 152-156. In Japanese. refs

In order to isolate a gravity-sensitive payload from vibrational and pulsed disturbances of the spacecraft transmitted through the rack, an active vibrational control system using electromagnetic (EM) suspensions is being developed. A ground experiment was performed to verify the PID control performance of the EM suspension system, where the payload model was suspended from a wire to approximate the microgravity environment. Experimental results were found to agree well with theoretical values. Y.P.Q.

A91-52586
MATHEMATICAL MODELING OF EULER TURNS OF THE MIR ORBITAL COMPLEX USING GYRODYNES [MATEMATICHESKOE MODELIROVANIE EILEROVYKH RAZVOROTOV ORBITAL'NOGO KOMPLEKSA 'MIR' GIRODINAMI]
V. A. SARYCHEV, M. IU. BELIAEV, S. G. ZYKOV, V. V. SAZONOV, and V. P. TESLENKO Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, July-Aug. 1991, p. 532-543. In Russian. refs
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Three mathematical models of the Eulerian turn of the Mir complex in inertial space using gyrodynes are described. The models are based on the combined integration of the equations describing a change in the total angular momentum of the gyrodynes and the equations of the complex's motion about the center of mass. The models have been implemented as programs for the IBM PC/XT and are employed for planning scientific experiments to be performed on the orbital complex. L.M.

A91-52880* Naval Research Lab., Washington, DC.
THE HIGH TEMPERATURE SUPERCONDUCTIVITY SPACE EXPERIMENT
DENIS C. WEBB and M. NISENOFF (U.S. Navy, Naval Research Laboratory, Washington, DC) Microwave Journal (ISSN 0192-6225), vol. 34, Sept. 1991, p. 85, 86, 88, 90, 91. Research supported by NASA, U.S. Navy, DARPA and SDIO.
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The history and the current status of the high temperature superconductivity space experiment (HTSSE) initiated in 1988 are briefly reviewed. The goal of the HTSSE program is to demonstrate the feasibility of incorporating high temperature superconductivity (HTS) technology into space systems. The anticipated payoffs include the development of high temperature superconductor devices for space systems; preparation and space qualification of a cryogenically cooled experimental package containing HTS devices and components; and acquisition of data for future space experiments using more complex HTS devices and subsystems. The principal HTSSE systems and devices are described. V.L.

A91-53403* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DEVELOPMENT OF A VIBRATION ISOLATION PROTOTYPE SYSTEM FOR MICROGRAVITY SPACE EXPERIMENTS
K. A. LOGSDON, C. M. GRODSINSKY, and G. V. BROWN (NASA, Lewis Research Center, Cleveland, OH) (Microgravity research: Material and fluid sciences; Proceedings of Symposium 11 of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A91-53401 23-29) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 7, 1991, p. 9-16. Previously announced in STAR as N91-19324. refs
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The presence of small levels of low-frequency accelerations on the Space Shuttle orbiters has degraded the microgravity environment for the science community. Growing concern about this microgravity environment has generated interest in systems that can isolate microgravity science experiments from vibrations. This interest has resulted primarily in studies of isolation systems with active methods of compensation. The development of a magnetically suspended, six-degree-of-freedom active vibration isolation prototype system capable of providing the needed compensation to the orbital environment is presented. A design for the magnetic actuators is described, and the control law for the prototype system that gives a nonintrusive inertial isolation respone to the system is also described. Relative and inertial sensors are used to provide an inertial reference for isolating the payload. Author

A91-53498
A TOTAL THROUGHPUT TRANSIENT SPECTROMETER FOR GAMMA-RAY BURSTERS
K. HURLEY (California, University, Berkeley) (Recent results and perspective instrumental developments in X- and gamma-ray astronomy; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission E /Meetings E4 and E8/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A91-53451 23-89) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 8, 1991, p. 365-368. refs
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The present instrument concept for a high-throughput/high-time/high-energy resolution gamma-ray detector based on an array of 12 high-purity Ge detectors; sesitivities thus obtainable would be sufficient not only to obtain data on the energy spectra of gamma-ray bursts, but also to accomplish polarization measurements. This spectrometer is envisioned as ideally suited for a large platform with substantial telemetry capacity, such as the NASA Space Station. Secondary objectives for the instrument would include solar gamma radiation spectroscopy and the monitoring of X-ray and gamma-ray pulsars, as well as surveying the sky for slow transients. O.C.

A91-55105
VERSATILE SAR FOR THE FIRST POLAR PLATFORM
F. G. SAWYER (Marconi Space and Defence Systems, Ltd., Stanmore, England), S. S. HARTLEY (Marconi Space Systems, Ltd., Portsmouth, England), and M. A. BROWN (GEC-Marconi Research Centre, Chelmsford, England) GEC Journal of Research (ISSN 0264-9187), vol. 9, no. 1, 1991, p. 13-22. refs
Copyright

This paper describes the design of a synthetic aperture radar (SAR) which has resulted from work at Marconi Space Systems Ltd. (MSS) and the GEC-Marconi Research Centre (MRC). The

SAR instrument is intended to fly on the first European Polar Platform. It offers the user greater operational flexibility than other designs, particularly by the use of an active-array antenna. The performance of the instrument is significantly better than that offered by alternative designs, taking into account the constraints of the platform. This paper outlines the background to the study, identifies the requirements for the instrument, and describes the design concept with a discussion on some of the technical issues involved. Author

N91-21165# Center for Industrial Research, Oslo (Norway).
ZEOLITES IN SPACE
ARNFINN G. ANDERSEN and MICHAEL STOECHER *In* Norwegian Space Center, From Earth to Space and Back: Selected Papers on Norwegian Space Activities p 31-32 Mar. 1990
Avail: CASI HC A01/MF A01

The synthesis of zeolites for use in industrial processes is described. Zeolites are used as calalysts in cracking of heavy oil components amongst other applications. Although found as minerals in nature, synthetic or modified zeolites are used in most industrial applications. A program involving a zeolite growth experiment under microgravity on board the Eureca-1 platform is described. Microgravity simulation crystal growth experiments carried out at the Solution Growth Facility (SGF) are described. They involve growing zeolites in numerous concentrations of the reactants. Products of such synthesis, characterized by X-ray techniques and electron microscopy, are described. ESA

N91-21192*# Virginia Univ., Charlottesville. Dept. of Mechanical and Aerospace Engineering.
CONTROL ISSUES OF MICROGRAVITY VIBRATION ISOLATION
CARL R. KNOSPE and RICHARD D. HAMPTON *In* NASA, Langley Research Center, Aerospace Applications of Magnetic Suspension Technology, Part 1 p 77-141 Mar. 1991 Sponsored by NASA, Lewis Research Center
Avail: CASI HC A04/MF A03 CSCL 22B

Active vibration isolation systems contemplated for microgravity space experiments may be designed to reach given performance requirements in a variety of ways. An analogy to passive isolation systems proves to be illustrative but lacks the flexibility as a design tool of a control systems approach and may lead to poor design. Control theory as applied to vibration isolation is reviewed and passive analogies discussed. Author

N91-21331*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PROCEEDINGS OF THE FIRST WORKSHOP ON CONTAINERLESS EXPERIMENTATION IN MICROGRAVITY
E. H. TRINH, ed. 1 May 1990 562 p Workshop held in Pasadena, CA, 17-19 Jan. 1990
(NASA-CR-187806; JPL-PUBL-90-30; NAS 1.26:187806) Avail: CASI HC A24/MF A04 CSCL 22A

The goals of the workshop were first to provide scientists an opportunity to acquaint themselves with the past, current, and future scientific investigations carried out in the Containerless Science programs of the Microgravity Science and Applications Div. of NASA, as well as ESA and Japanese Space Agencies. The second goal was to assess the technological development program for low gravity containerless experimentation instruments. The third goal was to obtain recommendations concerning rigorous but feasible new scientific and technological initiative for space experiments using noncontact sample positioning and diagnostic techniques.

N91-21333*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GROUND-BASED AND MICROGRAVITY CONTAINERLESS POSITIONING TECHNOLOGIES AND FACILITIES
MARTIN BARMATZ *In its* Proceedings of the First Workshop on Containerless Experimentation in Microgravity p 37-53 1 May 1990
Avail: CASI HC A03/MF A04 CSCL 22A

A presentation is given with the following outline: Containerless experiments; Uniqueness of microgravity; Microgravity experiments; Containerless program development; and Accommodating microgravity experiments. Under accommodating comes positioning approaches, space flight facilities, ground based facilities and technology development, and space station facilities. E.R.

N91-21337*# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
CONTAINERLESS PROCESSING IN THE EUROPEAN MICROGRAVITY PROGRAMME
P. BEHRMANN *In* JPL, Proceedings of the First Workshop on Containerless Experimentation in Microgravity p 99-112 1 May 1990
Avail: CASI HC A03/MF A04 CSCL 22A

Reasonable acoustic levitation for undercooled melts in space was obtained, but some residual instabilities in times of high thermal transients need to be eliminated. Electrostatic levitation was developed with the acoustic levitator with similar applications in mind. The system tested used a tetrahedral electrode configuration with unchanged samples. ESA's involvement in electromagnetic levitation is concentrated on accommodation studies for the European Containerless Processing Lab for the Space Station Freedom. The gas film technique is based on the processing of samples confined by porous walls. Air flow through the walls create air cushions which inhibit wall contact. This technique is particularly promising for glasses. Author

N91-21378*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AN EXAMINATION OF ANTICIPATED G-JITTER ON SPACE STATION AND ITS EFFECTS ON MATERIALS PROCESSES
EMILY S. NELSON May 1991 118 p
(NASA-TM-103775; E-6042; NAS 1.15:103775) Avail: CASI HC A06/MF A02 CSCL 22A

Discussed here are the effects of g-jitter, the residual acceleration aboard spacecraft, on selected cases of materials processes. In particular, the anticipated acceleration environment aboard Space Station Freedom and its potential effects are analyzed. The topic is covered with a sufficient level of generosity as to apply to other processes and vehicles as well. Key findings of the study are discussed. Author

N91-22026# Space Research Organization Netherlands, Groningen. Lab. for Space Research.
FIR AND SUB-MM DIRECT DETECTION SPECTROMETERS FOR SPACEBORNE ASTRONOMY
JAN J. WIJNBERGEN and THIJS DEGRAAUW *In* ESA, From Ground-Based to Space-Borne Sub-mm Astronomy p 259-263 Dec. 1990
Copyright Avail: CASI HC A01/MF A03; EPD, ESTEC, Noordwijk, Netherlands, HC 80 Dutch guilders

Candidate spaceborne sub-mm instrumentation proposed for space projects with large passively cooled telescopes are reviewed. Grating instruments and Fourier transform spectroscopy (FTS) spectrometers are discussed. Particular attention is given to imaging Fabry-Perot spectrometers. The special needs of the Large Deployable Reflector (LDR) and for the Far InfraRed Space Telescope (FIRST) missions in this area are outlined. Possible Fabry-Perot spectrometer setups are diagrammed and outlined. The use of spherical and multiplex Fabry-Perot spectrometers is discussed. ESA

N91-22297# Compagnia Italiana Servizi Tecnici, Rome.
TELESCIENCE EXPERIMENT INTEGRATION AND EVALUATION EXERCISE
A. GUERRAZZI *In* ESA, Ground Data Systems for Spacecraft Control p 671-676 Oct. 1990
Copyright Avail: CASI HC A02/MF A06

Definition of a generic approach for the integration and evaluation of teleoperated experiments in Columbus-like scenarios, is discussed. Basic points and procedures that have proved very useful in the integration and evaluation of two new pilot experiments are described. The Plateau Tank Facility (PTF) and TELEPODI are chosen as representative of user experiments. The PTF is meant to observe the mechanical behavior of liquid bridges in microgravity conditions, while TELEPODI is a teleoperated version of the PODI diagnostic tool capable of interferometry and Schlieren observation of a guest experiment volume. The roles of the telescience testbed, the user work station and onboard hardware interfaces are reviewed. ESA

N91-22364*# Alabama Univ., Huntsville. Dept. of Physics.
ENGINEERING SUPPORT FOR AN ULTRAVIOLET IMAGER FOR THE ISTP MISSION
DOUGLAS G. TORR Feb. 1991 343 p
(Contract NAS8-37586)
(NASA-CR-184138; NAS 1.26:184138) Avail: CASI HC A15/MF A03 CSCL 22B

Design and development activities were carried out for the Ultraviolet Imager (UVI) to be flown on the Polar Spacecraft of the INternational Solar Terrestrial Physics (ISTP) Mission. The following tasks were performed: (1) design and fabrication of prototype/engineering model of the UVI imager; (2) preliminary design review; (3) vacuum ultraviolet filter design; (4) auroral energy deposition code; (5) model of LBH vehicle glow; (6) laboratory measurement program of collision cross-sections; and (7) support of ISTP meetings. Author

N91-22365*# Stanford Univ., CA.
THE ULTRA HIGH RESOLUTION XUV SPECTROHELIOGRAPH: AN ATTACHED PAYLOAD FOR THE SPACE STATION FREEDOM Final Report
ARTHUR B. C. WALKER, JR., RICHARD B. HOOVER, TROY W. BARBEE, JR., EINAR TANDBERG-HANSSEN (National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.), J. GETHYN TIMOTHY, and JOAKIM F. LINDBLOM Oct. 1990 61 p
(Contract NAS8-38666)
(NASA-CR-184156; NAS 1.26:184156; UHRXS-90-2) Avail: CASI HC A04/MF A01 CSCL 22B

The principle goal of the ultra high resolution XUV spectroheliograph (UHRXS) is to improve the ability to identify and understand the fundamental physical processes that shape the structure and dynamics of the solar chromosphere and corona. The ability of the UHRXS imaging telescope and spectrographs to resolve fine scale structures over a broad wavelength (and hence temperature) range is critical to this mission. The scientific objectives and instrumental capabilities of the UHRXS investigation are reviewed before proceeding to a discussion of the expected performance of the UHRXS observatory. Author

N91-22697*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CENTRIFUGE FACILITY CONCEPTUAL SYSTEM STUDY. VOLUME 2: FACILITY SYSTEMS AND STUDY SUMMARY
ROBERT SYNNESTVEDT, ed., PATRICIA BLAIR, ALAN CARTLEDGE, JORGE GARCES-PORCILE, VLADIMIR GARIN, MIKE GUERRERO, PETER HADDELAND, MIKE HORKACHUCK, ULRICH KUEBLER, FRANK NGUYEN et al. Mar. 1991 458 p
(NASA-TM-102860-VOL-2; NAS 1.15:102860-VOL-2) Avail: CASI HC A20/MF A04 CSCL 06C

The Centrifuge Facility is a major element of the biological research facility for the implementation of NASA's Life Science Research Program on Space Station Freedom using nonhuman species (small primates, rodents, plants, insects, cell tissues, etc.). The Centrifuge Facility consists of a variable gravity Centrifuge to provide artificial gravity up to 2 earth G's' a Holding System to maintain specimens at microgravity levels, a Glovebox, and a Service Unit for servicing specimen chambers. The following subject areas are covered: (1) Holding System; (2) Centrifuge System; (3) Glovebox System; (4) Service System; and (5) system study summary. Author

N91-22894# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Cologne (Germany, F.R.).
THERMAL ANALYSES FOR EXPERIMENT PREPARATION WITH THE EXAMPLE OF A MIRROR FURNACE [THERMISCHE ANALYSEN ZUR EXPERIMENTVORBEREITUNG AM BEISPIEL EINES SPIEGELOFENS]
H. P. SCHMIDT *In its* Fourth Summer School on Microgravity: Conference Summaries and Forum Lectures p 113-121 Aug. 1990 In GERMAN
Avail: CASI HC A02/MF A03

The thermal model of the mirror furnace allows the prediction of the temperature profile on a reference specimen. The influence of gaseous atmosphere is examined. The measuring technique is improved by radiometry and a reference specimen with a movable temperature sensor. The models are used on 'genuine' crystal specimens. The temperature depends on surface properties, thermal conductivity, and specific heat. The problem of latent heat in the melting zone is examined. The thermal analyses are to be used in the experiments for the first European Retrieval Carrier (EURECA) Mission. ESA

N91-22911# Freiburg Univ. (Germany, F.R.). Inst. fuer Kristallographie.
THE HEATER UNIT OF THE ZONE MELTING FACILITY (ZMF): A RESISTANCE HEATED TEN ZONE FURNACE [DIE HEIZEREINHEIT DES ZMF (ZONE MELTING FACILITY): EIN WIDERSTANDSBEHEIZTER ZEHNZOENOFEN]
R. SCHWARZ *In* DLR, Fourth Summer School on Microgravity: Conference Summaries and Forum Lectures p 191-192 Aug. 1990 In GERMAN
Avail: CASI HC A01/MF A03

The Zone Melting Facility (ZMF) was designed as a modular growth unit for terrestrial operation and for further use under reduced gravity in a Spacelab or Columbus experimental plant. The ZMF heater is described. The flexible use of the heating zones allows the adjustment of very flat temperature gradients up to steep profiles. Such a profile is shown for corundum. The ZMF is shown to be a growing unit with which, for small power consumption, growing conditions can be adjusted. ESA

N91-23206*# Computer Technology Associates, Inc., Rockville, MD.
ASTROMAG PHASE A ASSEMBLY AND SERVICING OPERATIONS REPORT Final Report, Aug. - Dec. 1989
LINK A. PARIKH 31 Dec. 1989 64 p
(Contract NAS5-30546)
(NASA-CR-186262; NAS 1.26:186262) Avail: CASI HC A04/MF A01 CSCL 22B

Operations concepts for the assembly and servicing of the Astromag Attached Payload on the Space Station Freedom (SSF) are presented. Scenario scripts and graphical representations of the installation of the core facility (CF) on the SSF, installation of experiment hardware on the CF, and the changeout of experiments on the CF are also presented. Author

N91-23211*# Computer Technology Associates, Inc., Rockville, MD.
ASTROMAG DATA SYSTEM CONCEPT Final Report, Aug. - Dec. 1989
DARRELL ROOS, CHIEH-SAN CHENG, PENNY NEWSOME, and NITYA NATH 29 Dec. 1989 45 p
(Contract NAS5-30546)
(NASA-CR-186341; NAS 1.26:186341) Avail: CASI HC A03/MF A01 CSCL 22B

A feasible, top-level data system is defined that could accomplish and support the Astromag Data System functions and interfaces necessary to support the scientific objectives of Astromag. This data system must also be able to function in the environment of the Space Station Freedom Manned Base (SSFMB) and other anticipated NASA elements. Author

N91-23608# Aerospatiale, Cannes (France).
MEDIUM RESOLUTION IMAGING SPECTROMETER (MERIS)

G. BAUDIN, R. BESSUDO, M. A. CUTTER, D. LOBB, and J. L. BEZY (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA, Space and Sea p 303-308 Dec. 1990 Sponsored in part by Dornier-Werke G.m.b.H.
Copyright Avail: CASI HC A02/MF A03

The Medium Resolution Imaging Spectrometer (MERIS) is an optical instrument which is intended to be flown on the first European Polar Platform, scheduled for launch in 1997. The instrument has a spectral range of 400 nm to 1050 nm, a swath width of 1500 km, a spectral resolution of 1.25 nm and spatial resolution of 250 m. The instrument has applications in the fields of oceanographic, land and atmospheric research. ESA

N91-23887*# California Univ., Berkeley.
SCIENCE REQUIREMENTS FOR HEAVY NUCLEI COLLECTION (HNC) EXPERIMENT ON NASA LONG DURATION EXPOSURE FACILITY (LDEF) MISSION 2 Final Report
P. BUFORD PRICE Jun. 1991 77 p
(Contract NAS1-17806; RTOP 871-00-00-04)
(NASA-CR-187527; NAS 1.26:187527) Avail: CASI HC A05/MF A01 CSCL 20H

The Heavy Nuclei Collection (HNC) is a passive array of stacks of a special glass, 14 sheets thick, that record tracks of ultraheavy cosmic rays for later readout by automated systems on Earth. The primary goal is to determine the relative abundances of both the odd- and even-Z cosmic rays with Z equal to or greater than 50 with statistics a factor at least 60 greater than obtained in HEAO-3 and to obtain charge resolution at least as good as 0.25 charge unit. The secondary goal is to search for hypothetical particles such as superheavy elements. The HNC detector array will have a cumulative collection power equivalent to flying 32 sq m of detectors in space for 4 years. The array will be flown as a free-flight spacecraft and/or attached to Space Station Freedom. Author

N91-25557*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SATELLITE ORBIT CONSIDERATIONS FOR A GLOBAL CHANGE TECHNOLOGY ARCHITECTURE TRADE STUDY
EDWIN F. HARRISON, GARY G. GIBSON, JOHN T. SUTTLES, JAMES J. BUGLIA, and ISRAEL TABACK (Bionetics Corp., Hampton, VA.) May 1991 18 p
(Contract RTOP 673-53-01-70)
(NASA-TM-104081; NAS 1.15:104081) Avail: CASI HC A03/MF A01 CSCL 04B

A study was conducted to determine satellite orbits for earth observation missions aimed at obtaining data for assessing data global climate change. A multisatellite system is required to meet the scientific requirements for temporal coverage over the globe. The best system consists of four sun-synchronous satellites equally spaced in local time of equatorial crossing. This system can obtain data every three hours for all regions. Several other satellite systems consisting of combinations of sun-synchronous orbits and either the Space Station Freedom or a mid-altitude equatorial satellite can provide three to six hour temporal coverage, which is sufficient for measuring many of the parameters required for the global change monitoring mission. Geosynchronous satellites are required to study atmospheric and surface processes involving variations on the order of a few minutes to an hour. One or two geosynchronous satellites can be relocated in longitude to study processes over selected regions of earth. Author

N91-27092*# Mankato State Coll., MN. Dept. of Mathematics, Astronomy and Statistics.
MATHEMATICAL MODELING OF THE FLOW FIELD AND PARTICLE MOTION IN A ROTATING BIOREACTOR AT UNIT GRAVITY AND MICROGRAVITY Final Report
ERNEST J. BOYD *In* Houston Univ., NASA/ASEE Summer Faculty Fellowship Program, 1990, Volume 1 17 p Dec. 1990
(Contract NGT-44-005-803)
Avail: CASI HC A03/MF A03 CSCL 12A

The biotechnology group at NASA Johnson Space Center is developing systems for culturing mammalian cells that stimulate some aspect of microgravity and provide a low shear environment for microgravity-based studies on suspension and anchorage dependent cells. The design of these vessels for culturing cells is based on the need to suspend cells and aggregates of cells and microcarrier beads continually in the culturing medium. The design must also provide sufficient circulation for adequate mass transfer of nutrients to the cells and minimize the total force on the cells. Forces, resulting from sources such as hydrodynamic fluid shear and collisions of cells and walls of the vessels, may damage delicate cells and degrade the formation of three dimensional structures. This study examines one particular design in both unit gravity and microgravity based on two concentric cylinders rotating in the same direction at different speeds to create a Couette flow between them. A numerical simulation for the flow field and the trajectories of particles in the vessel. The flow field for the circulation of the culturing medium is modeled by the Navier-Stokes equations. The forces on a particle are assumed to be drag from the fluid's circulation, buoyancy from the gravitational force and centrifugal force from the rotation of the vessel. The problem requires first solving the system of partial differential equations for the fluid flow by a finite difference method and then solving the system of ordinary differential equations for the trajectories by Gear's stiff method. Results of the study indicate that the trajectories in unit gravity and microgravity are very similar except for small spatial deviations on the fast time scale in unit gravity. The total force per unit cross sectional area on a particle in microgravity, however, is significantly smaller than the corresponding value in unit gravity, which is also smaller than anticipated. Hence, this study indicates that this design for a bioreactor with optimal rates of rotation can provide a good environment for culturing cells in microgravity with adequate circulation and minimal force on the cells. Author

N91-27177*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TECHNOLOGY FOR THE FUTURE: IN-SPACE TECHNOLOGY EXPERIMENTS PROGRAM, PART 1
ROGER A. BRECKENRIDGE, comp., LENWOOD G. CLARK, comp., KELLI F. WILLSHIRE, comp., SHERWIN M. BECK, comp., and LISA D. COLLIER, comp. (Computer Technology Associates, Inc., Hampton, VA.) Jun. 1991 304 p Workshop held in Atlanta, GA, 6-9 Dec. 1988
(Contract RTOP 506-44-41-01)
(NASA-CP-10073-PT-1; NAS 1.55:10073-PT-1) Avail: CASI HC A14/MF A03 CSCL 22B

The purpose of the Office of Aeronautics and Space Technology (OAST) In-Space Technology Experiment Program (In-STEP) 1988 Workshop was to identify and prioritize technologies that are critical for future national space programs and require validation in the space environment, and review current NASA (In-Reach) and industry/university (Out-Reach) experiments. A prioritized list of the critical technology needs was developed for the following eight disciplines: structures; environmental effects; power systems and thermal management; fluid management and propulsion systems; automation and robotics; sensors and information systems; in-space systems; and humans in space. This is part one of two parts and is the executive summary and experiment description. The executive summary portion contains keynote addresses, strategic planning information, and the critical technology needs summaries for each theme. The experiment description portion contains brief overviews of the objectives, technology needs and backgrounds, descriptions, and development schedules for current industry, university, and NASA space flight technology experiments. Author

N91-27178*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TECHNOLOGY FOR THE FUTURE: IN-SPACE TECHNOLOGY EXPERIMENTS PROGRAM, PART 2
ROGER A. BRECKENRIDGE, comp., LENWOOD G. CLARK, comp., KELLI F. WILLSHIRE, comp., SHERWIN M. BECK, comp., and LISA D. COLLIER, comp. (Computer Technology Associates,

Inc., Hampton, VA.) Jun. 1991 304 p Workshop held in Atlanta, GA, 6-9 Dec. 1988
(Contract RTOP 506-44-41-01)
(NASA-CP-10073-PT-2; NAS 1.55:10073-PT-2) Avail: CASI HC A14/MF A03 CSCL 22B

The purpose of the Office of Aeronautics and Space Technology (OAST) In-Space Technology Experiments Program In-STEP 1988 Workshop was to identify and prioritize technologies that are critical for future national space programs and require validation in the space environment, and review current NASA (In-Reach) and industry/ university (Out-Reach) experiments. A prioritized list of the critical technology needs was developed for the following eight disciplines: structures; environmental effects; power systems and thermal management; fluid management and propulsion systems; automation and robotics; sensors and information systems; in-space systems; and humans in space. This is part two of two parts and contains the critical technology presentations for the eight theme elements and a summary listing of critical space technology needs for each theme. Author

N91-27201* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
NANO-G RESEARCH LABORATORY FOR A SPACECRAFT Patent
FRIEDRICH O. VONBUN, inventor (to NASA) and OWEN K. GARRIOTT, inventor (to NASA) 4 Jun. 1991 7 p Filed 28 Apr. 1989
(NASA-CASE-GSC-13197-1; US-PATENT-5,020,743; US-PATENT-APPL-SN-344872; US-PATENT-CLASS-244-159; INT-PATENT-CLASS-B64G-1/42) Avail: US Patent and Trademark Office CSCL 22B

An acceleration free research laboratory is provided that is confined within a satellite but free of any physical engagement with the walls of the satellite, wherein the laboratory has adequate power, heating, cooling, and communications services to conduct basic research and development. An inner part containing the laboratory is positioned at the center-of-mass of a satellite within the satellite's outer shell. The satellite is then positioned such that its main axes are in a position parallel to its flight velocity vector or in the direction of the residual acceleration vector. When the satellite is in its desired orbit, the inner part is set free so as to follow that orbit without contacting the inside walls of the outer shell. Sensing means detect the position of the inner part with respect to the outer shell, and activate control rockets to move the outer shell; thereby, the inner part is repositioned such that it is correctly positioned at the center-of-mass of the satellite. As a consequence, all disturbing forces, such as drag forces, act on the outer shell, and the inner part containing the laboratory is shielded and is affected only by gravitational forces. Power is supplied to the inner part and to the laboratory by a balanced microwave/laser link which creates the kind of environment necessary for basic research to study critical phenomena such as the Lambda transition in helium and crystal growth, and to perform special metals and alloys research, etc.
Official Gazette of the U.S. Patent and Trademark Office

N91-29204# California Univ., Berkeley. Lawrence Berkeley Lab.
THE ASTROMAG SUPERCONDUCTING MAGNET FACILITY CONFIGURED FOR A FREE FLYING SATELLITE
M. A. GREEN and G. F. SMOOT Jun. 1991 18 p Presented at the Space Cryogenics Workshop, Cleveland, OH, 18-20 Jun. 1991
(Contract DE-AC03-76SF-00098)
(DE91-014710; LBL-30773; CONF-9106134-1; ASTROMAG-034) Avail: CASI HC A03/MF A01

ASTROMAG is a particle astrophysics facility that was originally configured for the Space Station. The heart of the ASTROMAG facility is a large superconducting magnet which is cooled using superfluid helium. The task of resizing the facility so that it will fly in a satellite in a high angle of inclination orbit is driven by the launch weight capability of the launch rocket and the desire to be able to do nearly the same physics as the Space Station version of ASTROMAG. In order to reduce the launch weight, the magnet and its cryogenic system had to be downsized, yet the integrated field generated by the magnet in the particle detectors has to match the Space Station version of the magnet. The use of aluminum matrix superconductor and oriented composite materials in the magnet insulation permits one to achieve this goal. The net magnetic dipole moment from the ASTROMAG magnet must be small to minimize the torque due to interaction with the earth's magnetic field. The ASTROMAG magnet consists of identical two coils 1.67 meters apart. The two coils are connected in series in persistent mode. Each coil is designed to carry 2.34 million ampere turns. Both coils are mounted on the same magnetic axis and they operate at opposite polarity. This reduces the dipole moment by a factor of more than 1000. This is tolerable for the Space Station version of the magnet. A magnet operating on a free flying satellite requires additional compensation. This report presents the magnet parameters of a free flying version of ASTROMAG and the parameters of the space cryogenic system for the magnet. DOE

N91-30350*# Alabama Univ., Huntsville. Center for Microgravity and Materials Research.
RESIDUAL ACCELERATION DATA ON IML-1: DEVELOPMENT OF A DATA REDUCTION AND DISSEMINATION PLAN
Semiannual Progress Report No. 5, 1 Mar. - 31 Aug. 1991
MELISSA J. B. ROGERS, J. IWAN D. ALEXANDER, and RANDY WOLF 1991 48 p
(Contract NAG8-759)
(NASA-CR-188760; NAS 1.26:188760) Avail: CASI HC A03/MF A01 CSCL 22A

A residual acceleration data analysis plan is developed that will allow principal investigators of low-gravity experiments to efficiently process their experimental results in conjunction with accelerometer data. The basic approach consisted of the following program of research: (1) identification of sensitive experiments and sensitivity ranges by order of magnitude estimates, numerical modelling, and investigator input; (2) research and development towards reduction, supplementation, and dissemination of residual acceleration data; and (3) implementation of the plan on existing acceleration data bases. Author

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PLATFORMS & TETHERS

Descriptions and requirements of independent experimental platforms or missions using tethers aboard space stations.

A91-36432
ELECTRON BEAM INJECTION AND ASSOCIATED LHR WAVE EXCITATION - COMPUTER EXPERIMENTS OF ELECTRODYNAMIC TETHER SYSTEM
HIDEYUKI USUI, HIROSHI MATSUMOTO, and YOSHIHARU OMURA (Kyoto University, Uji, Japan) Geophysical Research Letters (ISSN 0094-8276), vol. 18, May 1991, p. 821-824. refs
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To study the nonlinear plasma dynamics associated with electrodynamic tether system, computer experiments were performed using a two-dimensional electromagnetic particle code. In the computer experiments, two conducting bodies, corresponding to the satellite and the orbiter, are placed in the x-y plane in a vehicle frame. The electrons collected by the tether system are emitted from the orbiter. At the satellite region, plasma depletion owing to the electron collection along B0 by the high potential satellite is found as well as a wake structure in the downsteam region of the plasma flow. At the orbiter region, an electron beam cloud is clearly created in the downstream region. The local electric field induced by the cloud modifies the beam pitch angle and accelerates some of the beam electrons along B0. Moreover, due to the cross-field current by the electron E x B drift motion around the cloud, LHR mode waves are enhanced locally. The local LHR wave excitation is quantitatively interpreted by the theory of the lower-hybrid-drift instability. Author

A91-36668

HARDWARE SIMULATION OF A SPACE PLATFORM LINE-OF-SIGHT STABILIZATION SYSTEM

BRUCE CONNORS (Martin Marietta Astronautics Group, Denver, CO) IN: Advances in optical structure systems; Proceedings of the Meeting, Orlando, FL, Apr. 16-19, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 263-273.

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This paper describes simulation of a space-platform line-of-sight (LOS) stabilization system on a ground-based hardware simulator. A definition of the two-body space platform system is given followed by an explanation of how that system is simulated on the hardware. Sensor synthesis, optical magnification simulation, and structural mode simulation are discussed. Two control systems are described: (1) Alignment Inertial Reference (AIR) platform, and (2) alignment system. The platform control system is a digital variable structure system known as Proximate Time-Optimal Servomechanism (PTOS). The alignment control system uses an analog linear control scheme to control two steering mirrors. Author

A91-38219

STABILITY OF A TETHERED SATELLITE SUBJECTED TO STOCHASTIC FORCES

GUIDO DE MATTEIS and LUCIANO M. DE SOCIO (Roma I, Universita, Rome, Italy) Acta Astronautica (ISSN 0094-5765), vol. 25, Feb. 1991, p. 61-66. Research supported by Ministero dell'Universita e della Ricerca Scientifica e Tecnologica and ASI. refs

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This paper considers the problem of the relative equilibrium and stability of a tethered subsatellite (TSS), when the aerodynamic forces can be only probabilistically evaluated. The location in the space of the TSS is thus a stochastic process. The range of possible stationary states of the system is determined and a procedure is adopted for giving the evolution in time of the probability density of that location and the range of possible trajectories. Author

A91-38953#

COLUMBUS POLAR PLATFORM - CONCEPT EVOLUTION AND CURRENT STATUS

ROMANO BARBERA (ESA, Paris, France) IN: Space commercialization: Platforms and processing; Symposium on Space Commercialization: Roles of Developing Countries, Nashville, TN, Mar. 5-10, 1989, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 19-35.

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The Columbus Polar Platform represents 1 of 3 European flight elements in the framework of the International Space Station Program. The platform's technical concept has substantially evolved since the early 1980s. Configurations analyzed during Phase A and B, based on European polar orbit mission scenarios and studies on the potential role of man in platform operations and servicing, featured large, serviceable platform designs. Then, tradeoffs taking into account the probable nonavailability of servicing vehicles for polar orbits, payload evolution trends, and life-cycle-cost aspects, led to smaller, nonserviceable platform designs. Two configurations are currently studied for the Columbus Polar Platform; Option A based on the earlier concepts devised by ESA, and Option B based on a concept derived from SPOT-4. Author

A91-39967

CAN TETHERS BE COMMERCIALIZED?

DONALD F. ROBERTSON Interavia Space Markets (ISSN 0258-4212), vol. 6, no. 5, 1990, p. 259-261.

Copyright

Plans by NASA and a private company to build SEDS (Small Expendable Deployer System), an experimental space tether which may serve as a model for a potential commercial market, are discussed. The agendas of NASA and the private company, which differ in some respects, are examined. A description of how SEDS works is given. C.D.

A91-42071

TETHER CONNECTED SATELLITE SYSTEMS - LAWS OF DEPLOYMENT/RETRIEVAL [SYSTEME DE SATELLITES CONNECTES PAR CABLE - LOIS D'ENROULEMENT/DEROULEMENT]

ABDELOUAHED DJEBLI and MADELEINE PASCAL (Paris VI, Universite, France) Academie des Sciences, Comptes Rendus, Serie II - Mecanique, Physique, Chimie, Sciences de la Terre et de l'Univers (ISSN 0764-4450), vol. 312, May 23, 1991, p. 1257-1262. In French. refs

Copyright

Stability conditions for the equilibrium of a tether connected satellite system during deployment or retrieval are established. The system's responses to four laws of deployment/retrieval, i.e., exponential, linear, sinusoidal and hyperbolic are compared. Using a simplified model of a tether connected satellite system, it is shown that the sinusoidal law gives the best responses of this system, in spite of the strong initial vibrations obtained during deployment. R.E.P.

A91-42525*# California Univ., Los Angeles.

LABORATORY EXPERIMENTS ON THE ELECTRODYNAMIC BEHAVIOR OF TETHERS IN SPACE

REINER L. STENZEL and MANUEL J. URRUTIA (California, University, Los Angeles) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 10 p. refs

(Contract NSF PHY-87-13829; NSF ATM-90-12709; NAGW-1570)

(AIAA PAPER 91-1475) Copyright

The transient current systems between tethered plasmas in a large magnetoplasma are investigated experimentally for extrapolation to electrodynamic tethers in space. The studies measure the perturbed magnetic fields and the current density associated with pulsed currents to electrodes in three-dimensional space and time. The electrodes excite electron whistlers because they produce fields that dominantly couple to electrons, allowing pulsed currents to propagate and disperse as whistler wave packets. The wave packets evolve into force-free, flux-ropelike field configurations, and a whistler 'wedge' is formed in the plasma due to 'eddy' currents caused by insulated tethers with dc currents. Substantial radiation into the whistler mode happens with moving VLF antennas as well as tethers, and the wave spread within the ray cone is the most significant characteristic event. The wave spread widens the current channel, incites current closure, and is also associated with a 'phantom loop' phenomenon. C.C.S.

A91-42526*# Massachusetts Inst. of Tech., Cambridge.

A THEORY OF NEUTRAL GAS EMISSIONS FROM A PLASMA CONTACTOR AND ITS EFFECT ON ELECTRODYNAMIC TETHER PERFORMANCE

R. I. S. ROY and D. E. HASTINGS (MIT, Cambridge, MA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 13 p. refs

(Contract NAG3-681)

(AIAA PAPER 91-1477) Copyright

An existing anisotropic anodic plasma contactor model is extended to include neutral gas emissions. Within the framework of the contactor model, the inclusion of external ionization leads to an integrodifferential equation. By choosing the ratio of the contactor radius to the neutral gas-electron ionization mean free path at the contactor exit as a suitable expansion parameter, an analytical expression for the current-voltage characteristic can be found. The performance of this contactor model is examined via a dynamic simulation model developed for electrodynamic tethers. Detailed models of the geomagnetic field and the ionosphere are used to create a realistic environment. The highly nonlinear contactor voltagle-current characteristic is incorporated into a circuit equation, which includes radiation impedance, and is solved along the tether's orbit. Results show that it is more effective to fully ionize the contactor gas internally, than to partially ionize it externally, and that based on the specific power for the tether system, the optimum gas to use is argon. In addition, the effect of the radiation impedance on tether system performance is examined. Author

A91-43536*# Science Applications International Corp., McLean, VA.

CURRENT COLLECTION AND CURRENT CLOSURE IN THE TETHERED SATELLITE SYSTEM

ADAM DROBOT, P. SATYANARAYANA, CHIA-LIE CHANG, KANG TSANG, and DENNIS PAPADOPOULOS (Science Applications International Corp., McLean, VA) AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 6 p. NASA-supported research. refs
(AIAA PAPER 91-1476) Copyright

Current collection and closure-path modeling are examined analytically with respect to the Tethered Satellite System (TSS). A particle-in cell code is compared with a one-dimensional unmagnetized fluid code to model the behavior of a positively charged satellite in the ionosphere. The morphology of the sheath and the sheath-region processes are thus examined, and the influence of ions leaving the sheath region is found to cause the attraction of an electron current that is 40 times greater than the steady state value. The enhancement is transient and enhances the acceleration of the electrons in the sheath. A set of modified MHD equations, including those for ion inertia, quasineutrality, and electron drift, is employed to model TSS current closure. Whistler modes are found to exist and can be excited as the TSS passes through the ionosphere. Important conclusions include a significant fluctuation level in the steady state sheath, an ion void which affects the electron population, and some long-lived electrons trapped in the settled sheath with respect to two directions. C.C.S.

A91-45129#

FEEDBACK CONTROL OF TETHERED SATELLITES USING LYAPUNOV STABILITY THEORY

S. R. VADALI (Texas A & M University, College Station) and E.-S. KIM Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, July-Aug. 1991, p. 729-735. Research supported by Texas Advanced Research and Technology Program. Previously cited in issue 10, p. 1444, Accession no. A90-26783. refs
(Contract F49620-87-C-0078)
Copyright

A91-45835

TETHERED SATELLITE ANTENNA ARRAYS FOR PASSIVE RADAR SYSTEMS

DALE F. DICKINSON and WILLIAM C. STRAKA (Lockheed Research Laboratories, Palo Alto, CA) IN: 1990 IEEE Aerospace Applications Conference, Vail, CO, Feb. 4-9, 1990, Digest. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 117-125.
Copyright

The possibility of using long (multikilometer) tethers in orbit, particularly for passive radar surveillance, is examined. Such devices could use the echo derived from common UHF and VHF sources (primarily commercial radio and television stations) for target range and Doppler estimation. Such systems could provide high gain (50-60 dB) and high spatial resolution at low frequencies. Configurations, stability, and other problems associated with satellite tethers are discussed. I.E.

A91-52122* Auburn Univ., AL.

ON STATE ESTIMATION FOR AN ORBITING SINGLE TETHER SYSTEM

MICHAEL E. GREENE (Auburn University, AL) and THOMAS S. DENNEY IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. 27, July 1991, p. 689-695. refs
(Contract NAG8-808)
Copyright

The effects of instrumentation accuracy and configuration on estimation error are studied for the small expendable-tether deployment system (SEDS) using a continuous-discrete extended Kalman filter (CDEKF) state estimator. A twelfth order model that incorporates the rigid body modes of the tether as well as the satellite attitude dynamics is developed. Simulation results using the model and the estimator indicate that the originally planned instrumentation package could not estimate the state vector adequately. Recommendations are made and results presented that reduce the estimation error by adding instruments and increasing selected measurement accuracies. I.E.

A91-54458

DYNAMICS AND CONTROL OF TETHERED SPACECRAFT DURING DEPLOYMENT AND RETRIEVAL

V. J. MODI, P. K. LAKSHMANAN (British Columbia, University, Vancouver, Canada), and A. K. MISRA (McGill University, Montreal, Canada) IN: Mechanics and control of large flexible structures. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 145-181. refs
Copyright

The potential of tether-connected orbiting systems has led to numerous studies of their dynamics and control during deployment, operational (stationkeeeping), and retrieval phases. This paper examines some of the important aspects of the studies, including the modeling of tether dynamics and control, and system dynamics and control. Significant conclusions based on these studies are discussesd, and future research that would aid in a better understanding of the system performance is outlined. L.M.

A91-54475

INSIGHTS AND APPROXIMATIONS IN DYNAMIC ANALYSIS OF SPACECRAFT TETHERS

ANDREAS H. VON FLOTOW and NORMAN M. WERELEY (MIT, Cambridge, MA) IN: Mechanics and control of large flexible structures (A91-54451 23-39). Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 667-696. Research supported by USAF. Previously cited in issue 10, p. 1445, Accession no. A90-26784. refs
Copyright

A91-55852

OFFSET CONTROL OF TETHERED SATELLITE SYSTEMS - AN EXPERIMENTAL DEMONSTRATION

V. J. MODI, P. K. LAKSHMANAN (British Columbia, University, Vancouver, Canada), and A. K. MISRA (McGill University, Montreal, Canada) IN: Space utilization and applications in the Pacific; Proceedings of the 3rd Pacific Basin International Symposium on Advances in Space Science Technology and its Applications, Los Angeles, CA, Nov. 6-8, 1989. San Diego, CA, Univelt, Inc., 1990, p. 681-700. refs
(Contract NSERC-5-80029)
(AAS PAPER 89-664) Copyright

Using a ground based experimental facility, the paper demonstrates validity of the mathematical model aimed at studying offset control of an orbiting platform supported tethered satellite system. The mathematical model for the system is discussed first and some representative control data presented. This is followed by a description of the ground based experimental simulation involving controller, actuator and sensors used in the test program. Results confirm effectiveness of the offset control strategy during both the station-keeping and retrieval phases. Author

N91-22163*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

REACTIONLESS PROPULSION USING TETHERS

GEOFFREY A. LANDIS *In its* Vision-21: Space Travel for the Next Millennium p 330-340 Apr. 1990
Avail: CASI HC A03/MF A06 CSCL 21H

An orbiting tethered satellite can propel itself by reaction against the gravitational gradient, with expenditure of energy but with no use of on-board reaction mass. Energy can be added to the orbit by pumping the tether length in the same way as pumping a swing. Examples of tether propulsion in orbit without use of reaction mass are discussed, including: (1) using tether extension to reposition a satellite in orbit without fuel expenditure by extending a mass on the end of a tether; (2) using a tether for eccentricity pumping to add energy to the orbit for boosting an orbital transfer; and (3) length modulation of a spinning tether to transfer angular momentum between the orbit and tether spin, thus allowing changes in orbital angular momentum. Author

N91-25163 Stanford Univ., CA.
CONTROL OF A TETHERED ARTIFICIAL GRAVITY SPACECRAFT Ph.D. Thesis
JOHN MOTLEY WILSON 1990 196 p
Avail: Univ. Microfilms Order No. DA9108921

Human endurance in space is currently limited by physiological changes due to weightlessness that can be debilitating and dangerous upon reentry into an environment with gravity. The only countermeasure currently known that can completely prevent this physiological deconditioning is the elimination of weightlessness itself via artificial gravity. It is possible to produce an Earth-like artificial gravity environment in a habitat module simply by connecting it to a counterweight with a long tether and slowly rotating the entire configuration. This results in a level of artificial gravity sufficient to eliminate all physiological deconditioning without exposing the inhabitants to rotation rates sufficient to induce motion sickness. This research focuses on the dynamics and control of such a tethered artificial gravity spacecraft, particularly during the spinup maneuver to achieve the desired configuration rotation rate. A laboratory model was used to investigate the dynamics of such a system in two dimensions. The hardware model consists of two free-floating modules supported on gas bearings and connected to one another with a lightweight tether. Each module is equipped with sensors, an onboard computer and cold gas thrusters for spinup and module attitude control. Experiments have demonstrated the natural motions of this system during spinup and the use of reaction jets to provide active module attitude control for improved performance. Results from the laboratory were used to validate a computer simulation for predicting the three-dimensional motions of a full size tethered artificial gravity spacecraft. Simulation results show that very massive tethers can produce disturbance torques that significantly alter the module attitude dynamics. The tether lateral oscillations caused by the spinup maneuver and the resultant disturbance torques on the modules can be decreased by substantially increasing the time taken to spin up the configuration to the desired rotation rate. Even for a very massive tether, it is possible to spin up slowly enough so that regulation of the module attitudes to within 2 degrees of their equilibrium orientation for all times during and subsequent to spinup can be achieved by limited use of reaction jets to provide control torques during the spinup period alone. Dissert. Abstr.

N91-25164 Maryland Univ., College Park.
FEEDBACK STABILIZATION VIA CENTER MANIFOLD REDUCTION WITH APPLICATION TO TETHERED SATELLITES Ph.D. Thesis
DER-CHERNG LIAW 1990 223 p
Avail: Univ. Microfilms Order No. DA9110326

Center manifold reduction has recently been introduced as a tool for design of stabilizing control laws for nonlinear systems in critical cases. Here, the center manifold approach is elaborated for general such non-linear systems in several critical cases of interest, and the results are applied to the control of tethered satellite systems (TSS). In addition, to address stability questions for satellite deployment via TSS, the authors obtain new results in finite-time stability theory. The critical cases considered in the general feedback stabilization studies include the cases in which the system linearization possesses a simple zero eigenvalue (of multiplicity one or two), a pair of simple pure imaginary eigenvalues, one zero eigenvalues along with a pair of simple pure eigenvalues, and two pairs of simple pure imaginary eigenvalues. The calculations involve center manifold reduction, normal form transformations, and Liapunov function construction for critical systems. These calculations are explicit. The tethered satellite systems considered here consist of a satellite and subsatellite connected by a tether, in orbit around the Earth. The Lagrangian formulation of dynamics is used to obtain a nonlinear system of ordinary differential equations for TSS dynamics. For simplicity, a rigid, massless tether is assumed. Linear analysis reveals the presence of critical eigenvalues in the station-keeping mode of operation. This renders useful results on stabilization in critical cases to this application. The control variable assumed is tether tension feedback. Besides the design of stabilizing station-keeping controllers, stability of deployment and instability of retrieval are also shown for a constant angle deployment/retrieval scheme. Dissert. Abstr.

N91-25629*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
A SCHEME FOR BANDPASS FILTERING MAGNETOMETER MEASUREMENTS TO RECONSTRUCT TETHERED SATELLITE SKIPROPE MOTION
M. E. POLITES Washington Jun. 1991 25 p
(NASA-TP-3123; M-663; NAS 1.60:3123) Avail: CASI HC A03/MF A01 CSCL 09B

A scheme is presented for reconstructing tethered satellite skiprope motion by ground processing of satellite magnetometer measurements. The measurements are modified based on ground knowledge of the earth's magnetic field and passed through bandpass filters tuned to the skiprope frequency. Simulation results are presented which verify the scheme and show it to be quite robust. The concept is not just limited to tethered satellites. Indeed, it can be applied wherever there is a need to reconstruct the coning motion of a body about a known axis, given measurements of a known vector in body-fixed axes. Author

N91-30344*# Aeritalia S.p.A., Naples (Italy). Space Systems Group.
TETHERED GRAVITY LABORATORIES STUDY Final Report
F. LUCCHETTI Nov. 1989 149 p
(Contract NAS9-17877)
(NASA-CR-185656; NAS 1.26:185656) Avail: CASI HC A07/MF A02 CSCL 22A

The use is studied of tether systems to improve the lowest possible steady gravity level on the Space Station. Particular emphasis is placed by the microgravity community on the achievement of high quality microgravity conditions. The tether capability is explored for active control of the center of gravity and the analysis of possible tethered configurations. Author

N91-30346*# Aeritalia S.p.A., Turin (Italy). Space Systems Group.
TETHERED GRAVITY LABORATORIES STUDY Mid-Term Review, 26-28 Sep. 1989
F. LUCCHETTI 1989 252 p
(Contract NAS9-17877)
(NASA-CR-185660; NAS 1.26:185660) Avail: CASI HC A12/MF A03 CSCL 22A

Information on the Tethered Gravity Laboratory on the International Space Station is given in viewgraph form. Topics covered include active control, low gravity processes identification, systems analysis, tether interfaces with the Laboratory, elevator and payload configurations, elevator subsystems, and accelerometer technology requirements. Author

N91-30347*# Aeritalia S.p.A., Naples (Italy). Space Systems Group.
TETHERED GRAVITY LABORATORIES STUDY Quarterly Progress Report No. 7, 25 Aug. - 24 Nov. 1989
F. LUCCHETTI Dec. 1989 83 p
(Contract NAS9-17877)
(NASA-CR-185659; NAS 1.26:185659) Avail: CASI HC A05/MF A01 CSCL 22A

Tethered gravity laboratories study is presented. The following subject areas are covered: variable gravity laboratory; attitude tether stabilizer; configuration analysis (AIT); dynamic analysis (SAO); and work planned for the next reporting period. Author

N91-30348*# Aeritalia S.p.A., Naples (Italy). Space Systems Group.
TETHERED GRAVITY LABORATORIES STUDY Quarterly Progress Report No. 5, 25 Feb. - 24 May 1989
F. LUCCHETTI Jun. 1989 83 p
(Contract NAS9-17877)
(NASA-CR-185657; NAS 1.26:185657) Avail: CASI HC A05/MF A01 CSCL 22A

Variable Gravity Laboratory studies are discussed. The following subject areas are covered: (1) conceptual design and engineering analysis; (2) control strategies (fast crawling maneuvers, main perturbations and their effect upon the acceleration level); and (3) technology requirements. Author

N91-30349*# Aeritalia S.p.A., Naples (Italy). Space Systems Group.
TETHERED GRAVITY LABORATORIES STUDY Quarterly Progress Report No. 6, 25 May - 24 Aug. 1989
F. LUCCHETTI Sep. 1989 88 p
(Contract NAS9-17877)
(NASA-CR-185658; NAS 1.26:185658) Avail: CASI HC A05/MF A01 CSCL 22A

The following subject areas are covered: (1) thermal control issues; (2) attitude control sybsystem; (3) configuration constraints; (4) payload; (5) acceleration requirements on Variable Gravity Laboratory (VGL); and (6) VGL configuration highlights. Author

N91-30616*# Aeritalia S.p.A., Turin (Italy). Space Systems Group.
TETHERED GRAVITY LABORATORIES STUDY Final Report
F. LUCCHETTI May 1990 379 p
(Contract NAS9-17877)
(NASA-CR-185628; NAS 1.26:185628) Avail: CASI HC A17/MF A03 CSCL 08G

The scope of the study is to investigate ways of controlling the microgravity environment of the International Space Station by means of a tethered system. Four main study tasks were performed. First, researchers analyzed the utilization of the tether systems to improve the lowest possible steady gravity level on the Space Station and the tether capability to actively control the center of gravity position in order to compensate for activities that would upset the mass distribution of the Station. The purpose of the second task was to evaluate the whole of the experiments performable in a variable gravity environment and the related beneficial residual accelerations, both for pure and applied research in the fields of fluid, materials, and life science, so as to assess the relevance of a variable g-level laboratory. The third task involves the Tethered Variable Gravity Laboratory. The use of the facility that would crawl along a deployed tether and expose experiments to varying intensities of reduced gravity is discussed. Last, a study performed on the Attitude Tether Stabilizer concept is discussed. The stabilization effect of ballast masses tethered to the Space Station was investigated as a means of assisting the attitude control system of the Station. Author

21

TRANSPORTATION NODE

Use of the space station as a node for the launching, assembly or support of lunar or other exploratory missions.

A91-34950#
MISSION AND TECHNOLOGY ASSESSMENT OF HUMAN EXPLORATION TO THE MOON AND MARS
MOSES WONG (Spar Aerospace, Ltd., Weston, Canada) IN: CASI Conference on Astronautics, 6th, Ottawa, Canada, Nov. 19-21, 1990, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1990, 10 p. refs

A comprehensive evaluation has been conducted of a manned exploration mission extending beyond a lunar staging area, to Mars, in view of generic mission infrastructure elements. This evaluation has given attention to ten generalized mission phases with sublevel definition; the mission phases furnish a structured sequence of increasing capabilities by which human explorers proceed from a LEO staging post to a moon base. Each phase is defined in sufficient detail for identification of relevant technology requirements and operational activities. The mission-phase definition scheme is aplicable to Martian exploration with only minor modifications. The technology drivers associated with the mission infrastructure are identified and evaluated for two representative mission phases. Technology-assessment results are presented in tabular form in order to ease data-synthesis and cross-referencing. O.C.

A91-34952#
APPLICATIONS OF THE MOBILE SERVICING SYSTEM TO THE SPACE EXPLORATION INITIATIVE
J. H. DUECKMAN (Spar Aerospace, Ltd., Weston, Canada) IN: CASI Conference on Astronautics, 6th, Ottawa, Canada, Nov. 19-21, 1990, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1990, p. 275-284. refs

Potential applications of the Mobile Servicing System (MSS) to the Space Exploration Initiative (SEI) have been analyzed with particular attention given to its functions and elements. The MSS is being developed as the Canadian contribution to the NASA Space Station Freedom (SSF). The SEI functions of the MSS could include LEO node construction and assembly; assembly, integration, and verification of SEI vehicles; servicing and maintenance; transportation; payload handling; and EVA support. It can also be applied to development of surface robotic systems. It is concluded that the performance capabilities of the MSS, in its baseline SSF role, are sufficient to accommodate its potential role in the SEI. O.G.

A91-41751#
TETHER TRANSPORT FROM LEO TO THE LUNAR SURFACE
ROBERT L. FORWARD (Forward Unlimited, Malibu, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 6 p. refs
(Contract F04611-87-C-0029)
(AIAA PAPER 91-2322) Copyright

A method is described which permits the transport of 5-ton payloads from a low earth orbit to the moon's surface without using propellant. A combination of the systems described by Moravec (1977) and Carroll (1991) is proposed which includes two earth tethers and one lunar tether. A payload obtained by a lower earth tether facility in a 400-km circular orbit is sent to the higher facility which follows a highly elliptical orbit with a 4 to 1 period resonance. From this orbit, the payload is sent to a 65-ton, 580-km rotating moon-based tether, where it is deposited and exchanged for an equivalent mass which returns to the earth. Because equivalent compensating masses are introduced in this concept, the tether facility masses can be less than those theorized by Carroll. Equal mass flow permits earth tether facilities above 30 tons to provide self-powered payload movement, with excess energy capable of compensating for friction and drag losses. C.C.S.

A91-44244#
U.S. SPACE STATION FREEDOM PROPULSION REQUIREMENTS IN SUPPORT OF LUNAR AND MARS EXPLORATION
BRIAN A. WINTERS (McDonnell Douglas Space Systems Co., Space Station Div., Huntington Beach, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 27th, Sacramento, CA, June 24-26, 1991. 10 p.
(AIAA PAPER 91-2439) Copyright

The need for the Space Station Freedom propulsion system to be modified from the current baseline configuration in order to be capable of meeting growth demands is discussed. Attention is given to the various station configurations considered in a NASA Langley study examining the requirements for each phase of station build-up. It is shown how a gaseous hydrogen-oxygen propulsion system provides promise in meeting propellant needs without putting excessive demands on propellant resupply. K.K.

A91-48013* National Aeronautics and Space Administration, Washington, DC.

HIGH ENERGY ASTROPHYSICS 21ST CENTURY WORKSHOP 'SPACE CAPABILITIES IN THE 21ST CENTURY'

ROBERT C. RHOME (NASA, Washington, DC) IN: High-energy astrophysics in the 21st century; Proceedings of the Workshop, Taos, NM, Dec. 11-14, 1989. New York, American Institute of Physics, 1990, p. 265-286; Discussion, p. 287, 288.
Copyright

An overview of 20th-century NASA accomplishments and of the infrastructure and technology that NASA plans to have in place in the 21st century is presented. Attention is given to the Great Observatories Program, AXAF, the Space Infrared Telescope Facility, the Cosmic Background Explorer, the Small Explorers Program, the Large Area Modular Array of Reflectors, and the X-Ray Background Survey Spectrometer. Also discussed are earth-to-orbit communication links, transportation in the 1990s, the evolution of the space infrastructure, and the Space Station Freedom. Consideration is given to the possibilities of the 21st-century infrastructure, with emphasis on exploration on Mars and the moon. Topics addressed include telecommunications, navigation, information management, and 21st-century space science. P.D.

A91-48572

WHY NOT EVOLVE INTO THE SOLAR SYSTEM WITH A SENSIBLE SPACE UTILIZATION ARCHITECTURE?

REX W. RIDENOURE (Ecliptic Astronautics Co., Pasadena, CA) and OLIVER P. HARWOOD SAE, Aerospace Technology Conference and Exposition, Long Beach, CA, Oct. 1-4, 1990. 26 p. refs
(SAE PAPER 901862) Copyright

A sensible space systems architecture is proposed, and a consistent conceptual framework is created with which a wide variety of space systems can be designed and interfaced with each other. The importance of architecture vs configuration is emphasized. Particular attention is given to the principles underlying the present design philisophy, namely: use of triangular architecture as much as possible; careful consideration of all interfaces; planning for the unforseeable with consistent geometry; and provision of a fixed or standard interface pattern in the structure for mounting auxiliary equipment. O.G.

A91-52384*# McDonnell-Douglas Space Systems Co., Huntington Beach, CA.

FUEL SYSTEMS ARCHITECTURE (FSA) EVALUATION CRITERIA AND CONCEPT EVALUATION METHODOLOGY

J. E. HENDERSHOT (McDonnell Douglas Space Systems Co., Huntington Beach, CA), R. R. CORBAN, and S. M. STEVENSON (NASA, Lewis Research Center, Cleveland, OH) AIAA, NASA, and OAI, Conference on Advanced SEI Technologies, Cleveland, OH, Sept. 4-6, 1991. 9 p. refs
(AIAA PAPER 91-3479) Copyright

Consideration is given to two methods developed for the evaluation, screening, and ranking of concepts for Space Exploration Initiative vehicle propellant management systems. The methods selected for handling this multicriteria decision problem are based on the utility theory which transforms both qualitative and quantitative criteria into a nondimensional utility scale for comparison of dissimilar figures of merit. The development of the resultant FSA evaluation criteria and concept evaluation methodology is summarized. O.G.

A91-54797*# Mitre Corp., Washington, DC.

SPACE NETWORK SUPPORT FOR LUNAR COMMUNICATIONS

MICHAEL A. JORDAN (Mitre Corp., Washington, DC) AIAA, NASA, and OAI, Conference on Advanced SEI Technologies, Cleveland, OH, Sept. 4-6, 1991. 10 p. refs
(Contract NASW-3458)
(AIAA PAPER 91-3531) Copyright

The space network can provide high data rate lunar communications as an alternative or adjunct to an expansion of the deep space network. Use of a space-based system can provide continuous coverage for lunar users and reduce terrestrial communication costs by delivering data directly to a single domestic location. Adapting the space network for lunar communications support would also maximize the use of the existing and planned space network and Space Station infrastructure. Several alternative architectures are evaluated. Author

N91-21183*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AEROBRAKE ASSEMBLY WITH MINIMUM SPACE STATION ACCOMMODATION

STEVEN J. KATZBERG, DAVID H. BUTLER, WILLIAM R. DOGGETT, JAMES W. RUSSELL, and THERESA HURBAN (North Carolina State Univ., Raleigh.) Apr. 1991 129 p
(Contract RTOP 326-81-20-02)
(NASA-TM-102778; NAS 1.15:102778) Avail: CASI HC A07/MF A02 CSCL 22A

The minimum Space Station Freedom accommodations required for initial assembly, repair, and refurbishment of the Lunar aerobrake were investigated. Baseline Space Station Freedom support services were assumed, as well as reasonable earth-to-orbit possibilities. A set of three aerobrake configurations representative of the major themes in aerobraking were developed. Structural assembly concepts, along with on-orbit assembly and refurbishment scenarios were created. The scenarios were exercised to identify required Space Station Freedom accommodations. Finally, important areas for follow-on study were also identified. Author

N91-22166*# NASA Space Station Program Office, Reston, VA.

SPACEPORT OPERATIONS FOR DEEP SPACE MISSIONS

ALAN C. HOLT *In* NASA. Lewis Research Center, Vision-21: Space Travel for the Next Millennium p 351-364 Apr. 1990
Avail: CASI HC A03/MF A06 CSCL 22A

Space Station Freedom is designed with the capability to cost-effectively evolve into a transportation node which can support manned lunar and Mars missions. To extend a permanent human presence to the outer planets (moon outposts) and to nearby star systems, additional orbiting space infrastructure and great advances in propulsion system and other technologies will be required. To identify primary operations and management requirements for these deep space missions, an interstellar design concept was developed and analyzed. The assembly, test, servicing, logistics resupply, and increment management techniques anticipated for lunar and Mars missions appear to provide a pattern which can be extended in an analogous manner to deep space missions. A long range, space infrastructure development plan (encompassing deep space missions) coupled with energetic, breakthrough level propulsion research should be initiated now to assist in making the best budget and schedule decisions. Author

N91-22170*# University of Southern California, Los Angeles. Inst. of Aerospace Systems Architecture and Technology.

MALEO: MODULAR ASSEMBLY IN LOW EARTH ORBIT. A STRATEGY FOR AN IOC LUNAR BASE

M. THANGAVELU and G. G. SCHIERLE *In* NASA. Lewis Research Center, Vision-21: Space Travel for the Next Millennium p 404-415 Apr. 1990
Avail: CASI HC A03/MF A06 CSCL 22A

Modular Assembly in Low Earth Orbit (MALEO) is a new strategy for building an initial operational capability lunar habitation base. In this strategy, the modular lunar base components are brought up to Low Earth Orbit by the Space Transportation System/Heavy Lift Launch Vehicle fleet, and assembled there to form a complete lunar base. Modular propulsion systems are then used to transport the MALEO lunar base, complete and intact, all the way to the moon. Upon touchdown on the lunar surface, the MALEO lunar habitation base is operational. An exo-skeletal truss superstructure is employed in order to uniformly absorb and distribute the rocket engine thrusting forces incurred by the MALEO lunar base during translunar injection, lunar orbit insertion, and lunar surface touchdown. The components, configuration, and structural aspects of the MALEO lunar base are discussed. Advantages of the MALEO strategy over conventional strategies are pointed out. It is concluded that MALEO holds promise for lunar base deployment.

Author

N91-22361# Bristol Univ. (England). Dept. of Aerospace Engineering.

THE SPACE STATION AS A TRANSPORT NODE B.S. Thesis

D. Y. MAHARAJ and F. E. H. MIFTACH Jun. 1990 99 p

(BU-510; ETN-91-99203) Avail: CASI HC A05/MF A02

The economic feasibility of a space station based comet nucleus sample return mission is investigated. The analysis evolves around launch and potential recovery to a space station. In order to do this, the scenario was compared to an Earth based mission. It was found that the overriding factor in the analysis were the launch costs, from which it was evident that conventional launches were not cost effective for transporting the hardware to the space station. However, with the advent of reusable launchers, space station based missions could prove to be more economical than Earth based missions.

ESA

N91-23227# Army Construction Engineering Research Lab., Champaign, IL.

LARGE SPACE STRUCTURES FIELDING PLAN Final Technical Report

CHARLES C. LOZAR, ALVIN SMITH, and ANDRE N. BRACKENS Jan. 1991 56 p

(Contract DA PROJ. 4A1-62731-AT-41)

(AD-A232097; CERL-TR-M-91/14) Avail: CASI HC A04/MF A01 CSCL 22A

As the U.S. space program advances, there will be a need for large space structures (LSS) to support different space missions. Construction of extraterrestrial base or extraterrestrial LSS, whether in orbit or on the surface of another body, requires the preparation and execution of exquisitely detailed plans. Requirements for the LSS - the high degree of reliability, the interface with other nodes of the overall operation, and effective contingency plans -- all point to the many integration activities that must occur before and during construction. This study develops the preliminary plan for identifying efforts that will be required for LSS construction to support future Army initiatives in space (including space defense systems). It provides a logical sequence of steps that can be followed whether the LSS are to be platforms (unmanned) or Stations (unmanned). The complexity of this fielding plan suggested that an automated version would make it easier to implement. Such computer programs should consist of a hierarchical, multiple-track format and should be designed to serve developers at the top level (overall management scheme) to lower levels (detailed, engineer usable information).

GRA

LARGE SPACE STRUCTURES AND SYSTEMS IN THE SPACE STATION ERA / *A Bibliography (Supplement 04)* **OCTOBER 1992**

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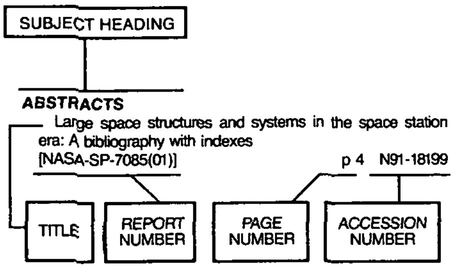

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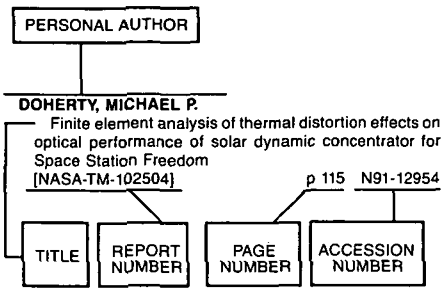

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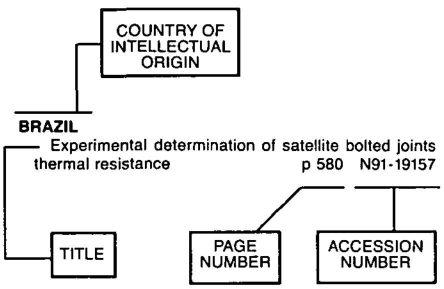

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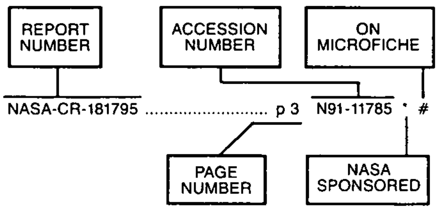

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9. Performing Organization Name and Address NASA Scientific and Technical Information Program		11. Contract or Grant No.
		13. Type of Report and Period Covered Special Publication
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546		14. Sponsoring Agency Code

15. Supplementary Notes

Compiled by Technical Library Branch and edited by Space Station Office, Langley Research Center, Hampton, Virginia.

16. Abstract

This bibliography lists 1211 reports, articles and other documents introduced into the NASA scientific and technical information system between July 1, 1991 and December 30, 1991. Its purpose is to provide helpful information to the researcher, manager, and designer in technology development and mission design according to system, interactive analysis and design, structural and thermal analysis and design, structural concepts and control systems, electronics, advanced materials, assembly concepts, propulsion, and solar power satellite systems.

17. Key Words (Suggested by Author(s)) Large Space Antenna Large Space Structures Large Space Systems Space Stations	18. Distribution Statement Unclassified - Unlimited Subject Category - 18

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 330	22. Price * A15

NASA-Langley, 1992

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