NASA SP-7085 (05)
March 1993

P-362

LARGE SPACE STRUCTURES AND SYSTEMS IN THE SPACE STATION ERA

A BIBLIOGRAPHY WITH INDEXES

NASA STI PROGRAM
SCIENTIFIC & TECHNICAL INFORMATION

NASA SP-7085 (05)
March 1993

LARGE SPACE STRUCTURES AND SYSTEMS IN THE SPACE STATION ERA

A BIBLIOGRAPHY WITH INDEXES

National Aeronautics and Space Administration
Scientific and Technical Information Program
Washington, DC 1993

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.

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

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 semi-annual 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 1363 reports, articles, and other documents announced between January 1, 1992 and July 31, 1992 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:

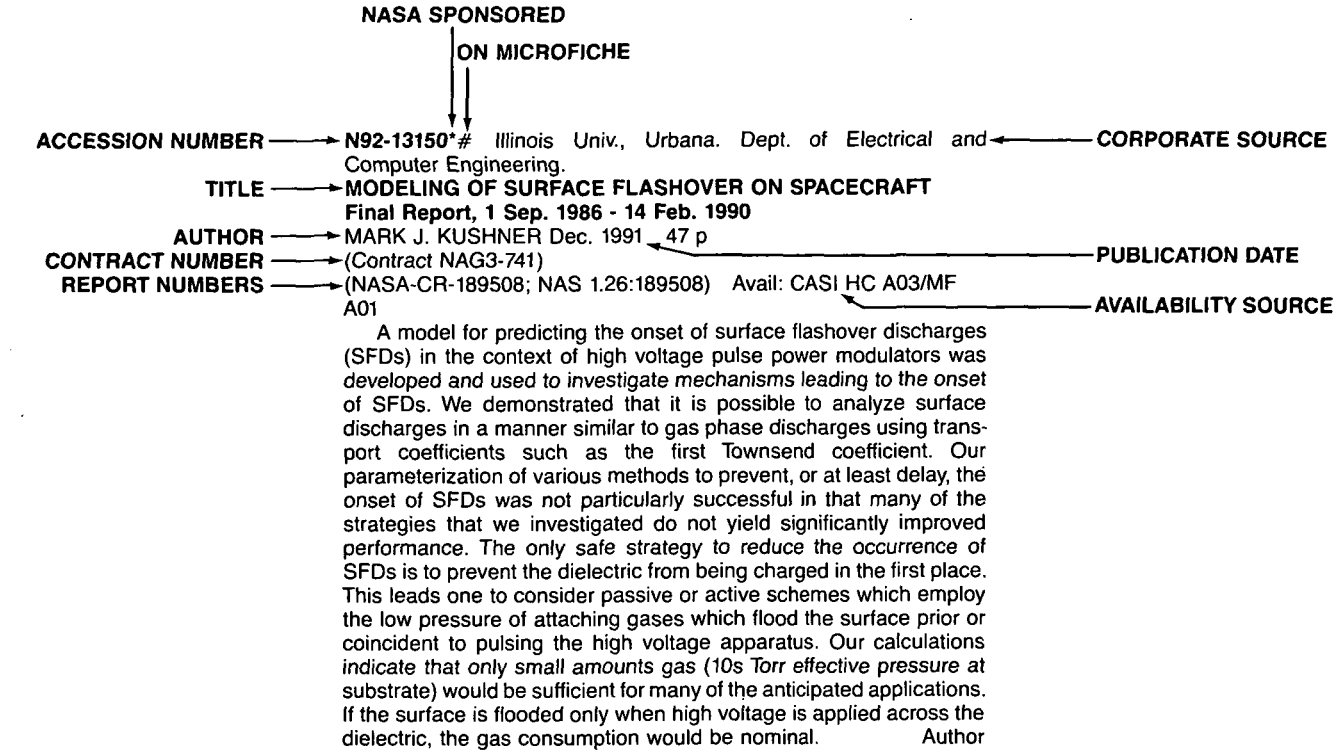
(1) *IAA* entries in ascending accession number order with the form A92-10000, followed by,
(2) *STAR* entries in ascending accession number order with the form N92-10000.

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*.

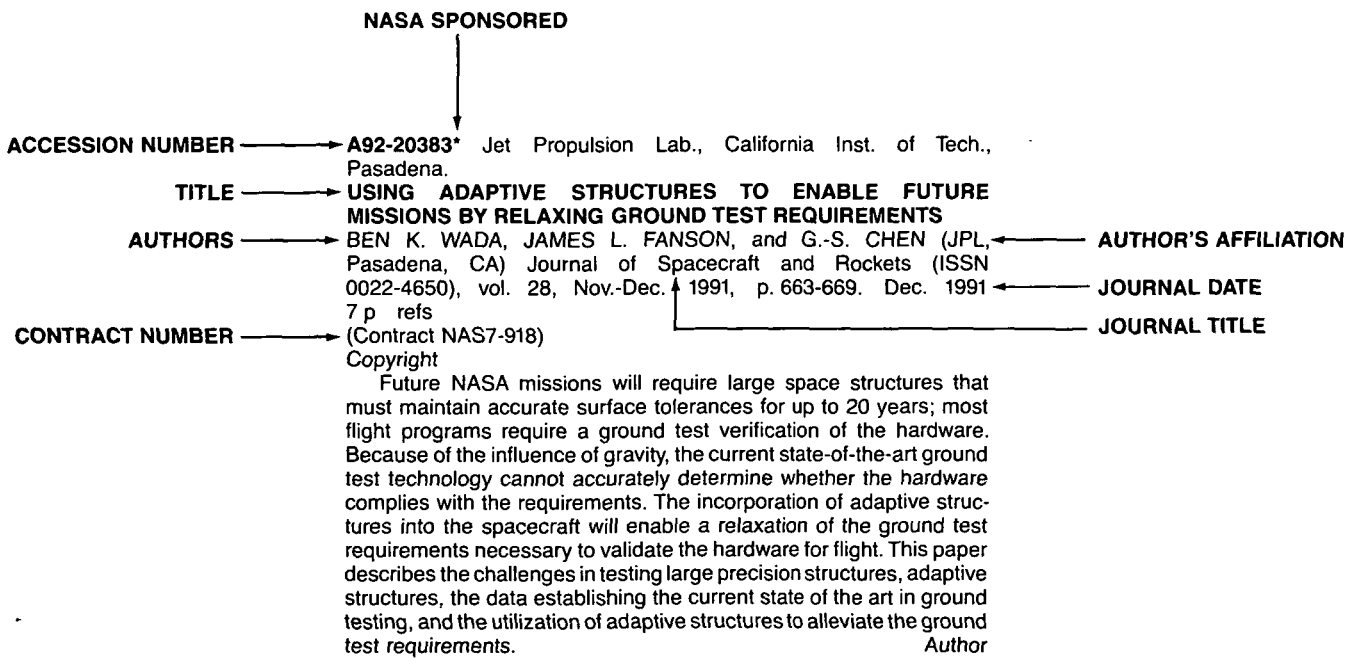
George F. Lawrence, *Space Station Office*
John J. Ferrainolo, *Technical Library Branch*

TABLE OF CONTENTS

TYPICAL REPORT CITATION AND ABSTRACT



TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



LARGE SPACE STRUCTURES AND SYSTEMS IN THE SPACE STATION ERA

A Bibliography (Suppl. 05)

MARCH 1993

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.

A92-10374
SPACE VEHICLE DESIGN
MICHAEL D. GRIFFIN and JAMES R. FRENCH Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1991, 473 p. 1991 473 p refs
Copyright

A comprehensive text on space systems engineering is presented. The topics addressed include: mission design, environmental considerations, astrodynamics, propulsion, atmospheric entry, attitude determination and control, configuration and structural design, thermal control, power, and telecommunications. The aim of the book is to provide fundamental knowledge for the space systems engineer to evaluate the overall impact of candidate design concepts on the various component subsystems and the integration system leading to the final design selection. C.D.

A92-12267
THE UNITED STATES IN SPACE
TRUDY E. BELL and KARL ESCH IEEE Spectrum (ISSN 0018-9235), vol. 28, Aug. 1991, p. 18-20, 45-51. Aug. 1991 10 p
Copyright

The U.S. space program is examined in three contexts: its position internationally, its role domestically, and NASA's workings internally. Some of the principal issues explored are: what it means for NASA to be simply a lead agency instead of the sole agency charged with implementing the U.S. space program; whether the types of technical and managerial troubles NASA has recently experienced are different in quality from the troubles it had during the Apollo era; how the various pressures to which it is being subjected are affecting its internal ways of doing business; and whether there are lessons from the experiences of other nations' space programs and their ways of overseeing projects and doing business that could be useful to the US space program, and vice versa. I.E.

A92-12430* Lamar Univ., Beaumont, TX.
INTERNATIONAL SPACE STATION FREEDOM PROGRAM (SSFP) FLIGHT TEST DEMONSTRATIONS - RESULTS AND FUTURE PLANS
WILLIAM E. SIMON (Lamar University, Beaumont, TX) and LUBERT J. LEGER (NASA, Johnson Space Center, Houston, TX) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 14 p. Oct. 1991 14 p refs
(IAF PAPER 91-005) Copyright

SSFP flight test demonstrations conducted to verify and quantify the performance of selected technologies needed for the development of the Space Station are described. Attention is focused on the performance of thermal systems, the effects of atomic oxygen on materials, and the difficulties of on-orbit crew mobility for assembly and operations utilizing either extravehicular robots or methods. Consideration is given to challenges in system development, a technology assessment summary for the areas of thermal systems, materials, EVA activities, and the results of flight demonstrations. R.E.P.

A92-12476* NASA Space Station Program Office, Reston, VA.
SPACE STATION FREEDOM - AN OVERVIEW
RICHARD H. KOHRS and EARLE K. HUCKINS, III (NASA, Space Station Freedom Program Office, Reston, VA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 7 p. Oct. 1991 7 p
(IAF PAPER 91-064) Copyright

NASA's Space Station Freedom has been designed with a built-in upgrading capability. Permanently manned status is scheduled for fiscal year 2000; it will at that point be able to offer its users fully 30 kW of electrical power, by means of which either numerous experiments can be run simultaneously, or a single piece of unique hardware with high power requirements can be supplied the power. During this permanently manned phase, NASA will contribute, in addition to the three power modules furnishing 30 kW, a 27-ft long laboratory module with 12 user racks, and equally long habitation module for a crew of 4, and design features allowing growth to accommodate a crew of 8 and power supplies of 75 kW. O.C.

A92-12489* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
VERIFICATION OF SPACE STATION FREEDOM ELEMENTS AND SYSTEMS
GEORGE D. HOPSON (NASA, Marshall Space Flight Center, Huntsville, AL) and RICHARD L. GRANT (Boeing Defense and Space Group, Huntsville, AL) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 8 p. Oct. 1991 8 p
(IAF PAPER 91-081) Copyright

NASA's Space Station Freedom (SSF) will be assembled in orbit over a period of more than four years, during which the completed sections of the SSF will proceed with research and experimentation. The feasibility of this process is being addressed by the SSF Verification Program (SSFVP), which encompasses development, qualification, acceptance, and prelaunch phases. The SSFVP emphasizes the ground-based verification of the physical and functional compatibility of interfaces for the different elements and launch packages prior to their mating in orbit. O.C.

A92-12496* National Aeronautics and Space Administration, Washington, DC.
PLANNING FOR THE LONG-TERM EVOLUTION OF SPACE STATION FREEDOM
EARLE K. HUCKINS and PETER R. AHLF (NASA, Washington, DC) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p refs
(IAF PAPER 91-089) Copyright

The possibility and scope of changes to the Space Station Freedom (SSF) are examined in terms of potential research directions to develop a strategy for long-term planning. The drivers

for changes are similar to those of other programs: limited initial capability, evolving user requirements, and the availability of new technologies. The requirements for addressing growth include identifying long-range goals, issues that affect success, mission-related strategies, and establishing decision-making contexts. The Permanently Manned Capability is a key long-range issue, and the phases related to its development and beyond it are discussed. The growth requirements suggest a balance of resources and full utilization of laboratory volume. The paper identifies 8 emerging technologies that are vital to the program and can affect the evolution of the Follow-on Phase and longer-term changes. C.C.S.

A92-14276
THE GAGARIN SCIENTIFIC LECTURES ON ASTRONAUTICS AND AVIATION - 1990, 1991 [GAGARINSKIE NAUCHNYE CHTENIIA PO KOSMONAVTIKE I AVIATSII - 1990, 1991 GG.]
VSEVOLOD S. AVDUEVSKII, ED. (AN SSSR, Institut Mashinovedeniia, Moscow, USSR) Moscow, Izdatel'stvo Nauka, 1991, 256 p. In Russian. No individual items are abstracted in this volume. 1991 256 p In RUSSIAN
Copyright

Papers are presented on such topics as problems in the development of space suits, the processing of heat-shield materials for the Buran vehicle using induction-type plasmatrons, the structural modeling of large free structures using anisotropic models, the design of training simulators with a flexible modular architectures, and a numerical method for calculating gas flows with internal shock waves. Abstracts of papers given at the 21st session of the Gagarin lectures are presented. L.M.

A92-15279* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
FOUR NASA SUBMILLIMETER-WAVELENGTH SPACE-ASTROPHYSICS MISSIONS
M. J. MAHONEY (JPL, Pasadena, CA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 10 p. Oct. 1991 10 p refs
(IAF PAPER 91-422) Copyright

For several years studies have been conducted at the NASA/Jet Propulsion Laboratory on four passively-cooled submillimeter-wavelength, space observatories. Two exploratory missions were studied: a 2.5-m Submillimeter Explorer (SMME) and a more ambitious 3.7-m Submillimeter Imager and Line Survey (SMILS). Only one of these missions would actually be flown, and its goal would be to perform a high-spectral-resolution survey of several hundreds of sources at wavelengths between 100 and about 750 microns with modest angular resolution. Following either SMME or SMILS, the Large Deployable Reflector (LDR) and/or the Synthesis Array for Lunar Submillimeter Astronomy (SALSA) would be flown. LDR is a 10- to 20-m diameter telescope with greatly increased sensitivity and imaging capabilities compared to the exploratory missions. SALSA is a lunar-based array consisting of twelve 3.5-m diameter telescopes with a maximum baseline of nearly 1-km. With operating wavelengths between 30 and 500 microns, SALSA would achieve 10 milliarcsecond angular resolution, and thus could explore source structure in much greater detail than the other missions. The purpose of this paper is to present the current conceptual designs for these missions, and to discuss the most recent payload analysis. Author

A92-17751
SPACE MANUFACTURING 8 - ENERGY AND MATERIALS FROM SPACE; PROCEEDINGS OF THE 10TH PRINCETON/AIAA/SSI CONFERENCE, PRINCETON UNIVERSITY, NJ, MAY 15-18, 1991
BARBARA FAUGHNAN, ED. and GREGG E. MARYNIAK, ED. (Space Studies Institute, Princeton, NJ) Washington, DC, American Institute of Aeronautics and Astronautics, 1991, 438 p. For individual items see A92-17752 to A92-17800. 1991 438 p
Copyright

The present conference on space-based manufacturing discusses topics in space power generation for industrial uses, the design and construction of lunar bases, international legal and space treaty considerations in space industrialization, and the potential contributions of space transportation to the Space Exploration Initiative. Also treated are topics in biomedical requirements, the applicability of Space Shuttle External Fuel Tank modifications to habitable space structures, advanced space colonization and mining concepts, the requirements and economics of habitable/bioregenerative space biospheres, and the character and utility of nonterrestrial natural resources. O.C.

A92-17771
THE ARCHITECTURE OF ARTIFICIAL GRAVITY - MATHEMATICAL MUSINGS ON DESIGNING FOR LIFE AND MOTION IN A CENTRIPETALLY ACCELERATED ENVIRONMENT
THEODORE W. HALL (Michigan, University, Ann Arbor) IN: Space manufacturing 8 - Energy and materials from space; Proceedings of the 10th Princeton/AIAA/SSI Conference, Princeton, NJ, May 15-18, 1991 1991 10 p refs
Copyright

This paper uses mathematical derivations and computer simulations to examine environmental design for life and motion in artificial gravity. Environmental design may help the inhabitants to adapt by specifically responding to the unearthliness of the gravity. Appropriate architecture forms should be derived not only from static geometric constraints, but also from the apparent dynamic behavior of hanging, falling, and moving objects, particularly with regard to concepts of verticality, horizontality, and modularity. This study reveals involute and catenary curves. If properly incorporated into the architecture, these curves may provide visual and tactile cues to aid the inhabitants in comprehending and adapting to their distorted gravity environment. Author

A92-17775
SUPPORTING THE INFRASTRUCTURE REQUIREMENTS OF A SPACE-FARING CIVILIZATION - AN OVERVIEW OF POSSIBLE ROLES FOR THE SPACE SHUTTLE'S EXTERNAL FUEL TANK IN FUTURE SPACE INFRASTRUCTURE
RONALD D. JONES (Phillips Petroleum Co., Robotics Group, Bartlesville, OK) IN: Space manufacturing 8 - Energy and materials from space; Proceedings of the 10th Princeton/AIAA/SSI Conference, Princeton, NJ, May 15-18, 1991 1991 4 p refs
Copyright

An evaluation is made of the potential contribution of the Space Shuttle's discarded External Tanks (ETs) to the LEO infrastructure system requirements of 21st-century solar power satellites, lunar outposts, and human exploration missions to Mars. Such infrastructure will require manned and man-tended laboratories, fuel-storage depots, and orbiting hangars for assembly and refurbishment of large spacecraft. Each empty ET contains over 70,000 cu ft of volume that is pressurizable to about 30 psi. The most simple uses of the ET are that of 'trash basket' for Space Station wastes and of a source of Al alloy for on-orbit construction. O.C.

A92-17778
SPACE BASE 1 - BUILDING A LARGE SPACE STATION USING EXTERNAL TANK TECHNOLOGIES
J. M. SNEAD IN: Space manufacturing 8 - Energy and materials from space; Proceedings of the 10th Princeton/AIAA/SSI Conference, Princeton, NJ, May 15-18, 1991 1991 15 p refs
Copyright

An account is given of the prospects for constructing a large, multiuse manned space station on the basis of discarded Space Shuttle External Tanks (ETs). The station, designated 'Space Base 1', is scaled to begin operations with a crew of 25 and expand to as many as 170. It will encompass variable-gravity processing and training facilities, recreational/physical fitness facilities, individual crew quarters, agricultural facilities, and a partially-closed life support system. The ETs used in Space Base 1's initial, 25-crewmember structure will be obtained from eight launches of

an unmanned launch system similar to NASA's proposed Shuttle C; four standard Space Shuttle flights will carry the crewmembers. O.C.

A92-21702
SKYLAB'S UNTIMELY END
JAMES E. OBERG Air and Space (ISSN 0886-2257), vol. 6, Feb.-Mar. 1992, p. 73-79. Mar. 1992 7 p
Copyright
When plans to launch a second Skylab mission were scrapped in 1975, preliminary studies were conducted on the possibility of Shuttle-Skylab missions beginning in 1979 and lasting for as long as Skylab's orbit remained stable, into the mid-1980s. The long-term exposure of Skylab was considered to be a unique source of information pertinent to space station design, as well as a platform offering expanded environmental support/control for Shuttle crews. A four-phase plan using Shuttle missions to rescue the orbitally-decaying Skylab was scheduled for 1982-1984; Skylab was destroyed upon reentry in 1979. O.C.

A92-24341*# NASA Space Station Program Office, Reston, VA.
SPACE STATION FREEDOM - DESIGN REVIEW PROCESS
ROBERT KOONTZ, ROY COURTNEY, TIM RAU (NASA, Space Station Freedom Program Office, Reston, VA), and MICHAEL STEINACHER (Boeing Computer Services Co., Reston, VA) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 10 p
(AIAA PAPER 91-4075) Copyright
The Space Station Freedom (SSF) design review process is described. The SSF program background is summarized, and the program review management plan and organization are described. The technical approach of the Integrated System Preliminary Design Review (ISPDR) is examined along with the Review Item Discrepancy Tracking System. ISPDR results are summarized and compared with its objectives. Lessons learned for the future support of the management life cycle are addressed. C.D.

A92-32308
SYSTEM COMPARISON CONSIDERATIONS OF PRONOUNCED LONG-TERM PERSPECTIVES ON ENVIRONMENTALLY NEUTRAL SPACE FLIGHT - 'CAN THE LIMITS TO GROWTH BE OVERCOME'? [SYSTEMVERGLEICHSBETRACHTUNGEN AUSGEPRAEGTER LANGZEITPERSPEKTIVEN ZU EINER UMWELTNEUTRALEN RAUMFAHRT - 'SIND DIE GRENZEN DES WACHSTUMS UEBERWINDBAR'?]
HELMUT MENKE (Hermann-Oberth-Gesellschaft, Bremen, Federal Republic of Germany), HANS F. BEUSSE, and HANS J. MUELLER Astronautik (ISSN 0004-6221), vol. 28, Oct.-Dec. 1991, p. 113-117, 119. In German. Dec. 1991 6 p In GERMAN refs
Copyright
An environmentally neutral manned space flight system for the long term is described. The design, construction, and characteristics of this GEO-tower system are shown. Planning phases for the construction of the GEO-tower are addressed along with the needed energy supply. C.D.

A92-32452
COLUMBUS PROGRAMME OVERVIEW
FREDRIK ENGSTROM (ESA, Paris, France) (Columbus VII - Symposium on Space Station Utilization, 7th, Anacapri, Italy, July 1-6, 1991, Proceedings. A92-32451 12-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, p. 113-115. Apr. 1992 3 p
Copyright
An overall assessment of the current status of the Columbus Development Programme is presented. The original objectives and constraints emphasizing the latest activities and reorientations are discussed. Attention is given to the Precursor Flights Programme, showing that the users now have the possibility of becoming involved in the development program at an early stage, ensuring that their requirements can be taken into account, and that they are ready when Columbus is operational. R.E.P.

N92-12044# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany). Berichtsstelle.
THE COLUMBUS FREE FLYING LABORATORY: MECHANICAL DESIGN ASPECTS
JOACHIM GUELPIN (Erno Raumfahrttechnik G.m.b.H. Bremen, Germany, F.R.) 1991 10 p Presented at the ESA/ESTEC International Conference on Spacecraft Structure and Mechanical Testing, Noordwijk, Netherlands, 24-26 Apr. 1991
(MBB-UO-0152-91-PUB; OTN-016407; ETN-91-90190) Avail: CASI HC A02/MF A01
The Columbus Free Flyer has a 30 year mission in low Earth orbit with the primary objective to provide microgravity laboratory capabilities. The particular mechanical requirements resulting from the mission are explained. The relevant design features are presented and the verification approach envisaged in the development program which shall lead to a launch of the laboratory in 2001 is outlined. ESA

N92-13701# Southwest Research Inst., San Antonio, TX.
COMPUTER-AIDED ENGINEERING (CAE) TOOL ASSESSMENT/DEVELOPMENT Final Report, Sep. 1989 - Sep. 1990
JOSEPH N. BARFIELD, JOHN LILLEY, and KIM BARCLAY Sep. 1990 117 p
(Contract F19628-89-C-0207)
(AD-A241556; GL-TR-90-0296) Avail: CASI HC A06/MF A02
Computer Aided Engineering (CAE) tools in use by Spacecraft Designers are assessed by means of a distributed survey. The types of tools in use, the computer platforms and peripherals used, and the extent to which the tools are used are assessed. ESABASE is examined as a prototype integrated CAE package. Recommendations are made for future CAE tool development. The spacecraft designer faces a number of significant challenges that are unique to his field. The spacecraft designer must account for environmental rigors that are either unknown or insignificant at the earth's surface. In addition to creating a component or system to perform a specific function, the spacecraft designer must ensure that it will operate properly in the hostile space environment. The system must be thoroughly checked out to verify that it will survive and operate successfully in space and that the many possible interactions between the spacecraft and its environment are each either suppressed or made benign. GRA

N92-14927# Committee on Appropriations (U.S. Senate).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
In its Departments of Veterans Affairs and Housing and Urban Development and Independent Agencies Appropriations for Fiscal Year 1992, Part 2 p 297-395 1991
Avail: Committee on Appropriations, Senate, Washington, DC, 20510 HC free
Following opening statements of members of the subcommittee of the Senate Committee on Appropriations, the National Aeronautics and Space Administration presents its fiscal year 1992 budget. Previous and planned programs are discussed. It is noted that the entire NASA budget equals only a little over 1 percent of the total Federal budget, and that 99 percent of NASA's $15.8 billion is needed for ongoing programs. The subcommittee noted that Congress and the General Accounting Office use different standards in measuring science and space programs. Concern was expressed for the future impact of current science and space program underfunding. Questions submitted to NASA after the hearing, and their answers, are included in the record. Topics discussed include NASA's priorities, a strategic plan, budget reserves, the space station, shuttles, the advanced solid rocket motor, Mission to Planet Earth, a new launch vehicle, the Mars Observer, Landsat, education, communications, management, commerce, NASA field Center maintenance, and technology and information transfer. J.P.S.

N92-14929# Committee on Commerce, Science, and Transportation (U.S. Senate).
NASA'S PLAN TO RESTRUCTURE THE SPACE STATION FREEDOM

Washington GPO 1991 126 p Hearing before the Committee on Commerce, Science, and Transportation, 102d Congress, 1st Session, 16 Apr. 1991
(S-HRG-102-268; GPO-46-368; ISBN-0-16-036846-4) Avail: Subcommittee on Science, Technology, and Space, Senate, Washington, DC 20510 HC free; also available SOD HC $3.75 as 552-070-11444-1

Hearings before the Subcommittee on Science, Technology, and Space of the Senate Committee on Commerce, Science, and Transportation on NASA's plans to restructure Space Station Freedom are presented. This was a preliminary to the hearings on the overall NASA budget request for fiscal year 1992. All written testimony and submittals for the record are included. The hearings address the importance of good communication between: (1) NASA and the Congress on the costs of the Space Station; and (2) the U.S. and its international partners on any changes to the Space Station project. Statements on the new space station design were made by the Space Studies Board, National Academy of Sciences; the Space Station Science and Applications Advisory Subcommittee, Vanderbilt University; the Aerospace Medical Advisory Committee, Bethesda; the Planetary Society, Pasadena, CA; and the Space Policy Project Director, Federation of American Scientists, Washington, DC. J.P.S.

N92-15937# Committee of Conference (U.S. Congress).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION RESEARCH AND DEVELOPMENT
In its Making Appropriations for the Depts. of Veterans Affairs and Housing and Urban Development, and for Sundry Independent Agencies, Commissions, Corps., and Other Offices for the Fiscal Year Ending 30 Sep. 1992, and for Other Purposes p 51-61 1991
Avail: Document Room, House of Representatives, Washington, DC 20515 HC free

The Conference Committee presents its report on recommended appropriations for the National Aeronautics and Space Administration (NASA) for the fiscal year ending September 30, 1992. Items addressed by the Conference Committee include agreed upon changes, amendments, funding by program, and decisions that the Committee made regarding differences. Both NASA's ongoing programs and new initiatives are included in the list of appropriations considered. J.P.S.

N92-17108*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A HISTORICAL PERSPECTIVE ON SPACE STATION
W. RAY HOOK *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 1: Space Station Freedom, Part 1 p 203-235 Sep. 1991
Avail: CASI HC A03/MF A03

The historical development of space stations is presented through a series of various spacecraft configurations including: (1) Salut 6; (2) Skylab; (3) the Space Operations Center (SOC); (4) the Manned Science and Applications Space Platform; (5) Space Station Freedom; and (4) the Mir Space Station. K.S.

N92-17110*# National Aeronautics and Space Administration, Washington, DC.
SPACE STATION FREEDOM ENGINEERING PROTOTYPE DEVELOPMENT
ALAN FERNQUIST *In its* Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 1: Space Station Freedom, Part 1 p 255-292 Sep. 1991
Avail: CASI HC A03/MF A03

The content of the Advance Development Program and subsequent Engineering Prototype Development activity has been guided by a series of focused studies. These studies started with the report of the Advance Development Task Force. An outline of issues relating to Automation, Data Systems, and Telerobotics was projected for the Space Station. Subsequent studies built upon and reaffirmed a focus on development and prototyping of Automation Technology for subsystem monitoring and problem diagnosis, Data System growth to accommodate more sophisticated automation, and use of Telerobotics technology to assist in the reduction ot required ExtraVehicular Activity (EVA) and IntraVehicular Activity (IVA) task time. Author

N92-17112*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EVOLUTION DESIGN REQUIREMENTS AND DESIGN STRATEGY
DONALD W. MONELL *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 1: Space Station Freedom, Part 1 p 309-347 Sep. 1991
Avail: CASI HC A03/MF A03

Evolution of Space Station Freedom is justified for reasons which vary from more effectively utilizing the manned base to providing a means for incorporating new technologies as they become available. Increasing or, more importantly, balancing the resources that are provided to the users is very critical to effectively utilizing the station. At permanently manned phases of the program, there will be four crew members that will be supporting and monitoring three laboratories. Accepted user mission databases have shown a demand for more crew, power, and volume than is provided by the baseline. As the work done in space by NASA continues to expand, the station will take a more active role in the missions. New functionalities for its operation and support of other missions will be required. One important driver for growth, particularly in the area of structures, is the inability of the baseline configuration to store all the Orbital Replacement Units (ORU) spares that will be required on orbit. New technologies drive growth by providing a means of streamlining operations and possibly reducing the demand on ExtraVehicular Activity (EVA). They will also ensure that the station does not become plagued with obsolete equipment. Author

N92-17413*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EVOLUTION USER REQUIREMENTS FOR THE RESTRUCTURED SPACE STATION
K. LEATH (McDonnell-Douglas Space Systems Co., Washington, DC.), R. J. SAUCILLO (McDonnell-Douglas Space Systems Co., Washington, DC.), and B. D. MEREDITH *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 1: Space Station Freedom, Part 2 p 417-447 Sep. 1991
Avail: CASI HC A03/MF A03

Space Station Freedom (SSF) is designed to be an Earth orbiting multidisciplinary R&D facility capable of evolving to accommodate a variety of potential uses. In order to identify SSF evolution requirement and define potential growth configurations, NASA-Langley is analyzing user resource requirements for the post-PMC time frame. The analysis goal is to define resource levels, including crew, power, and volume, which allow full utilization of SSF capabilities commensurate with minimum essential user requirements. Multiple scenarios were studied including core R&D and combined SEI plus R&D utilization. An analysis is presented of a core R&D utilization scenario. Included are discussions of resource allocation assumptions for specific R&D disciplines, user requirements trends, and growth resource projections. These preliminary results show total resource requirements of 13 crew, 150 kW power, and additional lab volume equivalent to a second U.S. lab module. Additionally, orthogonal growth structure was identified as required to support SSF systems and users. Author

N92-18309# Committee on Appropriations (U.S. House).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
In its Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Bill, 1992 p 63-67 3 Jun. 1991
Avail: Document Room, House of Representatives, Washington, DC 20515 HC free

The House of Representatives Committee on Appropriations recommended a total appropriation for the National Aeronautics and Space Administration (NASA) of 13,651,117,000 dollars in fiscal year 1992, which represents a reduction of 2,070,148,000

dollars below 1991. Funding was suspended for the space station program. Details are given for appropriations in research and development; space flight, control, and data communications; construction of facilities; research and program management; and the Office of Inspector General. Author

N92-19531# European Space Agency, Paris (France).
LASER TECHNOLOGY FOR SPACE TASKS
UWE BRAUCH (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (Germany, F.R.).), WOLFGANG SCHALL (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (Germany, F.R.).), GERHARD SPINDLER (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (Germany, F.R.).), WOLFRAM WITTWER (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (Germany, F.R.).), and EBERHARD ZEYFANG (Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Stuttgart, Germany, F.R.) Aug. 1991 42 p Transl. into ENGLISH of Lasertechnologie fuer Raumfahrtaufgaben (Stuttgart, Fed. Republic of Germany, DLR), 1990 114 p Original language document was announced as N91-12080
(ESA-TT-1246; DLR-FB-90-10; ETN-92-90746) Avail: CASI HC A03/MF A01; original German version available from DLR, Wissenschaftliches Berichtswesen, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, HC 41.50 DM

The use of lasers for a large variety of tasks in space is discussed. Its contribution to energy supply, to transportation and to debris elimination is considered. It is decided that the use of lasers could grow greatly in significance, particularly with an increasing utilization of space up to its industrialization. It is found that laser technology is a universally applicable technology with a high potential for the future in this area. Corresponding research and development work should therefore be started today. ESA

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.

A92-10667
LOST IN SPACE
TIM FURNISS Flight International (ISSN 0015-3710), vol. 140, Oct. 2, 1991, p. 43-45. 2 Oct. 1991 3 p
Copyright

A report is presented on the new concepts and directions currently under evaluation for the Soviet commercial space programs. Consideration is given to the commercial launch contracts that would be the most effective way to raise hard currency, including launch vehicles such as Cosmos, Vostok, Soyuz, and Proton, plus converted military missiles. Attention is given to the continuing manned flights to the Mir space station and the possible continuation of plans to fly Energia boosters with the Buran shuttle. R.E.P.

A92-11881
SOVIET SPACE AT THE CROSSROADS
LUCIEN VAN DEN ABEELEN Spaceflight (ISSN 0038-6340), vol. 33, Nov. 1991, p. 387-390. Nov. 1991 4 p refs
Copyright

New space projects planned for the next decade by Soviet scientists and engineers focusing on the exploitation of microgravity and the unique vantage point offered by space-based platforms are presented. Studies of natural resources and earth observation are planned in the framework of an international program. Consideration is given to various other projects involving geophysical experiments, biology, technology and biotechnology, and space technology. R.E.P.

A92-12477
THE SPACE STATION FREEDOM MOBILE SERVICING SYSTEM - THE CHALLENGE OF MANAGING IN CHANGING TIMES
W. M. EVANS (Canadian Space Agency, Ottawa, Canada) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 4 p. Oct. 1991 4 p
(IAF PAPER 91-065) Copyright.

The status of the project is reported with particular attention given to three significant circumstantial changes that have affected the context of the program. The restructuring of the international effort on Space Station Freedom includes a reconfiguration that impacts the design of key elements of the Mobile Servicing System (MSS). The Mobile Servicing Center Base System requires a separate launch, and the Remote Manipulator System is launched ahead of the final control workstation. The Special Purpose Dextrous Manipulator is subject to potential changes including managing all on-board robotics, and enhanced collision-detection capabilities are required. A view of the project is given with respect to the economic recession in Canada and the formation of the Canadian Space Agency, but the role of the country is essentially the same with respect to the MSS and the Space Station Freedom. C.C.S.

A92-12478
THE JAPANESE EXPERIMENT MODULE FOR SPACE STATION FREEDOM
K. IDA (Science and Technology Agency, Tokyo, Japan), H. MURAYAMA, and Y. HORIKAWA (NASDA, Tokyo, Japan) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 6 p. Oct. 1991 6 p
(IAF PAPER 91-066) Copyright

The development of the Japanese Experiment Module (JEM) is examined with specific reference to proposed areas of investigation and their corresponding levels of preparation. The organization of the Space Station program in Japan is described to establish the financial and philosophical context of the JEM. JEM is developed according to operational requirements with the User Support Center which encompasses payload integration, training and logistics support facilities, and an information network system. The Space Station Integration and Promotion Center supports the activities for both JEM and Space-Station preparation. The utilization of JEM is proposed for observational, technological, and life science applications of interest to the general scientific community. The restructuring of the international Space Station project is concluded to have a significant impact on the development and scope of JEM. C.C.S.

A92-12479
THE COLUMBUS PROGRAMME
L. EMILIANI (ESA, Paris, France) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 15 p. Oct. 1991 15 p
(IAF PAPER 91-067) Copyright

The development of the Columbus program of manned spaceflight is reviewed with attention given to the initiation of the second and final phase and the evolution of the technical baseline. Treatment is given to the strategy of reducing the length of the Attached Laboratory and introducing design trade-offs to optimize the Free-Flyer configuration and corresponding service requirements. Subsystem modifications are also outlined including features of the Resource Module, the Polar Platform, and the manned elements of the ground-based mission-control centers. The previewed operations program for the Columbus program includes Initial Operations Preparation and Initial Utilization Preparation in which readiness is assured and the payload structure is integrated. Precursor flights of the Columbus are planned for 1995-7, and target dates for implementing the Attached Laboratory and the Free-Flyer are tentatively proposed. C.C.S.

A92-12485
JEM TECHNOLOGY DEVELOPMENT
KUNIAKI SHIRAKI, FUMIO OTSUKI, KAZUYUKI TASAKI, NAOKI SATO (NASDA, Tokyo, Japan), NOBUYUKI TOMITA, HIROJIROU SHIOZAWA, and NOBUJI NISHINO (Mitsubishi Heavy Industries, Ltd., Nagoya, Japan) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 14 p. Oct. 1991 14 p
(IAF PAPER 91-076) Copyright

An overview is presented of the current status of the Japanese Experiment Module (JEM) and the major on-going technology developments. JEM is a multipurpose research and experiment laboratory in space to be permanently attached to the U.S. Space Station Freedom. The major elements of the laboratory are the pressurized module, the exposed facility, the experiment logistics module-pressurized section, the experiment logistics module-exposed section, and the remote manipulator system. Attention is given to the electrical power system, the environment control and life support systems, flight application software, and the payload attach mechanism. R.E.P.

A92-12486
COLUMBUS ATTACHED LABORATORY BASELINE DESIGN AND DEVELOPMENT PROGRAMME
PATRICE AMADIEU, FABRIZIO FELICI (ESTEC, Noordwijk, Netherlands), and LUIGI D'EMILIANO (Alenia Spazio S.p.A., Turin, Italy) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 14 p. Oct. 1991 14 p
(IAF PAPER 91-077) Copyright

The paper describes the current architecture of the Columbus Attached Laboratory, the major interface features to the Space Station Freedom (SSF), following the NASA 1990 SSF restructuring exercise, with special attention given to the impact of the SSF restructuring on the Attached Laboratory. Consideration is given to the physical configuration and layout in the Attached Laboratory, the internal architecture and layout, the functional architecture, the Data Management System, the Environmental Control and Life System, the Software/Information Management System. Also discussed are the payload capabilities of the Laboratory. Diagrams of the Columbus Attached Laboratory, its functional architecture and data management are included. I.S.

A92-12487
THE EUROPEAN FREE-FLYING LABORATORY OF THE INTERNATIONAL SPACE STATION FREEDOM PROGRAMME
PETER WOLF and RUDI SELG (ESA, Columbus System and Projects Dept., Noordwijk, Netherlands) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p
(IAF PAPER 91-078) Copyright

The ESA Free-Flying Laboratory of the International Space Station Freedom Program is described in relation to the future user community. The Man-tended Free-flyer (MTFF) is designed as an orbiting laboratory for internal and external microgravity and observational, scientific, and applications payload, with periodic manned access by the European HERMES space transportation system, or the NASA Space Shuttle as a back-up servicing mode. MTFF will be unmanned during selectable periods of main payload operations, but robot means will support the payload. The MTFF/Hermes is to become operational after the turn of the century. Consideration is given to the MTFF mission, system and subsystem, payload support features, and programmatics. P.D.

A92-12488
THE MINI PRESSURIZED LOGISTICS MODULE - A CANDIDATE ELEMENT FOR ITALIAN PARTICIPATION IN THE SPACE STATION FREEDOM LOGISTICS SCENARIO
LUCIANO BASILE (Alenia Spazio S.p.A., Turin, Italy) and GIOVANNI RUM (ASI, Rome, Italy) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 10 p. Oct. 1991 10 p
(IAF PAPER 91-079) Copyright

A design concept for the Mini Pressurized Logistics Module (MPLM) is presented and described in terms of NASA requirements, operations scenarios, and the MPLM systems and architecture. After introducing the basic MPLM elements the seven operational phases are detailed from prelaunch through revalidation. Element requirements and the MLPM architecture are analyzed, and estimates are given of the MPLM sizing and the mass and power budgets. The sizing satisfies the 8-rack and commonality requirements with two racks per side and a grapple fixture for on-orbit transfer. The subsystems include a thermal control system, environmental control and life-support systems, data management, audio/video, and a caution and warning system. The configurations, architecture, and mass and power data suggest that the MPLM is an effectively designed candidate element for the SSF logistics scenario. C.C.S.

A92-12492
SYSTEM DESIGN OF THE COLUMBUS MANNED FLIGHT CONFIGURATIONS
G. SCHNEIDER (MBB-ERNO, Bremen, Federal Republic of Germany) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. Research supported by ESA. Oct. 1991 12 p
(IAF PAPER 91-085) Copyright

The manned elements of the Columbus orbital infrastructure consist of two independent but related in-orbit laboratories: the Attached Laboratory (attached to the Space Station Freedom) and the Free Flying Laboratory. The Attached Laboratory will be launched by the Space Shuttle and joined with elements built in the United States, Japan, and Canada, to form the manned core of the Space Station. The Free Flying Laboratory will by launched by Ariane 5 and will be serviced by Hermes for maintenance and payload exchange every 5 years. The paper describes the overall concepts of the two Columbus laboratories and the details of the system's architecture. I.S.

A92-12500
STATUS OF JAPANESE EXPERIMENT MODULE OPERATIONS PROJECT
HIDESHI KOZAWA, YOSHIYUKI HASEGAWA, SHOJI MATSUBARA, and TORU OHUE (NASDA, Tokyo, Japan) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p
(IAF PAPER 91-094) Copyright

The development of the Japanese Experiment Module (JEM) is described with attention given to the operational systems, structures, and status. The 2D-matrix Work Breakdown Structure (WBS) is introduced to analyze the operations of the JEM and improve the efficiency of operational management. The 2D WBS comprises a WBS based on JEM operations system functions and a work-type WBS; functions of the major systems are listed, and reports are given on the major topics of JEM operations project. Issues of operational systems addressed include engineering support, logistics support, launch-site planning, and the crew-training system. The computer algorithm for JEM operations is introduced, and work is discussed for weightlessness training and facilities development. It is concluded that multilateral operations concepts are important for efficient development and use of module and space-station concepts. C.C.S.

A92-12554
HERMES - A FLEXIBLE SPACE SHUTTLE FOR STATIONS IN LOW EARTH ORBIT
P. MOSKWA, F. DI MAURO, and J. SIMON (ESA; CNES, Toulouse, France) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 8 p. Oct. 1991 8 p
(IAF PAPER 91-175) Copyright

A status report of the Hermes system including the main mission objectives is presented with emphasis on the servicing of the Columbus Free Flyer and flexibility of the system to cope with other missions such as those to the Freedom and Mir space stations. The system and space vehicle architectures selected on the basis of the trade-offs conducted during the 1987-1991 definition phase are described. Design solutions proposed for the

reusable manned space vehicle with associated technological choices, robotics and extra vehicular means, and for the launch and landing facilities, and mission control are discussed. R.E.P.

A92-12853
MICROGRAVITY SCIENCE ACTIVITIES IN CANADA
M. Z. SAGHIR and B. WETTER (Canadian Space Agency, Ottawa, Canada) IN: AIAA/IKI Microgravity Science Symposium, 1st, Moscow, USSR, May 13-17, 1991, Proceedings 1991 7 p
Copyright

The User Development Program (UDP) aimed at maximizing scientific knowledge obtained from microgravity experiments conducted on aircraft, rocket, Space Shuttle, and MIR flights is reviewed. The UDP areas of research include metals and alloys, glasses, composites, crystal growth of semiconductor materials and biological materials, fluid physics, and laser material processing. Also discussed are hardware developments, a parabolic flight program, a rocket program, and experiments on board the Space Shuttle and Space Station MIR. O.G.

A92-13466
PREPARING EUROPE'S SPACE FUTURE
BERTRAND DE MONTLUC (CNES, Service des Analyses Economiques et Politiques, Paris, France) Space Policy (ISSN 0265-9646), vol. 7, Nov. 1991, p. 285-288. Nov. 1991 4 p
Copyright

Europe has already acquired and demonstrated its capabilities in all the more traditional areas of space exploration except for manned flights (and military applications). At the Hague in 1987 Europe decided to acquire the capability to conduct manned missions and to obtain a working knowledge, under certain conditions, of how people live and work in space. This Viewpoint looks at the prospects for this initiative in the light of recent international developments. Author

A92-13467
ESA MINISTERIAL MEETING - CONSENSUS OR CONFRONTATION?
PETER CREOLA (Eidgenoessiches Departement fuer auswaertige Angelegenheiten, Bern, Switzerland) Space Policy (ISSN 0265-9646), vol. 7, Nov. 1991, p. 289-294. Nov. 1991 6 p
Copyright

This article looks at the issues facing the ESA ministerial meeting of November 1991. The background to European space collaboration is outlined, and the current position on the Hermes and Columbus programs is described. The financial overrun of the Hermes program is referred to and set in the context of the overall financial problems facing the ministers. Finally, possible areas of saving are highlighted. Author

A92-13468
WHERE IS EUROPE'S PLACE IN SPACE?
REIMAR LUEST (Max-Planck-Institut fuer Meteorologie, Hamburg, Federal Republic of Germany) Space Policy (ISSN 0265-9646), vol. 7, Nov. 1991, p. 295-299. Nov. 1991 5 p
Copyright

The long-term plans and commitments of the ESA are discussed in the light of economic considerations, the uncertainty of global cooperation, and the evolving aims of the European countries. A proposed ESA long-term plan is developed based on a balance between the user program and in-orbit and ground infrastructure, and the program is dedicated to space science, microgravity research, earth observations, and telecommunications. The proposal minimizes the importance of manned spaceflights, international cooperation, and fixed scheduling. C.C.S.

A92-18000
SPACE FOR PEACE AND PROGRESS - 41ST INTERNATIONAL ASTRONAUTICAL CONGRESS OF THE IAF, DRESDEN, FEDERAL REPUBLIC OF GERMANY, 1990
JAMES HARFORD, ED. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, 81 p. No individual items are abstracted in this volume. 1991 81 p
Copyright

This report presents papers in the fields of astrodynamics, automation and robotics, the commercialization of space, lunar and Mars exploration, and materials and structures. Also considered are microgravity sciences and processes, solar system exploration, space-based astronomy, space law, and space transportation. R.E.P.

A92-20585
EUROPEAN SPACE STATION - AN AFFORDABLE AND INCREMENTAL DESIGN APPROACH
ROBIN C. HUTTENBACH (Nelson Space Services, Ltd., London, England) and DAVID A. NIXON (Future Systems Consultants, Los Angeles, CA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 15 p. Oct. 1991 15 p refs
(IAF PAPER 91-629) Copyright

A design approach and phased assembly sequence for a proposed European Space Station are presented. The configuration architecture is assembled from a series of building-block elements which are delivered to orbit in an established sequence lasting several years. This proposed Space Station configuration is deemed to be a feasible concept and has demonstrated considerable flexibility in its capacity to accommodate alterations and suggested improvements during the course of initial studies. R.E.P.

A92-20641
PROSPECTS FOR SPACE COOPERATION - A REALISTIC ASSESSMENT
JOHN M. LOGSDON (George Washington University, Washington, DC) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. Oct. 1991 12 p refs
(IAF PAPER 91-710) Copyright

Prospects for international and intergovernmental cooperation as an important aspect of U.S. space activities have been analyzed. Particular attention is given to current U.S. policy objectives with respect to space cooperation and assessment of the current experience with cooperative programs. O.G.

A92-21259
THE MOON AND MARS MISSIONS - CAN INTERNATIONAL LAW MEET THE CHALLENGE?
CARL Q. CHRISTOL (Southern California, University, Los Angeles, CA) Journal of Space Law (ISSN 0095-7577), vol. 19, no. 2, 1991, p. 123-135. 1991 13 p refs
Copyright

An overview is presented of the international legal issues confronting the future of space stations, an aerospace plane, the Shuttle, and the proposed human presence on celestial bodies relevant to the moon and Mars missions. Even with a scaled-down approach to operational space stations, there will be continuing involvements in technology and science, commercial undertakings and the requirement for appropriate defense policies. It is anticipated that practical operations will seek the combined participation of international governmental organizations, governments, and commercial firms. From the legal point of view the most important issue will be to establish the appropriate jurisdictional areas for the various participants. R.E.P.

A92-22486
SPACE ACTIVITIES BEYOND EARTH ORBIT - A CHALLENGE FOR INTERNATIONAL COOPERATION
H. SAX, M. BAUMGART, and R. SCHMID (DLR, Cologne, Federal Republic of Germany) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p refs
(IAF PAPER 91-711) Copyright

The paper addresses the factors involved in the international cooperation programs for outer space activities. Two different scenarios are considered: a conventional scenario which is developed as an extrapolation from today's space activities; and an advanced scenario which includes, in addition to conventional

activities, potential new space activities in fields not yet developed. The elements discussed for the conventional scenario are the satellite launches into GEO, launches of Space Station elements, and logistic missions to space stations (the Space Station Freedom, Mir, Columbus, and follow-on missions). The elements discussed for the advanced scenario include those related to the manned missions to moon and Mars, industrial space processing, utilization of extraterrestrial materials, and development of solar-power satellites. I.S.

A92-28767
CROSSROADS IN SPACE
DUNCAN LUNAN (Association in Scotland to Research into Astronautics, Ltd., Glasgow) and BILL RAMSAY Space Policy (ISSN 0265-9646), vol. 8, Feb. 1992, p. 3-8. Feb. 1992 6 p refs
Copyright

A comparison is made between the potential collaboration of the former Soviet Union's space program with the U.S. space program and that of the former USSR and the ESA. Attention is given to the problems associated with both joint efforts such as the protectionist policies of the U.S. space program and the ESA's financial problems. It is suggested that the Russian and Kazakh republics could join the ESA and develop a highly competitive space infrastructure and program that could be beneficial to the U.S. as well. C.C.S.

A92-29419
GERMAN ASTRONAUTS ON NEW MISSIONS [DEUTSCHE ASTRONAUTEN AUF NEUEN MISSIONEN]
Luft- und Raumfahrt (ISSN 0173-6264), vol. 13, Jan.-Feb. 1992, p. 28-31. In German. Feb. 1992 4 p In GERMAN
Copyright

The participation of German astronauts in the Mir '92 mission is discussed. The cooperation of the astronauts performing the tasks of Mir '92 with NASA's International Microgravity Laboratory is addressed, and the German astronaut selection process is reviewed. C.D.

A92-30683
THE ROLE OF MAN IN SPACE
E. MESSERSCHMID (Stuttgart, Universitaet, Federal Republic of Germany) (IAA, Man in Space Symposium, 9th, Cologne, Federal Republic of Germany, June 17-21, 1991) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 16, no. 1, 1992, p. 1-7. 1992 7 p
Copyright

It is discussed to what extent risks generally have to be accepted in manned space flight. Trade-offs are considered such as manned versus automated space flights, mission to planet earth versus manned mission from planet earth, the technology base and the future earth-to-space transportation systems. Author

A92-32464
USO CONCEPT IN THE MEMBER STATES - GERMANY
K. WITTMANN and M. GAIDA (DLR, Cologne, Federal Republic of Germany) (Columbus VII - Symposium on Space Station Utilization, 7th, Anacapri, Italy, July 1-6, 1991, Proceedings. A92-32451 12-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, p. 209-212. Apr. 1992 4 p
Copyright

A review is presented of the German Microgravity User Support Center (MUSC) that offers support for preparation, operation, and evaluation of microgravity experiments. For multiuser experiment facilities MUSC acts as a facility responsible user support and operations center. The functions of MUSC user support include a ground support program, a mission support program, a scientific support program, and user information and promotion. R.E.P.

A92-32465
COLUMBUS USER SUPPORT ORGANIZATION CONCEPT IN ITALY
A. LORIA (ASI, Rome, Italy), C. MIRRA, and L. D'ANGELO (Microgravity Advanced Research and Support Center, Naples, Italy) (Columbus VII - Symposium on Space Station Utilization, 7th, Anacapri, Italy, July 1-6, 1991, Proceedings. A92-32451 12-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, p. 213-218. Apr. 1992 6 p refs
Copyright

A review is presented of work currently being done by the Italian Space Agency with support from the Microgravity Advanced Research and Support Center for Columbus utilization in Italy. At the operating level Italy is planning to exploit some already existing facilities to establish the user support infrastructure necessary to support users in all the disciplines of interest. Attention is given to the national user support concept, an overview of national centers, and a national user support scenario. R.E.P.

A92-32466
USO CONCEPT IN THE MEMBER STATES - BELGIUM
M. C. LIMBOURG (Bruxelles, Universite Libre, Brussels, Belgium) (Columbus VII - Symposium on Space Station Utilization, 7th, Anacapri, Italy, July 1-6, 1991, Proceedings. A92-32451 12-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, p. 221-224. Apr. 1992 4 p
Copyright

The Belgian interest in space activities is reviewed with particular emphasis placed for scientific space research. Consideration is given to Belgian participation in Columbus, the Belgian Institute of Space Aeronomy, development of a space research program in light of Columbus utilization, and the Belgian user support organization. R.E.P.

A92-32467
USO CONCEPT IN THE MEMBER STATES - THE NETHERLANDS
F. B. VISSER (National Aerospace Laboratory, Emmeloord, Netherlands) (Columbus VII - Symposium on Space Station Utilization, 7th, Anacapri, Italy, July 1-6, 1991, Proceedings. A92-32451 12-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, p. 225-227. Research supported by Netherlands Agency for Aerospace Programs. Apr. 1992 3 p
(Contract ESA-9465/91/F/HEW)
Copyright

User support for microgravity experimentation is currently under development in The Netherlands. A national User Support Organization is emerging, based on a central Dutch Utilization Center (DUC) at the NLR premises in the Northeast Polder, and several 'locations of expertise' and 'locations of facilities' at national industries, national research laboratories, or at ESTEC. The initial development of the Dutch User Support Organization is foreseen to be performed in parallel with the development and implementation of Dutch experiments in the Columbus precursor missions, thereby setting a target for user support as well as a time scale for the availability of user support. Author

A92-32468
USO CONCEPT IN THE MEMBER STATES - DENMARK
THOMAS A. E. ANDERSEN (Damec Research A/S, Copenhagen, Denmark) (Columbus VII - Symposium on Space Station Utilization, 7th, Anacapri, Italy, July 1-6, 1991, Proceedings. A92-32451 12-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, p. 229-233. Apr. 1992 5 p
Copyright

User support for space experimentation already exists in Denmark. Currently, several experimenters in various fields are supported in Denmark. A national user support structure is emerging, based on two support centers (USOC, primarily involved in space science, plus a support center for human physiology and other life science research), and a national coordination center. The prospects for space experiments in Denmark seem promising with regard to the pre-cursor flights. Support for promotion,

familiarization, and experiment proposals has already been given to Danish scientists. Author

A92-32469
SWEDISH USER SUPPORT FOR COLUMBUS
ERIK TILLBERG and CHRISTIAN LOCKOWANDT (Swedish Space Corp., Solna, Sweden) (Columbus VII - Symposium on Space Station Utilization, 7th, Anacapri, Italy, July 1-6, 1991, Proceedings. A92-32451 12-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, p. 235-238. Apr. 1992 4 p
Copyright

A review is presented of the national user support organization currently under development in Sweden to support experimenters and payload developers in their Columbus and related activities. From the user support and operations center and the interconnected user home bases it will be possible to perform experimental operations of payloads accommodated inside multiuser facilities and operation of experiments utilizing dedicated hardware. The functions of the user support and operations center also include administration, familiarization, and verification support to both the payload developers and experimenters. R.E.P.

A92-32470
USO CONCEPT IN THE MEMBER STATES - NORWAY
TOR-HENNING IVERSEN (Trondheim, University, Norway) (Columbus VII - Symposium on Space Station Utilization, 7th, Anacapri, Italy, July 1-6, 1991, Proceedings. A92-32451 12-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, p. 239-242. Apr. 1992 4 p
Copyright

A preliminary organization plan for a Norwegian Utilization Center (N-USO) is reviewed and the final plan for a proposed Norwegian Space Center is discussed. The concept of the N-USO calls for implementation to be performed progressively in a structured manner and in a way closely related to the plans for national and ESA-USOC's in the member states. R.E.P.

N92-10029# Norwegian Space Center, Oslo.
ACTIVITIES REPORT OF THE NORWEGIAN SPACE CENTER
Annual Report, 1990
1990 17 p
(ETN-91-90052) Avail: CASI HC A03/MF A01

The activities of the Norwegian Space Center during 1990 are presented. The management and organization of the Space Center is introduced, key figures from annual accounts are presented, and a report by the board of directors or the 1990 activities, the Tromso satellite station and future space plans is given. The contracts obtained by Norwegian companies active in space are considered. Reflections on the work of the Norwegian Space Center and Norwegian companies in telecommunications, connected to the Columbus Free Flying Laboratory, space transport, Earth observation and Space research are given. The activities of Andoya Rocket range, one of Norway's high technology companies are considered, as are the Earth observation activities of the Tromso (Norway) satellite stations. ESA

N92-15961# European Space Agency, Paris (France).
ACTIVITIES REPORT OF THE EUROPEAN SPACE AGENCY
Annual Report, 1990
NORMAN LONGDON, ed. and T. D. GUYENNE, ed. 1991 217 p Original contains color illustrations
(ISSN 0258-025X)
(ETN-92-90679) Copyright Avail: CASI HC A10/MF A03

The scientific and technical projects developed by ESA in 1990 are summarized. The following programs are discussed: Hubble Space Telescope, Ulysses, solar observatory, Giotto mission, Huygens mission, Earth observation, telecommunication, Columbus, microgravity, and European astronauts corps. The results from scientific and technological research are presented. Data handling and technical infrastructure facilities, which are ESA basic activities, are included. Concerning the installations, the following projects are discussed: ESAMET, computer systems, ground facilities for space systems, mission support, satellite operations, and ESA establishments. The ESA administrative organization and structure are summarized. ESA finance, contracts and international relations are reported. ESA

N92-17100*# European Space Agency, Paris (France).
COLUMBUS PROGRAMME (CURRENT STATUS)
In NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 1: Space Station Freedom, Part 1 p 21-37 Sep. 1991
Avail: CASI HC A03/MF A03

A description is presented for the Columbus Program. The Columbus program comprises a space segment, a ground segment, and operations preparation program, and a utilization preparation program. The space segment consist of three elements: an Attached Pressurized Module (APM); a Man Tended Free Flyer (MTFF); and a Polar platform (PPF). The ground segment is a program shared with other European programs such as Hermes, for communications, services, training and tracking facilities. The Operations preparation program focuses on preparing the ground segment for readiness for the launch of the space segment elements. And the Utilization preparation program includes definition of candidate payload facilities, initial payload selection and precursor flights (Eureca, Spacelab). Author

03

MANAGEMENT SYSTEMS AND LOGISTICAL SUPPORT

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

A92-12443
TOWARDS A TELESCIENCE PROGRAM FOR COLUMBUS
CHR. JUNGIUS, K. WITTMANN (DLR, Cologne, Federal Republic of Germany), F. LIMBURGER, and J.-CL. DEGAVRE (ESTEC, Noordwijk, Netherlands) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 7 p. Oct. 1991 7 p refs
(IAF PAPER 91-022) Copyright

A concept is presented for the stepwise implementation of telescientific services on the Columbus missions based on the Texus sounding rockets, the Holop Holographic Interferometer, and the ESA telescience testbed. The user requirements of the telescience operations are listed, and the Telex development proposal is outlined with specific requirements for decentralized operations. Several key engineering and operations issues to be addressed are identified including generic telescience tools, video system, real-time data processing, and a ground-network infrastructure. C.C.S.

A92-12444
TELESCIENCE WITH MARCO/HOLOP ON BOARD THE SPACELAB D2-MISSION AS A PREPARATION FOR COLUMBUS
E. BENNETT, K. HEIMANN, D. HEYLAND, K. D. SCHMIDT (DLR, Cologne, Federal Republic of Germany), W. GEIST (DARA GmbH, Bonn, Federal Republic of Germany), and G. HIBSCH (DLR, Oberpfaffenhofen, Federal Republic of Germany) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 11 p. Oct. 1991 11 p
(IAF PAPER 91-023) Copyright

As a preparation for Columbus mission, a fluid physics experiment called MARCO (Marangoni Convection in an open boat) will be performed in the telescience mode using the HOLOP-D2 (Holographic Optics Laboratory) experimental facility. The facility and the experiment are described along with the functions of the telescience ground segment, indicating the main participants, project status, measurement methods, and ground interfaces. The

main implementations at the German Space Operations Center are outlined, and mission assurance and safety considerations are addressed. C.D.

A92-12446
P/L OPERATIONS AND TELESCIENCE
J. TAILHADES and C. GRAULLE (Matra Marconi Space France, Toulouse) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 11 p. Oct. 1991 11 p refs
(IAF PAPER 91-025) Copyright

The role of a telescience test bed in the Columbus project is discussed. Emphasis is given to the activities of the Payload Operation and Coordination Center and the Users Support Operation Center, the Telecommand/Telemetry Unit, and the Standard Acquisition Unit. The mission preparation, mission execution, and mission analysis phases of the telescience activity are described, and the first results from the test bed are discussed. C.D.

A92-12482
SPACE STATION FREEDOM RESOURCE NODES
T. P. SAPP, J. S. RAECKER, H. A. CASTRO, and G. C. BOHN (McDonnell Douglas Space Systems Co., Space Station Div., Huntington Beach, CA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 15 p. Oct. 1991 15 p
(IAF PAPER 91-073) Copyright

The Space Station Freedom resource nodes provide primary and backup command, control, and communication centers for the station, as well as berthing, utilities connectivity, and passage between the attached pressurized modules and the orbiter. Functional requirements and allocations for the nodes are presented, including provisions for meeting failure tolerance/redundancy management (FT/RM) requirements. Separated redundant strings within the first node contribute to single failure tolerance for critical functions. A second control node provides an added command interface. Layouts and diagrams of the nodes are presented, including design rationale. Within each node up to four functional rack positions provide accommodation of command, control, and other equipment for the operation of the station. The design features tilt-out avionics racks and workstations, including provisions for maintenance access. A common interface pattern is defined for attaching elements.
Author

A92-12498
TIME-DELAYED REMOTE OPERATION AND MAINTENANCE OF SPACE STATION FREEDOM
DAVID G. HUNTER, Z. A. WOJCIK (Canadian Space Agency, Ottawa, Canada), and DAVID G. COOKE (Spar Aerospace, Ltd., Weston, Canada) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. Oct. 1991 12 p refs
(IAF PAPER 91-092) Copyright

The need for extensive ground support and continuous parallel activities during rest periods, as well as while preparing for EVA, presents a formidable time-scheduling problem for NASA's Space Station Freedom (SSF). Attention is presently given to an operational concept which employs ground control of SSF devices ranging from cameras to manipulators; possible solutions to the technical problems associated with time-delayed remote control are discussed. Ground control of robotic devices furnishes a major advantage in using available time between assembly flights and in assigning astronaut time more efficiently when they are on the SSF. O.C.

A92-12502
LOGISTIC VEHICLE APPROACH FOR SPACE STATIONS SUPPORT
P. ZGIRSKI, M. GRIMARD (Aerospatiale, Division Systemes Strategiques et Spatiaux, Les Mureaux, France), E. DEMCHENKO, and V. BOBKOV (NPO Energiia, Moscow, USSR) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 11 p. Research supported by Aerospatiale. Oct. 1991 11 p refs
(Contract ESA-9311/91/F/BZ)
(IAF PAPER 91-097) Copyright

Results are presented of two studies initiated to define an automatic logistic vehicle (Love) capable to support a space station in LEO. Starting from an analysis of logistic requirements for a future European manned space infrastructure, logistic scenarios are developed addressing the logistics sharing between the possible carriers. The various Love concepts associated with these scenarios are described, and these scenarios and concepts are compared on the basis of operational flexibility, possible service to users, and cost. I.S.

A92-12503
TV OPERATION CAPABILITIES AND RECOMMENDATIONS FOR THE NEXT DECADES
A. FLOETE (MBB-ERNO, Bremen, Federal Republic of Germany) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 11 p. Oct. 1991 11 p refs
(IAF PAPER 91-098) Copyright

A review is presented of the emerging capabilities of computer animated video scenes. The advantages of the proposed use of video simulation are described along with the logical and technical frontiers of such systems. It is indicated that the implementation of 3D objects in a realistic environment prior to the real hardware becoming available, can provide the operator with an early and precise definition of system and payload operations. R.E.P.

A92-12505* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
SPACE STATION FREEDOM PAYLOAD OPERATIONS IN THE 21ST CENTURY
C. S. GRINER and S. R. NONEMAN (NASA, Marshall Space Flight Center, Huntsville, AL) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 8 p. Oct. 1991 8 p
(IAF PAPER 91-101) Copyright

The modified approach to the accomodation of payload operations in light of both flight and ground systems changes to the operational concept for the Space Station Freedom is described. The challenges for the man-tended capability payload operations and those for the permanently manned capability are assessed. An overview of payload operations is presented including payload accomodations, operations modes, ground systems, the payload operations integration center, and the evolution from man-tended capability to permanent manning. R.E.P.

A92-12506
SPACE STATION UTILIZATION PLANNING IN CANADA
BARRY L. WETTER (Canadian Space Agency, Ottawa, Canada) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 5 p. Oct. 1991 5 p
(IAF PAPER 91-102) Copyright

An overview of the possible utilization scenarios that the Canadian program will support in the Space Station Freedom project is presented. Canada will supply the Mobile Servicing System and a Special Purpose Dexterous Manipulator for use on the manned base. The space science program is providing support for life science research in the microgravity environment thereby creating a closely related working relationship supporting all space science activities. Attention is given to areas of interest within the user community including both materials and life sciences in the microgravity environment. R.E.P.

A92-12507* National Aeronautics and Space Administration, Washington, DC.
RECENT PROGRESS IN UTILIZATION PLANNING FOR SPACE STATION FREEDOM
JOHN-DAVID F. BARTOE (NASA, Office of Space Flight, Washington, DC) and PETER S. THIRINGER (Booz, Allen & Hamilton, Inc., Bethesda, MD) IAF, International Astronautical

Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. Oct. 1991 12 p
(IAF PAPER 91-103) Copyright

The progress made in utilization planning for the redesigned Space Station Freedom (SSF) concept is described. Consideration is given to the SSF user capabilities, the strategic planning process, the strategic planning organizations, and the Consolidated Operations and Utilization Plan (COUP, which will be released in January 1993) as well as to the COUP development process and implementation. The process by which the COUP will be produced was exercised in the international Multilateral Strategic and Tactical Integration Process (MUSTIP) simulation. The paper describes the MUSTIP simulation and its activities along with MUSTIP findings and recommendations. I.S.

A92-12508
CONCEPT OF A EUROPEAN WIDE GROUND INFRASTRUCTURE FOR EXPERIMENTATION IN THE COLUMBUS ELEMENTS ATTACHED LABORATORY AND FREE FLYER
T. ANDERSEN, N. EILERSEN (DAMEC Research A/S, Copenhagen, Denmark), H. T. BLUME, H. DUWE, M. GAIDA, M. HERTEN (DLR, Cologne, Federal Republic of Germany), M. BROUWER (Nationaal Lucht- en Ruimtevaart Laboratorium, Emmeloord, Netherlands), L. D'ANGELO (MARS Centre, Naples, Italy), R. HENDERSON (RSI, Pfungstadt, Federal Republic of Germany), D. HERMANSEN (Norsk Romsenter, Oslo, Norway) et al. IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 10 p. Oct. 1991 10 p refs
(IAF PAPER 91-105) Copyright

The layout of the European ground structure for the experiments by Columbus elements in the Space Station Freedom Attached Laboratory and Free Flyer is described. The flexible and dynamic concept of this structure is based on a network of Utilization Centers covering all necessary support functions, which are distributed over all participating nations in Europe. The Utilization Centers are embedded into the broader scope of Columbus utilization by participating in their National User Support Organizations (N-USOs). I.S.

A92-15298* National Aeronautics and Space Administration, Washington, DC.
A METHOD FOR SELECTING AN OPERATIONS CONCEPT TO ACHIEVE SUCCESSFUL MISSION OPERATIONS
RHODA S. HORNSTEIN (NASA, Washington, DC) and JOHN K. WILLOUGHBY (Information Sciences, Inc., Englewood, CO) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. Oct. 1991 12 p refs
(IAF PAPER 91-460) Copyright

A procedure is presented for mapping operations concepts into design alternatives for a data system to be used in a generic ground based control center. A set of descriptive categories are developed to characterize the operational environment that relate to responsiveness, automation, and commitment. The operations concept is then developed according to a hierarchical decomposition of a mission statement into lower-level tasks, and the interpretation of the model's output is addressed. The method permits the description of operations concepts in terms of concept categories and ranges of alternatives between those categories. The descriptive framework can provide a mechanism for analyzing competing operations concepts. C.C.S.

A92-22630
A CONCEPTUAL STUDY OF HOPE
TETUJI NARASAKI and HIROSHI MIYABA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 39, no. 454, 1991, p. 560-564. In Japanese. 1991 5 p In JAPANESE

NASDA research and development on HOPE (H-II Orbiting Plane) is reviewed. Plans for the recovery of the Japanese experiment module of Space Station Freedom are discussed. Y.P.Q.

A92-23704* National Aeronautics and Space Administration, Washington, DC.
INTELLIGENT PERTURBATION ALGORITHMS FOR SPACE SCHEDULING OPTIMIZATION
CLIFFORD R. KURTZMAN (Space Industries International, Inc., Webster, TX) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs
(Contract NAGW-21)

The optimization of space operations is examined in the light of optimization heuristics for computer algorithms and iterative search techniques. Specific attention is given to the search concepts known collectively as intelligent perturbation algorithms (IPAs) and their application to crew/resource allocation problems. IPAs iteratively examine successive schedules which become progressively more efficient, and the characteristics of good perturbation operators are listed. IPAs can be applied to aerospace systems to efficiently utilize crews, payloads, and resources in the context of systems such as Space-Station scheduling. A program is presented called the MFIVE Space Station Scheduling Worksheet which generates task assignments and resource usage structures. The IPAs can be used to develop flexible manifesting and scheduling for the Industrial Space Facility. C.C.S.

A92-23705
AN INVESTIGATION OF MISSION SCHEDULING SYSTEM FOR THE JAPANESE EXPERIMENT MODULE
MASAO KOBAYASHI, YUICHI NAKAYAMA (Fujitsu, Ltd., Tokyo, Japan), MASAMI ICHIHARA (Fujitsu Social Science Laboratory, Ltd., Tokyo, Japan), HIROSHI YAMASHITA, and KENTARO KUROIWA (Mathematical Systems Institute, Inc., Tokyo, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p

The planning for the execution of space experiments on the Japanese Experiment Module attached to Space Station Freedom requires that a great many missions are effectively allocated within a fixed time span. In the past, a prototype system, named 'Mises II', for short-term planning by using a heuristic method was developed. Then the target to a middle-term planning system was extended, and developed two prototype systems, 'Mises III' which is based upon a heuristic method, and 'Maestro' which uses a numerical optimization method. Both systems will combine aiming at the development of a mission scheduling system for practical use. Author

A92-24326
AIAA/SOLE SPACE LOGISTICS SYMPOSIUM, 4TH, COCOA BEACH, FL, NOV. 4-6, 1991, TECHNICAL PAPERS
Symposium sponsored by AIAA and Society of Logistics Engineers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, 550 p. For individual items see A92-24327 to A92-24385. 1991 550 p
Copyright

Various papers on space logistics are presented. The general topics addressed include: commercial space systems operations and logistics; operations and logistics technology development; space operations and logistics CE, TQM, and LCC; ground systems infrastructure development supporting space operations; logistics support of orbital operations; logistics software, data, and documentation; ground operations supporting space operations; automation, robotics, and manned systems operations and logistics; Space Station operations and logistics; launch operations and processing support for space programs, space transportation operations and logistics, Space Exploration Initiative support. C.D.

A92-24328#
THE MISSION OPERATIONS DIRECTORATE'S SPACE STATION FREEDOM PROGRAM'S PREPARATION FOR, MANAGEMENT, AND CONDUCT OF ON-ORBIT LOGISTICS OPERATIONS
KENNETH W. ZINGREBE, II and WILLIAM W. ROBBINS, JR.

(Barrios Technology, Inc., Houston, TX) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 10 p refs
(AIAA PAPER 91-4052) Copyright

The Missions Operations Directorate (MOD) is the NASA organization responsible for the on-orbit operation of the Space Station Freedom (SSF). This paper describes MOD activities in relation to SSF program logistics and the planned conduct of MOD on-orbit logistics operations. The preparation and management of these operations and the external and internal MOD logistics activities are addressed. C.D.

A92-24330#
APPLICATIONS OF SPACE LOGISTICS ENGINEERING IN QUANTITATIVE RISKS ASSESSMENT AND MANAGEMENT OF SPACE STATION FREEDOM
F. SEPEHRY-FARD (F.S.F. Research Technologies, Inc., Pierrefonds, Canada) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 6 p
(AIAA PAPER 91-4054) Copyright

Canada's contribution to the Space Station, the Mobile Servicing System (MSS), is described and used as a context to discuss space logistics engineering. The latter is described as a disciplined, unified, and iterative approach to the management and technical activities to define, develop, and acquire necessary support resources for the operation of space systems at minimum cost. The MSS space segment and mobile servicing center are described and the Space Segment hierarchy is graphically shown. The general scope of SS risks is considered, and space insurance for the SS is addressed. Finally, space logistics engineering is briefly discussed. C.D.

A92-24338#
LOGISTICS, CALS AND TQA - HOW THESE CONCEPTS CAN WORK TOGETHER
ALBERG D. HORTON (Honeywell, Inc., Clearwater, FL) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 4 p
(AIAA PAPER 91-4070) Copyright

The intent of this paper is to present a discussion of some of the new CALS implementation concepts, and how they can be incorporated into Station planning, using TQ methods. It will review Logistics Management methods for the implementing of existing processes, incorporating off-the-shelf items into Space Station Logistics. It will discuss the way in which TQA, as applied to planning and using CALS compatible software, can cut costs while forwarding the aims of the Space Station concept. Author

A92-24340#
SERVICING PROLIFERATED CONSTELLATIONS - OPPORTUNITY AND CHALLENGE
JEANNIE LEE, THOMAS MISENCIK, WILLIAM ROBERTSON, and JOHN SLINEY (Dynamics Research Corp., Arlington, VA) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 9 p refs
(AIAA PAPER 91-4074) Copyright

The viability and potential cost savings of using on-orbit servicing for proliferated constellations of small spacecraft are addressed. Quantitative assessments based on servicing scenario examples are used to help identify design constraints on both potential servicing systems and constellation satellites where significant life cycle cost savings can be realized. It is found that factors that are helping to lead the move toward proliferation of constellations can be used synergistically to enhance the cost-effective application of on-orbit servicing for a relatively broad category of proliferated constellations. C.D.

A92-24344#
ON-ORBIT SERVICING - 'TECHNOLOGY AND LOGISTICS INTEGRATION'
RICHARD T. HENDRICK and BILL TEOH (Sparta, Inc., Huntsville, AL) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 8 p
(AIAA PAPER 91-4081) Copyright

An on-orbit servicing concept which applies technological advances to the logistics planning process is discussed. This unmanned servicer will have built-in artificial intelligence and robotics capability to perform manned functions. It will use dedicated low-cost launch, control, and repair facilities; fuels, cryogenics, and Orbital Replacement Units will be added on-orbit. A physical description of the servicer is provided, and a scenario is presented of a service and repair mission. C.D.

A92-24345#
RISK REDUCTION THROUGH ON-ORBIT SUPPORT
MICHAEL S. BRIDGMAN and THOMAS K. PARKS (Logistics Management Institute, Bethesda, MD) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 8 p
(AIAA PAPER 91-4082) Copyright

Space systems may fail during deployment or operations. They may exhaust a consumable resource before the mission is completed. They may become technologically obsolete. On-orbit support can reduce these risks. On-orbit support provides the options of repairing, replenishing, or upgrading satellites rather than abandoning them or accepting degraded performance. This paper describes an unmanned on-orbit support system for a constellation of sensor satellites and evaluates the risk reduction in terms of costs. For this example, on-orbit support greatly reduces the costs of small increases in failure rates and of a satellite design upgrade. Author

A92-24346#
COLUMBUS LOGISTICS IN THE OPERATIONAL PHASE
ARNIM EGLAUER (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) and JUERGEN KESSLER (Industrieanlagen-Betriebsgesellschaft mbH, Ottobrunn, Federal Republic of Germany) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 10 p
(AIAA PAPER 91-4083) Copyright

The paper presents the current status of the definition of the Integrated Logistics Support system for the COLUMBUS system. Main support tasks will be concentrated in the Element Centers, which are currently in the definition phase. As an example, the logistics tasks to be performed and the concept for their execution are given for the Free-Flyer Center, which is planned for Supporting the COLUMBUS Free Flying Laboratory. This includes logistics inputs to the physical center architecture and sizing estimates for the required facilities. Author

A92-24348#
SUPPORTING SPACE BASED SYSTEMS
RONALD J. RANCONT (Vitro Corp., Silver Spring, MD) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 9 p refs
(AIAA PAPER 91-4087) Copyright

Eight supportability functions that any space-based system must provide as part of its design and operation throughout its useful life are described. A conceptual approach to implementing a concurrent engineering model for supportability is presented. The need for a new field of space logistics is stressed. C.D.

A92-24349#
DEVELOPING SPACE LOGISTIC STRATEGIES VIA SIMULATION
JAMES W. NEIERS (Neoteric Technologies, Inc., Huntsville, AL) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 8 p refs
(AIAA PAPER 91-4088) Copyright

A logistic strategy for space missions is presented whose goal is optimizing results when emergency conditions occur. Previous applications of simulations in deriving realistic operational performance expectations as a function of alternative logistic

strategies are reviewed. The use of consumable repair parts stockage, maintenance policies, reliability tradeoffs, redundancy, and diagnostics in this context is considered. The Data System Dynamic Simulator developed for NASA to quantify throughput and performance under various conditions is addressed. Parallels for developing space logistic strategies and techniques to simulate failures and off-nominal conditions to measure and improve the system resiliency are discussed. C.D.

A92-24351#
USE OF FUNCTIONAL INTERCONNECT DIAGRAMS IN SPACE STATION FREEDOM INTEGRATION AND SUPPORT
THERON E. RUFF, JOHN R. PALMER, and CARL M. CASE (Boeing Defense and Space Group, Huntsville, AL) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 8 p
(AIAA PAPER 91-4092) Copyright

The use of Functional Interconnect Diagrams (FIDs), which consist of integrated electrical, mechanical, and fluid interface schematics, to integrate the Space Station Freedom is discussed. The implementation of FIDs is described, rack-level, intraelement, and station-level FIDs are briefly discussed. Examples of developmental FID utilization are described. C.D.

A92-24352#
ADOPTION OF THE LSA S/W 'DILSA' FOR THE COLUMBUS LSA TASKS
MIKE C. ATTWOOD and W. PABST (MBB-ERNO, Bremen, Federal Republic of Germany) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 12 p
(AIAA PAPER 91-4093) Copyright

The Columbus approach to performing logistics support analysis (LSA) is described. The front-end analysis, market survey of commercially available LSA S/W and associated PC/mainframe test activities are described. The tailoring process with the LSA S/W product 'Dilsa', necessary to comply with the Columbus-specific LSA and Management and Technical Information System requirements, is examined. The selected Data Record and Summary Reports and applicable LSA processes are presented. C.D.

A92-24358#
LAUNCH VEHICLE SELECTION AND LAUNCH FACILITY SIZING MODELS FOR SEI LOGISTICS SUPPORT
GEORGE W. MORGENTHALER and ALEX J. MONTOYA (Colorado, University, Boulder) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 11 p refs
(AIAA PAPER 91-4101) Copyright

Logistic modeling tools for SEI logistics support are discussed. These tools include: (1) a model for optimizing ground operations of the launch vehicle fleet; (2) launch-on-time statistical analyses; (3) a cost tradeoff model for on-orbit assembly logistics study; (4) a simulation of orbital construction operations; and (5) a launch vehicle selection model. C.D.

A92-24365#
INVENTORY BASED UPON SYSTEM AVAILABILITY - FOR THE SPACE STATION FREEDOM
ROBERT C. KLINE and CRAIG C. SHERBROOKE (Logistics Management Institute, Bethesda, MD) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 9 p
(AIAA PAPER 91-4111)

The Multiple Spares Prioritization and Availability to Resource Evaluation (M-SPARE) model has been developed in order to implement a methodology that estimates the optimal mix of spares for the Space Station Freedom. The model considers how often station parts fail, the resupply frequency of spare parts to the station, and the time to repair or replace broken parts on the ground. M-SPARE also optimizes the mix of on-orbit and ground spares for critical parts and optimizes the ground spares for noncritical parts not stored on-orbit or for support equipment. The model prioritizes Shuttle payload spares during Station assembly or general operations and estimate the benefit of changing the resupply frequency or designing common components. This paper describes the methodology, capabilities, and implementation of M-SPARE. C.D.

A92-24366#
COLUMBUS LOGISTICS SIMULATION MODEL
PER A. NYEN (Norwegian Marine Technology Research Institute, Trondheim, Norway) and TORBJORN DIGERNES (ESA, Columbus System and Projects Dept., Noordwijk, Netherlands) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 8 p refs
(AIAA PAPER 91-4112) Copyright

Discrete event simulation technique is utilized in order to verify the logistics concepts and scenarios in the COLUMBUS Program. The logistics concepts and scenarios include logistics support to the ESA Attached Laboratory (AL) at Space Station Freedom (SSF) and ESA Free-Flying Laboratory using NASA NSTS and ESA ARIANE 5/HERMES transportation systems. A brief description of the fundamentals for the applied methodology is presented. The simulation model under development is planned in three versions, one for each major system development phase. The concept of the first model version with its main elements/objects is presented. The model extensions foreseen for the successive model versions are discussed. Author

A92-24367#
OPERATIONS AND LOGISTICS TASKS IN THE COLUMBUS DEVELOPMENT PROGRAM
C. KOOPMANN (MBB-ERNO, Bremen, Federal Republic of Germany), T. KNUDSON (ESTEC, Noordwijk, Netherlands), and M. ATTWOOD (MBB-ERNO, Bremen, Federal Republic of Germany) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 11 p
(AIAA PAPER 91-4113) Copyright

Past operations and logistics activities in European space programs from the beginnings to Columbus are briefly reviewed, and the major results of operations and logistics tasks in the Columbus program are discussed. The organization and distribution of responsibility for operational and logistics tasks in Columbus are described along with the tasks, methods, and tools involved in the logistics activities. C.D.

A92-24368*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
MAINTENANCE OF SPACE STATION FREEDOM - THE ROLE OF MISSION CONTROLLERS
J. K. WATSON (NASA, Johnson Space Center, Houston, TX), M. T. DAVISON (Barrios Technology, Inc., Houston, TX), and S. E. LANGENDORF (Rockwell Space Operations Co., Houston, TX) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 6 p refs
(AIAA PAPER 91-4114) Copyright

The key roles played in the on-orbit maintenance of Space Station Freedom by mission controllers working in the Space Station Control Center are discussed. Responsibilities ranging from planning and procedure development to training and real-time support are addressed. The organization of the Mission Operations Directorate is described. C.D.

A92-24369*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MAINTENANCE AND RESUPPLY IN THE UNPRESSURIZED ENVIRONMENT - DESIGN AND OPERATIONAL CONCEPTS FOR THE SPACE STATION FREEDOM LOGISTICS CARRIERS
GARY M. CREPS, STEVEN A. ERNST (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA), and ROBERT D. CRAWFORD (NASA, Lewis Research Center, Cleveland, OH) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 11 p refs
(AIAA PAPER 91-4116) Copyright

A significant percentage of the maintenance tasks for Space Station Freedom are anticipated to be conducted in the unpressurized environment. The maintenance concept for this environment essentially involves the removal and replacement of relatively large orbital replacement units (ORUs). Major constraints will be the on-orbit availability of both crew time and spare ORUs. The challenge presented to the program will be the performance of unpressurized cargo resupply that provides maximum cargo-carrying capability (mass and volume) and flexibility (type and quantity), while minimizing the impact to maintenance task times. The design of the logistics carriers is a critical component for successful resupply and maintenance operations, and to the success of Space Station Freedom. Author

A92-24371#
COLUMBUS LOGISTICS TRANSPORTATION AND GROUND PROCESSING
MIKE C. ATTWOOD, MANFRED NORDHOFF, and HORST GOERLICH (MBB-ERNO, Bremen, Federal Republic of Germany) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 12 p
(AIAA PAPER 91-4118) Copyright

The handling, transportation, and ground processing of the Columbus Man-Tended Free Flyer (MTFF) and Attached Pressurized Module are discussed. The Columbus transportation analysis approach is depicted and the air and sea transportation modes are described. The analysis of sea transportation vessel, selection, and excitation estimation are examined. MTFF ground processing concept, MTFF launch configuration, ground processing facilities, ground support equipment, ground processing schedule, and manpower are outlined in detail, with emphasis on the ground processing facilities. C.D.

A92-24373#
HERMES INTEGRATED LOGISTICS MANAGEMENT SYSTEM
INGO ERMISCH (ESA; CNES, Toulouse, France) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 5 p
(AIAA PAPER 91-4121) Copyright

The contribution of the Hermes Integrated Logistics Management System to the integrated logistics support (ILS) of the ESA's In-Orbit Infrastructure is described. The Hermes program phases and operational scenarios are examined, and the ILS tasks, logistics support analysis (LSA), and LSA outputs are addressed. ILS management is discussed. C.D.

A92-24381#
A SIMULATION OF OPERATIONS (SIMOP) MODEL FOR SHUTTLE LOGISTIC SUPPORT OF SPACE CONSTRUCTION PROJECTS
KADETT CHAN and KENDALL NII (Colorado, University, Boulder) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 14 p refs
(AIAA PAPER 91-4136) Copyright

The development and use of the SIMOP (simulation of operations) model to study the launch vehicle support of space construction projects is described. The model was used to determine the ability to complete Space Station Freedom (SSF) assembly on the planned 1600-day timeline using the current Shuttle fleet and existing facilities. The results indicate that the probability of assembling SSF on schedule is low (13 percent). SIMOP, combined with statistical analysis, can be used to predict accurately historical Shuttle operations statistics and to design launch infrastructure to achieve desired launch rates. C.D.

A92-24382*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
OPTIMAL SELECTION OF ORBITAL REPLACEMENT UNIT ON-ORBIT SPARES - A SPACE STATION SYSTEM AVAILABILITY MODEL
DOUGLAS G. SCHWAAB (Dayton, University, OH) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 7 p refs
(AIAA PAPER 91-4137) Copyright

A mathematical programing model is presented to optimize the selection of Orbital Replacement Unit on-orbit spares for the Space Station. The model maximizes system availability under the constraints of logistics resupply-cargo weight and volume allocations. C.D.

A92-24391*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
THE AUTOMATED LOGISTICS ELEMENT PLANNING SYSTEM (ALEPS)
DOUGLAS G. SCHWAAB (Boeing Defense and Space Group, Huntsville, AL) AIAA and Society of Logistics Engineers, Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991. 11 p. Nov. 1991 11 p refs
(Contract NAS8-50000)
(AIAA PAPER 91-4103) Copyright

The design and functions of ALEPS (Automated Logistics Element Planning System) is a computer system that will automate planning and decision support for Space Station Freedom Logistical Elements (LEs) resupply and return operations. ALEPS provides data management, planning, analysis, monitoring, interfacing, and flight certification for support of LE flight load planning activities. The prototype ALEPS algorithm development is described. C.D.

A92-24392*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
OPTIMIZATION OF THE PRESSURIZED LOGISTICS MODULE - A SPACE STATION FREEDOM ANALYTICAL STUDY
J. M. SCALLAN (Boeing Defense and Space Group, Missiles and Space Div., Huntsville, AL) AIAA and Society of Logistics Engineers, Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991. 12 p. Nov. 1991 12 p refs
(Contract NAS8-5000)
(AIAA PAPER 91-4115) Copyright

The analysis for determining the optimum cylindrical length of the Space Station Freedom (SSF) Pressurized Logistics Module, whose task is to transport the SSF pressurized cargo via the NSTS Shuttle Orbiter, is described. The major factors considered include the NSTS net launch lift capability, the pressurized cargo requirements, and the mass properties of the module structures, mechanisms, and subsystems. C.D.

A92-28407#
LAUNCH DELAYS IN THE EVALUATION OF SPACE STATION SUPPORTABILITY
EDMUND DEJULIO, CHRISTOPHER STRICKLAND (Boeing Co., Cocoa Beach, FL), and JAMES MCCORMICK (Boeing Co., Huntsville, AL) AIAA and Society of Logistics Engineers, Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Paper. 8 p. Nov. 1991 8 p refs
Copyright

The National Space Transportation System (NSTS) will be the sole provider of assembly items and support resources to Space Station Freedom. Using an operations simulation tool, the consequences of spares provisioning levels and launch schedule perturbations to onorbit systems' effectiveness are explored. The extent of post-Challenger launch delay experiences and how they are modeled are described. By using simulation modeling, the operational availability of space station hardware and distinctions in support requirements are investigated for the Mission Build flights, MB-1 through MB-7. Author

A92-28408#
ESA LOGISTICS PROGRAM - STATUS AND ORGANIZATION
TH. N. KNUDSON (ESTEC, Noordwijk, Netherlands) AIAA and Society of Logistics Engineers, Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Paper. 5 p. Nov. 1991 5 p
Copyright

Developments in the Logistics segment of the ESA space program are examined with reference to the Columbus program and to future plans. Logistics as a field is shown to have initially

been related to simply storing, packaging, and transporting flight equipment. The development of Spacelab in conjunction with NASA led to the advancement of logistics as an identifiable discipline, and a semiautomated logistics program was established. This effort spawned the development of the stand-alone in-orbit infrastructure - Columbus - and elements of the Space Station Freedom. The problems of reducing the requirements of the Man-Tended Free Flyer and increasing the resupply/return capabilities of the Hermes Space Plane are presently being addressed to optimize the payload and servicing balance of Columbus. The logistics efforts are conducted at the ESA Logistics and Ground Processing Section under the headings of Engineering Support Function, Integrated Logistics Function, and Payload Integration Function. C.C.S.

A92-28411#
THE NEED FOR A SIMPLER AND LESS EXPENSIVE COMPUTERIZED DESIGN ANALYSIS TOOL
ANTHONY J. BUTINA, TIMOTHY P. SOMMER, CHIP L. PEDERSEN, and PHILIP W. LUDWIG (McDonnell Douglas Corp., Space Station Div., Huntington Beach, CA) AIAA and Society of Logistics Engineers, Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Paper. 6 p. Nov. 1991 6 p
Copyright

This paper discusses some of the aspects of computer aided design (CAD) systems as they apply to upfront logistics support analysis and integrated logistics support tasks, and explains the simulation and animation processes. A comparison is made between the hours expended to simulate and animate a piece of Space Station hardware. The uses of animation as they apply to front-end analysis are presented along with reasons why the current costs are expected to further decline. Commercially available hardware and software required to create and animate three-dimensional models are presented. Lastly, the description of the accompanying video presentation is discussed. Author

A92-30684
THE ARIANE TRANSFER VEHICLE
U. THOMAS and A. THIRKETTLE (ESTEC, Noordwijk, Netherlands) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 16, no. 1, 1992, p. 8-14. 1992 7 p
Copyright

The use of the Ariane Transfer Vehicle as a supplement to the manned resupply systems of Space Station Freedom is addressed. The ATV design drivers are summarized and two different design approaches currently under study are examined: one based on upgrading Ariane 5 hardware and one involving a dedicated design 'optimized' to lead to the most operationally efficient system. It is shown that ATV type vehicles are very flexible with reset to their missions and can deliver in-orbit infrastructure building elements and provide pressurized, unpressurized, and fluid logistics resupplies at competitive costs. C.D.

A92-32453
COLUMBUS GROUND SEGMENT AND OPERATIONS
GUISEPPE GIAMPALMO (ESA, Paris, France) (Columbus VII - Symposium on Space Station Utilization, 7th, Anacapri, Italy, July 1-6, 1991, Proceedings. A92-32451 12-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, p. 117-121. Apr. 1992 5 p
Copyright

The current status of the Columbus ground segment is presented. The main elements of the Columbus ground segment are reviewed in the context of that of the overall in-orbit infrastructure (IOI), and specific operational functions are described. The ground elements of the Columbus infrastructure, both those centralized and those common with other IOI elements, as well as those that are dedicated to Columbus specifically, are discussed together with their main functions. R.E.P.

N92-11035*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
USER MODELING TECHNIQUES FOR ENHANCED USABILITY OF OPSMODEL OPERATIONS SIMULATION SOFTWARE
WILLIAM T. DAVIS Washington Nov. 1991 13 p
(Contract RTOP 506-49-3101)
(NASA-TM-4306; L-16915; NAS 1.15:4306) Avail: CASI HC A03/MF A01

The PC based OPSMODEL operations software for modeling and simulation of space station crew activities supports engineering and cost analyses and operations planning. Using top-down modeling, the level of detail required in the data base can be limited to being commensurate with the results required of any particular analysis. To perform a simulation, a resource environment consisting of locations, crew definition, equipment, and consumables is first defined. Activities to be simulated are then defined as operations and scheduled as desired. These operations are defined within a 1000 level priority structure. The simulation on OPSMODEL, then, consists of the following: user defined, user scheduled operations executing within an environment of user defined resource and priority constraints. Techniques for prioritizing operations to realistically model a representative daily scenario of on-orbit space station crew activities are discussed. The large number of priority levels allows priorities to be assigned commensurate with the detail necessary for a given simulation. Several techniques for realistic modeling of day-to-day work carryover are also addressed. Author

N92-11062*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
A METHOD FOR INTERFERENCE MITIGATION IN SPACE COMMUNICATIONS SCHEDULING
YEN F. WONG and JAMES L. RASH *In its* Space Network Control Conference on Resource Allocation Concepts and Approaches p 270-284 Sep. 1991
Avail: CASI HC A03/MF A03

Increases in the number of user spacecraft and data rates supported by NASA's Tracking and Data Relay Satellite System (TDRSS) in the S and Ku bands could result in communications conflicts due to mutual interference. A method to mitigate interference while minimizing unnecessary scheduling restrictions on both TDRSS network and user resources, based on consideration of all relevant communications parameters, was developed. The steps of this method calculate required separation angles at TDRS and produce interference intervals, which can be used in the production of schedules free of unacceptable interference. The method can also be used as a basis for analysis, evaluation, and optimization of user schedules with respect to communications performance. Described here are the proposed method and its potential application to scheduling in space communications. Test cases relative to planned missions, including the Earth Observing System, the Space Station Manned Base, and the Space Shuttle are discussed. Author

N92-11063*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
A PLANNING LANGUAGE FOR ACTIVITY SCHEDULING
DAVID R. ZOCH (Ford Aerospace and Communications Corp., Seabrook, MD.), DAVID LAVALLEE (Ford Aerospace and Communications Corp., Seabrook, MD.), STUART WEINSTEIN (Ford Aerospace and Communications Corp., Seabrook, MD.), and G. MICHAEL TONG *In its* Space Network Control Conference on Resource Allocation Concepts and Approaches p 285-294 Sep. 1991
Avail: CASI HC A02/MF A03

Mission planning and scheduling of spacecraft operations are becoming more complex at NASA. Described here are a mission planning process; a robust, flexible planning language for spacecraft and payload operations; and a software scheduling system that generates schedules based on planning language inputs. The mission planning process often involves many people and organizations. Consequently, a planning language is needed to facilitate communication, to provide a standard interface, and to

represent flexible requirements. The software scheduling system interprets the planning language and uses the resource, time duration, constraint, and alternative plan flexibilities to resolve scheduling conflicts. Author

N92-11064*# Space Industries, Inc., Webster, TX. Intelligent Systems.
INTELLIGENT PERTURBATION ALGORITHMS TO SPACE SCHEDULING OPTIMIZATION
CLIFFORD R. KURTZMAN *In* NASA. Goddard Space Flight Center, Space Network Control Conference on Resource Allocation Concepts and Approaches p 295-298 Sep. 1991
Avail: CASI HC A01/MF A03

The limited availability and high cost of crew time and scarce resources make optimization of space operations critical. Advances in computer technology coupled with new iterative search techniques permit the near optimization of complex scheduling problems that were previously considered computationally intractable. Described here is a class of search techniques called Intelligent Perturbation Algorithms. Several scheduling systems which use these algorithms to optimize the scheduling of space crew, payload, and resource operations are also discussed. Author

N92-12016*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
SPACE STATION CONTROL CENTER ARCHITECTURE
KAREN SCHMALZ *In its* Control Center Technology Conference Proceedings p 209-235 Aug. 1991
Avail: CASI HC A03/MF A06

The Space Station control center (SSCC) is under the cognizance of the Johnson Space Center and is located adjacent to the Shuttle's mission control center. Responsibility for design, development, and operations of the control center is the responsibility of the mission operations directorate at JSC. Space Station Ground Systems Division is responsible for design and development of the control center systems which is currently in process under the mission support contractor team led by Loral Space Information Systems. It is early in the life cycle of the SSCC project. System functional design review was completed. Subsystem requirements are now being developed and reviewed. A new facility will be available for development activities. Author

N92-12034# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany). Berichtsstelle.
LAUNCH SITE OPERATIONS FOR COLUMBUS FREE FLYER AND RESUPPLY MISSION
HORST MICHAELIS (Erno Raumfahrttechnik G.m.b.H. Bremen (Germany, F.R.).), KLAUSDIETER FUGEL (Erno Raumfahrttechnik G.m.b.H. Bremen (Germany, F.R.).), and HARALD SCHMIDT-GERSTMEYER (Erno Raumfahrttechnik G.m.b.H. Bremen, Germany, F.R.) 1991 8 p Presented at the AAAF/DGLR/RAeS International Conference: Launch Bases and Control Infrastructures for Spacecraft, Paris, France, 13-16 May 1991
(MBB-UO-0153-91-PUB; OTN-018406; ETN-91-90191) Avail: CASI HC A02/MF A01

The Columbus Free Flying Laboratory (MTFF) and subsequent resupply performed by Hermes will be launched from CSG (French acronym for French Guyana Space Station) with Ariane 5. Launch site operations for the initial MTFF launch include among others transportation and receiving activities, MTFF servicing, checkout, mating of MTFF to Ariane 5 and interface verification. These operations also include a data end to end test involving the in orbit infrastructure ground segment for flight operations in Europe, the DRS, ESA Earth terminals, IGS and manned space laboratories flight control center to verify all nominal and backup communication links and ascertain the final configuration and readiness of the involved space elements and ground facilities. The MTFF resupply missions are processed differently and follow mainly the Hermes preparation flow with integration of payload in Europe, transport to CSG, Hermes processing in the Hermes integration building in Kourou and final assembly building. ESA

N92-12588# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany). Berichtsstelle.
COLUMBUS FREE FLYER CENTER: TASKS AND MANPOWER PROFILES
HANS JUERGEN C. KOOPMANN (Erno Raumfahrttechnik G.m.b.H. Bremen, Germany, F.R.) 1991 9 p Presented at the 28th Space Congress, Cocoa Beach, FL, 23-26 Apr. 1991
(MBB-UO-0154-91-PUB; OTN-019398; ETN-91-90192) Avail: CASI HC A02/MF A01

The role of element centers within the Columbus ground infrastructure is considered. They will provide system expertise for mission/increment planning, execution and assessment and they will give support to strategical, tactical and executional levels of operations. Center tasks and tasks execution approach are defined together with the implementation approach. Manpower requirements and profiles are given. ESA

N92-12589# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany). Berichtsstelle.
COLUMBUS FREE FLYING LABORATORY (MTFF) LOGISTICS, TRANSPORTATION, AND GROUND PROCESSING
MIKE C. ATTWOOD (Erno Raumfahrttechnik G.m.b.H. Bremen (Germany, F.R.).), MANFRED NORDHOFF (Erno Raumfahrttechnik G.m.b.H. Bremen (Germany, F.R.).), and HORST GOERLICH (Erno Raumfahrttechnik G.m.b.H. Bremen, Germany, F.R.) 1991 15 p Presented at the 4th European Aerospace Conference, Paris, France, 13-16 May 1991
(MBB-UO-0155-91-PUB; OTN-019397; ETN-91-90193) Avail: CASI HC A03/MF A01

The Columbus Free Flying Laboratory (MTFF) logistics, handling and transportation and ground processing are discussed. MTFF requires the implementation of an integration logistics support system in order to ensure the supportability of the MTFF throughout its operational life of 30 years. Handling and transportation of the MTFF to the launch Site in configuration as close as possible to the launch configuration presents a challenge to transportation methods and scenarios, and requires an innovative infrastructure. Ground processing and checkout activities at the launch site need to be organized and time lined in a way to have existing launch site facilities and capabilities support the MTFF needs, and to meet the scheduled launch date. ESA

N92-13138*# Rockwell International Corp., Downey, CA. Space Systems Div.
PERSONNEL LAUNCH SYSTEM (PLS) STUDY Final Report
CARL F. EHRLICH, JR. 25 Oct. 1991 280 p
(Contract NAS1-18975; RTOP 906-11-01)
(NASA-CR-187620; NAS 1.26:187620) Avail: CASI HC A13/MF A03

NASA is currently studying a personnel launch system (PLS) approach to help satisfy the crew rotation requirements for the Space Station Freedom. Several concepts from low L/D capsules to lifting body vehicles are being examined in a series of studies as a potential augmentation to the Space Shuttle launch system. Rockwell International Corporation, under contract to NASA, analyzed a lifting body concept to determine whether the lifting body class of vehicles is appropriate for the PLS function. The results of the study are given. Author

N92-13269# Aerospatiale, Cannes (France).
SOLAR ARRAY MANAGEMENT GUIDE
J. C. VERMALLE (Aerospatiale, Cannes (France).) and M. ROUSSEL (Centre National d'Etudes Spatiales, Toulouse, France) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 771-773 Aug. 1991
Copyright Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

A solar array management guide aimed at controlling project progress so as to prevent untimely events was validated. The management guide proposed is based on the idea that anticipation is the clue to solving problems. Application of this tenet is achieved by steps: ensuring good understanding of requirements; identification of potential risks; heritage analysis and status;

definition of verifications taking into account risks and heritage; simulation of activities; implementation of activities; survey of project progress versus simulation; final examination to draw lessons. The innovation in this management guide comes from organization and systematization of step investigation, which are generally followed intuitively. This logic is applicable to all space products, from part of equipment up to system level. ESA

N92-14700*# Bendix Field Engineering Corp., Columbia, MD.
USING C TO BUILD A SATELLITE SCHEDULING EXPERT SYSTEM: EXAMPLES FROM THE EXPLORER PLATFORM PLANNING SYSTEM
DAVID R. MCLEAN, ALAN TUCHMAN, and WILLIAM J. POTTER 1991 11 p Previously announced in IAA as N91-22774
(Contract NAS5-31000; NAS5-27772)
(NASA-CR-189247; NAS 1.26:189247) Avail: CASI HC A03/MF A01

A C-based artificial intelligence (AI) development effort which is based on a software tools approach is discussed with emphasis on reusability and maintainability of code. The discussion starts with simple examples of how list processing can easily be implemented in C and then proceeds to the implementations of frames and objects which use dynamic memory allocation. The implementation of procedures which use depth first search, constraint propagation, context switching, and blackboard-like simulation environment are described. Techniques for managing the complexity of C-based AI software are noted, especially the object-oriented techniques of data encapsulation and incremental development. Finally, all these concepts are put together by describing the components of planning software called the Planning And Resource Reasoning (PARR) Shell. This shell was successfully utilized for scheduling services of the Tracking and Data Relay Satellite System for the Earth Radiation Budget Satellite since May of 1987 and will be used for operations scheduling of the Explorer Platform in Nov. of 1991. Author

N92-17353*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPERATIONS MISSION PLANNER BEYOND THE BASELINE
ERIC BIEFELD and LYNNE COOPER *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 2: Space Station Freedom, Part 2 p 1157-1200 Sep. 1991
Avail: CASI HC A03/MF A04

The scheduling of Space Station Freedom must satisfy four major requirements. It must ensure efficient housekeeping operations, maximize the collection of science, respond to changes in tasking and available resources, and accommodate the above changes in a manner that minimizes disruption of the ongoing operations of the station. While meeting these requirements the scheduler must cope with the complexity, scope, and flexibility of SSF operations. This requires the scheduler to deal with an astronomical number of possible schedules. The Operations Mission Planner (OMP) is centered around minimally disruptive replanning and the use of heuristics limit search in scheduling. OMP has already shown several artificial intelligence based scheduling techniques such as Interleaved Iterative Refinement and Bottleneck Identification using Process Chronologies. Author

N92-17410*# National Aeronautics and Space Administration, Washington, DC.
SPACE STATION FREEDOM BASELINE OPERATIONS CONCEPT
GRANVILLE PAULES *In its* Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 1: Space Station Freedom, Part 2 p 349-366 Sep. 1991
Avail: CASI HC A03/MF A03

The Baseline Operations Concept is designed to support the multiflight-multistage assembly sequence and post-Permanent Manned Configuration (PMC) era for the Space Station Freedom (SSF). Initial implementation of procedures and systems are consistent with experience gained during the operation of the Shuttle and Spacelab. Author

N92-20624 MATRA Espace, Toulouse (France).
GROUND SYSTEM SOFTWARE MAINTENANCE [MAINTENANCE DES LOGICIELS DES SYSTEMES SOL]
JEAN-LOUIS DUCUING, JEAN-PAUL DENIER, OLIVIER PASERO, and AMAURY SIMON (Durham Univ., England) *In* CNES, The Management of Large Software Projects in the Space Industry p 405-417 Jun. 1991 In FRENCH Previously announced in IAA as A91-47786
Copyright Avail: CEPADUES-Editions, 111 Rue Nicolas-Vauquelin, 31100 Toulouse, France

The need for new flight system software maintenance systems for future space projects such as Hermes and Columbus is stressed. A satellite control center with a lifespan of 10 years and a software volume of 180,000 operations is submitted to a number of performance tests. The problems encountered during these tests, and the solutions found to correct them are outlined. The needs of future systems are shown to demand a global rethinking of the space project requirements as early as the B phase of development and refined over the life of the system. ESA

N92-20715# European Space Agency, Paris (France).
LAUNCH BASES AND CONTROL INFRASTRUCTURES FOR SPACECRAFT
BRIGITTE KALDEICH, ed. Oct. 1991 490 p In ENGLISH and FRENCH The 4th European Aerospace Conference was held in Paris, France, 13-16 May 1991
(ESA-SP-342; ISBN-92-9092-210-9; ETN-92-91203) Copyright Avail: CASI HC A21/MF A04; ESA, EPD, ESTEC, Noordwijk, Netherlands, HC 90 guilders

Launch bases and spacecraft control centers were addressed. Conference papers are grouped under the following headings: world launch bases; facilities for preparing and launching vehicles; facilities for preparing and integrating payloads (automatic or manned); general coordination of operations on a launch base; safety for persons and property; evolution of the measuring and communications systems needed for launches; industrial support and logistics; control centers and station networks; placing and keeping satellites on station; tracking, measuring and monitoring during missions; ground support for rendezvous and in orbit operations; return sites and means of recovery; control of deorbiting and return to Earth; identification of space debris. ESA

N92-20731# Erno Raumfahrttechnik G.m.b.H., Bremen (Germany). Main Dept. Operations.
LAUNCH SITE OPERATIONS FOR COLUMBUS FREE FLYER AND RESUPPLY MISSION
HORST MICHAELIS, KLAUSDIETER FUGEL, and HARALD SCHMIDT-GERSTMEYER *In* ESA, Launch Bases and Control Infrastructures for Spacecraft p 91-97 Oct. 1991 Previously announced as N92-12034
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, ESTEC, Noordwijk, Netherlands, HC 90 guilders

The Columbus Man Tended Free Flying (MTFF) laboratory and subsequent resupply performed by Hermes will be launched from CSG (French acronym for Guianan Space Center) with Ariane 5. Launch site operations for the initial MTFF launch includes among other transportation and receiving activities, MTFF servicing, checkout, mating of MTFF to Ariane 5 and interface verification. The operations also include a data end to end test involving the IOI GS (In Orbit Infrastructure Ground Segment) for flight operations in Europe, the DRS (Data Relay System), EET's, IGS and MSCC to verify all nominal and back up communication links and ascertain the final configuration and readiness of the involved space elements and ground facilities. The MTFF resupply missions are processed differently and follow mainly the Hermes preparation flow with integration of payload in Europe, transport to CSG, Hermes processing in the HIBK and BAF. ESA

N92-20748# Erno Raumfahrttechnik G.m.b.H., Bremen (Germany).
COLUMBUS FREE FLYING LABORATORY (MTFF) LOGISTICS, TRANSPORTATION, AND GROUND PROCESSING

MIKE C. ATTWOOD, MANFRED NORDHOFF, and HORST GOERLICH *In* ESA, Launch Bases and Control Infrastructures for Spacecraft p 199-212 Oct. 1991 *Previously announced as* N92-12589

Copyright Avail: CASI HC A03/MF A04; ESA, EPD, ESTEC, Noordwijk, Netherlands, HC 90 guilders

Columbus Man Tended Free Flying laboratory (MTFF) requires the implementation of an integration logistics support system in order to ensure the supportability of the MTFF throughout its operational life of 30 years. MTFF handling and transportation of the MTFF to the launch site in configuration as close as possible to the launch configuration presents a challenge to transportation methods and scenarios, and requires an innovative infrastructure. Ground processing and checkout activities at the Guiana space center launch site need to be organized and timelined in a way to have existing launch site facilities and capabilities support the MTFF needs, and to meet the scheduled launch date. ESA

N92-20770# Erno Raumfahrttechnik G.m.b.H., Bremen (Germany).

GROUND SEGMENTS FOR MISSION CONTROL AND OPERATION OF EURECA

F. SCHWAN (Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (Germany, F.R.).) and J. DETTMER (Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen, Germany, F.R.) *In* ESA, Launch Bases and Control Infrastructures for Spacecraft p 363-369 Oct. 1991

Copyright Avail: CASI HC A02/MF A04; ESA, EPD, ESTEC, Noordwijk, Netherlands, HC 90 guilders

EURECA represents a free flying, multipurpose, reusable space platform. Complementary to the complex onboard system new and challenging requirements were also put on the ground segments, on their concepts, and architectures. Ground and flight control are essentially driven by the large number of experiments to be monitored and controlled, the long mission duration, and the extremely limited periods of ground contacts. The ESOC flight operation control center has taken prime responsibility to guide the EURECA system through all phases of the mission, including the deployment and retrieval interactions with NASA Space Shuttle. ESA

N92-20771# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).

GROUND SUPPORT TO IN-ORBIT SERVICING OPERATIONS

M. GUERIN *In its* Launch Bases and Control Infrastructures for Spacecraft p 371-378 Oct. 1991

Copyright Avail: CASI HC A02/MF A04; ESA, EPD, ESTEC, Noordwijk, Netherlands, HC 90 guilders

ESA's plan concerning the ground support to in orbit servicing of the Columbus Man Tended Free Flyer by the Hermes Manned Spaceplane are presented. The operations which are concerned are: the rendezvous and docking; the external servicing, by means of telemanipulation and/or EVA (Extravehicular Activity); and the internal servicing operations. Focus is on the facilities foreseen to provide engineering support during equipment development and validation, mission preparation and training, mission execution, and postflight analysis. The concept is based on a gradual transition of simulation facilities and expertise from the development phase to the operations phase. ESA

N92-20772# Aerospatiale, Les Mureaux (France). Dept. Controle du Vol.

GROUND CONTROL FOR THE HERMES-MTFF: APPLICATION OF THE MISSION ANALYSIS METHODS DEVELOPED AT AEROSPATIALE [CONTROLE SOL POUR LE RENDEZ-VOUS HERMES-MTFF: APPLICATIONS DES METHODES D'ANALYSE DE MISSION DEVELOPPEES A AEROSPATIALE]

GILLES MORTAL (Aerospatiale, Paris (France).), FRANCK MARTEL (Aerospatiale, Paris (France).), and HELMUT LUTTMANN (Erno Raumfahrttechnik G.m.b.H. Bremen, Germany, F.R.) *In* ESA, Launch Bases and Control Infrastructures for Spacecraft p 379-384 Oct. 1991 In FRENCH

Copyright Avail: CASI HC A02/MF A04; ESA, EPD, ESTEC, Noordwijk, Netherlands, HC 90 guilders

The increasing complexity of space mission entails increased support of flight control centers; the latter have to coordinate vehicle activity and observation means, while managing possible conflicts of authority or possible failures. Onboard systems evaluating the good passing of the mission, its planning, or under various operational constraints its replanning, falls to one of the ground control centers. Simple sequencing no longer answers such requirements. An evolving mission plan execution tool is proposed, using as an illustration example the orbital rendezvous between Hermes and the Columbus MTFF (Man Tended Free Flyer). ESA

N92-21536*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

BETA 2: A NEAR TERM, FULLY REUSABLE, HORIZONTAL TAKEOFF AND LANDING TWO-STAGE-TO-ORBIT LAUNCH VEHICLE CONCEPT

LEO A. BURKARDT *In its* Rocket-Based Combined-Cycle (RBCC) Propulsion Technology Workshop. Tutorial Session 7 p 1992

Avail: CASI HC A02/MF A03

A recent study has confirmed the feasibility of a near term, fully reusable, horizontal takeoff and landing two-stage-to-orbit (TSTO) launch vehicle concept. The vehicle stages at Mach 6.5. The first stage is powered by a turboramjet propulsion system with the turbojets being fueled by JP and the ramjet by LH2. The second stage is powered by a space shuttle main engine (SSME) rocket engine. For about the same gross weight as growth versions of the 747, the vehicle can place 10,000 lbm. in low polar orbit or 16,000 lbm. to Space Station Freedom. D.R.D.

N92-22092# National Space Development Agency, Tokyo (Japan). Environmental and Structural Test Dept.

SPACECRAFT INTEGRATION AND TEST FACILITIES AT TSUKUBA SPACE CENTER

SENJIRO IIDE and MITSUHIRO TSUCHIYA *In its* Preprints of NASDA's 5th Technical Symposium p 65-89 1 Jun. 1990 In JAPANESE; ENGLISH summary

Avail: CASI HC A03/MF A03

In order to perform the development test of large scale test objects such as large satellites, manned space station, space planes, and so on, launched on the H-2 Rocket, the National Space Development Agency of Japan (NASDA) built the Spacecraft Integration and Test Building (SITE) during fiscal years 1986 and 1989. An outline of the constructing details and the specifications of these test facilities are presented, and the operating situation after construction including results of the facilities' test data are provided. Author (NASDA)

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.

A92-10040

THE GROWING HAZARD OF ORBITING DEBRIS

RAY A. WILLIAMSON (Office of Technology Assessment, Washington, DC) Issues in Science and Technology (ISSN 0748-5492), vol. 8, Fall 1991, p. 77-82. 1991 6 p refs

Copyright

A review is presented of the continuously increasing amount of orbiting space debris, the hazards created by it and some suggestions for reducing and/or eliminating this space environmental problem. Various objects making up this orbital debris include discarded upper rocket stages, inactive satellites and spacecraft, protective shields, incidental hardware items, paint

chips, and exhaust particles from rocket engines. Recommendations proposed for attacking this problem include the convening of a multilateral working group, limited to nations with launching capability, to address mitigation strategies and attempt to reach consensus on them. R.E.P.

A92-10466
ORBITAL ELEMENTS DETERMINATION FOR BREAKUP AND DEBRIS
STEPHEN H. KNOWLES (U.S. Navy, Naval Space Surveillance Center, Dahlgren, VA) Oct. 1991 5 p refs
Copyright

A92-10471
LARGE SOLAR PROTON EVENTS AND GEOSYNCHRONOUS COMMUNICATION SPACECRAFT SOLAR ARRAYS
L. J. LANZEROTTI (AT&T Bell Laboratories, Murray Hill, NJ), D. W. MAURER (AT&T Bell Laboratories, Cranbury, NJ), H. H. SAUER, and R. D. ZWICKL (NOAA, Space Environnment Laboratory, Boulder, CO) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Sept.-Oct. 1991, p. 614-616. Oct. 1991 3 p refs
Copyright

The occurrence of the high fluence solar events in October 1989 led to a reexamination of some of the assumptions made on the appropriate energy spectral representation of the large solar-flare proton events used for engineering designs of solar arrays for geosynchronous communication spacecraft. This paper discusses the solar event characteristics and some aspects of the design of solar proton fluence models. It is estimated that, for a design of a spacecraft with about 12-15-yr life expectancy, it will be necessary to take into account the launch data in the particular phase of the solar cycle (i.e., whether two solar maxima or one) that is likely to be encountered. I.S.

A92-12190
SPATIAL-TEMPORAL DYNAMICS OF TWO-DIMENSIONAL WAVE BEAMS IN MEDIA WITH RELAXATION NONLINEARITY [PROSTRANSTVENNO-VREMENNAIA DINAMIKA DVUMERNYKH VOLNOVYKH PUCHKOV V SREDAKH S RELAKSATSIONNOI NELINEINOST'IU]
E. V. VANIN, V. A. MIRONOV, E. A. PIAN'KINA, A. M. SERGEEV, and A. V. KHIMICH (AN SSSR, Institut Prikladnoi Fiziki, Nizhni Novgorod, USSR) Fizika Plazmy (ISSN 0367-2921), vol. 17, July 1991, p. 821-829. In Russian. Jul. 1991 9 p In RUSSIAN refs
Copyright

A study is made of the spatial-temporal dynamics of two-dimensional wave beams described by a system including a stationary Schroedinger equation and a dynamic equation for a perturbed medium (potential). Despite the asymptotic transition to a stationary structure with a strictly spatial evolution, systems of this kind exhibit a complex behavior which cannot be separated into purely spatial and temporal types of evolution. Some characteristics of this behavior are discussed. The problem is relevant to microwave power transmission from a solar space station to the earth. V.L.

A92-12821
THE RADIATION ENVIRONMENT ON THE MIR ORBITAL COMPLEX DURING SEPTEMBER-OCTOBER 1989 [RADIATSIONNAIA OBSTANOVKA NA ORBITAL'NOM KOMPLEKSE 'MIR' V SENTIABRE-OKTIABRE 1989 G.]
I. N. ARESTOVA, V. I. LIAGUSHIN, B. V. MAR'IN, M. A. SARAEVA, M. V. TEL'TSOV, and P. I. SHAVRIN Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, Sept.-Oct. 1991, p. 794-797. In Russian. Oct. 1991 4 p In RUSSIAN refs
Copyright

Results of a study of the radiation environment on the Mir complex during September-October 1989 are presented. The radiation environment of this spacecraft on its trajectory were monitored by an onboard scintillation counter and ionization chamber. L.M.

A92-13167* Phillips Lab., Hanscom AFB, MA.
ORIGIN OF THE SHUTTLE GLOW
R. A. VIERECK, EDMOND MURAD, C. P. PIKE (USAF, Phillips Laboratory, Hanscom AFB, MA), B. D. GREEN, P. JOSHI (Physical Sciences, Inc., Andover, MA), R. HIEB, and G. HARBAUGH (NASA, Johnson Space Center, Houston, TX) Nature (ISSN 0028-0836), vol. 354, Nov. 7, 1991, p. 48-50. Research supported by SDIO. 7 Nov. 1991 3 p refs
Copyright

On a recent Shuttle mission four gases, NO, CO2, Xe, and Ne were released for a plasma experiment. Unintentionally, enough gas was scattered onto the surfaces of the Shuttle tail that when NO was released a much more intense version of Shuttle glow was observed. The other gases did not affect the normal Shuttle glow. Under normal conditions the adsorbed NO that causes the glow probably come either from the ambient atmosphere or from reactions in exhaust gases from the Shuttle thrusters. C.D.

A92-13698
REMOVING SMALL DEBRIS FROM EARTH ORBITS
W. O. SCHALL (DLR, Institut fuer Technische Physik, Stuttgart, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 15, Oct. 1991, p. 333-341. Oct. 1991 9 p refs
Copyright

The use of high-power lasers is suggested for removing dangerous small orbital debris. Partial vaporization of the debris with high ablation rates allows orbit changes for the debris by using the rapidly exhausting vapor as a propellant. The idea is to force the debris to a descend down into earth's atmosphere, where it burns up. Requirements for laser energy and power are calculated for the removal of debris in the orbital range from 500 km to 2000 km of altitude. Geometry related limitations of the method, thrust production and optical constraints are discussed. A method for the preventive removal of debris as well as one for protection against a collision are investigated. An autonomous orbital vehicle equipped with a moderately sized laser, proper optics and instrumentation for the detection and tracking of debris is suggested for the cleanup of LEO. A strategy for this purpose is described and cleaning times are calculated on the basis of the debris distribution given in the literature. Author

A92-14062
ON SOME ELECTROMAGNETIC PHENOMENA IN THE TETHER MAGNETOPLASMA CLOUD
YA. L. ALPERT (Harvard-Smithsonian Center for Astrophysics, Cambridge, MA) Nuovo Cimento C, Serie 1 (ISSN 0390-5551), vol. 14 C, Sept.-Oct. 1991, p. 501-522. Oct. 1991 22 p refs
Copyright

The tethered satellite system (TSS) will be accompanied by a variety of electromagnetic phenomena. An independent interconnected formation, a tethered magnetoplasma cloud moving in space along the orbit of TSS, at an altitude of about 300 km, will be created. Rarefied regions of the magnetoplasma behind, and dense regions in front of the shuttle orbiter and the subsatellite will arise. The neutral nitrogen beam ejected by the thruster becomes an ion beam on the daylight part of the orbit. Its energy is much greater than the local thermal energy. Instabilities of different kind as well as diffusion and recombination effects are expected to accompany the interaction of these beams with the surrounding plasma. The electron beams will produce other types of instabilities. Author

A92-14713* Institute for Space Science and Technology, Inc., Gainesville, FL.
LDEF INTERPLANETARY DUST EXPERIMENT - TECHNIQUES FOR IDENTIFICATION AND STUDY OF LONG-LIVED ORBITAL DEBRIS CLOUDS
S. F. SINGER, J. P. OLIVER, J. L. WEINBERG, W. J. COOKE, N. L. MONTAGUE (Institute for Space Science and Technology, Gainesville, FL), J. D. MULHOLLAND (Institute for Space Science and Technology, Gainesville, FL and Grasse, France), J. J. WORTMAN (North Carolina State University, Raleigh), P. C.

KASSEL, and W. H. KINARD (NASA, Langley Research Center, Hampton, VA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. Oct. 1991 12 p refs
(IAF PAPER 91-285) Copyright

The Long Duration Exposure Facility (LDEF) is a 12-sided, 4.3-m-diameter, 9.1-m-long cylinder designed and built by NASA Langley to carry experiments for extended periods in space. The LDEF was first placed in orbit by the Shuttle Challenger on 7 April 1984 and recovered by the Shuttle Columbia in January 1990, only days before it was expected to burn up in the earth's atmosphere. The Interplanetary Dust Experiment (IDE) was designed to detect impacts of extra-terrestrial particles and orbital debris. The IDE detectors (which covered about 1 sq m of the surface of LDEF) were sensitive to particles ranging in size from about 0.2 to 100 microns. Data were recorded for 11.5 months before the supply of magnetic tape was exhausted. Examination of the LDEF IDE dataset shows that impacts often occurred in 'bursts', during which numerous impacts occurred in a short time (typically 3-5 min) at a rate much greater than the average impact rate. In several cases, such events reoccurred each time the LDEF returned to the same point in its orbit. Such multi-orbit event sequences were found to extend for as many as 25 or more orbits. Author

A92-15771
DOES DEBRIS FROM THE FORMATION OF OTHER PLANETARY SYSTEMS IMPACT EARTH?
THOMAS G. BROPHY (Tokyo, University, Japan) Icarus (ISSN 0019-1035), vol. 94, Nov. 1991, p. 250-254. Nov. 1991 5 p refs
Copyright

Model size distributions for the ejected debris from extrasolar planet formation are used to calculate the small and large particle fluxes impacting earth, on the assumption that the framework of the standard solar system formation scenario can be applied to other planetary systems. Long Duration Exposure Facility-detected and Kharkov radar-detected impactors with extrasolar velocities are interpretable along these lines, as are several recovered meteorites. O.C.

A92-15812 Utah State Univ., Logan.
IONIZATION IN THE MAGNETIZED IONOSPHERE SURROUNDING A HIGH VOLTAGE SPHERE
T.-Z. MA and R. W. SCHUNK (Utah State University, Logan) Planetary and Space Science (ISSN 0032-0633), vol. 39, Oct. 1991, p. 1325-1342. Oct. 1991 18 p refs
(Contract NAG3-792; AF-AFOSR-90-0026; NAS8-37110)
Copyright

Solutions are derived for time-dependent 3D nonlinear fluid equations for ions and electrons and for the Poisson equation, for use in studies of high-voltage current characteristics during the initial response of a partially ionized magnetized ionospheric plasma to positive high-voltage spheres. Different neutral densities (10 exp 11/cu cm to 10 exp 14/cu cm), species (Ar, Ba, O, and N2), and magnetic field strengths are considered. The simulations indicate that a rapidly rotating electron density torus tends to form around a high-voltage sphere embedded in magnetized partially ionized plasma. Depending on the applied voltage, neutral gas pressure, and magnetic field, steady toroidal configurations were obtained both with and without ionization, a toroidal discharge, and a spherical discharge. The results agree qualitatively with measurements. I.S.

A92-16332* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE EFFECT OF IONOSPHERIC REFLECTED NOISE ON THE PERFORMANCE OF AN ORBITAL-DEBRIS RADAR SYSTEM
DENNIS F. BISHOP (JPL, Pasadena, CA) IEEE Transactions on Electromagnetic Compatibility (ISSN 0018-9375), vol. 33, Nov. 1991, p. 362-366. Nov. 1991 5 p refs
Copyright

An orbital-debris radar system was designed to detect the presence of small objects in low earth orbit by reflecting radio waves off the objects. The author provides a rigorous derivation of the ionospheric reflected noise power and provides an integration over the complete pulse period. Free electrons and ions contained in the ionosphere cause incoherent scatter of the radar signal. This ionospheric reflection tends to increase the noise at the terrestrial radar receiver. A parameter called the ionospheric scattering cross section per unit volume, which is a function of altitude, is useful for computing the power of the ionospheric reflection signal. The Doppler frequency speed of the ionospheric reflected signal is a function of altitude also. The ionospheric noise of a 9-GHz orbital-debris radar receiver is computed using these concepts. Annual and diurnal variations of the noise are included. I.E.

A92-17040
COMMENT ON 'THEORY AND OBSERVATION OF TRIPLE-ROOT JUMP IN SPACECRAFT CHARGING' BY SHU T. LAI
R. C. OLSEN (U.S. Naval Postgraduate School, Monterey, CA) Journal of Geophysical Research (ISSN 0148-0227), vol. 96, Dec. 1, 1991, p. 21,411, 21,412; Reply, p. 21,413. 1 Dec. 1991 3 p refs

A92-17561
HIGH RESOLUTION SPECTROSCOPIC MEASUREMENTS FROM THE SPACE SHUTTLE - ORBITER GLOW AND ATMOSPHERIC EMISSIONS
D. J. W. KENDALL (Canadian Space Agency, Ottawa, Canada), E. J. LLEWELLYN, M. R. GALE (Saskatchewan, University, Saskatoon, Canada), S. B. MENDE, G. R. SWENSON (Lockheed Research Laboratories, Palo Alto, CA), and R. L. GATTINGER (National Research Council of Canada, Herzberg Institute of Astrophysics, Ottawa) Canadian Journal of Physics (ISSN 0008-4204), vol. 69, Aug.-Sept. 1991, p. 1209-1215. Research supported by NSERC. Sep. 1991 7 p refs
Copyright

The orbiter glow (OGLOW) experiment, flown in 1984 on shuttle mission STS-41G, included observations of spacecraft glow and atmospheric emissions. The instrument consisted of a simple hand-held photographic imager combined with a series of high-resolution interference filters, Fabry-Perot interferometers, and a grating spectrometer. In the case of spacecraft glow, the results are summarized and compared with recent laboratory measurements. For the atmospheric emissions, a detailed analysis of the oxygen atmospheric band is presented to show how the data can be used to infer atomic-oxygen height profiles. Author

A92-17612*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
GENSAA - ADVANCING SATELLITE MONITORING WITH EXPERT SYSTEMS
PETER M. HUGHES (NASA, Goddard Space Flight Center, Greenbelt, MD) and EDWARD C. LUCZAK (Computer Sciences Corp., Beltsville, MD) IN: AIAA Computing in Aerospace Conference, 8th, Baltimore, MD, Oct. 21-24, 1991, Technical Papers. Vol. 1 1991 11 p refs
(AIAA PAPER 91-3948) Copyright

During numerous contacts with a satellite each day, spacecraft analysts must closely monitor real time data watching for combinations of telemetry parameter values, trends, and other indications that may signify a problem or failure. At the NASA Goddard Space Flight Center, fault-isolation expert systems are currently in operation supporting this data monitoring task. Based on the lessons learned during these initial efforts in expert system automation, a new domain-specific expert system development tool is being developed to facilitate the rapid development and reuse of real-time expert systems to serve as fault-isolation assistants for spacecraft analysts. Author

A92-18575
ACTIVITIES ON SPACE DEBRIS IN EUROPE
W. FLURY (ESA, European Space Operations Centre, Darmstadt,

Federal Republic of Germany) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p refs
(IAF PAPER 91-589) Copyright

Space debris is receiving increased attention as a growing threat to manned and unmanned space activities. It is a global issue, which may ultimately affect all users of space. As the risk posed by space debris to present and future missions reached a level which requires serious considerations and measures, especially for manned missions, ESA, together with its member states, has initiated first steps to better understand and mitigate the problem. European efforts in the space debris field are described. In the technical area, activities can be grouped into three main subdivisions, namely improved knowledge of the terrestrial particulate environment including the future evolution of the space debris population, assessment of the risk for manned and unmanned space missions, and finally, protective and preventive measures. To avoid serious consequences in later periods, measures to reduce the growth of the number of space debris should be initiated now. Author

A92-18576* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
MANAGEMENT OF THE ORBITAL ENVIRONMENT
JOSEPH P. LOFTUS, JR., DONALD J. KESSLER, and PHILLIP D. ANZ-MEADOR (NASA, Johnson Space Center, Houston, TX) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 10 p. Oct. 1991 10 p refs
(IAF PAPER 91-590) Copyright

Data regarding orbital debris are presented to shed light on the requirements of environmental management in space, and strategies are given for active intervention and operational strategies. Debris are generated by inadvertent explosions of upper stages, intentional military explosions, and collisional breakups. Design and operation practices are set forth for minimizing debris generation and removing useless debris from orbit in the low-earth and geosynchronous orbits. Self-disposal options include propulsive maneuvers, drag-augmentation devices, and tether systems, and the drag devices are described as simple and passive. Active retrieval and disposition are considered, and the difficulty is examined of removing small debris. Active intervention techniques are required since pollution prevention is more effective than remediation for the problems of both earth and space. C.C.S.

A92-18577
ANALYSIS OF THE NECESSITY AND THE EFFECTIVENESS OF COUNTERMEASURES TO PREVENT A CHAIN REACTION OF COLLISIONS
PETER EICHLER (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 11 p. Research supported by BMFT. Oct. 1991 11 p refs
(IAF PAPER 91-592) Copyright

At present, the collision risk with space debris, which is increasingly endangering all spaceflight activities, is probably predominated by fragments from explosions of payloads and rocket upper stages in earth orbits. In the future interactive collisions between objects in earth orbits could become the main source for the generation of fragments. The risk of a catastrophic collision, i.e., with the total destruction of the target object, is presently in the order of some percent per year, and it will rise squared to the number of larger objects in earth orbits. The larger fragments generated by such a collision could produce new catastrophic collisions and this could successfully lead to the formation of an artificial debris belt in the way of a chain reaction. As a steady increase of the population will always lead to a chain reaction of collisions, the necessity of effective countermeasures is evident. The results of a new analysis of the possible evolution of the population in earth orbits including fragment generation by collisions using an advanced version of the simulation program CHAIN will be presented. Of special interest in this concern is the analysis of the effectiveness of the different kinds of possible countermeasures. Author

A92-18578
EXAMINATION OF POSSIBLE COLLISIONS IN SPACE
DARREN MCKNIGHT (Kaman Sciences Corp., Alexandria, VA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 6 p. Oct. 1991 6 p refs
(IAF PAPER 91-593) Copyright

In recent years, discussions about orbital debris have often centered on the possibility of accidental collision-induced satellite breakups. The onset of this type of event may mark a significant phase in man's exploitation of space, possibly eventually leading to increased growth rates of the debris population and a corresponding increase in the hazard posed by orbital debris. Present analysis examines the probability of a collision-induced breakup occurring and correlating this statistical analysis with observable fragmentation events. Sustained high spatial density values in the 900-1000 km altitude range since the mid-1970's has made it likely that a collision-induced breakup has already occurred. The fragmentation of Kosmos 1275 is the most likely candidate. A similar, but slower developing trend is evident in the 1400-1500-km altitude band. This paper shows that the risk from orbital debris may significantly affect space operations without a corresponding exponential growth in the orbital debris population. Author

A92-18579
QUANTIFYING THE ORBITAL DEBRIS ENVIRONMENT
PHAN DAO, R. MCNUTT (USAF, Phillips Laboratory, Hanscom AFB, MA), F. M. JONAS, P. SOLIZ, and K. YATES (Orion International Technologies, Inc., Albuquerque, NM) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 13 p. Oct. 1991 13 p refs
(Contract F29601-89-C-0001)
(IAF PAPER 91-595) Copyright

The orbital debris environment is of increasing concern to users of space. Models describing this environment depend on accurate and precise measurements of debris for all sizes and altitudes. This paper presents the assessment of an environment model, developed by NASA, and the uncertainties of that model. The uncertainties are shown to be dominated by the lack of knowledge of the debris environment. A Phillips Laboratory (Geophysics Directorate) measurement program is described that will enhance man's understanding of the debris environment. It uses the 2.54-m telescope located at Wright Laboratory (Wright-Patterson AFB, Ohio). Author

A92-18580
BREAKUP IN GEOSTATIONARY ORBIT - A POSSIBLE CREATION OF A DEBRIS RING
TETSUO YASAKA (NTT, Radio Communication Systems Laboratory, Yokosuka, Japan) and NOBUAKI ISHII (Institute of Space and Astronautical Science, Sagamihara, Japan) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 13 p. Oct. 1991 13 p refs
(IAF PAPER 91-596) Copyright

The possibilities and ramifications of the generation of a debris ring are analyzed with a dynamic model of the geostationary ring. The model incorporates the momentum, energy, and velocity relationships of collisions between objects and the resulting fragment clouds. The equations are considered in the light of collision probabilities of geosynchronous satellites, and debris-cloud evolution is illustrated. Consideration is given to the effects of solar radiation pressure and corridor-passage time, and collision rates are computed with a numerical simulation. Debris in the geostationary region remain near the region but are evenly distributed after a few weeks, and all debris fragments are equally hazardous to operating satellites. Fragments from collisions or explosions in the geosynchronous region can cover the entire arc after a period of cascading, and preventive measures are needed to protect the geostationary region. C.C.S.

A92-18651 National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
SPACE DUST AND DEBRIS; PROCEEDINGS OF THE TOPICAL MEETING OF THE INTERDISCIPLINARY SCIENTIFIC COMMISSION B (MEETINGS B2, B3, AND B5) OF THE COSPAR 28TH PLENARY MEETING, THE HAGUE, NETHERLANDS, JUNE 25-JULY 6, 1990
D. J. KESSLER, ED. (NASA, Johnson Space Center, Houston, TX), J. C. ZARNECKI, ED. (Kent, University, Canterbury, England), and D. L. MATSON, ED. (JPL, Pasadena, CA) Meeting sponsored by COSPAR. Advances in Space Research (ISSN 0273-1177), vol. 11, no. 12, 1991, 207 p. For individual items see A92-18652 to A92-18677. 1991 207 p
Copyright
The present conference on space dust and debris encompasses orbital debris, in situ measurements and laboratory analysis of space-dust particles, comparative studies of comets, asteroids, and dust, the protection and maneuvering of spacecraft in space-debris environments, and the out-of-elliptic distribution of interplanetary dust derived from near-earth flux. Specific issues addressed include asteroid taxonomy, the optical properties of dust from cometary and interplanetary grains, light scattering by rough surfaces on asteroidal/lunar regoliths, and the first results of particulate impacts and foil perforations on the Long Duration Exposure Facility. Also addressed are collision probability and spacecraft disposition in the geostationary orbit, a flash on the moon caused by orbital debris, the limits of population growth in low earth orbit due to collisional cascading, and the simulation of cosmic man-made dust effects on space-vehicle elements in rocket and laboratory experiments. C.C.S.

A92-18652
COLLISIONS IN SPACE - A RETROSPECTIVE OVERVIEW OF ISAS STUDIES
K. UESUGI (Institute of Space and Astronautical Science, Sagamihara, Japan) (Space dust and debris; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission B /Meetings B2, B3, and B5/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-18651 05-12) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 12, 1991, p. 19-27. 1991 9 p refs
Copyright
A chronological review of studies in ISAS concerning collisions in space is presented. The collision probability in space with artificial orbiting bodies was estimated, and a Space Traffic Control System was proposed, in 1971. The design of a space station for safety against collision hazards was discussed in 1972. A trajectory optimization technique for low-thrust multiple rendezvous mission in order to sweep space debris around the earth was developed in 1977. In 1984, the collision probability was reestimated using space debris data accumulated for more than a decade. Several experimental projects in ISAS, such as hypervelocity impact experiments using a railgun system, sampling and measuring of alumina particles in exhaust plume of solid-propellant rocket motors, and a result of analysis on the behavior of such alumina particles in orbit are also introduced. Author

A92-18653
THE IMPACT OF ALTERNATIVE MISSION MODELS ON THE FUTURE ORBITAL DEBRIS ENVIRONMENT
R. C. REYNOLDS (Systems Planning Corp., Houston, TX), P. D. ANZ-MEADOR, and G. W. OJAKANGAS (Lockheed Engineering and Sciences Co., Houston, TX) (Space dust and debris; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission B /Meetings B2, B3, and B5/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-18651 05-12) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 12, 1991, p. 29-32. 1991 4 p refs
Copyright
In reviewing discussions of future directions for space activity, it becomes obvious that there are a large number of groups formulating a wide diversity of plans for the future use of space. These plan alternatives are being made to account for user needs, technology development constraints, economic constraints, and launch support, and each of the plans will have direct or indirect effects on the orbital debris environment in terms of mass to orbit, deposition of operational debris, and control of accidental breakups. Thus it is important to develop the ability to project future debris states for a range of possible space traffic scenarios. The impact that these possible traffic environments would have on space operations forms the basis for studies of alternative options for the usage of space. In this paper, the effects on the orbital debris environment of a base-line mission model and two alternatives are investigated, using a numerical debris environment simulation code under development at JSC. Author

A92-18656
DISCOS - ESA'S DATABASE AND INFORMATION SYSTEM CHARACTERISING OBJECTS IN SPACE
H. KLINKRAD (ESA, European Space Operations Centre, Darmstadt, Federal Republic of Germany) (Space dust and debris; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission B /Meetings B2, B3, and B5/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-18651 05-12) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 12, 1991, p. 43-52. 1991 10 p refs
Copyright
This paper presents an overview of the main features of ESA's future space debris database DISCOS (Database and Information System Characterizing Objects in Space). The DISCOS system has been developed around an ORACLE relational database management software by the University of Kent (UK) under an ESA contract. The DISCOS catalog will be installed at ESOC, the European Space Operations Centre, and serve as a common ESA information system for the space debris environment. Author

A92-18657
PROTECTION AND MANOEUVRING OF SPACECRAFT IN SPACE DEBRIS ENVIRONMENT
D. REX, J. BENDISCH, P. EICHLER, and J. ZHANG (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) (Space dust and debris; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission B /Meetings B2, B3, and B5/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-18651 05-12) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 12, 1991, p. 53-62. Research supported by BMFT. 1991 10 p refs
Copyright
An overview is given on the fields of debris research. The orbital debris flux of all objects larger than 1 cm has been established and simulated by a mathematical model in the past mainly on the basis of simulating explosion fragments. However, the flux in the millimeter and submillimeter size range seems to be largely influenced by collisions and their ejecta on high circular or eccentric orbits. The angular distribution of the impact flux on targets at various altitudes and on various inclinations are presented. This angular distribution influences the surface impact flux on a space station, where the self-shielding has to be considered. The risk of impacts of larger objects on a space station can become too high, so that collision avoidance maneuvers must be envisaged. Author

A92-18658* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
COLLISIONAL CASCADING - THE LIMITS OF POPULATION GROWTH IN LOW EARTH ORBIT
DONALD J. KESSLER (NASA, Johnson Space Center, Houston, TX) (Space dust and debris; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission B /Meetings B2, B3, and B5/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-18651 05-12) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 12, 1991, p. 63-66. 1991 4 p refs
Copyright
Random collisions between made-made objects in earth orbit will lead to a significant source of orbital debris, but there are a

number of uncertainties in these models, and additional analysis and data are required to fully characterize the future environment. However, the nature of these uncertainties are such that while the future environment is uncertain, the fact that collisions will control the future environment is less uncertain. The data that already exist is sufficient to show that cascading collisions will control the future debris environment with no, or very minor increases in the current low-earth-orbit population. Two populations control this process: explosion fragments and expended rocket bodies and payloads. Practices are already changing to limit explosions in low earth orbit; it is necessary to begin limiting the number of expended rocket bodies and payloads in orbit. Author

A92-18659
COLLISION PROBABILITY AND SPACECRAFT DISPOSITION IN THE GEOSTATIONARY ORBIT
W. FLURY (ESA, European Space Operations Centre, Darmstadt, Federal Republic of Germany) (Space dust and debris; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission B /Meetings B2, B3, and B5/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-18651 05-12) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 12, 1991, p. 67-79. 1991 13 p refs
Copyright

The collision probabilities and disposition options of the satellites are considered by analyzing long-term orbital evolution both in the geostationary ring and at higher altitudes. The influence of attitude-orbit cross-coupling effects is considered in terms of secular orbit perturbations, and other major perturbations are examined. Various approaches to modeling the problem are considered including a stochastic method for controlled satellites and a deterministic treatment of the uncontrolled spacecraft *population. Collision probabilities are developed, and the* probabilities for special situations are also mentioned such as colocation. It is shown that to protect a geostationary orbit the only practical safety measure is to use a disposition option called reorbiting in which defunct satellites are placed in orbits much higher than the geostationary orbit. C.C.S.

A92-18662
SIMULATION OF COSMIC MAN-MADE DUST EFFECTS ON SPACE VEHICLE ELEMENTS IN ROCKET AND LABORATORY EXPERIMENTS
IU. I. PORTNIAGIN, O. F. KLIUEV, A. A. SHIDLOVSKII, A. N. EVDOKIMOV, T. W. BUZDIGAR, P. G. MATIUKHIN, S. G. PASYNKOV, K. N. SHAMSHEV (Institut Eksperimental'noi Meteorologii; NPO Taifun, Obninsk, USSR), V. V. SOKOLOV (Tsentral'nyi NII Khimii i Mekhaniki, Moscow, USSR), and N. D. SEMKIN (Kuibyshevskii Aviatsionnyi Institut, Kuibyshev, USSR) (Space dust and debris; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission B /Meetings B2, B3, and B5/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-18651 05-12) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 12, 1991, p. 89-92. 1991 4 p refs
Copyright

Institute of Experimental Meteorology initiated investigations of anthropogenic contamination (AC) and its influence on the near-earth environment and orbiting vehicles. These investigations are based on rocket experiments on simulation of the effects of gas-dust fluxes at the rate of 7-8 km/s on vehicle optical elements under real space conditions. The fluxes are generated by rocket-borne explosive generators. Author

A92-18663
COSMIC DUST AND ORBITAL DEBRIS - COLLECTION OF MIR SPACE STATION
J. C. MANDEVILLE (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) (Space dust and debris; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission B /Meetings B2, B3, and B5/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-18651 05-12) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 12, 1991, p. 93-96. Research supported by CNES and Glavkosmos. 1991 4 p refs
Copyright

During the last mission to the MIR Space Station an experiment devoted to the collection and detection of cosmic dust and space debris was deployed in space for 13 months. A variety of sensors and collecting devices has made possible the study of the effects and the distribution of cosmic particles after the recovery of exposed material. Remnants of particles, suitable for chemical identification are expected to be found within the stacked foil detectors. Discrimination between true cosmic particles and man-made orbital debris is expected. Author

A92-18664
STUDY OF COSMIC DUST PARTICLES ON BOARD LDEF - THE FRECOPA EXPERIMENT
J. C. MANDEVILLE (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) (Space dust and debris; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission B /Meetings B2, B3, and B5/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-18651 05-12) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 12, 1991, p. 101-107. 1991 7 p refs
Copyright

A French experiment partly devoted to the detection of cosmic dust has been flown on the Long Duration Exposure Facility (LDEF), launched in April 1984, and retrieved in January 1990. A variety of sensors and collecting devices will make possible the study of cosmic particles after recovery of exposed material. Remnants of particles, suitable for chemical identification are expected to be found within the stacked foil detectors. Discrimination between true cosmic particles and man-made orbital debris is expected. Author

A92-18666 Institute for Space Science and Technology, Inc., Gainesville, FL.
FIRST SPATIO-TEMPORAL RESULTS FROM THE LDEF INTERPLANETARY DUST EXPERIMENT
S. F. SINGER (Institute for Space Science and Technology, Gainesville, FL; Virginia, University, Charlottesville), J. E. STANLEY (Virginia, University, Charlottesville), P. C. KASSEL, W. H. KINARD (NASA, Langley Research Center, Hampton, VA), J. J. WORTMAN (North Carolina State University, Raleigh), J. L. WEINBERG (Institute for Space Science and Technology, Gainesville, FL), J. D. MULHOLLAND (Institute for Space Science and Technology, Gainesville, FL; Observatoire de la Cote d'Azur, Grasse, France), G. EICHHORN (Institute for Space Science and Technology, Gainesville, FL; Steward Observatory, Tucson, AZ), W. J. COOKE, and N. L. MONTAGUE (Florida, University, Gainesville) (Space dust and debris; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission B /Meetings B2, B3, and B5/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-18651 05-12) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 12, 1991, p. 115-122. 1991 8 p refs
(Contract NAG9-437; NAS1-16550)
Copyright

The LDEF Interplanetary Dust Experiment is unique in providing a time history of impacts of micron-sized particles on six orthogonal faces of the vehicle over a span of nearly a full year. Over 15,000 hits were recorded, representing a mix of zodiacal dust, meteor-stream grains, orbital debris, perhaps beta-meteoroids, and possibly interstellar matter. Although the total number was higher than predicted, the relative panel activity distribution was near expectations. Detailed deconvolution of the impact record with orbital data is underway, to examine each of these populations. Very preliminary results of the fairly crude 'first-look' analysis suggest that debris is the major particle component at 500 km. The data show clear evidence of some known meteor streams as sharp, tightly-focused events, unlike their visible counterparts. Some apparent debris events show similar signatures. Data from the leading and trailing edges suggest a detection of beta-meteoroids,

but the analysis is not yet conclusive. Absolute fluxes and flux ratios are not yet known, since the detector status analysis is yet incomplete. Author

A92-18938
HIGH-PERFORMANCE LASER FOR SPACE FLIGHT APPLICATIONS - LASER TECHNOLOGY AS CROSS SECTION TECHNOLOGY [HOCHLEISTUNGSLASER FUER RAUMFAHRTAUFGABEN - LASERTECHNOLOGIE ALS QUERSCHNITTSTECHNOLOGIE]
UWE BRAUCH, WOLFGANG SCHALL, and WOLFRAM WITTWER (DLR, Institut fuer Technische Physik, Stuttgart, Federal Republic of Germany) DLR-Nachrichten (ISSN 0937-0420), Nov. 1991, p. 3-5. In German. Nov. 1991 3 p In GERMAN
Copyright

A scheme is described for a space-based laser which converts sunlight into laser radiation. The laser light can be radiated to other satellites or platforms for any necessary application. Special attention is given to the use of such lasers for destroying space debris. C.D.

A92-20384
DEBRIS EVOLUTION AND LIFETIME FOLLOWING AN ORBITAL BREAKUP
V. A. CHOBOTOV and D. B. SPENCER (Aerospace Corp., El Segundo, CA) Dec. 1991 7 p refs
Copyright

A92-20385
MU RADAR MEASUREMENTS OF ORBITAL DEBRIS
TORU SATO, IWANE KIMURA (Kyoto University, Japan), HIDETOSHI KAYAMA, and AKIRA FURUSAWA Dec. 1991 6 p refs
Copyright

A92-20386
RELATIONSHIP BETWEEN ELECTROSTATIC DISCHARGES ON SPACECRAFT P78-2 AND THE ELECTRON ENVIRONMENT
HARRY C. KOONS and DAVID J. GORNEY (Aerospace Corp., Los Angeles, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Nov.-Dec. 1991, p. 683-688. Dec. 1991 6 p refs
(Contract F04701-88-C-0089)
Copyright

Pulses detected by the P78-2 spacecraft charging at high altitudes (SCATHA) pulse analyzer are divisible into two groups: those from surface charges, which occurred when the test samples on the vehicle surface were charged relative to the vehicle frame, and those from internal discharges, which occurred when the test samples on the surface were not charged. SCATHA data have confirmed all aspects of the spacecraft charging hypotheses first postulated as a basis for satellite anomalies in the mid-1970s; the connections among the energetic electron environment, the surface and internal charging of vehicle materials, electrostatic discharges, and spacecraft anomalies, have been verified. O.C.

A92-23433
A METHOD FOR DETERMINING THE POTENTIAL OF A SPACECRAFT [METOD ZA OPREDELIANE POTENTSIALA NA KOSMICHESKIIA OBEKT]
S. K. CHAPK'NOV, TS. P. DACHEV, I. B. IVANOV (B'lgarska Akademiia na Naukite, Institut za Kosmicheski Izsledvaniia, Sofia, Bulgaria), V. N. ORAEVSKII, and V. V. TEMNYI (IZMIRAN, Troitsk, USSR) Aerokosmicheski Izsledvaniia v B'lgaria (ISSN 0861-1432), vol. 7, 1991, p. 70-74. In Bulgarian. 1991 5 p In BULGARIAN refs
Copyright

The existing methods for determining the potential of a spacecraft are described. Problems of the existence of the object's potential are connected with the space conditions in the presence of operating injectors on board the active vehicles, and require the development and application of specialized devices for determining potential. A method is described where the potential value is determined, as well as its time characteristics in the first few microseconds after injection. A unique analyzing voltage sine scanning generator is used instead of the conventional step generators. In this case the energy consumption is half that of conventional methods. P.D.

A92-24067* National Aeronautics and Space Administration, Washington, DC.
A SPACECRAFT CHARGING STUDY ON THE SCEX 3 ROCKET
E. G. MULLEN, M. S. GUSSENHOVEN, D. A. HARDY, G. P. MURPHY, J. W. F. LLOYD, W. SLUTTER (USAF, Phillips Laboratory, Hanscom AFB, MA), P. MALCOLM (U.S. Air Force Academy, Colorado Springs, CO), P. J. KELLOGG, and S. MONSON (Minnesota, University, Minneapolis) (1991 IEEE Annual Conference on Nuclear and Space Radiation Effects, 28th, San Diego, CA, July 15-19, 1991, Proceedings. A92-24025 08-33) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 38, pt. 1, Dec. 1991, p. 1622-1628. Research sponsored by NASA. Dec. 1991 7 p refs
Copyright

Instruments on the SCEX 3 rocket payload were used to study charging during electron beam emissions. The data show that electrostatic analyzers can be used to measure vehicle charging and direct beam return currents in dense plasma conditions. The data also show return current dependencies on pitch angle, beam current and beam energy. It is found that if the proper care is taken, ESAs can be used to detect charging on vehicles in low altitude orbits which are contaminated with high levels of outgassing and in dense plasma regimes. These results are particularly important for the TSS-1 electrodynamic tether program where ESAs are being used to determine Shuttle charging levels during tether employment and to look for high fluxes of directly returning electrons during electron generator operations to balance the Shuttle charging. I.E.

A92-24074
DOSE VARIATION DURING SOLAR MINIMUM
M. S. GUSSENHOVEN, E. G. MULLEN, D. H. BRAUTIGAM (USAF, Phillips Laboratory, Hanscom AFB, MA), and E. HOLEMAN (Boston College, Chestnut Hill, MA) (1991 IEEE Annual Conference on Nuclear and Space Radiation Effects, 28th, San Diego, CA, July 15-19, 1991, Proceedings. A92-24025 08-33) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 38, pt. 1, Dec. 1991, p. 1671-1677. Dec. 1991 7 p refs
Copyright

The authors use direct measurement of dose to show the variation in inner and outer radiation belt populations at low altitude from 1984 to 1987. This period includes the recent solar minimum that occurred in September 1986. The dose is measured behind four thicknesses of aluminum shielding and for two thresholds of energy deposition, designated HILET and LOLET. An average dose per day is calculated for each month of satellite operation. It is found that the average proton (HILET) dose per day (obtained primarily in the inner belt) increased systematically from 1984 to 1987, and has a high anticorrelation with sunspot number when offset by 13 months. The average LOLET dose per day behind the thinnest shielding is produced almost entirely by outer zone electrons and varies greatly over the period of interest. If any trend can be discerned over the 4 year period it is a decreasing one. For shielding of 1.5 gm/sq cm (227 mil) Al or more, the LOLET dose is complicated by contributions from greater than 100 MeV protons and bremsstrahlung. I.E.

A92-24078
RADIATION ENVIRONMENT MEASUREMENTS AND SINGLE EVENT UPSET OBSERVATIONS IN SUN-SYNCHRONOUS ORBIT
C. S. DYER, A. J. SIMS (Royal Aerospace Establishment, Farnborough, England), J. FARREN, J. STEPHEN (Harwell Laboratory, England), and C. UNDERWOOD (Surrey, University, Guildford, England) (1991 IEEE Annual Conference on Nuclear

and Space Radiation Effects, 28th, San Diego, CA, July 15-19, 1991, Proceedings. A92-24025 08-33) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 38, pt. 1, Dec. 1991, p. 1700-1707. Dec. 1991 8 p refs
Copyright

Analysis of data from the Cosmic Radiation Environment and Dosimetry experiment (CREDO) carried in sun-synchronous polar orbit on UoSat-3 shows the influence of cosmic rays, trapped protons, and solar particles and allows comparison with device behavior. For the quiet-time cosmic ray environment, a comparison has been made between CREDO count rates as a function of LET and the predicted count rate (for several values of rigidity) using the Adams model and applying a full treatment to the isotropic pathlength distribution in the 1 sq cm by 300 micron diodes. Two periods of very intense solar activity have been observed from the data set to date; an analysis of the count rate LET spectra during this event reveals that in the 2-3 GV rigidity range, counts are enhanced up to 103 MeV/(g/sq cm) and that solar flare effects are observed for rigidity values up to 6-7 GV. A CREDO count rate contour map of the South Atlantic Anomaly at 800 km altitude has been constructed from frequent UoSat-3 traversals of this region. I.E.

A92-24079
TDRS-1 SINGLE EVENT UPSETS AND THE EFFECT OF THE SPACE ENVIRONMENT
DANIEL C. WILKINSON (NOAA, National Geophysical Data Center, Boulder, CO), STUART C. DAUGHTRIDGE (INTELSAT, Washington, DC), JOHN L. STONE (Contel Federal Systems, Chantilly, VA), HERBERT H. SAUER (NOAA, Space Environment Laboratory, Boulder, CO), and PHIL DARLING (Contel Federal Systems, Las Cruces, NM) (1991 IEEE Annual Conference on Nuclear and Space Radiation Effects, 28th, San Diego, CA, July 15-19, 1991, Proceedings. A92-24025 08-33) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 38, pt. 1, Dec. 1991, p. 1708-1712. Dec. 1991 5 p refs
Copyright

The systematic recording of single event upsets on TDRS-1 from 1984 to 1990 allows correlations to be drawn between those upsets and the space environment. Ground based neutron monitor data are used to illustrate the long-term relationship between galactic cosmic rays and TDRS-1 upsets. The short-term effects of energetic solar particles are illustrated with space environment data from GOES-7. I.E.

A92-24080
A DOUBLE-PEAKED INNER RADIATION BELT - CAUSE AND EFFECT AS SEEN ON CRRES
E. G. MULLEN, M. S. GUSSENHOVEN, K. RAY, and M. VIOLET (USAF, Phillips Laboratory, Hanscom AFB, MA) (1991 IEEE Annual Conference on Nuclear and Space Radiation Effects, 28th, San Diego, CA, July 15-19, 1991, Proceedings. A92-24025 08-33) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 38, pt. 1, Dec. 1991, p. 1713-1717. Dec. 1991 5 p refs
Copyright

Data from the Combined Release and Radiation Effects Satellite (CRRES) show the formation of a second peak in the inner proton radiation belt during the Sudden Storm Commencement (SSC) at 03:42 UT on 24 March 1991. The authors believe that the injection of high energy protons into an L-shell of 2.55 RE is directly related to the solar-initiated shock accompanying the SSC. Once injected, the greater than 20 MeV protons became stably trapped and produced the second peak in the proton belt that continues for months after the event. The secondary peak protons increased single event upset rates in microelectronic test devices on CRRES by over an order of magnitude in the region of the second peak, that is, for L-values of 1.8 RE to 2.6 RE. This second belt has far-reaching effects for radiation belt modelers and for determining radiation degradation and single event upset (SEU) levels that must operate in this region of near-Earth space. I.E.

A92-24336#
ORBITAL DEBRIS CONTROL AND SPACE ASSET DISPOSAL STRATEGIES FOR THE STRATEGIC DEFENSE SYSTEM
STEPHAN A. GREENE (Dynamics Research Corp., Arlington, VA) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 11 p refs
(Contract SDIO84-88-C-0017)
(AIAA PAPER 91-4065) Copyright

Orbital debris is a new challenge for space system design and operations. This paper identifies four main strategies for dealing with orbital debris: avoidance, protection, prevention, and removal. Technological maturity and development risk are assessed for technologies and techniques associated with each strategy. Space system developers and users have several options already available to begin addressing the orbital debris problem. Technologies for prevention and some avoidance and removal technologies are reasonably mature and have low development risk. Protection and some avoidance and removal technologies require further development. With additional research and development, other technologies and techniques will become available for controlling the growth of debris and their effect on earth-orbiting spacecraft.
Author

A92-24361#
IMPACT OF ORBITAL DEBRIS ON ROBOTICS AND MANNED SPACE OPERATIONS AND LOGISTICS
F. N. RODRIGUES (Advanced Sciences, Inc., Albuquerque, NM) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 10 p refs
(AIAA PAPER 91-4106) Copyright

This paper summarizes some practical considerations in designing manned and unmanned space platforms to mitigate orbital debris generation. Included are considerations in preventing space logistics platforms from on-orbit collisions with space debris. The debris environment in low-earth and geosynchronous orbits contains hazards from objects ranging from milligrams to kilograms and with relative velocities ranging from 0 to 14 km/sec. With an anticipated increase of space operations and logistics support missions by year 2000, development of debris mitigation techniques such as use of new materials, atmospheric drag, and deorbiting could sharply reduce orbital debris growth. Shielding and collision avoidance techniques could prevent debris damage. Finally, legal and environmental implications are presented to address the consequences of liability for damages caused by orbital debris.
Author

A92-24387#
IMPACT FRAGMENT MODELING USING MAGI
M. ELIASSI, T. CARNEY, J. MIMS, S. ANDERSON, and J. HIPP (Advanced Sciences, Inc., Albuquerque, NM) AIAA and Society of Logistics Engineers, Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991. 6 p. Nov. 1991 6 p refs
(AIAA PAPER 91-4066) Copyright

A procedure for modeling impact fragmentation and the preliminary findings are discussed. The procedure consists of a coupled approach between a smoothed particle hydrodynamics-based hydrocode, MAGI, and an energy-based fragmentation model for computation of subscale fragments. Other model components include a fracture algorithm, a fragment counter, and a postprocessor for graphical display of debris cloud data.
Author

A92-24424
PREDICTION OF SOLAR ACTIVITY WITH A NEURAL NETWORK AND ITS EFFECT ON ORBIT PREDICTION
KENNETH E. WILLIAMS (Johns Hopkins University, Laurel, MD) Johns Hopkins APL Technical Digest (ISSN 0270-5214), vol. 12, Oct.-Dec. 1991, p. 310-317. Dec. 1991 8 p refs
Copyright

Neural networks are presently shown to provide useful models for the highly complex variability of solar activity. Although the problem of solar activity prediction during maxima has not been satisfactorily resolved, the neural network generally performs better

than the linear regression method in solar-activity prediction. Attention is given to the consequentiality of improved solar activity predictions via neural networks for predictions of the orbital position of satellites at orbital altitudes of less than 1000 km, for periods of up to 1 yr. O.C.

A92-24656
DEFINING ORBITAL DEBRIS ENVIRONMENTAL CONDITIONS FOR SPACECRAFT VULNERABILITY ASSESSMENT
ROBERT C. REYNOLDS (*System Planning Corp., Houston, TX*), GREGORY W. OJAKANGAS, and PHILLIP D. ANZ-MEADOR (Lockheed Engineering and Sciences Co., Houston, TX) Feb. 1992 7 p refs
Copyright

A92-24657
CATALOG GROWTH RATE STUDY (HAZARD ANALYZED IN GEOSYNCHRONOUS TRANSFER ORBITS)
D. S. MCKNIGH (Kaman Sciences Corp., Alexandria, VA) and N. L. JOHNSON (*Teledyne Brown Engineering, Colorado Springs, CO*) Feb. 1992 6 p refs
Copyright

A92-24659* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
SOLAR F10.7 RADIATION - A SHORT-TERM STATISTICAL MODEL
JOHN D. VEDDER and JILL L. TABOR (McDonnell Douglas Space Systems Co., Houston, TX) Feb. 1992 5 p refs
(Contract NAS9-17885)
Copyright

A92-24663* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
SKIRT SPACE SHUTTLE GLOW EXPERIMENT
M. AHMADJIAN (USAF, Systems Command, Hanscom AFB, MA), D. E. JENNINGS, M. J. MUMMA (NASA, Goddard Space Flight Center, Greenbelt, MD), B. D. GREEN (Physical Sciences, Inc., Andover, MA), B. D. DIX (Space Systems Engineering, Logan, UT), and R. W. RUSSELL (Aerospace Corp., Los Angeles, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 29, Jan.-Feb. 1992, p. 102-107. Feb. 1992 6 p refs
(Contract F19628-88-C-0069; F04701-88-C-0089)
Copyright

This paper describes a spectrometer/radiometer experiment to obtain infrared, visible, and ultraviolet measurements of Space Shuttle glow. The payload, Spacecraft Kinetic Infrared Test (SKIRT), is a cryogenic circular variable filter infrared spectrometer with a number of infrared, visible, and ultraviolet radiometers covering the spectral range of 0.2-5.4 microns and 9.9-10.3 microns. It will measure Shuttle glow as a function of mission elapsed time, orbiter attitude, temperature, and orbiter events such as thruster firings. The measured data should have sufficient spectral resolution and sensitivity to identify molecular species contributing to Shuttle glow emissions. SKIRT is manifested on STS-39. Author

A92-24824
THE PROPERTIES OF SPACECRAFT CHARGING IN CONSIDERATION OF EFFECTS OF ANGLES OF INCIDENCE OF CHARGED PARTICLES ON THE SECONDARY ELECTRON EMISSION
BOYI WANG (Chinese Academy of Sciences, Institute of Mechanics, Beijing, People's Republic of China), QINGSONG WU, RUNGFU JIANG, and YANHOU XU (University of Science and Technology of China, Hefei, People's Republic of China) Chinese Society of Astronautics, Journal (ISSN 1000-1328), no. 3, 1991, p. 92-98. In Chinese. 1991 7 p In CHINESE refs

The relationships of effects induced by different angles of incidence of charged particles on the secondary electron emission, which are based on experimental data, are applied. On the basis of the theory of orbit-limited currents, the expressions of number fluxes of secondary electron emission with these effects for spacecrafts of different shapes are obtained. Also, according to the local current balance model, the shaded-side spacecraft potentials under the condition of no photoelectrons are calculated. Comparing these calculation results with those without the effects, the negative potentials are decreased to some extent. When calculating the practical spacecraft charging, these effects should be considered. Author

A92-25085 Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RADAR DETECTION OF CENTIMETER-SIZED ORBITAL DEBRIS - PRELIMINARY ARECIBO OBSERVATIONS AT 12.5-CM WAVELENGTH
T. W. THOMPSON, R. M. GOLDSTEIN (JPL, Pasadena, CA), D. B. CAMPBELL (Cornell University, Ithaca, NY), E. G. STANSBERY, and A. E. POTTER, JR. (NASA, Johnson Space Center, Houston, TX) Geophysical Research Letters (ISSN 0094-8276), vol. 19, Feb. 7, 1992, p. 257-259. 7 Feb. 1992 3 p refs
Copyright

Orbital debris objects with sizes of 6 mm and larger were detected when they passed through the main beam of the high-power, 12.6-cm wavelength radar at the Arecibo Observatory. The number of objects detected at altitudes below 1000 km in the size range of 6 mm to 2 cm agreed with orbital debris model predictions to better than a factor of two. Radar detections of larger orbital debris (10-cm diameter and above) were also compared with the objects in the U.S. Space Command catalog (the cataloged objects have UHF radar cross-sections larger than 0.01 sq m). This experiment demonstrated that the large, earth-based radar telescopes normally used for planetary studies can provide useful data about the near-earth orbital debris populations. Author

A92-26982#
THRUSTER FIRINGS AND OTHER RELEASES FROM ORBITING SPACECRAFT AND THE INDUCED PLASMA AND RADIATION EMISSION ENVIRONMENT
NIKOLAOS A. GATSONIS and DANIEL E. HASTINGS (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 20 p. Jan. 1992 20 p refs
(AIAA PAPER 92-0575) Copyright

Attention is given to the neutral, plasma, and radiation environment induced around spacecraft in low earth orbit. The 3D evolution of an artificial plasma cloud created by spacecraft which release neutrals and/or plasma into the ambient ionosphere is examined. Simulations of spacecraft operations which release neutral water and create a water plasma cloud, such as thruster firings or effluent dumps, are performed. It is shown that for time scales of interest in contamination studies the flow of the released neutrals is in the free molecular regime. The effects of the altitude of the release, orientation of the thrust vector with regard to the magnetic field, and latitude on the induced environment are considered. It is shown that a large water ion cloud is formed with densities of the order of the ambient oxygen ions. It is predicted that the ambient oxygen forms depletion and enhancement regions. C.A.B.

A92-26984# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE FORMATION AND STRUCTURE OF PLASMA WAKES BEHIND LARGE HIGH-VOLTAGE SPACE PLATFORMS IN IONOSPHERE
J. WANG (JPL, Pasadena, CA) and DANIEL E. HASTINGS (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 18 p. Jan. 1992 18 p refs
(Contract NAG3-695)
(AIAA PAPER 92-0577) Copyright

Theory and particle simulation results are presented for ionospheric plasma flow over space platforms in the large-dimension and high-voltage range. Both the transient formation of the space-charge wake and its steady state structure are studied. The wake-side ion impact and current collection are obtained. It is found that the wake behind a high-voltage plate is characterized by two ion-rich sheaths embedded in a quasi-neutral

background wake. The embedded sheath is formed by the ions passing through the sheath around the plate edge and serves as their trajectory path. Depending on the surface potential, the plate dimension, and the angle of attack, the embedded sheath may either extend downstream or curve back to the plate causing a high, localized ion flux density at the location it strikes. Author

A92-27124#
LIQUID DISPERSAL STUDY - A PROPOSED SPACE SHUTTLE LIQUID RELEASE EXPERIMENT
J. A. GARDNER, D. L. A. RALL, I. L. KOFSKY (PhotoMetrics, Inc., Woburn, MA), A. SETAYESH (Radex, Inc., Bedford, MA), and E. MURAD (USAF, Phillips Laboratory, Hanscom AFB, MA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 7 p. Jan. 1992 7 p refs
(AIAA PAPER 92-0793) Copyright

An important component of the low earth orbit environment is the presence of submicron to millimeter diameter particles resulting in part from routine Space Shuttle liquid releases (waste management, fuel cell by-products). The scattering of solar radiation and earthshine by these particles may interfere with spacecraft-borne operations such as spectrometer measurements. A two-dimensional computer model is being developed to provide insight into the effect that various liquid physical parameters (e.g., heat capacity, thermal conductivity, temperature dependence of vapor pressure) have on the liquid dispersal. An experiment designed to disperse several liquids with differing physical parameters to provide information on the lifetime and temperature history of the liquid and particles in the space environment is proposed. Author

A92-27130
SPACE ENVIRONMENT: PREVENTION OF RISKS RELATED TO SPACECRAFT CHARGING; INTERNATIONAL COURSE ON SPACE TECHNOLOGY, TOULOUSE, FRANCE, NOV. 26-30, 1990, PROCEEDINGS [ENVIRONNEMENT SPATIAL: PREVENTION DES RISQUES LIES AUX PHENOMENES DE CHARGE; COURS INTERNATIONAL DE TECHNOLOGIE SPATIALE, TOULOUSE, FRANCE, NOV. 26-30, 1990, PROCEEDINGS]
Course sponsored by CNES. Toulouse, France, Cepadues-Editions, 1992, 487 p. In French and English. For individual items see A92-27131 to A92-27146. 1992 487 p
(ISBN 2-85428-288-4) Copyright

The present volume discusses topics concerning the earth's magnetosphere and ionosphere, space environment modeling, ion effects on integrated circuits, orbital anomalies due to electrostatic discharges, analytical and computer modeling of spacecraft potentials, and the electrical properties of materials. Also discussed are electrostatic charging by high-energy electrons, surface discharges on electron-irradiated polymers, the environmental interactions of solar cell arrays in LEO, and numerical simulations of the electromagnetic environment. O.C.

A92-27135
MODELLING THE SPACE ENVIRONMENT
E. J. DALY (ESTEC, Noordwijk, Netherlands) IN: Space environment: Prevention of risks related to spacecraft charging; International Course on Space Technology, Toulouse, France, Nov. 26-30, 1990, Proceedings 1992 28 p refs
Copyright

Evaluation of the effects of the space environment on spacecraft and their components clearly requires a quantitative knowledge of the space environment. This is provided in the form of numerical models of the space environment, based on satellite measurements. A review is made of these various models, of the data from which they are derived and of their physical basis. The emphasis is on models of the energetic particle and plasma environments which are used for analyses of radiation effects, and surface and internal charging. Models of other aspects of the space environment are also summarized. Spacecraft in high altitude orbits and those at low altitudes (e.g., polar or low-inclination) encounter very different plasma environments which result in very different interactions with spacecraft. In addition, energetic particles can penetrate materials, causing damage, interfering with operation and generating an internal charge. The ways in which models are used for evaluating these various interactions are described. Limitations of the models are discussed, along with measures which are being undertaken to improve them. Author

A92-27137
EFFECTS OF HEAVY IONS ON INTEGRATED CIRCUITS (THE SINGLE EVENT EFFECT) [EFFETS DES IONS LOURDS SUR LES CIRCUITS INTEGRES /S.E.E. - SINGLE EVENT EFFECT/]
JACQUES BOURRIEAU (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) IN: Space environment: Prevention of risks related to spacecraft charging; International Course on Space Technology, Toulouse, France, Nov. 26-30, 1990, Proceedings 1992 18 p In FRENCH refs
Copyright

ICs aboard spacecraft have been susceptible to various soft and hard failures under exposure to primary cosmic rays and the secondary ions generated by energetic proton-generated nuclear reactions. Such single-event phenomena (SEP) occur in the reverse-bias p-n junctions that collect the charges induced along the ion trajectory crossing the sensitive node. The SEPs most often observed are single-event 'upsets' and single-event 'latchups'. Attention is given to the physical processes involved, as well as to the parameter defining a device's susceptibility to SEP, and to SEP rate-forecasting methods. O.C.

A92-27138
ANOMALIES IN FLIGHT - THE CASE OF ANOMALIES DUE TO ELECTROSTATIC DISCHARGES [ANOMALIES EN VOL - CAS DES ANOMALIES DUES A DES DECHARGES ELECTROSTATIQUES]
JEAN-PIERRE CATANI (CNES, Toulouse, France) IN: Space environment: Prevention of risks related to spacecraft charging; International Course on Space Technology, Toulouse, France, Nov. 26-30, 1990, Proceedings 1992 17 p In FRENCH refs
Copyright

Some of the anomalies in satellite behavior occurring in orbit are due to electrostatic discharges, although it is generally difficult to identify this cause with certainty. It is suggested that the assumption that a particular anomaly may have been caused by an electrostatic discharge can be supported by analyzing the satellite's environment (illumination and geomagnetic activity) at the time of the event and by reproducing the anomaly in the laboratory. Case studies are presented which illustrate the variety of situations that can arise in orbit. L.M.

A92-27139
ANALYTICAL AND COMPUTER MODELING OF SPACECRAFT POTENTIALS
MYRON J. MANDELL (Maxwell Laboratories, Inc., La Jolla, CA) IN: Space environment: Prevention of risks related to spacecraft charging; International Course on Space Technology, Toulouse, France, Nov. 26-30, 1990, Proceedings 1992 18 p refs
Copyright

The present effort to model spacecraft electrical potentials proceeds by characterizing the electrical currents and electrostatic interactions between idealized surfaces and the plasma encountered by spacecraft in LEO, giving attention to the relative importance of various terms for a thin, hot plasma, as represented by a magnetic substorm, vs a dense cold plasma, as represented by the LEO environment. Phenomena associated with real spacecraft, which complicate surface-potential calculations, are noted. Calculations are presented for illustrative cases of various physical conditions and electrical and geometrical configurations. O.C.

A92-27144
THE ELECTROMAGNETIC ENVIRONMENT AND NUMERICAL SIMULATIONS [ENVIRONNEMENT ELECTROMAGNETIQUE & SIMULATIONS NUMERIQUES]
J. P. ESTIENNE (Matra Marconi Space France,

Velizy-Villacoublay) IN: Space environment: Prevention of risks related to spacecraft charging; International Course on Space Technology, Toulouse, France, Nov. 26-30, 1990, Proceedings 1992 51 p In FRENCH refs
Copyright

The paper considers the electromagnetic environment in earth orbit that can cause charging and electrostatic discharge effects, especially in geostationary orbit. Only electric and electromagnetic phemonena are considered. Particular emphasis is placed on numercial methods which reproduce the electric and electromagnetic behavior (EMC, ESD, etc.) of a system in this environment. The main causes of system malfunction are reviewed. The different applicable numerical techniques (finite difference, finite volume, and moment method) are described, along with examples of their application. L.M.

A92-27647
ANALYTICAL MODEL FOR THE PREDICTION OF THE MICROMETEROID HAZARD FOR THE REFLECTING SURFACE OF A SOLAR SAIL [ANALITICHESKAIA MODEL' PROGNOZIROVANIIA MIKROMETEORITNOI OPASNOSTI DLIA OTRAZHAIUSHCHEI POVERKHNOSTI SOLNECHNOGO PARUSA]
E. N. POLIAKHOVA Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), July 1991, p. 98-111. In Russian. Jul. 1991 14 p In RUSSIAN refs
Copyright

It is pointed out that erosion caused by micrometeroid collisions on the reflecting surface of a solar sail in interplanetary space can susbtantially affect the sail performance and lifetime, reduce the reflectivity and area-to-mass ratio, and produce a change in the orbital elements. The erosion effect is modeled in the present work by incorporating degradation effects in the equations of the perturbed orbital heliocentric motion of the spacecraft with the solar sail. Attention is given to models for the deterioration in the optical reflection properties and in the effective working surface of the sail. L.M.

A92-28090
SOLAR CYCLE DEPENDENCE OF SPACECRAFT CHARGING IN LOW EARTH ORBIT
T. B. FROONINCKX and J. J. SOJKA (Utah State University, Logan) Journal of Geophysical Research (ISSN 0148-0227), vol. 97, no. A3, March 1, 1992, p. 2985-2996. 1 Mar. 1992 12 p refs
(Contract AF-AFOSR-90-0026)
Copyright

The primary causes, frequency, severity, and solar cycle dependence of high-latitude spacecraft charging in low earth polar orbit (840 km) were identified from extensive satellite measurements in the Northern Hemisphere for winter periods of solar maximum, medium, and minimum. The conditions generating satellite-to-plasma potential differences were analyzed using measured precipitating ion, precipitating electron, and ambient plasma data as well as model ambient plasma results. The conditions which did not cause spacecraft charging were similarly examined. It was found that an extreme solar cycle dependence exists and that solar minimum conditions generate charging more frequently and with greater magnitude. The chief cause of this dependence is the solar cycle variation of ambient plasma density; the lack of significant charging during solar maximum is due to high ambient plasma densities. Kilovolt charging can occur via natural processes within low earth orbit. Electrons with energies from 2 to 3 keV contribute to charging, though higher energy electrons make greater contributions. C.A.B.

A92-28230*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INTERACTIONS OF THE SPACE ENVIRONMENTS WITH THE LONG DURATION EXPOSURE FACILITY (LDEF)
WILLIAM H. KINARD, GLENNA L. MARTIN (NASA, Langley Research Center, Hampton, VA), and ROBERT L. O'NEAL (Lockheed Engineering and Sciences Co., Hampton, VA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 9 p. Jan. 1992 9 p refs
(AIAA PAPER 92-0792) Copyright

The Long Duration Exposure Facility (LDEF) was retrieved from space after 69 months in orbit. Post-retrieval observations of the facility and the 57 experiments that were onboard have revealed unique and valuable observations of the space environments and the interactions of these environments with the LDEF during the prolonged stay. This paper describes the LDEF, the onboard experiments, the flight mission, and what some of the post-retrieval LDEF observations have revealed about the radiation, meteoroids, manmade debris, atomic oxygen, and contamination environments and their effects on spacecraft. Author

A92-28490
ORBITAL DEBRIS - THE VIEW FROM RUSSIA
YU. A. MOZJOURIN and S. V. CHEKALIN Aerospace America (ISSN 0740-722X), vol. 30, March 1992, p. 15-17. Mar. 1992 3 p
Copyright

Recommendations are made for integrated modeling and monitoring of space debris and curbing the levels of orbiting spacecraft fragments. Promising measures include the development of universal space platforms capable of replacing several satellites and the development of separation devices for launcher stages and spacecraft. Structures and coatings resistant to space environmental effects and secondary erosive emissions need to be developed. C.D.

A92-29613#
THE POSSIBILITY OF CRITICAL VELOCITY IONIZATION NEAR THE SPACE STATION - SIMULATION RESULTS
RODGER J. BIASCA, DANIEL E. HASTINGS (MIT, Cambridge, MA), and DAVID L. COOKE (USAF, Phillips Laboratory, Hanscom AFB, MA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 7 p. Jan. 1992 7 p refs
(Contract F19628-90-K-0021)
(AIAA PAPER 92-0847) Copyright

This paper investigates the possibility of the 'critical velocity ionization' of the effluents of thruster firings or other neutral gas releases from an orbiting vehicle. One-dimensional particle-in-cell simulations are used to derive reaction rates for the anomalous ionization process. These reaction rates are then used to suggest the magnitude of possible plasma density increases near the vehicle. If critical velocity ionization should occur, the results show that order of magnitude increases in the plasma density are possible. Author

A92-30297
THE PLASMA-WAVE EXPERIMENT ON THE VEGA INTERPLANETARY PROBES [EKSPERIMENT PO IZUCHENIIU PLAZMENNYKH VOLN NA MEZHPLANETNYKH STANTSIIAKH 'VEGA']
S. I. KLIMOV, V. E. KOREPANOV, P. M. SOPRUNIUK, and S. A. SAVIN Kosmicheskaia Nauka i Tekhnika (ISSN 0321-4508), no. 5, 1990, p. 80-89. In Russian. 1990 10 p In RUSSIAN refs
Copyright

The paper describes the instruments and methods used in a study of plasma waves conducted aboard the Vega-1 and -2 interplanetary spacecraft, with special attention given to the characteristics of the two plasma wave analyzers (PWAs) used in the study: the PWA for low-frequency plasma waves and the PWA for high frequencies. Results are presented together with interpretation. I.S.

A92-30625
NEW CLASS OF SIMULATORS FOR THE CHARACTERIZATION OF EQUIPMENT CARRIED BY LARGE STRUCTURES [NOUVELLE CLASSE DE SIMULATEURS PERMETTANT LA CARACTERISATION DE DISPOSITIFS EMBARQUES SUR DES STRUCTURES DE GRANDES DIMENSIONS]
JOEL ANDRIEU, YVES RAINGEAUD (Limoges, Institut de

Recherches en Communications Optiques et Microondes, France), OMAR DAFIF, BERNARD JECKO (Institut Universitaire de Technologie, Limoges, France), DANIEL NEGRET, and BERNARD PECQUEUX (DGA, Centre d'Etudes de Gramat, France) Annales des Telecommunications (ISSN 0003-4347), vol. 47, Jan.-Feb. 1992, p. 73-85. In French. Research supported by DGA. Feb. 1992 13 p In FRENCH refs
Copyright

A simulation technique is described which can be applied to large aerospace structures to evaluate the electromagnetic environment generated by a vehicle and its proposed subsystems. The concept is based on the use of a horizontal-polarization transmission-line simulator which is employed to study the spatial and temporal characteristics of the electromagnetic fields within each volume of the structure. A high-voltage generator provides transient currents for the simulator, and Maxwell integral equations with the Lorentz condition are used to solve the values of the currents in the space-time domain. The simulated values for current density corresponding to the interiors and surfaces of the structures compare favorably with experimental values for the time evolution of the electric field and for values of current density. The simulation technique is shown to be an effective method for analyzing the electromagnetic environment in an aerospace structure and thereby its impact on critical subsystems. C.C.S.

A92-30633 National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
RECENT RESULTS FROM STUDIES OF ELECTRON BEAM PHENOMENA IN SPACE PLASMAS
TORSTEN NEUBERT and PETER M. BANKS (Michigan, University, Ann Arbor) Planetary and Space Science (ISSN 0032-0633), vol. 40, Feb.-Mar. 1992, p. 153-173, 175-183. Mar. 1992 30 p refs
(Contract NAS8-35350; NAGW-2350)
Copyright

The paper examines selected results from experiments, performed in 1980s, involving the ejection of beams of electrons from spacecraft. Special attention is given to the basic processes associated with the spacecraft charging, passive current collection, beam-atmosphere interactions, beam-plasma interactions, and neutral gas emission. Consideration is also given to future experiments on active electron beam ejections in space. I.S.

A92-30868
IMPACT CRATERING FROM LDEF'S 5.75-YEAR EXPOSURE - DECODING OF THE INTERPLANETARY AND EARTH-ORBITAL POPULATIONS
J. A. M. MCDONNELL (Kent, University, Canterbury, England) IN: Proceedings of Lunar and Planetary Science, Volume 22; Conference, Houston, TX, Mar. 18-22, 1991 1992 9 p refs
Copyright

Penetration records from exposure of the LDEF multiple-foil microabrasion experiment (MAP) in five pointing directions have been obtained in order to decode the possible contribution from earth orbital (bound) components and hyperbolic (unbound) particles of extraterrestrial origin. A preliminary flux redistribution is derived for the nominal east- (ram), west- (trailing) and space-pointing detector surfaces. Orbital dynamics and collisional probabilities are used to demonstrate a high anisotropy in the flux rate for the different detector locations. The east-to-west flux ratio for the MPA data is 34 +/- 7 for the penetration of aluminum at 5 microns and 7.3 +/- 1.7 at 30 microns; the space-to-west ratio is 4.9 +/- 1.0 at 5 microns. These data demonstrate that LDEF impacts on all detectors are dominated by unbound and hence extraterrestrial particulates above particulate masses of 6.4 x 10 exp -10 g mass. However, for small particulates an orbital component is clearly identified on the east and side faces that exceeds the interplanetary flux distribution by a factor of about four on the east face. C.D.

A92-32191* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
TECHNIQUES FOR ORBITAL DEBRIS CONTROL
ANDREW J. PETRO (NASA, Johnson Space Center, Houston, TX) Apr. 1992 4 p refs
Copyright

N92-11898*# Southwest Research Inst., San Antonio, TX.
A SIMULATION STUDY OF INTERACTIONS OF SPACE-SHUTTLE GENERATED ELECTRON BEAMS WITH AMBIENT PLASMA AND NEUTRAL GAS Annual Progress Report, Nov. 1990 - Nov. 1991
Nov. 1991 26 p
(Contract NAGW-1936; SWRI PROJ. 15-3399)
(NASA-CR-189025; NAS 1.26:189025) Avail: CASI HC A03/MF A01

The object was to conduct large scale simulations of electron beams injected into space. The study of active injection of electron beams from spacecraft is important since it provides valuable insight into beam-plasma interactions and the development of current systems in the ionosphere. However, the beam injection itself is not simple, being constrained by the ability of the spacecraft to draw return current from the ambient plasma. The generation of these return currents is dependent on several factors, including the density of the ambient plasma relative to the beam density, the presence of neutrals around the spacecraft, the configuration of the spacecraft, and the motion of the spacecraft through the plasma. Two dimensional particle simulations with collisional processes included are used to show how these different and often coupled processes can be utilized to enhance beam propagation from the spacecraft. To understand the radical expansion of mechanism of an electron beam from a highly charged spacecraft, two dimensional particle in cell simulations were conducted for a high density electron beam injected parallel to magnetic fields from an isolated equipotential conductor into a cold background plasma. The simulations indicate that charge buildup at the beam stagnation point causes the beam to expand radially to the beam electron gyroradius. Author

N92-12041 California Univ., San Diego.
A DIFFERENTIAL CHARGING MODEL FOR SYNCHRONOUS SATELLITES Ph.D. Thesis
WEI-WEI LI 1990 159 p
Avail: Univ. Microfilms Order No. DA9118988

A semi-analytic model was developed for differential charging of satellites. The model applies to a plasma whose free path is much greater than Debye Length is much greater than the size of the satellite. The potential of a barrier free surface is solved from the local charging current. On surfaces under barriers, the potentials are regulated by the self-consistency between barriers and the net charging current. When the potential under the barrier goes more positive, the barrier height increases. On other hand, a stronger barrier suppresses more outgoing electrons so that net current become more negative. When the a negative charge accumulates on the surface, the barrier would decrease. These two opposite tendencies are balanced if the barrier height reaches an appropriate value. After the potential on the barrier free surfaces and barrier structures are determined, the complete potential contours around a satellite can be solved. The differential potential can be separated into a normalized potential and a scale factor. The scale factor is the most negative potential on the barrier free surface which includes all the information about ambient plasma, time, and material. The normalized potential shows the ratio between the potential at any given location and the most negative potential. It indicates the relative differential charging which is an intrinsic property of the geometry. Dissert. Abstr.

N92-13149# Photometrics, Inc., Woburn, MA.
MEASUREMENT AND INTERPRETATION OF CONTAMINANT RADIATIONS IN THE SPACECRAFT ENVIRONMENT Final Report, 1 Jun. 1988 - 31 May 1991
I. L. KOFSKY, D. L. RALL, and R. B. SLUDER 28. Jun. 1991 117 p
(Contract F19628-88-C-0070)
(AD-A241756; PL-TR-91-2174) Avail: CASI HC A06/MF A02

Video photographs and spectra of the optical radiations excited

by reactions of the energetic exhaust gases from space shuttle's aspect-controlling bipropellant rocket engines with the orbital atmosphere are analyzed. The data were taken with the Air Force Maui Optical Station's cameras and a new imaging spectrograph as these 400 kgf Primary Reaction Control System thrusters operated in ram-wake-perpendicular to the trajectory sequences planned by Geophysics Directorate. Emission originated from a few km parallel and transverse to the symmetry axis of the exhaust; the surface brightness distributions from the firings to windward are well fit by Gaussians; and the total sterances determined by calibration against known stars were in the approximate ration 10 (ram) : 5 (perpendicular) : 1 (wake), showing that the kinetic energy of the combustion products plays a major part in exciting chemiluminescence. Three orders of magnitude less radiation arose from the spacecraft region than from the much larger volume in which the exhaust interacts, from which the hard body appeared physically separated. GRA

N92-13150*# Illinois Univ., Urbana. Dept. of Electrical and Computer Engineering.
MODELING OF SURFACE FLASHOVER ON SPACECRAFT Final Report, 1 Sep. 1986 - 14 Feb. 1990
MARK J. KUSHNER Dec. 1991 47 p
(Contract NAG3-741)
(NASA-CR-189508; NAS 1.26:189508) Avail: CASI HC A03/MF A01

A model for predicting the onset of surface flashover discharges (SFDs) in the context of high voltage pulse power modulators was developed and used to investigate mechanisms leading to the onset of SFDs. We demonstrated that it is possible to analyze surface discharges in a manner similar to gas phase discharges using transport coefficients such as the first Townsend coefficient. Our parameterization of various methods to prevent, or at least delay, the onset of SFDs was not particularly successful in that many of the strategies that we investigated do not yield significantly improved performance. The only safe strategy to reduce the occurrence of SFDs is to prevent the dielectric from being charged in the first place. This leads one to consider passive or active schemes which employ the low pressure of attaching gases which flood the surface prior or coincident to pulsing the high voltage apparatus. Our calculations indicate that only small amounts gas (10s Torr effective pressure at substrate) would be sufficient for many of the anticipated applications. If the surface is flooded only when high voltage is applied across the dielectric, the gas consumption would be nominal. Author

N92-14099# Royal Signals and Radar Establishment, Malvern (England). Aerospace Div.
ANALYSIS OF THE SPACE SHUTTLE CABIN RADIATION ENVIRONMENT. PART 1: SAM GAMMA RADIATION DETECTOR RESULTS
P. R. TRUSCOTT, C. S. DYER, A. J. SIMS, and P. S. HASKINS (Institute for Space Science and Technology, Inc., Gainesville, FL.) May 1991 68 p Original contains color illustrations
(RAE-TM-SPACE-383-PT-1; BR304206-PT-1; ETN-92-90702; AD-A241888) Copyright Avail: CASI HC A04/MF A01

The result of a preliminary analysis of the gamma radiation detector experiment is presented. The experiment was part of the Shuttle Activation Monitor (SAM) flown on Shuttle mission STS-28 in August 1989. The count rates observed by the two types of detector flown (sodium iodide and bismuth germanate) are compared with the predicted variation of the cosmic ray vertical cutoff rigidity, and with the predicted trapped particle environment, based on the AP8MAX and AE8MAX models of the radiation belts. The observed count rate is found to be closely correlated with the predicted vertical cutoff rigidity. Times of expected increases in trapped radiation levels are in good agreement with the count rate enhancements observed when the spacecraft in the South Atlantic anomaly region of the high latitude outer electron belts. Higher gamma radiation levels are experienced when the detectors are in the mode shielded locations of the spacecraft. This situation is reversed for parts of the orbit when the count rates are dominated by trapped radiation. Higher rates are observed at less well shielded locations of Shuttle. South Atlantic anomaly radiation gives rise to overall enhancements in the pulse height spectra collected, indicating that trapped protons are of importance in this region. ESA

N92-14186*# Utah State Univ., Logan.
DATA ANALYSIS AND INTERPRETATION RELATED TO SPACE SYSTEM/ENVIRONMENT INTERACTIONS AT LEO ALTITUDE Final Report
W. JOHN RAITT and ROBERT W. SCHUNK Dec. 1991 46 p
(Contract NAG3-792)
(NASA-CR-189524; NAS 1.26:189524) Avail: CASI HC A03/MF A01

Several studies made on the interaction of active systems with the LEO space environment experienced from orbital or suborbital platforms are covered. The issue of high voltage space interaction is covered by theoretical modeling studies of the interaction of charged solar cell arrays with the ionospheric plasma. The theoretical studies were complemented by experimental measurements made in a vacuum chamber. The other active system studied was the emission of effluent from a space platform. In one study the emission of plasma into the LEO environment was studied by using initially a 2-D model, and then extending this model to 3-D to correctly take account of plasma motion parallel to the geomagnetic field. The other effluent studies related to the releases of neutral gas from an orbiting platform. One model which was extended and used determined the density, velocity, and energy of both an effluent gas and the ambient upper atmospheric gases over a large volume around the platform. This model was adapted to study both ambient and contaminant distributions around smaller objects in the orbital frame of reference with scale sizes of 1 m. The other effluent studies related to the interaction of the released neutral gas with the ambient ionospheric plasma. An electrostatic model was used to help understand anomalously high plasma densities measured at times in the vicinity of the space shuttle orbiter. Author

N92-14846*# Southwest Research Inst., San Antonio, TX.
A SIMULATION STUDY OF INTERACTIONS OF SPACE-SHUTTLE GENERATED ELECTRON BEAMS WITH AMBIENT PLASMA AND NEUTRAL GAS Annual Progress Report
ROBERT M. WINGLEE 14 Nov. 1991 26 p
(Contract NAGW-1936; SWRI PROJ. 15-3399)
(NASA-CR-189019; NAS 1.26:189019) Avail: CASI HC A03/MF A01

The objective was to conduct large scale simulations of electron beams injected into space. The study of the active injection of electron beams from spacecraft is important, as it provides valuable insight into the plasma beam interactions and the development of current systems in the ionosphere. However, the beam injection itself is not simple, being constrained by the ability of the spacecraft to draw current from the ambient plasma. The generation of these return currents is dependent on several factors, including the density of the ambient plasma relative to the beam density, the presence of neutrals around the spacecraft, the configuration of the spacecraft, and the motion of the spacecraft through the plasma. Two dimensional (three velocity) particle simulations with collisional processes included are used to show how these different and often coupled processes can be used to enhance beam propagation from the spacecraft. To understand the radial expansion mechanism of an electron beam injected from a highly charged spacecraft, two dimensional particle-in-cell simulations were conducted for a high density electron beam injected parallel to magnetic fields from an isolated equipotential conductor into a cold background plasma. The simulations indicate that charge build-up at the beam stagnation point causes the beam to expand radially to the beam electron gyroradius. Author

N92-15890*# Florida International Univ., Miami. Dept. of Physics.
HIGH VOLTAGE PLASMA SHEATH ANALYSIS RELATED TO TSS-1

JOHN W. SHELDON *In* Alabama Univ., Research Reports: 1991 NASA/ASEE Summer Faculty Fellowship Program 4 p Oct. 1991
(Contract NGT-01-008-021)
Avail: CASI HC A01/MF A03

On the first mission of the Tethered Satellite System (TSS-1), a 1.8 m diameter spherical satellite will be deployed a distance of 20 km above the space shuttle Orbiter on an insulated conducting tether. The satellite will be held at electric potentials up to 5000 volts positive with respect to the ambient plasma. Due to the passage of the conducting tether through the Earth's magnetic field, an emf will be created, driving electrons down the tether to the orbiter, out through an electron gun into the ionosphere and back into the positive biased satellite. Instrumentation on the satellite will measure electron flow to the surface at several locations, but these detectors have a limited range of acceptance angle. The problem addressed herein is the determination of the electron current distribution over the satellite surface and the angle of incidence of the incoming electrons relative to the surface normal. Author

N92-16491 Institut d'Aeronomie Spatiale de Belgique, Brussels.
DEVELOPMENT STUDY OF IMPROVED MODELS OF THE EARTH'S RADIATION ENVIRONMENT Final Report
JOSEPH LEMAIRE (Institut d'Aeronomie Spatiale de Belgique, Brussels.), MICHEL ROTH (Institut d'Aeronomie Spatiale de Belgique, Brussels.), JACQUES WISEMBERG (Institut d'Aeronomie Spatiale de Belgique, Brussels.), POL DOMANGE (Institut d'Aeronomie Spatiale de Belgique, Brussels.), DOMINIQUE FONTEYN (Institut d'Aeronomie Spatiale de Belgique, Brussels.), JEAN MICHEL LESCEUX (Institut d'Aeronomie Spatiale de Belgique, Brussels.), GERARD LOH (Institut d'Aeronomie Spatiale de Belgique, Brussels.), GEORGES FERRANTE (MATRA Espace, Toulouse (France).), CHRISTIAN GARRES (MATRA Espace, Toulouse (France).), JACQUES BORDES (MATRA Espace, Toulouse, France) et al. 25 Sep. 1990 365 p Prepared in cooperation with JIV Associates, VA
(Contract ESTEC-8011/88/NL/MAC) (ISSN 0065-3713)
(AERONOMICA-ACTA-A-360-1991; ETN-92-90318) Avail: Institut d'Aeronomie Spatiale de Belgique, 3 Avenue Circulaire, B-1180 Brussels, Belgium

The radiation environment models of the Earth were reviewed and reevaluated. Several limitations of the earlier Earth's radiation models and of the way they have been used in the past for dose predictions along orbits of future spacecraft are identified and discussed. A new solar proton events statistical model was documented and implemented in the UNIRAD software used by ESA for expected dose calculations. Two sets of trapped electron flux measurements from LANL and IUE satellites were analyzed and compared to the existing NASA model predictions. The urgent need for continued updating of space environment models is shown. Recommendations and directions for future developments in modeling the radiation environment of the Earth are given. ESA

N92-17215*# Boeing Co., Seattle, WA. Defense and Space Group.
ATOMIC OXYGEN FLUX AND FLUENCE CALCULATION FOR LONG DURATION EXPOSURE FACILITY (LDEF)
ROGER J. BOURASSA and JAMES R. GILLIS 18 Jan. 1991 267 p
(Contract NAS1-18224)
(NASA-CR-187418; NAS 1.26:187418) Avail: CASI HC A12/MF A03

The LDEF mission was to study the effects of the space environment on various materials over an extended period of time. One of the important factors for materials degradation in low earth orbit is the atomic oxygen fluxes and fluences experienced by the materials. These fluxes and fluences are a function of orbital parameters, solar and geomagnetic activity, and material surface orientation. Calculations of atomic oxygen fluences and fluxes for the LDEF mission are summarized. Included are descriptions of LDEF orbital parameters, solar and geomagnetic data, computer code FLUXAV, which was used to perform calculations of fluxes and fluences, along with a discussion of the calculated fluxes and fluences. Author

N92-18023*# San Francisco Univ., CA.
IONIZING RADIATION EXPOSURE OF LDEF
E. V. BENTON, ed. (San Francisco State Univ., CA.) and W. HEINRICH, ed. (Siegen Univ.,, Germany, F.R.) Aug. 1990 66 p
(Contract NAG8-138)
(NASA-CR-189536; NAS 1.26:189536; USF-TR-77) Avail: CASI HC A04/MF A01

The Long Duration Exposure Facility (LDEF) was launched into orbit by the Space Shuttle 'Challenger' mission 41C on 6 April 1984 and was deployed on 8 April 1984. The original altitude of the circular orbit was 258.5 nautical miles (479 km) with the orbital inclination being 28.5 degrees. The 21,500 lb NASA Langley Research Center satellite, having dimensions of some 30x14 ft was one of the largest payloads ever deployed by the Space Shuttle. LDEF carried 57 major experiments and remained in orbit five years and nine months (completing 32,422 orbits). It was retrieved by the Shuttle 'Columbia' on January 11, 1990. By that time, the LDEF orbit had decayed to the altitude of 175 nm (324 km). The experiments were mounted around the periphery of the LDEF on 86 trays and involved the representation of more than 200 investigators, 33 private companies, 21 universities, seven NASA centers, nine Department of Defense laboratories and eight foreign countries. The experiments covered a wide range of disciplines including basic science, electronics, optics, materials, structures, power and propulsion. The data contained in the LDEF mission represents an invaluable asset and one which is not likely to be duplicated in the foreseeable future. The data and the subsequent knowledge which will evolve from the analysis of the LDEF experiments will have a very important bearing on the design and construction of the Space Station Freedom and indeed on other long-term, near-earth orbital space missions. A list of the LDEF experiments according to experiment category and sponsor is given, as well as a list of experiments containing radiation detectors on LDEF including the LDEF experiment number, the title of the experiment, the principal investigator, and the type of radiation detectors carried by the specific experiment. Author

N92-18270*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
METEOROID AND DEBRIS IMPACT FEATURES DOCUMENTED ON THE LONG DURATION EXPOSURE FACILITY: A PRELIMINARY REPORT
T. SEE, comp. (Lockheed Engineering and Management Services Co., Inc., Houston, TX.), M. ALLBROOKS, comp. (Nova Univ., Dania, FL.), D. ATKINSON, comp. (POD Associates, Inc., Albuquerque, NM.), C. SIMON, comp. (Washington Univ., Saint Louis, MO.), and M. ZOLENSKY, comp. Aug. 1990 583 p
(NASA-TM-105463; PUBL-84; JSC-24608; NAS 1.15:105463)
Avail: CASI HC A25/MF A06

The Long Duration Exposure Facility (LDEF) was host to several individual experiments designed to characterize aspects of the meteoroid and space-debris environment in low-Earth orbit. It was realized from the very start, however, that the most complete way to accomplish this goal was to exploit the meteoroid and debris record of the entire LDEF. The Meteoroid and Debris Special Investigation Group (M&D SIG) was organized to achieve this end. Two dominant goals of the M&D SIG are the documentation of the impact record of the entire LDEF, and the dissemination of this information to all interested workers. As a major step towards the accomplishment of these goals, we have prepared this publication describing the M&D SIG observations of impact features made during LDEF deintegration activities at KSC in the spring of 1990. It is hoped that this report will serve as a useful guide for spacecraft designers as well as for meteoroid and space-debris workers, and that it will spur further work on the LDEF impact-laden surfaces collected by the M&D SIG and now available for allocation to qualified investigators. An important aim is to present all data and descriptions of impact features in a form which, though terse,

remains comprehensible to the wider community. There is a deliberate minimum of interpretations. Thus, this catalog is intended to serve as a guide to the impact features found on LDEF and is not intended to stand as a definitive interpretive work. Author

N92-19727*# National Aeronautics and Space Administration, Washington, DC.
SIXTY-NINE MONTHS IN SPACE: A HISTORY OF THE FIRST LDEF (LONG DURATION EXPOSURE FACILITY)
1990 15 p Original contains color illustrations
(NASA-NP-149; NAS 1.83:149)

The LDEF project is summarized from its conception, through its deployment, to the return of the experiments. A LDEF chronology and a fact sheet is included. The experiments carried more than 10,000 specimens to gather scientific data and to test the effects of long term space exposure on spacecraft materials, components, and systems. Results will be invaluable for the design of future spacecraft such as Space Station Freedom. Author

N92-20779# European Space Agency. European Space Operations Center, Darmstadt (Germany). Mission Analysis Section.
OVERVIEW ON EUROPEAN ACTIVITIES ON SPACE DEBRIS
WALTER FLURY *In its* Launch Bases and Control Infrastructures for Spacecraft p 427-432 Oct. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, ESTEC, Noordwijk, Netherlands, HC 90 guilders

Space debris is a growing threat to manned and unmanned space activities. It is a global issue, which affects all users of space. As the risk posed by space debris reaches a level which requires serious considerations and measures, especially for manned missions, ESA, together with its memberstates, has inititiated steps to better understand and mitigate the problem. European efforts to address the issue of space debris are described. Three main areas are discussed: improved knowledge of the terrestrial particulate environment, including the future evolution of the space debris population; assessment of the risk for manned and unmanned space missions; and protective and preventive measures. The seriousness of the problem is such that measures to reduce the growth of space debris should be initiated now. ESA

N92-20780# Technische Univ., Brunswick (Germany). Inst. for Spaceflight and Nuclear Reactor Technology.
CLOSING THE DATA GAP OF SPACE DEBRIS: GROUND BASED OR SPACE BASED SENSORS?
PETER EICHLER, J. BENDISCH, and J. ZHANG *In* ESA, Launch Bases and Control Infrastructures for Spacecraft p 433-438 Oct. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, ESTEC, Noordwijk, Netherlands, HC 90 guilders

The increasing risk of collision with man-made orbital debris is a threat to all spaceflight activities. Due to the very high velocities, on the order of 10 km/s, occurring in such collisions, even mm sized particles can penetrate the outer walls of a spacecraft. Currently, only the orbits of objects larger than 10 cm were determined by ground based measurements. Only sporadic measurements in the cm size range were performed. Hence, there is a data gap in the critical size range of the cm and mm population. Deterministic data on the cm size population, and better statistical data on the mm sized population are urgently needed to enable more detailed analysis of the collision risk and possible countermeasures, e.g., shielding and collision warning and avoidance for the Space Station. The potential contributions of the different kinds of sensors (ground based or space based) are discussed. ESA

N92-20781*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
TECHNIQUES FOR DEBRIS MITIGATION
JOSEPH P. LOFTUS, JR. *In* ESA, Launch Bases and Control Infrastructures for Spacecraft p 439-446 Oct. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, ESTEC, Noordwijk, Netherlands, HC 90 guilders

Techniques for space debris abatement and removal are discussed. Characteristics of the total debris population and the low Earth orbit population are illustrated. Self disposal options that utilize propulsion maneuvers and drag augmentation devices are described. The active retrieval and disposition of large debris objects by collection with a maneuverable space vehicle are discussed. The removal of small debris by using a solar reflector to melt particles or by destruction with high energy laser devices is discussed. ESA

N92-20782*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
RADAR MEASUREMENTS OF THE ORBITAL DEBRIS ENVIRONMENT
EUGENE G. STANSBERY and CARL C. PITTS (XonTech, Inc., Los Angeles, CA.) *In* ESA, Launch Bases and Control Infrastructures for Spacecraft p 447-452 Oct. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, ESTEC, Noordwijk, Netherlands, HC 90 guilders

The collection and preliminary processing of the first significant accumulation of orbital debris data collected by the Haystack radar is described. The data are collected in the 'beam park' mode of operation in which the radar stares in a fixed direction and debris randomly passes through the field of view. Haystack's processing system performed automatic real-time processing and threshold detection, and saved only data associated with a possible detection. Approximately 123 hours of data were collected with the radar beam parked at an elevation angle of 10 deg and an azimuth of 180 deg; 3.8 hours were collected at an elevation angle of 30 deg and an azimuth of 180 deg; and 33.9 hours were collected at an elevation angle of 90 deg. A computer model of the response of the Haystack radar while in beam park operation is described. The model calculates the probability of detection and collection area for all sizes and orbital inclinations of debris visible to the radar. At this time, the approximate sizes of the detected objects have not been determined. However, the observed detection rates and cumulative signal to noise ratio distributions agree well with the results of the radar response model using NASA's current orbital debris environment. ESA

N92-21023# SRI International Corp., Menlo Park, CA.
TRANSIENT PULSE MONITOR (TPM) Final Report, Sep. 1986 - Apr. 1991
D. R. DANA Nov. 1991 77 p
(Contract F19628-86-C-0231)
(AD-A244502; PL-TR-91-2131) Avail: CASI HC A05/MF A01

The Transient Pulse Monitor (TPM) detects and characterizes transient electric fields and currents on satellites to help investigate arc discharge phenomena affecting spacecraft operation in various space environments. The TPM was originally developed to measure arc discharge parameters for several different experiments on a combined mission. However, in its present configuration, the TPM will be used to characterize arc discharges resulting from high-voltage solar-array operation (simulated by biasing) in the low- to medium-altitude space-plasma environment for Phillips Laboratory's Photovoltaic Array Space Power Plus Diagnostics (PASP Plus) experiment. This report describes the TPM design, the nature of its measurements, and the results of the calibration and environmental testing of the instrument in its flight configuration as part of the PASP Plus Experiment. Author (GRA)

N92-21051# Edgerton, Germeshausen and Grier, Inc., Idaho Falls, ID.
MAGNETIC SHIELDING FOR INTERPLANETARY SPACECRAFT
J. S. HERRING and B. J. MERRILL 1991 11 p Presented at the 28th Space Congress, Cocoa Beach, FL, 23-26 Apr. 1991
(Contract DE-AC07-76ID-01570)
(DE92-003295; EGG-M-90501; CONF-9104322-1) Avail: CASI HC A03/MF A01

The protection of spacecraft crews from the radiation produced

by high energy electrons, protons and heavier ions in the space environment is a major health concern on long duration missions. Conventional approaches to radiation shielding in space have relied on thicker spacecraft walls to stop the high energy charged particles and to absorb the resulting gamma and bremsstrahlung photons. The shielding concept described here uses superconducting magnets to deflect charged particles before they collide with the spacecraft, thus avoiding the production of secondary particles. A number of spacecraft configurations and sizes have been analyzed, ranging from a small 'storm cellar' for use during solar flares to continuous shielding for space stations having a crew of 15-25. The effectiveness of the magnetic shielding has been analyzed using a Monte Carlo program with incident proton energies from 0.5 to 1000 MeV. Typically the shield deflects 35-99 percent of the incident particles, depending, of course on particle energy and magnetic field strength. Further evaluation studies have been performed to assess weight comparisons between magnetic and conventional shielding; to determine magnet current distributions which minimize the magnetic field within the spacecraft itself; and to assess the potential role of ceramic superconductors. DOE

N92-21242*# Old Dominion Univ., Norfolk, VA. Advanced Design Program.
CONCEPTUAL DESIGN OF AN ORBITAL DEBRIS COLLECTOR
PETER ODONOGHUE, ed., BRIAN BRENTON, ERNEST CHAMBERS, THOMAS SCHWIND, CHRISTOPHER SWANHART, and THOMAS WILLIAMS 25 Nov. 1991 100 p
(Contract NASW-4435)
(NASA-CR-189989; NAS 1.26:189989) Avail: CASI HC A05/MF A02

The current Lower Earth Orbit (LEO) environment has become overly crowded with space debris. An evaluation of types of debris is presented in order to determine which debris poses the greatest threat to operation in space, and would therefore provide a feasible target for removal. A target meeting these functional requirements was found in the Cosmos C-1B Rocket Body. These launchers are spent space transporters which constitute a very grave risk of collision and fragmentation in LEO. The motion and physical characteristics of these rocket bodies have determined the most feasible method of removal. The proposed Orbital Debris Collector (ODC) device is designed to attach to the Orbital Maneuvering Vehicle (OMV), which provides all propulsion, tracking, and power systems. The OMV/ODC combination, the Rocket Body Retrieval Vehicle (RBRV), will match orbits with the rocket body, use a spin table to match the rotational motion of the debris, capture it, despin it, and remove it from orbit by allowing it to fall into the Earth's atmosphere. A disposal analysis is presented to show how the debris will be deorbited into the Earth's atmosphere. The conceptual means of operation of a sample mission is described. 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.

A92-10129
AN ORGANIC MATRIX FOR SPACE APPLICATIONS - LIGHTLY CROSSLINKED THERMOSETS
SCOTT LUCAS and ROB MASKELL (ICI Fiberite, Tempe, AZ) IN: International SAMPE Symposium and Exhibition, 36th, San Diego, CA, Apr. 15-18, 1991, Proceedings. Book 1 1991 8 p refs
Copyright

Several experimental lightly crosslinked thermosets (LxT) with space applications as a primary concern are presented. These matrix systems are not only tough but demonstrate low moisture absorption and show good resistance toward microcracking while maintaining good mechanical properties. The low moisture requirements and the need to use materials in space that resist microcracking make the LxT systems ideal candidates for continued research in the development of matrices in space. R.E.P.

A92-10156* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CHARACTERIZATION OF SELECTED LDEF POLYMER MATRIX RESIN COMPOSITE MATERIALS
PHILIP R. YOUNG, WAYNE S. SLEMP, WILLIAM G. WITTE, JR. (NASA, Langley Research Center, Hampton, VA), and JAMES Y. SHEN (Lockheed Engineering and Sciences Co., Hampton, VA) IN: International SAMPE Symposium and Exhibition, 36th, San Diego, CA, Apr. 15-18, 1991, Proceedings. Book 1 1991 14 p refs
Copyright

The characterization of selected graphite fiber reinforced epoxy (934 and 5208) and polysulfone (P1700) matrix resin composite materials which received 5 years and 10 months of exposure to the LEO environment on the Long Duration Exposure Facility is reported. Resin loss and a decrease in mechanical performance as well as dramatic visual effects were observed. However, chemical characterization including infrared, thermal, and selected solution property measurements showed that the molecular structure of the polymeric matrix had not changed significantly in response to this exposure. The potential effect of a silicon-containing molecular contamination of these specimens is addressed. Author

A92-10317
EXPERIMENTAL OBSERVATIONS OF THE PLASTIC MEMORY PHENOMENON OCCURRING IN POLYETHER ETHER KETONE/GRAPHITE AND POLYBUTYLENE TERAPHTHALATE/GRAPHITE COUPONS
DAVE R. ROURK (Concept Analysis Corp., Plymouth, MI) IN: Electronic materials - Our future; Proceedings of the 4th International SAMPE Electronic Materials and Processes Conference, Albuquerque, NM, June 12-14, 1990 1990 12 p refs
(Contract F04611-89-C-0043)
Copyright

The use of thermoplastic materials that exhibit the shape-memory phenomenon is reviewed with reference to the application of the materials in the deployment of space-based antenna reflectors. The plastic memory phenomenon is described with a review of related research, and small-scale coupons of the PEEK/graphite and polybutylene teraphthalate/graphite are tested in a three-point bending apparatus. The plastic memory characteristic is identified in both materials except when the testing temperatures exceed the glass-transition temperature. C.C.S.

A92-10527* Air Force Systems Command, Kirtland AFB, NM.
EFFECTS OF SPACE ENVIRONMENT ON STRUCTURAL MATERIALS - A PRELIMINARY STUDY AND DEVELOPMENT OF MATERIALS CHARACTERIZATION PROTOCOLS
C. MIGLIONICO, C. STEIN (USAF, Phillips Laboratory, Kirtland AFB, NM), and L. E. MURR (Texas, University, El Paso) Journal of Materials Science (ISSN 0022-2461), vol. 26, Oct. 1, 1991, p. 5134-5142. Research supported by USAF. 1 Oct. 1991 9 p refs
(Contract NAG9-481)
Copyright

A preliminary study of materials exposed in space in LEO for nearly six years in the NASA Long-Duration Exposure Facility is presented. It is demonstrated that it will be necessary to isolate surface debris and reaction products from materials exposed in space. Replication techniques originally designed for electron microscopy examination of surfaces can be applied to lift off and isolate such surface features. Debris and reaction products were examined through a variety of analytical techniques, including the surface morphology by SEM, and internal microstructures by STEM

and TEM, EDS, and SAD. The results illustrate the role that atomic oxygen and micrometeorites play in surface alteration and reaction in LEO space environments, as well as the role of debris created from other proximate materials. O.G.

A92-12432
A GENERAL PURPOSE BUS FOR MATERIALS EXPERIMENTS AND SATELLITE HEALTH MONITORING
W. J. WHATLEY and S. RUBIN (Sparta, Inc., San Diego, CA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 6 p. Oct. 1991 6 p refs
(IAF PAPER 91-007) Copyright

A distributed architecture system capable of conducting a wide variety of materials experiments is presented. This system is developed utilizing standard configurations for all data acquisition and system control functions, which allows easy adaptibility, low cost, flexibility of experiment configuration, and rapid delivery. R.E.P.

A92-12604 Alabama Univ., Huntsville.
COMPOSITE MATERIAL DEBRIS SHIELDING FOR LONG-TERM SPACE STRUCTURES
WILLIAM P. SCHONBERG (Alabama, University, Huntsville) and EVE J. WALKER IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 10 p. Oct. 1991 10 p refs
(Contract NGT-50643; NAS8-36955)
(IAF PAPER 91-282) Copyright

This paper represents the results of an experimental investigation in which several different composite materials were tested for their ability to prevent the perforation of multiwall systems under hypervelocity projectile impact. The damage in the composite material specimens is compared to the damage in aluminum specimens of similar geometry and weight caused by hypervelocity projectiles with similar impact energies. The analysis shows that using composite materials in combination with metallic materials in multiwall structures can increase the protection afforded a spacecraft against perforation by orbital debris particles over that provided by traditional, purely metallic multiwall structures. Author

A92-12605
LOW EARTH ORBIT DEBRIS EFFECTS ON MATERIALS
CARL R. MAAG (Science Applications International Corp., Glendora, CA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 8 p. Oct. 1991 8 p refs
(IAF PAPER 91-284) Copyright

Flight experiments conducted on the Space Shuttle to develop an understanding of the spatial density of space debris are discussed with emphasis placed on the techniques used for intact capture of particles. Particular attention is given to effects of cratering and particle impacts on the various materials as well as measured changes in the optical properties of mirrors. O.G.

A92-14068
INVESTIGATION OF MATERIALS FOR SPACEBORNE EQUIPMENT
PETER WEISSBRODT, LUTZ RAUPACH, and ERICH HACKER Jena Review (ISSN 0448-9497), vol. 36, no. 3, 1991, p. 140-142. Research sponsored by Deutsche Agentur fuer Raumfahrtangelegenheiten GmbH. 1991 3 p refs
Copyright

A laboratory system for the complex characterization of material changes and surface contaminations under simulated field conditions is described. Material behavior was investigated under the conditions prevailing in the close-to-earth orbit. These investigations make it possible to select materials for spaceborne equipment, to predict the behavior of materials and equipment in their service environments, to derive critical field conditions for implementation in equipment tests, and to supply data for complex contamination analyses. O.G.

A92-14179 Alabama Univ., Huntsville.
USE OF COMPOSITE MATERIALS IN MULTI-WALL STRUCTURES TO PREVENT PERFORATION BY HYPERVELOCITY PARTICLE IMPACT
WILLIAM P. SCHONBERG and EVE J. WALKER (Alabama, University, Huntsville) Composite Structures (ISSN 0263-8223), vol. 19, no. 1, 1991, p. 15-40. 1991 26 p refs
(Contract NGT-50643; NAS8-36955)
Copyright

Several different composite materials (Spectra 900/epoxy, Kevlar 49/epoxy, and Kevlar 49/cloth) were experimentally tested for their ability to prevent the perforation of pressure walls in a multiwall system subjected to hypervelocity projectile impacts, such as impacts by meteoroids and pieces of orbital debris on spacecraft walls. The wall systems consisted of 2219-T87 aluminum in front of which were placed one, two, or three bumbers made of aluminum or one of the composite materials. The tests used an instrumented two-stage light-gas gun capable of launching projectiles at velocities of 2-8 km/sec, and results included the extent of perforation, the crater size, and spall damage. It was found that use of composite materials in combination with metallic materials in multiwall structures can significantly increase the protection afforded a spacecraft against high-speed impacts over that provided by traditional metallic double-wall structures. I.S.

A92-14722
EFFECTS OF ATOMIC OXYGEN ON SPACECRAFT MATERIALS - SIMULATION AND MEASUREMENT
I. L. HARRIS, T. M. WATKINSON, A. R. CHAMBERS, G. T. ROBERTS, A. R. L. TATNALL (Southampton, University, England), and J. P. W. STARK (British /Space Systems/, Ltd., Stevenage, England) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 8 p. Research supported by Defence Research Agency Oct. 1991 8 p refs
(Contract SERC-GR/F/03622; SERC/GR/F/60755)
(IAF PAPER 91-305) Copyright

This paper describes the atomic oxygen environment encountered in space and the effect it has on materials used for spacecraft and instrumentation. The novel simulation facilities at Southampton University are described and the material effects observed are discussed. At Southampton a 3kW arcjet device has been used to provide a beam of atomic oxygen with energies up to 1eV and flux levels of 10 exp 15 atoms/sq cm s. This device has been used to measure the erosion of different materials and these results are comparable with those observed by other laboratory experiments and those observed on Shuttle. In order to achieve the energies and fluxes found in LEO, a new facility is being developed using magnetoplasmadynamic effects. Another related project to develop an instrument capable of remotely monitoring atomic oxygen flux and materials erosion in ground-based facilities or in orbit, is also described. Author

A92-14726
APPLICATION OF TO FILM FOR CONTROLLING CHARGING ON SATELLITE SURFACE
YU-SUN LU, HUA LI, and CUN CAI (Chinese Academy of Space Technology, Lanzhou Institute of Physics, People's Republic of China) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 6 p. Oct. 1991 6 p refs
(IAF PAPER 91-309) Copyright

The performance of TO films designed to control charging on the satellite surface and the stability of the films under these conditions were investigated in experiments performed in simulated space environment. It is shown that, if the suitable technical process and parameters are selected, TO films whose performance approaches that of ITO and IO films can be obtained at the preparation cost that is nearly one thousandth of that of IO and ITO films. I.S.

A92-15920
STUDY OF THE DAMPING PROPERTIES OF VARIOUS METAL MATRIX COMPOSITES [CONTRIBUTION A L'ETUDE DE LA CAPACITE D'AMORTISSEMENT DE DIVERS COMPOSITES A MATRICE METALLIQUE]
M. SALVIA (METRAVIB R.D.S., Ecully, France) and L. VINCENT (Lyon, Ecole Centrale, Ecully, France) IN: National Workshop on Composites, 7th, Lyons, France, Nov. 6-8, 1990, Proceedings 1991 12 p In FRENCH refs
Copyright

The paper presents a preliminary study of the torsional damping properties of seven metal matrix composites consisting of several fillers and two different matrices (the Al alloys 6061 and AS7GO3). At low frequency (0.78 x 10 exp -2 Hz) and room temperature the specific damping capacity is always higher than that of the matrix but appreciably lower than the damping capacities of high-damping metals. The global behavior of the material is explained by taking into account the contribution of the reinforcement-matrix interface. L.M.

A92-17560
ATOMIC OXYGEN EFFECTS ON POLYMER-BASED MATERIALS
R. C. TENNYSON (Toronto, University, Downsview, Canada) Canadian Journal of Physics (ISSN 0008-4204), vol. 69, Aug.-Sept. 1991, p. 1190-1208. Research supported by Institute for Space and Terrestrial Science, Ontario Centre for Materials Research, and Auburn University. Sep. 1991 19 p refs
(Contract N60921-86-C-A226)
Copyright

This paper describes the operation and performance of an atomic-oxygen (AO) beam facility capable of providing ground-state neutral oxygen atoms at about 2.2 eV for flux levels as high as about 10 exp 16 atoms/(sq cm - s). Results are presented on the AO erosion of polymer thin films and composite materials containing graphite and aramid fibers in epoxy matrices. Comparisons with space flight tests are also given, including studies of samples recently retrieved from a composite-materials experiment on the NASA Long Duration Exposure Facility after 70 months exposure in low earth orbit. Parameters that have been investigated include synergistic effects of UV radiation, surface-morphology changes, and accelerated testing. Author

A92-18003
EASY RIDER
LEWIS CHUMBLEY (Dow Chemical Co., Midland, MI) Aerospace Composites and Materials (ISSN 0954-5832), vol. 3, Nov.-Dec. 1991, p. 18-20. Dec. 1991 3 p
Copyright

While epoxy resin-based composite space structures pose thermal-cycling and moisture-absorption concerns, it has been found that a rubber-modified cyanate-ester resin, XU 71787.07, can be thermally cycled thousands of times without microcracking. High-modulus carbon-fiber prepregs of this resin, designated RS-3, are currently being tested for optical space-structures as well as for parabolic antenna dishes. Composites employing XU 71787.07 resin have a very flat dielectric-response surface; the resin also appears ideally applicable to cryogenic structures. O.C.

A92-18661
FACE-DEPENDENT IMPACT PROBABILITIES, VELOCITIES AND ANGLES UPON LDEF BY SPACE DEBRIS AND NATURAL METEOROIDS
DUNCAN OLSSON-STEEL (Adelaide, University; Spaceguard Pty., Ltd., Australia) (Space dust and debris; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission B /Meetings B2, B3, and B5/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-18651 05-12) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 12, 1991, p. 85-88. Research supported by Australian Research Council and SERC. 1991 4 p refs
Copyright

For specified geocentric orbits the impact probabilities, velocities, and angles upon the different faces of the Long Duration Exposure Facility are calculated, and it is found that quite different distributions of microcratering are to be expected. In particular the flux to the east (leading) face exceed that to the west (trailing) face by a very large ratio. The north and south faces receive exposures slightly in excess of the east face for lower-velocity impacts from low-inclination orbits, but much lower exposures than the east face for high-velocity impacts from high-inclination orbits. The space face (pointing directly away from the earth) and the earth face (pointing directly toward the earth) is subject to very few impacts from geocentric orbits. Therefore, while three sides (the east, north and south) are hit many times by artificial space debris, the other three (the west, space and earth) are impacted almost solely by natural meteoroids from heliocentric orbits, and can be used to determine the flux of such particles in the vicinity of the earth. The ratios of impacts upon the east, west and space faces are useful indicators of the velocity/orbit distribution of meteoroids. Author

A92-18665
FIRST RESULTS OF PARTICULATE IMPACTS AND FOIL PERFORATIONS ON LDEF
J. A. M. MCDONNELL, S. P. DESHPANDE, S. F. GREEN, P. J. NEWMAN, M. T. PALEY, P. R. RATCLIFF, T. J. STEVENSON, and K. SULLIVAN (Kent, University, Canterbury, England) (Space dust and debris; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission B /Meetings B2, B3, and B5/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-18651 05-12) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 12, 1991, p. 109-114. 1991 6 p refs
(Contract SERC-GR/F/80463)
Copyright

The interpretation of the Long Duration Exposure Facility (LDEF) Microabrasion Package (MAP) is considered in the light of both natural and artificial particulate impacts. The use of attitude stabilization is described emphasizing its role in the collection of a broader range of direct penetration data that confirm near-earth data. Expected north/south symmetry is not observed, and a distinct feature is noted in the penetration spectrum of all the faces in the form of a steep distribution at the 25-30-micron foil thickness. C.C.S.

A92-19364
MAGNETIC-FIELD EFFECTS ON VACUUM INSULATOR FLASHOVER
M. LEHR, R. KORZEKWA, H. KROMPHOLZ, and M. KRISTIANSEN (Texas Tech University, Lubbock) Journal of Applied Physics (ISSN 0021-8979), vol. 71, Jan. 1, 1992, p. 389-394. Research supported by DNA. 1 Jan. 1992 6 p refs
Copyright

The effect of magnetic fields on dielectric surface breakdown in vacuum and simulated LEO conditions is investigated using pulsed test voltages. Predictions from the saturated secondary electron emission avalanche breakdown model and experimental results both show magnetic insulation effects at magnetic-field amplitudes as low as 0.1 T. The most favorable configuration for magnetic insulation is with the magnetic field oriented parallel to the insulator surface and perpendicular to the electric field. The magnitude of the insulation effect depends on the dielectric material, ambient pressure, surface roughness, and the presence of background plasma. Predictions from simulations indicate the importance of conditions at the cathode in producing magnetic insulation effects. C.D.

A92-20381
PLASMA-DEPOSITED PROTECTIVE COATINGS FOR SPACECRAFT APPLICATIONS
D. G. ZIMCIK (Canadian Space Agency, Ottawa, Canada), M. R. WERTHEIMER (Ecole Polytechnique, Montreal, Canada), K. B. BALMAIN, and R. C. TENNYSON (Toronto, University, Canada) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Nov.-Dec. 1991, p. 652-657. Research supported by NSERC,

Institute for Space and Terrestrial Science, and U S. Navy. Dec 1991 6 p refs
Copyright

This article describes the properties of thin films that can be applied to polymers used on spacecraft to protect against environmental influences that may affect the life and performance of a space mission. These protective films, derived from volatile compounds via microwave glow discharge, include amorphous hydrogenated silicon and inorganic silicon compounds (silicon nitride, oxide, and oxynitride). The paper describes the performance of these coatings in the presence of deleterious effects of the space environment, including atomic oxygen degradation, electrostatic charging, thermal excursions, and vacuum The coatings are thin and adhere tightly to the substrate. Application of the coatings does not appear to alter the thermal radiative properties of the substrate. Electrical performance of underlying material in the microwave frequency range is unaffected. Accordingly, these materials provide promising candidates for exterior surfaces of spacecraft to protect the underlying materials from the space environment. Author

A92-20393
ATOMIC OXYGEN PROTECTION OF CARBON AND POLYCARBONATE USING BORON CARBIDE COATING
BRUCE M. SWINYARD (Rutherford Appleton Laboratory, Didcot, England) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol 28, Nov.-Dec. 1991, p. 730-732. Dec. 1991 3 p refs
Copyright

Measurements have been obtained of the effects of atomic oxygen erosion on polycarbonate/carbon composite optical filters and the behavior of protective coatings for the filters. Attention was given to the novel application of boron carbide as a protective coating against atomic oxygen erosion, a 1000-A layer of boron carbide is found to be capable of furnishing virtually complete protection against erosion. O C.

A92-21063* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
LONG-LIFE ASSESSMENT OF GRAPHITE EPOXY MATERIALS FOR SPACE STATION FREEDOM PRESSURE VESSELS
DONALD A. THOMAS (NASA, Johnson Space Center, Houston, TX) Journal of Propulsion and Power (ISSN 0748-4658), vol 8, Jan.-Feb. 1992, p. 87-92. Feb 1992 6 p refs
Copyright

Graphite/epoxy composite overwrapped pressure vessels are being considered for use on Space Station Freedom because of their light weight and high efficiency. These composite pressure vessels weigh roughly one-third of comparable all-metal aluminum pressure vessels, and could result in a 15,000-lb weight saving for the propulsion and fluid management and distribution systems. These vessels must resist failures under sustained pressure loads for crew safety considerations and adequate protection of the space structure during their 30-yr life Weibull statistical analysis techniques have been applied, and a model developed, for predicting long-term stress-rupture behavior based on published short-term test data on composite strands and pressure vessels Graphite/epoxy materials are calculated to have a 99.99-percent probability of surviving stress rupture for 30 yr under a sustained load of 50 percent ultimate failure strength Stress-rupture lifetimes are predicted to increase as the size of the pressure vessels increases in support of the viscoelastic load-transfer mechanism proposed for stress rupture of fiber/epoxy composite materials Author

A92-21611
ANOMALOUS EMISSION FROM DIELECTRICS IN INTENSE FIELDS [ANOMAL'NAIA EMISSIIA DIELEKTRIKOV V SIL'NYKH POLIAKH]
E. A. BESEDINA and M. V KREMKOV Radiotekhnika i Elektronika (ISSN 0033-8494), vol. 36, Dec. 1991, p 2418-2420. In Russian Dec. 1991 3 p In RUSSIAN refs
Copyright

The anomalous emission of electrons from dielectric coatings in intense electric fields was investigated for the Mg-Ta, NaCl-Ta, and Ta-NaCl-Ni systems The results obtained are of interest in connection with the charging of spacecraft surfaces, especially under conditions when an intense electric field (10 exp 6 to 10 exp 7 V/cm and higher) arises between the dielectric surface and the metal casing The results are analogous to those obtained in investigations of the electric breakdown of solar-array elements and brightening coatings under irradiation L M.

A92-24025* Jet Propulsion Lab , California Inst. of Tech., Pasadena.
1991 IEEE ANNUAL CONFERENCE ON NUCLEAR AND SPACE RADIATION EFFECTS, 28TH, SAN DIEGO, CA, JULY 15-19, 1991, PROCEEDINGS
DOUGLAS G. MILLWARD, ED. (Science Applications International Corp., San Diego, CA) Conference sponsored by IEEE, DNA, Sandia National Laboratories, and JPL. IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol 38, pt 1, Dec 1991, 668 p. For individual items see A92-24026 to A92-24080 Dec 1991 668 p
Copyright

Various papers on nuclear science are presented The general topics addressed are basic mechanisms of radiation effects, dosimetry and energy-dependent effects, isolation technologies, device radiation response and hardening, microcircuit radiation response and hardening, single-event phenomena, hardness assurance and testing techniques, spacecraft charging, space environments and effects C.D.

A92-24035
SPACE RADIATION EFFECTS IN INP SOLAR CELLS
R J WALTERS (U.S. Navy, Naval Research Laboratory, Washington, DC), S. R MESSENGER (SFA, Inc , Landover, MD), G. P SUMMERS (U.S Navy, Naval Research Laboratory, Washington, DC, Maryland, University, Baltimore), E. A BURKE, and C. J KEAVNEY (Spire Corp , Bedford, MA) (1991 IEEE Annual Conference on Nuclear and Space Radiation Effects, 28th, San Diego, CA, July 15-19, 1991, Proceedings A92-24025 08-33) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 38, pt. 1, Dec. 1991, p 1153-1158. Research supported by U.S Navy Dec. 1991 6 p refs
Copyright

InP solar cells and mesa diodes grown by metalorganic chemical vapor deposition (MOCVD) were irradiated with electrons and protons at room temperature. The radiation-induced defects (RIDs) were characterized by deep level transient spectroscopy (DLTS), and the degradation of the solar cell performance was determined through I-V measurements. The nonionizing energy loss (NIEL) of electrons and protons in InP was calculated as a function of energy from 1 to 200 MeV and compared to the measured defect introduction rates. A linear dependence was evident InP solar cells showed significantly more radiation resistance than c-Si or GaAs/Ge cells under 1 MeV electron irradiation Using the calculated InP damage rates and measured damage factors, the performance of InP solar cells as a function of orbital altitude and time in orbit was predicted and compared with the performance of c-Si solar cells in the same environment In all cases, the InP cells showed highly superior radiation resistance. I E

A92-24048
IONIZING SPACE RADIATION EFFECTS ON SURFACE ACOUSTIC WAVE RESONATORS
W J STAPOR, J H. HINES, and D H WILSON (U.S. Navy, Naval Research Laboratory, Washington, DC) (1991 IEEE Annual Conference on Nuclear and Space Radiation Effects, 28th, San Diego, CA, July 15-19, 1991, Proceedings A92-24025 08-33) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 38, pt 1, Dec. 1991, p 1329-1335. Dec 1991 7 p refs
Copyright

Two available types of single pole 199 MHz SAW resonators were irradiated to determine space radiation performance, some fabricated on air-swept 40 deg Y-rotated quartz substrate, and some fabricated on non-swept quartz In addition, some of the

resonators on non-swept quartz were coated with 400 A RF sputtered layer of SiO(x). It was found that sensitivity to radiation is substrate material dependent, with pure substrates showing less radiation degradation in performance. An unexpected reduction in sensitivity was found for the coated devices I E

A92-24066* Jet Propulsion Lab, California Inst of Tech, Pasadena.
RADIATION-INDUCED INSULATOR DISCHARGE PULSES IN THE CRRES INTERNAL DISCHARGE MONITOR SATELLITE EXPERIMENT
A. R FREDERICKSON, E G MULLEN, D H BRAUTIGAM, K J KERNS (USAF, Phillips Laboratory, Hanscom AFB, MA), P. A ROBINSON, JR (JPL, Pasadena, CA), and E G HOLMAN (Boston College, Chestnut Hill, MA) (1991 IEEE Annual Conference on Nuclear and Space Radiation Effects, 28th, San Diego, CA, July 15-19, 1991, Proceedings A92-24025 08-33) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 38, pt 1, Dec 1991, p. 1614-1621 Dec. 1991 8 p refs
Copyright

The Internal Discharge Monitor (IDM) is designed to observe electrical pulses from common electrical insulators in space service. The IDM is flying on the Combined Release and Radiation Effects Satellite (CRRES) The sixteen insulator samples include G10 circuit boards, FR4 and PTFE fiberglass circuit boards, FEP Teflon, alumina, and wires with common insulations. The samples are fully enclosed, mutually isolated, and space radiation penetrates 0.02 cm of aluminum before striking the samples. The IDM results indicate the rate at which insulator pulses occur Pulsing began on the seventh orbit. The maximum pulse rate occurred near orbit 600 when over 50 pulses occurred The average pulse rate is approximately two per orbit, but nearly half of the first 600 orbits experienced no pulses The pulse rate per unit flux of high energy electrons has not changed dramatically over the first ten months in space. These pulse rates are in agreement with laboratory experience on shorter time scales Several of the samples have never pulsed IDM pulses are the seeds of larger satellite electrical anomalies. The pulse rates are compared with space radiation intensities, L shell location, and spectral distributions from the radiation spectrometers on CRRES I E.

A92-24068
SPACECRAFT CHARGING THRESHOLDS IN SINGLE AND DOUBLE MAXWELLIAN SPACE ENVIRONMENTS
SHU T LAI (USAF, Phillips Laboratory, Hanscom AFB, MA) (1991 IEEE Annual Conference on Nuclear and Space Radiation Effects, 28th, San Diego, CA, July 15-19, 1991, Proceedings. A92-24025 08-33) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 38, pt 1, Dec 1991, p. 1629-1634 Dec 1991 6 p refs
Copyright

With the single Maxwellian electron distribution model of space environment, the results suggest that the ambient electron temperature is the only decisive parameter controlling the onset of spacecraft charging The value of the critical temperature is a property of the surface material The ambient electron density has no influence on the onset at all. With the double Maxwellian electron and ion model of space environment, the results suggest that positive charging, negative charging, triple-root charging, and, of course, no charging are all possible behaviors A domain diagram for various behaviors is presented as an example In the triple-root situation, the middle root is unstable The spacecraft potential may require either of the static roots, which root is acquired depends on the initial condition and the way the environment changes in time. Hysteresis of spacecraft potential may occur The critical or threshold temperature derived in the single Maxwellian model plays an important role in the triple-root condition of the double Maxwellian model. I.E.

A92-24669 Jet Propulsion Lab., California Inst of Tech, Pasadena.
VACUUM ULTRAVIOLET RADIATION/ATOMIC OXYGEN SYNERGISM IN FLUORINATED ETHYLENE PROPYLENE TEFLON EROSION
A E. STIEGMAN, DAVID E BRINZA, ERIC G. LAUE, MARK S. ANDERSON, and RANTY H LIANG (JPL, Pasadena, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol 29, Jan -Feb 1992, p. 150, 151 Research supported by SDIO and NASA Feb. 1992 2 p refs
Copyright

A micrographic investigation is reported of samples of the fluorinated ethylene propylene (FEP) Teflon thermal-blanketing materials recovered from the Long-Duration Exposure Facility (LDEF) satellite. The samples are taken from the trailing edge and row 8 which correspond to exposures to vacuum UV (VUV) and VUV + atomic O, respectively. Data are taken from SEM and IR-spectra observations, and the LDEF leading-edge FEP shows a high degree of erosion, roughening, and sharp peaks angled in the direction of the flow of atomic O. The trailing edge sample influenced primarily by VUV shows a hard brittle layer and some cracked mosaic patterns Comparisons to a reference sample suggest that the brittle layer is related to exposure to VUV and is removed by atomic-O impingement. Polymers that are stable to VUV radiation appear to be more stable in terms of atomic oxygen C.C.S.

A92-27004#
HIGH ENERGY ELECTRON PENETRATION AND INSULATOR DISCHARGE PULSES IN THE CRRES INTERNAL DISCHARGE MONITOR SATELLITE EXPERIMENT
A. R FREDERICKSON, E G. MULLEN, D H BRAUTIGAM (USAF, Phillips Laboratory, Hanscom AFB, OH), and E. G HOLEMAN (Boston College, Chestnut Hill, MA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992 7 p Jan 1992 7 p refs
(AIAA PAPER 92-0609)

The Internal Discharge Monitor (IDM) is designed to observe electrical pulses from common electrical insulators in space service The IDM is flying on the Combined Release and Radiation Effects Satellite (CRRES). The sixteen insulator samples include G10 circuit boards, FR4 and PTFE fiberglass circuit boards, FEP Teflon, alumina, and wires with common insulations. The samples are fully enclosed, mutually isolated, and space radiation penetrates 0 02 cm of aluminum before striking the samples Published data in the literature provide a simple method for determining the flux of penetrating electrons The pulse rate is compared to the penetrating flux of electrons, and it is found that the pulse rate per unit flux of high energy electrons has not changed dramatically over the first ten months in space. These pulse rates are in agreement with laboratory experience on shorter time scales. Several of the samples have never pulsed. Author

A92-27125*# National Aeronautics and Space Administration Lewis Research Center, Cleveland, OH
SYNERGISTIC EFFECTS OF ULTRAVIOLET RADIATION, THERMAL CYCLING AND ATOMIC OXYGEN ON ALTERED AND COATED KAPTON SURFACES
JOYCE A DEVER (NASA, Lewis Research Center, Cleveland, OH), ERIC J. BRUCKNER, and ELVIN RODRIGUEZ (Cleveland State University, OH) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan 6-9, 1992 10 p. Previously announced in STAR as N92-14114. Jan. 1992 10 p refs
(AIAA PAPER 92-0794) Copyright

The photovoltaic (PV) power system for Space Station Freedom (SSF) uses solar array blankets which provide structural support for the solar cells and house the electrical interconnections In the low earth orbital (LEO) environment where SSF will be located, surfaces will be exposed to potentially damaging environmental conditions including solar ultraviolet (UV) radiation, thermal cycling, and atomic oxygen It is necessary to use ground based tests to determine how these environmental conditions would affect the mass loss and optical properties of candidate SSF blanket materials Silicone containing, silicone coated, and SiO(x) coated polyimide film materials were exposed to simulated LEO environmental conditions to determine their durability and whether the environmental conditions of UV, thermal cycling and oxygen atoms act synergistically on these materials. A candidate PV blanket

material called AOR Kapton, a polysiloxane polyimide cast from a solution mixture, shows an improvement in durability to oxygen atoms erosion after exposure to UV radiation or thermal cycling combined with UV radiation. This may indicate that the environmental conditions react synergistically with this material, and the damage predicted by exposure to atomic oxygen alone is more severe than that which would occur in LEO where atomic oxygen, thermal cycling and UV radiation are present together.
Author

A92-27136
RADIATION-MATERIAL INTERACTIONS [INTERACTIONS 'RAYONNEMENT-MATIERE']
JACQUES BOURRIEAU (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) IN: Space environment: Prevention of risks related to spacecraft charging; International Course on Space Technology, Toulouse, France, Nov. 26-30, 1990, Proceedings 1992 33 p In FRENCH refs
Copyright

Radiation effects on spacecraft materials are a function of the energy transferred by incident particles to the atomic, electronic, and nucleus components of the materials encountered. The results of such encounters are such point defects as interstitial vacancies and electron-hole pairs, which in turn give rise to macroscopic defects. The main parameters used to characterize these radiation-matter interactions are the interaction cross section, the stopping-power of the material, the radiation path, and the adsorbed radiation dose. O.C.

A92-27140
ELECTROSTATIC CHARGING BY HIGH-ENERGY ELECTRONS [CHARGE ELECTROSTATIQUE PAR ELECTRONS DE HAUTE ENERGIE]
DENIS PAYAN (CNES, Paris, France) IN: Space environment: Prevention of risks related to spacecraft charging; International Course on Space Technology, Toulouse, France, Nov. 26-30, 1990, Proceedings 1992 32 p In FRENCH refs
Copyright

The electrostatic charging of spacecraft components by high- and medium-energy electrons is considered. Such electrons can charge the spacecraft as a result of surface effects or they can be implanted deep in spacecraft dielectric materials, including those deep in the spacecraft. This paper examines laboratory data and flight-measurement data in this area, and considers the associated electrostatic-discharge hazards. L.M.

A92-27141
DIFFERENT MODES OF ELECTROSTATIC DISCHARGE - ELECTROMAGNETIC SIGNATURES [DIFFERENTS MODES DE DECHARGES ELECTROSTATIQUES - SIGNATURES ELECTROMAGNETIQUES]
L. LEVY (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) IN: Space environment: Prevention of risks related to spacecraft charging; International Course on Space Technology, Toulouse, France, Nov. 26-30, 1990, Proceedings 1992 12 p In FRENCH refs
Copyright

Electron-bombardment studies conducted for representative dielectric materials in the wake of complete spacecraft failures have in the past established that orbital charging had reached levels at which rapid discharging was responsible for system failure. More recent spacecraft design efforts have accordingly concentrated on the avoidance of discharges and of charge couplings with onboard circuitry. Attention is presently given to different discharge modes obtained in the laboratory on materials and small systems; these are characterized in terms of rise time, total duration, magnitude, and total current-pulse and electric field-pulse charges. These data allow the formulation of realistic charging tests for prospective spacecraft. O.C.

A92-27142
TECHNIQUES FOR IRRADIATION [MOYENS D'IRRADIATION]
R. REULET (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) IN: Space environment: Prevention of risks related to spacecraft charging; International Course on Space Technology, Toulouse, France, Nov. 26-30, 1990, Proceedings 1992 31 p In FRENCH refs
Copyright

Spacecraft materials' electrostatic behavior, which determines the electrical state of external and internal components, depends on intrinsic material properties as well as such space-environment parameters as charged particle fluxes, insolation intensities, temperature, and incident ionizing radiation. Attention is presently given to conductivity, secondary electron emission, and other such properties which affect the surface potentials that cause in-flight electrostatic discharges, as well as to devices which have been developed to initiate and analyze induced transients. These include simulation chambers that reproduce space-environment parameters, and instrumentation for various diagnostic methods.
O.C.

A92-27146
DESIGN RULES AND SYSTEM TESTING METHODS
DANIEL DODI (Aerospatiale, Cannes, France) IN: Space environment: Prevention of risks related to spacecraft charging; International Course on Space Technology, Toulouse, France, Nov. 26-30, 1990, Proceedings 1992 17 p refs
Copyright

Methods used at Aerospatiale to minimize charging and prevent discharge effects in spacecraft in GEO are discussed. To prevent charging of GEO satellites, Aerospatiale emphasizes the grounding of metallic or conductive pieces when directly exposed to space, the selection of space-exposed dielectric materials using the NASCAP code, the limiting of MLI outer kapton layer thickness to 25 microns, and the abandonment of teflon as outer layer material and of SSM. The prevention of coupling mechanisms in order to prevent discharge, and the efficiency of the protection, are considered. The verification of satellite design for these functions is addressed. C.D.

A92-28229*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
PROPERTY CHANGES INDUCED BY THE SPACE ENVIRONMENT IN POLYMERIC MATERIALS ON LDEF
ANN F. WHITAKER, MIRIA M. FINCKENOR, and RACHEL R. KAMENETZKY (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 8 p. Jan. 1992 8 p refs
(AIAA PAPER 92-0790) Copyright

Property changes that occurred in four groups of polymer-based materials in the Long Duration Exposure Facility (LDEF) due to exposure to the outer space environment for 5.8 yrs are examined. Evaluations of contamination and mass loss are presented along with optical, thermal, and electrical analyses and mechanical property evaluations for TFE Teflon, the fluorinated material Halar, the silicone-based material RTV 511, and PEEK resin. C.D.

A92-29593*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
ELECTRICAL BREAKDOWN OF SPACE STATION FREEDOM SURFACES
M. R. CARRUTH, JR., J. A. VAUGHN, R. T. BECHTEL (NASA, Marshall Space Flight Center, Huntsville, AL), and P. A. GRAY (Sverdrup Technology, Inc., Huntsville, AL) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 8 p. Jan. 1992 8 p refs
(AIAA PAPER 92-0820) Copyright

Space Station Freedom (SSF) will be the largest and highest power spacecraft that the U.S. has put into orbit. The solar array will generate 160 volts nominal when in sunlight, and the present baseline design is for the negative end of the solar array to be tied to SSF structure. Due to the balance of leakage currents through the plasma, the structure will be driven approximately 140 volts negative of the ambient conductive ionospheric plasma. Surface materials such as anodized aluminum will have this voltage

drop across a thin dielectric which may not have sufficient dielectric strength to prevent dielectric breakdown. This can lead to arcing on the exterior surfaces of Space Station. Author

A92-29594*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
EXTRAPOLATION OF ELECTRICAL BREAKDOWN CURRENTS FROM THE LABORATORY TO SPACE STATION
JASON A. VAUGHN, MELVIN R. CARRUTH, JR. (NASA, Marshall Space Flight Center, Huntsville, AL), IRA KATZ, MYRON J. MANDELL, and GARY A. JONGEWARD (Maxwell Laboratories, Inc., S-Cubed Div., La Jolla, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 9 p. Jan. 1992 9 p refs
(AIAA PAPER 92-0822) Copyright

Recent experiments conducted in a plasma chamber at NASA/MSFC on anodized aluminum coatings representative of Space Station Freedom design show that if the aluminum used as a thermal control coating is biased more than 80 V negative with respect to the plasma, the anodization will experience dielectric breakdown. As the thin anodization layer creates a capacitive charge buildup, large currents are observed during the arc. How plasma generation at the arc site can support large currents and discharge the surface charge layer is investigated. The importance for Space Station Freedom is that currents similar to those observed in the laboratory can be observed on orbit. R.E.P.

A92-29615#
ANALYSIS AND SIMULATION OF POLYMERS EXPOSED TO LOW EARTH ORBIT (LEO) ENVIRONMENTS
THOMAS W. STRGANAC, D. A. FARROW, ALAN LETTON, KEVIN D. WILLIAMS, and NEIL I. ROCK (Texas A & M University, College Station) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 8 p. Jan. 1992 8 p refs
(AIAA PAPER 92-0849) Copyright

Several analytical and mechanical tests have been conducted on the exposed specimens and control specimens placed in LEO by NASA's Long Duration Exposure Facility Satellite to differentiate relative changes in mechanical behavior. Tests including dynamic mechanical analysis (DMA), DSC, size-exclusion chromatography, FTIR, and SEM have also been conducted to identify chemical and morphological properties. The results of the DMA studies, i.e., the viscoelastic characterization of the polymeric samples, are discussed. R.E.P.

A92-29616*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LOW EARTH ORBIT DURABILITY EVALUATION OF HAYNES 188 SOLAR RECEIVER MATERIAL
KIM K. DE GROH, SHARON K. RUTLEDGE (NASA, Lewis Research Center, Cleveland, OH), CHRISTOPHER A. BURKE, THERESE M. DEVER, RAYMOND M. OLLE (Cleveland State University, OH), and JUDITH A. TERLEP (Ohio Aerospace Institute, Cleveland) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 9 p. Jan. 1992 9 p refs
(AIAA PAPER 92-0850) Copyright

The effects of elevated-temperature vacuum and elevated-temperature atomic oxygen exposure on the mass, surface chemistry, surface morphology, and optical properties of Haynes 188, a possible heat receiver material for space-based solar dynamic power systems, have been studied. Pristine and surface modified Haynes 188 were exposed to vacuum less than or equal to 10 exp -6 torr at 820 C for 5215.5 h, and to atomic oxygen in an air plasma asher at 34 and 827 C for fluences up to 5.6 x 10 exp 21 atoms/sq cm. Results obtained indicate that vacuum heat treatment caused surface morphology and chemistry changes with corresponding optical property changes. Atomic oxygen exposure caused optical property changes which diminished with time. Mass changes are considered to be negligible for both exposures. O.G.

A92-31285
AIAA MATERIALS SPECIALIST CONFERENCE - COATING TECHNOLOGY FOR AEROSPACE SYSTEMS, DALLAS, TX, APR. 16, 17, 1992, TECHNICAL PAPERS
Washington, DC, American Institute of Aeronautics and Astronautics, 1992, 127 p. For individual items see A92-31286 to A92-31300. 1992 127 p
Copyright

Consideration is given to protective coatings for spacecraft applications; contamination; anodized coatings; and advanced coatings development, testing, and evaluation. Particular attention is given to SiO(x) coatings for atomic oxygen protection of polyimide Kapton in LEO, evaluation of plasma-deposited protective coatings for spacecraft applications, effects of contamination on solar cell cover glass, anodized aluminum coatings for thermal control, use of cobalt sulfide (black dye) anodize for thermal control of the SSF airlock, optical property degradation of anodic coatings in the Space Station LEO, molecular engineering of pigments for degradation-resistant thermal control coatings, estimation of the end-of-life optical properties for Z-93 thermal control coating for SSF, the effects of RF plasma ashing on zinc orthotitanate/potassium silicate thermal control coatings, and atomic oxygen effects on thin-film space coatings studied by spectroscopic ellipsometry, atomic force microscopy, and light scattering. O.G.

A92-31286*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SIO(X) COATINGS FOR ATOMIC OXYGEN PROTECTION OF POLYIMIDE KAPTON IN LOW EARTH ORBIT
BRUCE A. BANKS, SHARON K. RUTLEDGE (NASA, Lewis Research Center, Cleveland, OH), LINDA GEBAUER, and CINDY LAMOREAUX (Cleveland State University, OH) IN: AIAA Materials Specialist Conference - Coating Technology for Aerospace Systems, Dallas, TX, Apr. 16, 17, 1992, Technical Papers 1992 10 p refs
(AIAA PAPER 92-2151) Copyright

Sputter-deposited SiO(X) (where X between 1.9 and 2.0) thin film coatings have been found to be durable to atomic oxygen. Such coatings will be used to protect polyimide Kapton photovoltaic array blankets from atomic oxygen attack in low earth orbit (LEO) on the Space Station Freedom (SSF). Monte Carlo modeling of atomic oxygen attack at defect sites in protected Kapton exposed in laboratory RF plasma ashers and on solar tracking photovoltaic arrays in space has been conducted to enable understanding of degradation processes relevant to the durability of the SSF solar array blanket. SiO(X) protective coating performance data from RF plasma asher tests will be presented, along with Monte Carlo modeling considerations, to enable the projection of in-space durability of the SSF solar array blankets based on ground laboratory test results. Author

A92-31287#
EVALUATION OF PLASMA-DEPOSITED PROTECTIVE COATINGS FOR SPACECRAFT APPLICATIONS
R. C. TENNYSON, W. D. MORISON (Toronto, University, Canada), J. E. KLEMBERG, L. MARTINU, M. R. WERTHEIMER (Ecole Polytechnique, Montreal, Canada), and D. G. ZIMCIK (Canadian Space Agency, Ottawa, Canada) IN: AIAA Materials Specialist Conference - Coating Technology for Aerospace Systems, Dallas, TX, Apr. 16, 17, 1992, Technical Papers 1992 10 p refs
(AIAA PAPER 92-2152) Copyright

Thin-film protective layers applied to selected organic substrates (Kapton polyimide, graphite/epoxy, and amorphous carbon) have been evaluated. These protective films include a-Si:H, silicon nitride, P-SiN, oxide P-SiO2, hexamethyldisiloxane, and PP-HMDSO, which have been exposed to attack from atomic oxygen beam bombardment with simultaneous vacuum ultraviolet radiation. The results of mass loss measurements made in situ using quartz crystal microbalances coated with the candidate materials indicate that the coatings provide excellent protection compared to unprotected specimens of the same materials. The laboratory results are found to be in good agreement with those obtained

during space flight test on Shuttle missions STS-32 and STS-44. It is concluded that coating materials are resistant to attack by atomic oxygen as they adhere tightly chemically to the substrate and do not alter the thermal radiative properties of the substrate. O.G.

A92-31288*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
THE EVALUATION OF GOES BLACK PAINT MATERIALS
PHILIP T. CHEN, LONNY R. KAUDER (NASA, Goddard Space Flight Center, Greenbelt, MD), and JACK J. TRIOLO (EER Systems Corp., Seabrook, MD) IN: AIAA Materials Specialist Conference - Coating Technology for Aerospace Systems, Dallas, TX, Apr. 16, 17, 1992, Technical Papers 1992 8 p refs
(AIAA PAPER 92-2155) Copyright

The purpose of this paper is to study the contamination effect of black paint materials on the GOES instrument performance. The GOES spacecraft materials were originally selected for their low outgassing properties. Samples of the materials were tested according to the ASTM E-595 test method to fulfill the total mass loss and collected volatile condensable materials criteria for traditional spacecraft material selection. Due to the instrument design, the cavity will experience high temperatures during operation greater than the specified temperature in the ASTM test. As a result of this high cavity temperature, normally stable paint materials on the painted surface may severely outgas even though they have passed the ASTM test. Further enhancement of the contaminant remaining on the mirror by UV irradiation is also a great consideration. This concern prompted an investigation into the outgassing characteristics of the black paints at the predicted operating temperatures. Author

A92-31289#
EFFECTS OF CONTAMINATION ON SOLAR CELL COVER GLASS
ALECK L. LEE (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: AIAA Materials Specialist Conference - Coating Technology for Aerospace Systems, Dallas, TX, Apr. 16, 17, 1992, Technical Papers 1992 6 p refs
(AIAA PAPER 92-2156) Copyright

The integrated transmittance of a solar cell cover glass and the effects of contamination are predicted using the energy method. This approximation method computes the spectral reflectance by tracing the energy path through a number of reflections in a multilayer system which consists of a contaminant deposit, a UV/AR coating, and the glass cover of a solar cell. The overall transmittance is obtained by a weighted integration of the spectral transmittance, which is assumed to be one minus the reflectance. The weighting functions include the spectral solar irradiance and the solar cell spectral responses. The method can be used as a preliminary design tool when an analytical software package for thin-film stack analysis and the exact properties of the constituent coatings are not available. O.G.

A92-31290#
THERMAL CONTROL COATING OPTICAL PROPERTIES VERSUS CONTAMINATION EFFECTS FOR SPACE STATION FREEDOM
ROY E. BOOTH and JOE E. STOYACK (LTV Aerospace and Defense Co., Dallas, TX) IN: AIAA Materials Specialist Conference - Coating Technology for Aerospace Systems, Dallas, TX, Apr. 16, 17, 1992, Technical Papers 1992 4 p refs
(AIAA PAPER 92-2157) Copyright

This paper discusses contamination due to particle settling on radiators for Space Station Freedom during their fabrication in dust controlled environments. Mathematical models and experimental results were used to predict the degradation to solar absorptance of the Z-93 white thermal control coating which covers space radiators as a passive means of improving the efficiency. In order to minimize degradation, either a class 100,000 clean room and/or protective coverings, such as Tedlar or unplasticized Mylar, are recommended. For certain operations, the change of contamination is high and redundant engineering solutions are required, such as baffling and/or special handling. A plan is presented which estimates an increase in solar absorptance of only 0.03. Author

A92-31295*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
OPTICAL PROPERTY DEGRADATION OF ANODIC COATINGS IN THE SPACE STATION LOW EARTH ORBIT
KAIA E. DAVID and HANK W. BABEL (McDonnell Douglas Space Systems Co., Huntington Beach, CA) IN: AIAA Materials Specialist Conference - Coating Technology for Aerospace Systems, Dallas, TX, Apr. 16, 17, 1992, Technical Papers 1992 10 p refs
(Contract NAS9-18200)
(AIAA PAPER 92-2162) Copyright

The anodic coatings and optical properties to be used for passive thermal control of the SSF are studied. Particular attention is given to the beginning-of-life optical properties for aluminum alloys suitable for structural and radiator applications, the statistical variation in the beginning-of-life properties, and estimates of the end-of-life properties of the alloys based on ultraviolet radiation testing and flight test results. It is concluded that anodic coatings can be used for thermal control of long life, low earth orbit spacecraft. Some use restrictions are defined for specific cases. Anodic coatings have been selected as baseline thermal control coating for large portions of the SSF. O.G.

A92-31300*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ATOMIC OXYGEN EFFECTS ON THIN FILM SPACE COATINGS STUDIED BY SPECTROSCOPIC ELLIPSOMETRY, ATOMIC FORCE MICROSCOPY, AND LASER LIGHT SCATTERING
R. A. SYNOWICKI, JEFFREY S. HALE, and JOHN A. WOOLLAM (Nebraska, University, Lincoln) IN: AIAA Materials Specialist Conference - Coating Technology for Aerospace Systems, Dallas, TX, Apr. 16, 17, 1992, Technical Papers 1992 5 p refs
(Contract NAG3-95)
(AIAA PAPER 92-2172) Copyright

The University of Nebraska is currently evaluating Low Earth Orbit (LEO) simulation techniques as well as a variety of thin film protective coatings to withstand atomic oxygen (AO) degradation. Both oxygen plasma ashers and an electron cyclotron resonance (ECR) source are being used for LEO simulation. Thin film coatings are characterized by optical techniques including Variable Angle Spectroscopic Ellipsometry, Optical spectrophotometry, and laser light scatterometry. Atomic Force Microscopy (AFM) is also used to characterize surface morphology. Results on diamondlike carbon (DLC) films show that DLC degrades with simulated AO exposure at a rate comparable to Kapton polyimide. Since DLC is not as susceptible to environmental factors such as moisture absorption, it could potentially provide more accurate measurements of AO fluence on short space flights. Author

N92-10091* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
HELMET OF A LAMINATE CONSTRUCTION OF POLYCARBONATE AND POLYSULFONE POLYMERIC MATERIAL Patent
JOSEPH J. KOSMO, inventor (to NASA) and FREDERIC S. DAWN, inventor (to NASA) 15 Oct. 1991 60 p Filed 30 Nov. 1989 Supersedes N90-16925 (28 - 9, p 1195)
(NASA-CASE-MSC-21503-1; US-PATENT-5,056,156; US-PATENT-APPL-SN-443414; US-PATENT-CLASS-2-2.1A; US-PATENT-CLASS-2-411; US-PATENT-CLASS-2-424; US-PATENT-CLASS-428-412; US-PATENT-CLASS-428-419; US-PATENT-CLASS-428-458; US-PATENT-CLASS-428-215)
Avail: US Patent and Trademark Office

An article of laminate construction is disclosed which is comprised of an underlayer of polycarbonate polymer material to which is applied a chemically resistant outer layer of polysulfone. The layers which are joined by compression-heat molding, are molded to form the shape of a body protective shell such as a space helmet comprising a shell of polycarbonate, polysulfone

laminate construction attached at its open end to a sealing ring adapted for connection to a space suit. The front portion of the shell provides a transparent visor for the helmet. An outer visor of polycarbonate polysulfone laminate construction is pivotally mounted to the sealing ring for covering the transparent visor portion of the shell during extravehicular activities. The polycarbonate under layer of the outer visor is coated on its inner surface with a vacuum deposit of gold to provide additional thermal radiation resistance.

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

N92-10639*# Alabama Univ., Huntsville. Center for Applied Optics.
CONTAMINATION STUDY Final Report
R. BARRY JOHNSON and KENNETH A. HERREN Sep. 1990 81 p
(Contract NAS8-36955)
(NASA-CR-184225; NAS 1.26:184225; UAH-5-32180) Avail: CASI HC A05/MF A01

The time dependence of the angular reflectance from molecularly contaminated optical surfaces in the Vacuum Ultraviolet (VUV) is measured. The light scattering measurements are accomplished in situ on optical surfaces in real time during deposition of molecular contaminants. The measurements are taken using non-coherent VUV sources with the predominant wavelengths being the Krypton resonance lines at 1236 and 1600 A. Detèction of the scattered light is accomplished using a set of three solar blind VUV photomultipliers. An in-plane VUV BRDF (Bidirectional Reflectance Distribution Functions) experiment is described and details of the ongoing program to characterize optical materials exposed to the space environment is reported. Author

N92-11074*# Alabama Univ., Huntsville. Dept. of Chemistry.
ANALYSIS OF SURFACES FROM THE LDEF A0114, PHASE 4 Semiannual Progress Report, 1 Mar. - 31 Aug. 1991
JOHN C. GREGORY 31 Aug. 1991 46 p
(Contract NAG1-1228)
(NASA-CR-188990; NAS 1.26:188990) Avail: CASI HC A03/MF A01

Progress made from 1 Mar. to 31 Aug. 1991 is presented. The work concentrated on profilometry measurements of eroded and corroded sample surfaces, optical transmission measurements, analysis of the pinhole camera, and x-ray photoelectron spectroscopic (XPS) analysis of some samples. The following papers are presented: (1) observation of Be-7 on the surface of the Long Duration Exposure Facility (LDEF) Spacecraft; (2) measurement of the passive attitude control performance of a recovered spacecraft; (3) effects on LDEF exposed copper flim and bulk; (4) measurements of erosion characteristics for metal and polymer surfaces using profilometry; (5) the interactions of atmospheric cosmogenic radionuclides with spacecraft surfaces; (6) pinhole cameras as sensors for atomic oxygen in orbit; and (7) interaction of atomic oxygen with solid surfaces in low earth orbit- results from LDEF experiment A0114.

N92-11075*# Alabama Univ., Huntsville.
THE INTERACTIONS OF ATMOSPHERIC COSMOGENIC RADIONUCLIDES WITH SPACECRAFT SURFACES
JOHN C. GREGORY (Alabama Univ., Huntsville.), G. J. FISHMAN (National Aeronautics and Space Administration. Goddard Space Flight Center, Albuquerque, NM.), B. A. HARMON (National Aeronautics and Space Administration. Goddard Space Flight Center, Albuquerque, NM.), and T. A. PARNELL (National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.) *In its* Analysis of Surfaces from the LDEF A0114, Phase 4 15 p 31 Aug. 1991
Avail: CASI HC A03/MF A01

The discovery of the cosmogenic radionuclide Be-7 on the front surface (and the front surface only) of the Long Duration Exposure Facility (LDEF) spacecraft has opened opportunities to investigate new phenomena in several disciplines of space science. The experiments performed for this work show that the Be-7 results only if the source of the isotope is the atmosphere through which the spacecraft passed. We should expect that the uptake of beryllium in such circumstances will depend on the chemical form of the Be and the chemical nature of the substrate. It was found that the observed concentration of Be-7 does, in fact, differ between metal surfaces and organic surfaces such as PTFE (teflon). It is noted, however, that: (1) organic surfaces, even PTFE, are etched by the atomic oxygen found under these orbital conditions, and (2) the relative velocity of the species is 8 km(exp -1)s relative to the surface and the interaction chemistry and physics may differ from the norm. The Be-7 is formed by spallation of O and N nuclei under cosmic ray proton bombardment. The principal source region is at altitudes of 12-15 km. While very small quantities are produced above 300 km, the amount measured on the LDEF was 3 to 4 orders of magnitude higher than expected from production at orbital attitude. The most reasonable explanation is that Be-7 is rapidly transported from low altitudes by some unknown mechanism. The process must take place on a time scale similar to the half-life of the isotope (53 days). Many other isotopes are produced by cosmic ray reactions, and some of these are suited to measurement by the extremely sensitive methods of accelerator mass spectrometry. A program was initiated to search for these isotopes and it is hoped that such studies will provide new methods for studying mixing in the upper atmosphere. Author

N92-11076*# Alabama Univ., Huntsville.
EFFECTS ON LDEF EXPOSED COPPER FILM AND BULK
PALMER N. PETERS (National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.), JOHN C. GREGORY, LIGIA C. CHRISTL, and GANESH N. RAIKAR *In its* Analysis of Surfaces from the LDEF A0114, Phase 4 8 p 31 Aug. 1991
(Contract NAS8-36645; NAGW-812)
Avail: CASI HC A02/MF A01

Two forms of copper were exposed to the Long Duration Exposure Facility (LDEF) Mission 1 environment: a copper film, initially 74.2 plus or minus 1.1 nm thick sputter coated on a fused silica flat and a bulk piece of oxygen-free, high conductivity (OFHC) copper. The optical density of the copper film changed from 1.33 to 0.70 where exposed, and the film thickness increased to 106.7 plus or minus 0.5 nm where exposed. The exposed area appears purple by reflection and green by transmission for the thin film and maroon color for the bulk copper piece. The exposed areas increased in thickness, but only increase in the thickness of the thin film sample could be readily measured. The increase in film thickness is consistent with the density changes occurring during conversion of copper to an oxide. However, we have not been able to confirm appreciable conversion to an oxide by x-ray diffraction studies. We have not yet subjected the sample to e-beams or more abusive investigations out of concern that the film might be modified. Author

N92-11077*# Alabama Univ., Huntsville.
MEASUREMENTS OF EROSION CHARACTERISTICS FOR METAL AND POLYMER SURFACES USING PROFILOMETRY
LIGIA C. CHRISTL (Alabama Univ., Huntsville.), JOHN C. GREGORY (Alabama Univ., Huntsville.), and PALMER N. PETERS (National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.) *In its* Analysis of Surfaces from the LDEF A0114, Phase 4 12 p 31 Aug. 1991
(Contract NAS8-36645; NAGW-812)
Avail: CASI HC A03/MF A01

The surfaces of many materials exposed in low earth orbit are modified due to interaction with atomic oxygen. Chemical changes and surface roughening effects can occur which alter optical and other properties. The experiment A0114 contained 128 solid surface samples, half of which were exposed on the front and half on the rear of Long Duration Exposure Facility. Each sample was subjected to many analyses, but only the methods and techniques are described which were used to measure the changes in roughness, erosion depths, and material growth using profilometry. Author

N92-12046*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ATOMIC OXYGEN INTERACTION WITH SPACECRAFT MATERIALS: RELATIONSHIP BETWEEN ORBITAL AND GROUND-BASED TESTING FOR MATERIALS CERTIFICATION
J. B. CROSS (Los Alamos National Lab., NM.), S. L. KOONTZ (Los Alamos National Lab., NM.), and E. H. LAN (McDonnell-Douglas Space Systems Co., Huntington Beach, CA.) 1991 17 p Presented at the 5th International Symposium on Materials in Space Environment, Cannes, France, 16-20 Sep. 1991
(Contract W-7405-ENG-36)
(NASA-TM-105449; NAS 1.15:105449; DE92-000190; LA-UR-91-3052; CONF-9109285-1) Avail: CASI HC A03/MF A01

The effects of atomic oxygen on boron nitride, silicon nitride, solar cell interconnects used on the Intelsat 6 satellite, organic polymers, and MoS2 and WS2 dry lubricant have been studied in low Earth orbit (LEO) flight experiments and in our ground-based simulation facility at Los Alamos National Laboratory. Both the in-flight and ground-based experiments employed in situ electrical resistance measurements to detect penetration of atomic oxygen through materials and ESCA analysis to measure chemical composition changes. In the presence of atomic ozygen, silver oxidizes to form silver oxide, which has a much higher electrical resistance than pure silver. Permeation of atomic oxygen through BN overcoated on thin silver was observed. No permeation of atomic oxygen through Si3N4 was observed. Test results on the Intelsat 6 satellite interconnects used on its photovoltaic array indicate that more than 60-80 percent of the original thickness of silver should remain after completion of the proposed Space Shuttle rescue/reboost mission. Gas phase reaction products produced by the interaction of high kinetic energy atomic oxygen (AO) with Kapton were found to be H2, H2O, CO, and CO2 with NO being a possible secondary product. Hydrogen abstraction at high AO kinetic energy is postulated to be the key reaction controlling the erosion rate of Kapton. 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. Oxidation of MoS2 and WS2 dry lubricants in both ground-based and orbital exposures indicated the formation of MoO3 and WO3 respectively. A protective oxide layer is formed approximately 30 monolayers thick which has a high initial friction coefficient until the layer is worn off.
DOE

N92-12064# Aerospatiale, Paris (France). Space and Strategic Systems Div.
STRUCTURES AND FRACTURE MECHANIC OF BRITTLE MATRIX COMPOSITES
J. F. JAMET and P. PERES 1991 104 p Presented at the Comet Courses, Paris, France, 24-26 Jun. 1991
(REPT-911-430-131; ETN-91-90262) Avail: CASI HC A06/MF A02

Although ceramic and carbon/carbon composites with protective coatings ally toughness, refractoriness and resistance to oxidation progress is under way to meet new demands for toughness at high temperature in special environments and to develop the industrial technology for manufacturing parts, in accordance with traditional quality methods. A course which is founded on the research and development experience of space materials and structures laboratory charged with the following is described: developing industrial manufacturing processes (prototypes); characterizing materials and predicting their behavior; elaborating nondestructive testing technology; the corresponding appraisals. The aim of this course is to show how the mechanical and thermomechanical aspects of this new type of material are closely linked to the constantly advancing process. ESA

N92-13241# Montpellier Univ. (France).
TESTING METHOD OF INSULATING MATERIALS FOR SPATIAL APPLICATIONS
A. CHERIFI (Centre Val d'Aurelle Paul Lamarque, Montpellier (France).), M. ABOU-DAKKA, A. TOUREILLE, J. B. DUBOIS, and R. DELARD (Centre Val d'Aurelle Paul Lamarque, Montpellier, France) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 597-601 Aug. 1991
Copyright Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

By using a new method and varying the forming parameters, the development of space charge in several thick insulating materials submitted (or not) to beta or gamma high energy radiations is studied. This permits their sensitivity to the spatial conditions to be estimated with a view to selecting the best material for the satellite protection and insulation. By using this testing method the reliability of the future insulating materials in space can be increased. ESA

N92-13246# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Etudes et Recherches en Technologie Spatiale.
INVESTIGATION OF THE EFFECTS OF PROTON IRRADIATION ON THE INSULATION PROPERTIES OF KAPTON
V. HUDE and A. P. ROBBEN (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 627-631 Aug. 1991
Copyright Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Following power loss anomalies experienced on the solar arrays of satellites, short circuits were recognized to have occurred between the solar array sections and the carbon fiber structure. A possible cause of the short circuits is a failure of the insulating layer which can be degraded by the space environment. A more singular study of Kapton layer was made. The electrical resistivities of Kapton H, HN and Kapton HN(+) polymer primer were measured for proton irradiations, the irradiated polymeric material being progressively transformed into a conducting or semi conducting layer. Different experiment results are shown. ESA

N92-13258*# International Telecommunications Satellite Organization, Washington, DC.
ASSESSMENT OF ATOMIC OXYGEN EROSION OF SILVER INTERCONNECTS ON INTELSAT 6, F3
A. DUNNET and T. D. KIRKENDALL (Communications Satellite Corp., Clarksburg, MD.) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 701-706 Aug. 1991 Sponsored by NASA, Washington
Copyright Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Intelsat 6 F-3 was launched from Cape Canaveral on a Titan 3 launch vehicle. Failure of the launch vehicle resulted in the satellite being marooned in Low Earth Orbit (LEO). During its sojourn in LEO, Intelsat 6 is exposed to an unanticipated environment consisting primarily of atomic oxygen, which will subject the unprotected silver interconnects (nominally 12.5 microns thick) on the solar panel to oxidation and erosion. Rescue by Space Shuttle is being examined. Consequently, Intelsat and Comsat have joined in an effort to determine the condition of the silver interconnects at the anticipated time of reboost and to assess the long term risks to the intended geostationary mission. Ground based tests, theoretical analysis, and a flight experiment aboard STS-41 were executed, and new software was written to calculate the expected total atomic oxygen fluence on the interconnects.
ESA

N92-13266# Ceskoslovenska Akademie Ved, Prague. Inst. of Physics.
ORIGIN OF THE SELF-ANNEALING OF THE RADIATION DAMAGE IN SI, INP, AND GAAS CONCENTRATOR SOLAR CELLS
V. POULEK *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 755-758 Aug. 1991
Copyright Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Radiation damage in concentrator solar cells is, under concentrated sunlight, simultaneously annealed. Possible origins

of the self annealing of the radiation damage in Si, InP, and GaAs concentrator solar cells are investigated. A thermal recombination enhanced annealing theory is proposed to explain this phenomenon. Physical parameters which play a dominant role in the self annealing process are included in the new self annealing parameter. This parameter influences the efficiency of the self annealing process in concentrator solar cells. ESA

N92-13989# Toronto Univ., Downsview (Ontario). Inst. for Aerospace Studies.
STRUCTURAL MECHANICS AND MATERIALS SCIENCE
R. C. TENNYSON, J. S. HANSEN, W. G. ELLIOTT, W. J. UNGER, B. BLAGOJEVIC, M. G. BLUM, R. C. BOWSER, T. H. BRAITHWAITE, P. G. CAMERON, T. L. C. CHEN et al. *In its* Activities of the University of Toronto Institute for Aerospace Studies p 103-105 1989
Avail: CASI HC A01/MF A02

Progress in structural mechanics and materials science research programs at the University of Toronto Institute for Aerospace Studies is reviewed. Two major research programs are underway in the study of composite materials. The first program involves the study of fatigue life of fiber matrix thermoplastic laminates, tailoring residual stress distribution in these materials through selective local melting, and fiber composite repair using external heating. In the second program, experiments are underway to evaluate the capabilities of embedded fiber optic sensors to respond to thermomechanical loading of composite laminates. Four space simulators have been assembled which provide the capability of studying in-situ the effect of thermal-vacuum cycling, ultraviolet radiation, electron bombardment, and atomic oxygen on the mechanical, thermal, and physical properties of polymer matrix composites and thin films. Analytical and experimental projects are underway dealing with viscoelastic characteristics of reinforced fiber composites including: high strain load analysis, mathematical treatment of damping on large space structures, failure prediction, and determination of residual strength in damaged systems. Finite element strategies are being developed for viscoelastic damping of large space structures, prediction of failure of composite structures, analysis of composite systems subject to large strain loading, determination of the residual strength of damaged composite systems, and the modeling of damage to composite laminates subject to low energy impact. CISTI

N92-14114*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SYNERGISTIC EFFECTS OF ULTRAVIOLET RADIATION, THERMAL CYCLING, AND ATOMIC OXYGEN ON ALTERED AND COATED KAPTON SURFACES
JOYCE A. DEVER (Cleveland State Univ., OH.), ERIC J. BRUCKNER, and ELVIN RODRIGUEZ (Cleveland State Univ., OH.) 1992 11 p Presented at the 30th Aerospace Sciences Meeting and Exhibit, Reno, NV, 6-9 Jan. 1992; sponsored by AIAA
(Contract RTOP 474-46-10)
(NASA-TM-105363; E-6741; NAS 1.15:105363; AIAA PAPER 92-0794) Avail: CASI HC A03/MF A01

The photovoltaic (PV) power system for Space Station Freedom (SSF) uses solar array blankets which provide structural support for the solar cells and house the electrical interconnections. In the low Earth orbital (LEO) environment where SSF will be located, surfaces will be exposed to potentially damaging environmental conditions including solar ultraviolet (UV) radiation, thermal cycling, and atomic oxygen. It is necessary to use ground based tests to determine how these environmental conditions would affect the mass loss and optical properties of candidate SSF blanket materials. Silicone containing, silicone coated, and SiO(x) coated polyimide film materials were exposed to simulated LEO environmental conditions to determine there durability and whether the environmental conditions of UV, thermal cycling and oxygen atoms act synergistically on these materials. A candidate PV blanket material called AOR Kapton, a polysiloxane polyimide cast from a solution mixture, shows an improvement in durability to oxygen atoms erosion after exposure to UV radiation or thermal cycling combined with UV radiation. This may indicate that the environmental conditions react synergistically with this material, and the damage predicted by exposure to atomic oxygen alone is more severe than that which would occur in LEO where atomic oxygen, thermal cycling and UV radiation are present together. Author

N92-14119*# California Polytechnic State Univ., San Luis Obispo.
MATERIAL PROPERTY FOR DESIGNING, ANALYZING, AND FABRICATING SPACE STRUCTURES Final Report, 15 Nov. 1989 - 31 Dec. 1991
FAYSAL A. KOLKAILAH 31 Dec. 1991 145 p
(Contract NAG2-637)
(NASA-CR-189516; NAS 1.26:189516) Avail: CASI HC A07/MF A02

An analytical study was made of plasma assisted bullet projectile. The finite element analysis and the micro-macromechanic analysis was applied to an optimum design technique for the multilayered graphite-epoxy composite projectile that will achieve hypervelocity of 6 to 10 Km/s. The feasibility was determined of dialectics to monitor cure of graphite-epoxies. Several panels were fabricated, cured, and tested with encouraging results of monitoring the cure of graphite-epoxies. The optimum cure process for large structures was determined. Different orientation were used and three different curing cycles were employed. A uniaxial tensile test was performed on all specimens. The optimum orientation with the optimum cure cycle were concluded. Author

N92-15189*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN ANALYSIS OF LDEF-EXPOSED SILVERED FEP TEFLON THERMAL BLANKET MATERIAL
PHILIP R. YOUNG and WAYNE S. SLEMP Dec. 1991 28 p
(Contract RTOP 506-43-11)
(NASA-TM-104096; NAS 1.15:104096) Avail: CASI HC A03/MF A01

The characterization of selected silvered fluorinated ethylene propylene (FEP) teflon thermal blanket material which received 5 years and 9 months of exposure to the LEO environment on the Long Duration Exposure Facility is reported. X-ray photoelectron spectroscopy, infrared, and thermal analyses did not detect a significant change at the molecular level as the result of this exposure. However, various microscopic analyses revealed a roughening of the coating surface due to atomic oxygen erosion which resulted in some materials changing from specular reflectors of visible radiation to diffuse reflectors. The potential effect of silicon-containing molecular contamination on these materials is addressed. Author

N92-17376*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
LONG-TERM CORROSION EVALUATION OF STAINLESS STEELS IN SPACE SHUTTLE IODINATED RESIN AND WATER
DOUGLAS D. KROHN Jan. 1992 28 p
(NASA-TM-104743; S-660; NAS 1.15:104743) Avail: CASI HC A03/MF A01

The effects of stainless steel exposure to iodinated water is a concern in developing the Integrated Water System (IWS) for Space Station Freedom. The IWS has a life requirement of 30 years, but the effects of general and localized corrosion over such a long period have not been determined for the candidate materials. In 1978, Umpqua Research Center immersed stainless steel 316L, 321, and 347 specimens in a solution of deionized water and the Space Shuttle microbial check valve resin. In April 1990, the solution was chemically analyzed to determine the level of corrosion formed, and the surface of each specimen was examined with scanning electron microscopy and metallography to determine the extent of general and pitting corrosion. This examination showed that the attack on the stainless steels was negligible and never penetrated past the first grain boundary layer. Of the three alloys, 316L performed the best; however, all three materials proved to be compatible with an aqueous iodine environment. In addition to

the specimens exposed to aqueous iodine, a stainless steel specimen (unspecified alloy) was exposed to moist microbial check valve resin and air for a comparable period. This environment allowed contact of the metal to the resin as well as to the iodine vapor. Since the particular stainless steel alloy was not known, energy dispersive spectroscopy was used to determine that this alloy was stainless steel 301. The intergranular corrosion found on the specimen was limited to the first grain boundary layer.
Author

N92-19369# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
A COMPARISON OF FRACTIONAL ORDER TIME DERIVATIVE MODELS OF THE VISCOELASTIC STRESS RELATIONS IN THERMORHEOLOGICALLY COMPLEX MATERIALS M.S. Thesis
VICTOR B. CHAMBERS Dec. 1991 110 p
(AD-A243971; AFIT/GAE/ENY/91D-23) Avail: CASI HC A06/MF A02

The purpose of this thesis was to examine the viscoelastic behavior of thermorheologically complex materials, a typical example of which is a soft, rubbery material. Materials such as these are very useful in damping vibrations in structures, but the relaxation moduli of these materials change significantly with temperature and frequency. In the case of space structures applications where temperatures vary greatly and a stable platform is necessary, a method to predict this changing modulus is needed. The original approach was to validate a previously developed viscoelastic model, but the task expanded to include extending the model to materials with two transitions from a low modulus value to a higher value and applying thermodynamic principles to validate the extended model. GRA

N92-19694*# McCrone Associates, Inc., Westmont, IL.
ANALYSIS OF PARTICULATE CONTAMINATION ON TAPE LIFT SAMPLES FROM THE VETA OPTICAL SURFACES
MARK S. GERMANI 21 Feb. 1992 26 p
(Contract NASA ORDER H-11942-D)
(NASA-CR-189918; NAS 1.26:189918; MA-21600) Avail: CASI HC A03/MF A01

Particulate contamination analysis was carried out on samples taken from the Verification Engineering Test Article (VETA) x-ray detection system. A total of eighteen tape lift samples were taken from the VETA optical surfaces. Initially, the samples were tested using a scanning electron microscope. Additionally, particle composition was determined by energy dispersive x-ray spectrometry. Results are presented in terms of particle loading per sample. D.R.D.

N92-20040*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ELECTRICAL PROPERTIES OF TEFLON AND CERAMIC CAPACITORS AT HIGH TEMPERATURES
A. N. HAMMOUD (Sverdrup Technology, Inc., Brook Park, OH.), E. D. BAUMANN, I. T. MYERS, and E. OVERTON 1992 6 p Proposed for presentation at the 1992 International Symposium on Electrical Insulation, Baltimore, MD, 7-9 Jun. 1992; sponsored by IEEE Dielectrics and Electrical Insulation Society
(Contract RTOP 506-41-41)
(NASA-TM-105569; E-6894; NAS 1.15:105569) Avail: CASI HC A02/MF A01

Space power systems and components are often required to operate efficiently and reliably in harsh environments where stresses, such as high temperature, are encountered. These systems must, therefore, withstand exposure to high temperature while still providing good electrical and other functional properties. Experiments were carried out to evaluate Teflon and ceramic 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. DC leakage current measurements were also performed in a temperature range from 25 to 200 C. The results obtained are discussed and conclusions are made concerning the suitability of the capacitors studied for high temperature applications. Author

N92-20065*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ATOMIC OXYGEN DURABILITY OF SOLAR CONCENTRATOR MATERIALS FOR SPACE STATION FREEDOM
KIM K. DEGROH (National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.), JUDITH A. TERLEP (Case Western Reserve Univ., Cleveland, OH.), and THERESE M. DEVER (Cleveland State Univ., OH.) 1990 13 p Presented at the 5th Annual Air Force Workshop on Surface Reactions in the Space Environment, Evanston, IL, 24-25 Sep. 1990; sponsored by Northwestern Univ.
(Contract NCC3-19; RTOP 474-52-10)
(NASA-TM-105378; E-6745; NAS 1.15:105378) Avail: CASI HC A03/MF A01

The findings are reviewed of atomic oxygen exposure testing of candidate solar concentrator materials containing SiO2 and Al2O3 protective coatings for use on Space Station Freedom solar dynamic power modules. Both continuous and iterative atomic oxygen exposure tests were conducted. Iterative air plasma ashing resulted in larger specular reflectance decreases and solar absorptance increases than continuous ashing to the same fluence, and appears to provide a more severe environment than the continuous atomic oxygen exposure that would occur in the low Earth orbit environment. First generation concentrator fabrication techniques produced surface defects including scratches, macroscopic bumps, dendritic regions, porosity, haziness, and pin hole defects. Several of these defects appear to be preferential sites for atomic oxygen attack leading to erosive undercutting. Extensive undercutting and flaking of reflective and protective coatings were found to be promoted through an undercutting tearing propagation process. Atomic oxygen erosion processes and effects on optical performance is presented. Author

N92-20561# Japan Atomic Energy Research Inst., Tokyo.
IRRADIATION EFFECTS ON RESISTANCE TO THERMAL IMPACT FOR COMPOSITES USED IN SPACE, 2
AKIRA UDAGAWA (Japan Atomic Energy Research Inst., Tokyo.), TSUNEO SASUGA (Japan Atomic Energy Research Inst., Tokyo.), TADAO SEGUCHI (Japan Atomic Energy Research Inst., Tokyo.), KENJI NAKAO (Japan Atomic Energy Research Inst., Tokyo.), TOSHIO SAKAKIBARA (Japan Atomic Energy Research Inst., Tokyo.), NORIAKI SUGAHARA (Japan Atomic Energy Research Inst., Tokyo.), TAKAYUKI KAMIYAMA (Japan Atomic Energy Research Inst., Tokyo.), YOSUKE NAGAO (Japan Atomic Energy Research Inst., Tokyo.), and KATSUMI KAMEI (Fuji Heavy Industries Ltd., Utsunomiya, Japan) Jun. 1991 52 p In JAPANESE; ENGLISH summary
(DE92-731701; JAERI-M-91-099) Avail: CASI HC A04/MF A01

Mechanical properties of carbon-fiber-reinforced plastics (CFRP) and adhesives which are of practical importance for structural materials in space systems, were studied after being exposed to individual radiation, thermal shock, and a combination of both of them. The IM-6/6376 composite, which includes the modified TGDDM(DDS) matrix and high strength intermediate modulus carbon fiber (IM-6), showed sufficient adoptability for space material. The mechanical properties for fiber directions of 0 and 90 deg did not change after irradiation of up to 10 MGy and/or after thermal shock of up to 3000 cycles (-100 to approximately 100 C). Preliminary experiments were carried out using an interlaminar adhesive panel with modified epoxy resin-adhesive films. The resistance of adhesives to thermal shock was dependent on the commercial products, so that it was difficult to classify the curing condition of adhesives. It was also found that the thickness of adhesives in the panel specimens should be increased and the adhesion strength was greatly affected by thermal expansion of the adherends. The CFRP with polyimide resins such as PMR-15 and the newly developed CFRP with new-TPI possessed the same initial mechanical properties and no microcracks appeared after their exposure to radiation and thermal

shocks. It was revealed that these materials showed high resistance to radiation and thermal shock which is of interest for their use in space systems. DOE

N92-20808*# Vitro Corp., Washington, DC.
A GUIDE TO STRUCTURAL FACTORS FOR ADVANCED COMPOSITES USED ON SPACECRAFT
ROBERT VANWAGENEN Aug. 1989 42 p
(Contract NASW-4311)
(NASA-CR-186010; NAS 1.26:186010) Avail: CASI HC A03/MF A01

The use of composite materials in spacecraft systems is constantly increasing. Although the areas of composite design and fabrication are maturing, they remain distinct from the same activities performed using conventional materials and processes. This has led to some confusion regarding the precise meaning of the term 'factor of safety' as it applies to these structures. In addition, composite engineering introduces terms such as 'knock-down factors' to further modify material properties for design purposes. This guide is intended to clarify these terms as well as their use in the design of composite structures for spacecraft. It is particularly intended to be used by the engineering community not involved in the day-to-day composites design process. An attempt is also made to explain the wide range of factors of safety encountered in composite designs as well as their relationship to the 1.4 factor of safety conventionally applied to metallic structures. Author

N92-21548*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ION BEAM TREATMENT OF POTENTIAL SPACE MATERIALS AT THE NASA LEWIS RESEARCH CENTER
MICHAEL KUSSMAUL (Sverdrup Technology, Inc., Brook Park, OH.), MICHAEL J. MIRTICH, and ARTHUR CURREN 1992 17 p Presented at the Surface Modification of Metals by Ion Beams, Washington, DC, 15-19 Jul. 1991; sponsored by the Naval Research Lab.
(Contract RTOP 506-41-41)
(NASA-TM-105398; E-6794; NAS 1.15:105398) Avail: CASI HC A03/MF A01

Ion source systems in different configurations, have been used to generate unique morphologies for several NASA space applications. The discharge chamber of a 30 cm ion source was successfully used to texture potential space radiator materials for the purpose of obtaining values of thermal emittance greater than 0.85 at 700 and 900 K. High absorptance surfaces were obtained using ion beam seed texturing, for space radiator materials that were flown on the Long Duration Exposure Facility (LDEF) for 5.8 years in space. An ion source discharge chamber was also used to develop electrode surfaces with suppressed secondary electron emission characteristics for use in collectors in microwave amplifier traveling wave tubes. This was accomplished by sputtering textured carbon onto copper as well as texturing copper using tantalum and molybdenum as sacrificial texture inducing seeding materials. In a third configuration, a dual ion beam system was used to generate high transmittance diamondlike carbon (DLC) films. Author

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.

A92-10470* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
OPTIMIZATION OF PAYLOAD PLACEMENT ON ARBITRARY SPACECRAFT
MELVIN J. FEREBEE, JR. and CHERYL L. ALLEN (NASA, Langley Research Center, Hampton, VA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Sept.-Oct. 1991, p. 612-614. Oct. 1991 3 p refs
Copyright

A systematic method for determining the optical placement of instrumentation on an arbitrary spacecraft is described. The method maximizes the resource utilization by minimizing the spacecraft's need for propulsive attitude control. The mathematical program developed with considerations toward reducing the size of the optimization effort is presented. I.S.

A92-11072* Virginia Polytechnic Inst. and State Univ., Blacksburg.
LIMITS ON STATIC SHAPE CONTROL FOR SPACE STRUCTURES
RAPHAEL T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 29, Nov. 1991, p. 1945-1950. Nov. 1991 6 p refs
(Contract NAG1-224)
Copyright

This paper deals with correction of shape distortion due to zero-mean normally distributed errors in structural sizes. The concept of ideal actuators - actuators that can produce any desired displacement field - is introduced. Using this concept, a bound on the possible improvement in the expected value of the root-mean-square shape error is obtained. The shape correction associated with the ideal actuators is also characterized. An actuator effectiveness index is developed by comparing the displacement field generated by the actuator to the ideal. The results are specialized to a simple form for truss structures composed of nominally identical members. The bound and effectiveness index are tested on a 55-m radiometer antenna truss structure. It is found that previously obtained results for optimum actuators had a performance close to the bound obtained here. Also, it is found that large numbers of actuators are needed for large reductions in shape errors. Furthermore, the actuators associated with the optimum design are shown to have high effectiveness indices. Since only a small fraction of truss elements tend to have high effectiveness indices, the use of the effectiveness index can greatly reduce the number of truss members that need to be considered actuator sites. Author

A92-12104
TENSION ICOSAHEDRON AS A STRUCTURE FOR USE IN TERRESTRIAL AND OUTER SPACE ENVIRONMENTS
N. S. GOEL and V. PRAKASH (New York, State University, Binghamton) Computers and Structures (ISSN 0045-7949), vol. 41, no. 2, 1991, p. 189-196. 1991 8 p refs
Copyright

A modified form of the icosahedron, the tension icosahedron, has six edges which are compression elements (e.g. beams) and 24 edges which are tension elements (e.g. wires or cables). These modifications make it a structure which (1) can withstand loads that are greater than those for traditional structures, (2) has omnidirectional stability independent of gravity, (3) can be folded into a compact form and then unfolded on demand, and (4) can be easily assembled into larger and more complex structures that

retain the properties found in the single unit. In this paper, these attractive features are quantified through computer modeling. These structures should be useful in terrestrial and outer space environment as a unit which has maximum static and dynamic stability for a minimum weight and which could be used in a modular construction of bigger structures. Author

A92-12440
INTEGRATED MODELING FOR SPACECRAFT SYSTEM DESIGN
CARL D. GRAVES, ALAN ROSEN, ROBERT H. VAN VOOREN, and JOSEPH L. VOGL (TRW Space and Technology Group, Redondo Beach, CA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 16 p. Oct. 1991 16 p
(IAF PAPER 91-016) Copyright

The design of advanced complex spacecraft entails the quick resolution of a variety of requirements at the system level prior to allocation at the subsystem level. Three-dimensional integrated modeling using CATIA and I-DEAS speeds up the analyses and trade-offs required to evaluate design alternatives in at least three ways: results from one analysis can be directly fed into another; the common data base ensures that all analyses are being done on the same design; and changes can be passed through each analysis. Two design trades illustrate the approach: (1) the interactive analysis of structural, thermal, and optical parameters, and (2) configuration and deployment trades. Author

A92-12481
PRE-INTEGRATED TRUSS ASSEMBLIES FOR SPACE STATION FREEDOM
F. D. RIEL and G. MARKUS (McDonnell Douglas Space Systems Co., Space Station Div., Huntington Beach, CA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 14 p. Oct. 1991 14 p
(IAF PAPER 91-071) Copyright

The recent evolvement of the preintegrated truss design for SSF is presented and the specifics of the truss evaluation process are summarized. Structural models of the truss segments were evaluated in detail and compared in weight, size, cost impact and construction ease. Specific parameters addressed include the launch weight, volume and surface area for mounting equipment and for maintenance access, assembly techniques, loads, deflections, stiffness, and packaging. R.E.P.

A92-12493* Boeing Co., Huntsville, AL.
DESIGNING BERTHING MECHANISMS FOR INTERNATIONAL COMPATIBILITY
JOHN WINCH (Boeing Co., Missiles and Space Div., Huntsville, AL) and JUAN J. GONZALEZ-VALLEJO (Sener Ingenieria y Sistemas, S.A., Madrid, Spain) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Research supported by NASA and ESA. Oct. 1991 9 p
(IAF PAPER 91-086) Copyright

The paper examines the technological issues regarding common berthing interfaces for the Space Station Freedom and pressurized modules from U.S., European, and Japanese space programs. The development of the common berthing mechanism (CBM) is based on common requirements concerning specifications, launch environments, and the unique requirements of ESA's Man-Tended Free Flyer. The berthing mechanism is composed of an active and a passive half, a remote manipulator system, 4 capture-latch assemblies, 16 structural bolts, and a pressure gage to verify equalization. Extensive graphic and verbal descriptions of each element are presented emphasizing the capture-latch motion and powered-bolt operation. The support systems to complete the interface are listed, and the manufacturing requirements for consistent fabrication are discussed to ensure effective international development. C.C.S.

A92-12602
MICROMETEOROID/DEBRIS PROTECTION OF THE COLUMBUS PRESSURIZED MODULE
E. SCHNEIDER, K. KITTA, A. STILP (Fraunhofer-Institut fuer Kurzzeitdynamik, Freiburg im Breisgau, Federal Republic of Germany), M. LAMBERT (ESTEC, Noordwijk, Netherlands), and H. G. REIMERDES (MBB-ERNO, Bremen, Federal Republic of Germany) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 6 p. Research supported by MBB-ERNO and Aeritalia S.p.A. Oct. 1991 6 p refs
(IAF PAPER 91-280) Copyright

ESA's Columbus laboratory module for Space Station Freedom is vulnerable to micrometeoroid and space debris impacts to a degree that has prompted the experimental simulation of candidate protection systems' effectiveness against potential impacts in a light gas gun facility. Dual and triple Al-plate 'bumper shield' arrangements of various plate thicknesses, as well as shield systems of such other materials as hybrid laminates, have been tested for antiballistic effectiveness. Fundamental impact damage phenomena have thus been obtained and applied to shield design-optimization procedures. Both Al and composite plate systems show promise. O.C.

A92-12603* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
A COMPARISON OF WHIPPLE SHIELD HYPERVELOCITY IMPACT TESTS TO PENETRATION PREDICTORS
SCOTT A. HILL (NASA, Marshall Space Flight Center, Huntsville, AL), LALIT C. CHHABILDAS, and EUGENE S. HERTEL (Sandia National Laboratories, Albuquerque, NM) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 5 p. Oct. 1991 5 p refs
(Contract NASA ORDER H-99071-B)
(IAF PAPER 91-281) Copyright

An analytical model is presented for converting ballistic limit curves obtained from flat plate projectile experiments to ballistic limit curves based on equivalent diameter spheres. The developed method demonstrates good correlation of the ballistic limit of the shield concept for the flat-plate projectiles to the theoretical ballistic limit for equivalent spheres as predicted by the penetration equations. O.G.

A92-14563
NONLINEAR CONTACT DYNAMICS AND PARAMETER IDENTIFICATION OF ELASTIC JOINTS USING ARMA PROCESS - MODELING AND SIMULATION
H. S. TZOU and Y. RONG (Kentucky, University, Lexington) IN: Computers in engineering 1990; Proceedings of the ASME International Computers in Engineering Conference and Exposition, Boston, MA, Aug. 5-9, 1990. Vol. 2 1990 9 p refs
Copyright

Improper joint dynamic characteristics can seriously hamper the high-demanding performance and accuracy of joint dominated mechanical systems, e.g. deployable space structures, flexible robot manipulators, mechanism, etc. This paper presents a mathematical modeling and stochastic simulation study of a three-dimensional elastic joint. An analytical model of the joint including friction and clearance effects is studied; and a system equation with time-variant coefficient matrices is then derived. A parametric study, including joint clearance size, joint's rigidity/damping, and link's elasticity/damping, is first investigated. The friction is assumed to be a normally distributed random variable and the external excitation is also treated random in a stochastic simulation study using ARMA model. Simulation results are presented in the paper. Author

A92-14712
ORBITAL DEBRIS SHIELDING DESIGN OF THE RADARSAT SPACECRAFT
F. TERRILLON, H. R. WARREN, and M. J. YELLE (Canadian Space Agency, RADARSAT Program Technical Office, Ottawa, Canada) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 10 p. Oct. 1991 10 p refs
(IAF PAPER 91-283) Copyright

Radarsat is a Canadian-led cooperative program with the United

States to launch and operate a remote sensing satellite. The 3-axis stabilized spacecraft, to be launched in early 1995, is designed to operate in a sun-synchronous dawn-dusk circular orbit for five years at a mean altitude of 794 km and mean inclination of 98.5 deg. A preliminary survivability analysis was performed to calculate the probability of survival of its various components. A test program was then initiated at NASA Johnson Space Center's Hypervelocity Impact Research Lab to verify assumptions on the ability of some components to withstand impacts. Throughout this process a number of modifications to the spacecraft were introduced, and tested, to improve the shielding effectiveness. The test results will eventually be incorporated in a final spacecraft survivability analysis. The analyses which were performed, the tests which were conducted, and the modifications which were incorporated in the spacecraft design to ensure Radarsat's survival in the orbital debris environment, are described. Author

A92-14727
CONSISTENT LOAD ASSUMPTIONS AND STRUCTURAL DESIGN CRITERIA FOR NSTS/ARIANE 5/HERMES TRANSPORTED COLUMBUS ELEMENTS
KLAUS WALZ, HANS MAAGER, and ERNST WINKELHOFF (MBB-ERNO, Bremen, Federal Republic of Germany) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 18 p. Oct. 1991 18 p refs
(IAF PAPER 91-311) Copyright

The Columbus systems-engineering staff was faced, when considering the environmental conditions, load assumptions, etc., for initial structural design of the spacecraft, with changing requirements and the simultaneous development of the Ariane 5 launch vehicle and Hermes service vehicle. Structural design criteria and test conditions are accordingly defined which are independent of the transport vehicles employed and take into account the comparatively immature development status of transport vehicles and structures, while avoiding excessive conservatism with respect to stringent mass constraints. Attention is given to the special case of structural response to acoustic excitation. O.C.

A92-15255
DYNAMIC SIMULATION OF STRUCTURE DESTRUCTION PROCESS CAUSED BY SPACE DEBRIS COLLISION
YOSHIAKI OHKAMI and OSAMU OKAMOTO (National Aerospace Laboratory, Chofu, Japan) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 7 p. Oct. 1991 7 p refs
(IAF PAPER 91-340) Copyright

This paper deals with a digital simulation of a collision process of a ball with a plate from dynamical point of view, for the prediction of the structural damage and debris dispersion. A flat plate structure is modeled as a collection of rigid bodies connected by nonlinear springs which posses the material deformation characteristics. The collision process is modeled as repulsive force of a connecting hinge which changes from a free condition (pre-collision phase) to a kinetic constrain with a extremely hard spring and a certain amount of damping. After a possible passage of a kinetic constraint, the debris may penetrate through the plate or may be reflected. This scheme has turned out useful in debris collision simulation, which in some cases the collision can produce pieces of debris, and their trajectories and attitudes are precisely predicted. Illustrative examples are given which clearly show the destruction process and structural damage of the space structure as well as the secondary debris dispersion trajectories. Author

A92-15394
GENERAL DESIGN TOOL FOR FLEXIBLE SPACE MECHANISMS
O. I. SIVERTSEN, K. AAMNES, and T. ROLVAG (SINTEF Production Engineering, Trondheim, Norway) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 18 p refs
Copyright

Mechanism simulation based on a nonlinear finite element formulation is presented as a general tool for a designer using the finite element dynamics in elastic mechanisms (FEDEM) system. This approach to mechanism simulation is based on reduced simulation models using the component mode synthesis transformation of substructures, updated corotated coordinate systems at super element level, and robust and effective integration algorithms for nonlinear multidiscipline dynamic simulation. It is concluded that for a wide variety of mechanical systems FEDEM will make it possible to reduce the costs and time required for prototyping and testing. Full dynamic simulation of the entire mechanical system and the deformation and stress analysis of individual links are provided. O.G.

A92-15396
ACTIVE DAMPING OF A TRUSS STRUCTURE USING PIEZOELECTRIC ACTUATORS
A. PREUMONT, J.-P. DUFOUR, and M. SPARAVIER (Brussels, Free University, Belgium) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 14 p refs
Copyright

An active element based on a piezoelectric linear actuator collocated with a force transducer has been developed using commercially available components. It was applied to the active damping of a truss structure. The digital controller based on a rate feedback on the force is implemented with a sampling frequency of 100 Hz. The damping ratio of the first mode of the controlled structure has been increased from 0.0033 to 0.03. The nondimensional parameters controlling the damping augmentation are discussed. O.G.

A92-15399
FINITE ELEMENT MODELING OF FLEXIBLE TRACKS
A. CARDONA (INTEC, Santa Fe, Argentina) and M. GERADIN (Liege, Universite, Belgium) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 14 p refs
Copyright

The formulation of a straight flexible slider joint is presented. It is described as a straight Bernoulli beam in a corotational frame, over which a third node slides. The sliding node can pass from one joint to the next one, thus making it possible to refine the mesh up to achieving convergence. Applications of this joint are illustrated by two examples: the dynamic analysis of a telescopic mast and the dynamic analysis of missile launching. O.G.

A92-15401
DYNAMIC STABILITY OF BUCKLING ELASTIC STRUCTURES
D. DINKLER and B. KROEPLIN (Stuttgart, Universitaet, Federal Republic of Germany) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 12 p refs
Copyright

The development of stability estimates for structures under time dependent loads is considered. The estimates are based on general norms and can be used for the investigation of safety against stability loss by buckling. Starting from a state of equilibrium, the proposed procedure makes it possible to decide whether the structure stays for a certain load history within the critical bounds, which separate the motion around the prebuckling state from the motion in a postbuckling region. For an arbitrary load history, the Galerkin procedure is applied to the equations of motion using a representation of the deformations from static modal analysis. O.G.

A92-15402
MATERIAL PROPERTY MEASUREMENTS FOR VISCOELASTIC SPACE STRUCTURES
D. J. MCTAVISH and P. C. HUGHES (Toronto, University, Downsview, Canada) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 13 p refs
Copyright

Consideration is given to a procedure through which certain key material properties can be used to construct a rigorous linear viscoelastic dynamical description for a space structure. Models under consideration can be applied in both the time domain and the frequency domain. They can also be applied to different types of structures including frame, spatially discretized, and 'continuum' structures. Appropriate material property measurements are discussed, including the test philosophy and an examination of how to reduce the principal sources of error. The proposed procedure is illustrated using modal test data for a representative space structure. O.G.

A92-15973
THE APPLICATION OF A FINITE SHELL ELEMENT FOR COMPOSITES CONTAINING PIEZO-ELECTRIC POLYMERS IN VIBRATION CONTROL
R. LAMMERING (DLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) Computers and Structures (ISSN 0045-7949), vol. 41, no. 5, 1991, p. 1101-1109. 1991 9 p refs
Copyright

Advanced composite structures with integrated sensors and actuators are becoming increasingly important due to the demand for very large, low-mass space structures. This paper focuses on the finite element analysis of shell structures with thin piezo-electric layers bonded to the surfaces. A finite element formulation taking the piezo-electric effect into account is given and a finite shell element is presented, allowing for the computation of these advanced composite structures. The dynamic matrix equation accounting for the piezo-electric material response is formulated and found to have the same form as the well-known equation of structural dynamics. By using the second or direct method of Liapunov, a control law is derived, which is used in vibration control and ensures asymptotic stability. A numerical example is given to show the accuracy of the finite element, as well as the efficiency of the algorithm. Author

A92-17779
SELECTED ON-ORBIT APPLICATIONS FOR LARGE ROCKET PROPELLANT TANKS
DAVID L. CHRISTENSEN (Wyle Laboratories, Huntsville, AL) IN: Space manufacturing 8 - Energy and materials from space; Proceedings of the 10th Princeton/AIAA/SSI Conference, Princeton, NJ, May 15-18, 1991 1991 5 p refs
Copyright

Described are several on-orbit applications for large rocket propellant tanks after they have fulfilled their primary function. Included are several examples for potential use of large tanks as used by the Space Shuttle and recommendations for implementing broader use in space of large propellant tanks in the future. Current plans to modify and use the Space Shuttle external tank as a key element of the new National Launch System are also discussed, and a proposal is made for incorporating certain 'orbital utilization' features into the core element during the redesign phase. Author

A92-17914
CONCURRENT OPTIMIZATION OF LARGE STRUCTURES. I - ALGORITHMS. II - APPLICATIONS
HOJJAT ADELI and OSAMA KAMAL (Ohio State University, Columbus) Journal of Aerospace Engineering (ISSN 0893-1321), vol. 5, Jan. 1992, p. 79-110. Jan. 1992 32 p refs
Copyright

Algorithms and procedures for concurrent optimization of framed structures on shared-memory multiprocessor computers are presented. Examples are given for assessing the efficiency and versatility of the algorithms. Consideration is given to speed-ups and work-load-balance issues at various steps of the optimization process. The efficiency of the parallel-processing algorithms increases with the size of the structure, thus making them particularly suitable for optimization of large structures. R.E.P.

A92-18378* Alabama Univ., Huntsville.
SPACECRAFT WALL DESIGN FOR INCREASED PROTECTION AGAINST PENETRATION BY ORBITAL DEBRIS IMPACTS
WILLIAM P. SCHONBERG (Alabama, University, Huntsville) and RANDY J. TULLOS (Southwest Research Institute, San Antonio, TX) Dec. 1991 8 p refs
(Contract NAS8-36955)
Copyright

A92-18571
LASER SYSTEMS FOR SPACECRAFT HULL PROTECTION
P. M. SFORZA (Polytechnic University, Brooklyn, NY) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. Oct. 1991 12 p refs
(IAF PAPER 91-583) Copyright

A study of the applicability of a laser-based system for the protection of spacecraft hulls from meteoroid and space debris impact is presented. Hazard particles of aluminum, iron, polycrystalline graphite, and stone with velocities of 10 to 20 km/sec and characteristic dimensions of 1 cm are considered. The failure criterion employed is complete vaporization of the particle prior to impact. Design analyses and data for treating laser and aperture sizing and thermal response of the target particles are described. Laser powers required are determined to be in the range of 50 to 500 kW with projector apertures around 1 to 4m for laser wavelengths from 0.5 to 2.7 microns. Author

A92-19930* McDonnell-Douglas Space Systems Co., Houston, TX.
A MULTI-SHOCK CONCEPT FOR SPACECRAFT SHIELDING
BURTON G. COUR-PALAIS (McDonnell Douglas Space Systems Co., Houston, TX) and JEANNE L. CREWS (NASA, Johnson Space Center, Houston, TX) International Journal of Impact Engineering (ISSN 0734-743X), vol. 10, 1990, p. 135-146. 1990 12 p refs
Copyright

A spacecraft-shielding technique is investigated in which the geometrical configuration and material used are emphasized. Ultrathin spaced shield elements are employed to repeatedly shock the impacting projectile to a high energy state that causes melting and vaporization. The ratio of the thickness of the elements to projectile diameter corresponds to a relatively small percentage of debris-plume mass that can be withstood by the backsheet. The strength of the backsheet is thereby reduced and employed in a specific configuration that prevents the debris plume from destroying successive sheets before the particulates reach the sheet. The primary benefit is weight reduction of 30 percent when compared to a 'Whipple shield' fabricated with the same material. The concept is shown to be effective against all impact types tested and produces minimal secondary debris. C.C.S.

A92-20383* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
USING ADAPTIVE STRUCTURES TO ENABLE FUTURE MISSIONS BY RELAXING GROUND TEST REQUIREMENTS
BEN K. WADA, JAMES L. FANSON, and G.-S. CHEN (JPL, Pasadena, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Nov.-Dec. 1991, p. 663-669. Dec. 1991 7 p refs
(Contract NAS7-918)
Copyright

Future NASA missions will require large space structures that must maintain accurate surface tolerances for up to 20 years; most flight programs require a ground test verification of the hardware. Because of the influence of gravity, the current state-of-the-art ground test technology cannot accurately determine whether the hardware complies with the requirements. The incorporation of adaptive structures into the spacecraft will enable a relaxation of the ground test requirements necessary to validate the hardware for flight. This paper describes the challenges in testing large precision structures, adaptive structures, the data establishing the current state of the art in ground testing, and the utilization of adaptive structures to alleviate the ground test requirements. Author

A92-21170* Lockheed Engineering and Sciences Co., Hampton, VA.
USE OF A VELOCITY COMMAND MOTOR AS A REACTION MASS ACTUATOR
JEFFREY L. SULLA (Lockheed Engineering and Sciences Co., Hampton, VA), JER-NAN JUANG, and LUCAS G. HORTA (NASA, Langley Research Center, Hampton, VA) Feb. 1992 6 p refs
Copyright

A92-24658* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
INTERPOLATION/EXTRAPOLATION TECHNIQUE WITH APPLICATION TO HYPERVELOCITY IMPACT OF SPACE DEBRIS
WILLIAM K. RULE (Alabama, University, Tuscaloosa) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 29, Jan.-Feb. 1992, p. 70-75. Feb. 1992 6 p refs
(Contract NAG8-123)
Copyright

A new technique for the interpolation/extrapolation of engineering data is described. The technique easily allows for the incorporation of additional independent variables, and the most suitable data in the data base is automatically used for each prediction. The technique provides diagnostics for assessing the reliability of the prediction. Two sets of predictions made for known 5-degree-of-freedom, 15-parameter functions using the new technique produced an average coefficient of determination of 0.949. Here, the technique is applied to the prediction of damage to the Space Station from hypervelocity impact of space debris. A new set of impact data is presented for this purpose. Reasonable predictions for bumper damage were obtained, but predictions of pressure wall and multilayer insulation damage were poor.
Author

A92-24776
FIBER OPTIC SMART STRUCTURES AND SKINS III; PROCEEDINGS OF THE MEETING, SAN JOSE, CA, SEPT. 19-21, 1990
ERIC UDD, ED. (McDonnell Douglas Electronic Systems Co., McLean, VA) and RICHARD O. CLAUS, ED. (Virginia Polytechnic Institute and State University, Blacksburg) Meeting sponsored by SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Vol. 1370), 1990, 394 p. For individual items see A92-24777 to A92-24811. 1990 394 p
(ISBN 0-8194-0431-4; SPIE-1370) Copyright

The present conference on fiber-optically equipped 'smart' aerospace structures discusses topics in fiber-embedding in materials, the relationship of sensors to signal-processing capabilities, materials evaluation methods, active structural control, and damage assessment. Attention is given to the USAF Astronautics Laboratory's smart structures/skins program, on-orbit structural health monitoring, optimal coatings for smart structure fiber-optic sensors, a composite material-embedded fiber-optic Fabry-Perot strain rosette, and the embedding of fiber-optic sensors in Ti-matrix composites. Also discussed are neural-network processing of fiber-optic sensors and sensor arrays, the degradation of laminate composites by embedded fiber-optic sensors, a 'smart strut' interferometric differential-strain sensor, shape-memory alloys for flexible structure control, and the optical-signal analysis of impact-induced fracture in smart structures. O.C.

A92-24777* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ON-ORBIT STRUCTURAL HEALTH MONITORING
ROBERT S. ROGOWSKI (NASA, Langley Research Center, Hampton, VA) IN: Fiber optic smart structures and skins III; Proceedings of the Meeting, San Jose, CA, Sept. 19-21, 1990 1990 4 p refs
Copyright

On-orbit structural health monitoring aboard space platforms requires the development of sensor systems for assessing impact damage from particles and debris, the effects of atomic oxygen erosion, and the integrity of power systems, storage tanks, pressure vessels, and major structural elements. The task of implementing such a smart structure diagnostic system during the initial phase of the NASA Space Station Freedom is evaluated, with a view to more complete smart structures implementation in the course of station evolution. The data processing/cataloguing task may ultimately require AI and neural networks. O.C.

A92-24779
ASTRONAUTICS LABORATORY SMART STRUCTURES/SKINS PROGRAM OVERVIEW
STEVE GRIFFIN (USAF, Astronautics Laboratory, Edwards AFB, CA) IN: Fiber optic smart structures and skins III; Proceedings of the Meeting, San Jose, CA, Sept. 19-21, 1990 1990 9 p
Copyright

The development status of the USAF Astronautics Laboratory's contractual and in-house investigations into 'smart' aerospace structures and skins is evaluated. Plans have been drawn up for the incorporation of smart-structures technologies into future satellite vibration active control systems capable of sensing, evaluating, and damping-out any natural and spurious vibrations. In addition, health monitoring to sense any major degradation of the structure will be incorporated. Attention is given to the major role played by fiber-optics. O.C.

A92-25523
SOLAR SAILBOAT TO THE MOON AND MARS [SONNENSEGLER ZUM MOND UND ZUM MARS]
MICHAEL ODENWALD Sterne und Weltraum (ISSN 0039-1263), vol. 31, Feb. 1992, p. 95-97. In German. Feb. 1992 3 p In GERMAN

The international race to develop a solar sailboat for a Space Regatta to the moon is discussed. The designs being developed by the competitors are briefly described. The possibility of using solar sailboats in expeditions to Mars and other planets is addressed. C.D.

A92-28410#
MAGI, A SMOOTHED PARTICLE HYDRODYNAMICS CODE FOR SPACE IMPACT ANALYSIS
LARRY LIBERSKY (New Mexico Institute of Mining and Technology, Socorro), FIROOZ ALLAHDADI (USAF, Phillips Laboratory, Kirtland AFB, NM), TED CARNEY, and JIM HIPP (Advanced Sciences, Inc., Albuquerque, NM) AIAA and Society of Logistics Engineers, Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991. 9 p. Nov. 1991 9 p refs
(AIAA PAPER 91-4067) Copyright

This paper describes a smoothed particle hydrodynamics (SPH) code, MAGI, that was developed for application to spacecraft impact simulation and analysis. The physics, numerics, and architecture of the code are briefly described. Example calculations of high speed impact are presented. Author

A92-29930#
DEVELOPMENT FOR A PRECISION LARGE DEPLOYABLE ANTENNA FOR THE SPACE VLBI
KUNITO OHKUBO, TAKAHIKO NODA, OSAMI ISHIDA, KAZUO YAMAMOTO (Mitsubishi Electric Corp., Kamakura, Japan), KORYO MIURA, and TADASHI TAKANO (Institute of Space and Astronautical Science, Sagamihara, Japan) IN: AIAA International Communication Satellite Systems Conference and Exhibit, 14th, Washington, DC, Mar. 22-26, 1992, Technical Papers. Pt. 3 1992 8 p refs
(AIAA PAPER 92-2011) Copyright

Japan's Institute of Space and Astronautical Science has scheduled a 1995 launch for the Muses-B astronomical satellite, which will be used in conjunction with ground-based radio telescopes to create a VLBI system suitable for high-resolution studies of distant galaxies. Muses-B will deploy a 10-m diameter radio telescope antenna in orbit, and operate at 22, 5.0, and 1.6 GHz. A displaced-axis Cassegrain antenna is employed whose surface-accuracy design goal is less than 0.5 mm rms. Attention

is given to initial system tests conducted with a quarter-scale model of the antenna. O.C.

A92-29934#
CHARACTERISTICS OF LARGE DEPLOYABLE MESH REFLECTOR ANTENNAS FOR FUTURE MOBILE COMMUNICATIONS SATELLITES
TAKASHI EBISUI, AKIO ISO, TERUAKI ORIKASA, TOSHIO SUGIMOTO, and SHIN-ICHI SATO (Space Communications Research Corp., Tokyo, Japan) IN: AIAA International Communication Satellite Systems Conference and Exhibit, 14th, Washington, DC, Mar. 22-26, 1992, Technical Papers. Pt. 3 1992 7 p refs
(AIAA PAPER 92-2015) Copyright

A large deployable antenna is essential for effective mobile communication satellites. This paper describes the key technologies needed for such an antenna, the development plan, and the characteristics of various scale models. The electrical scale models of the mesh reflector antenna and the mechanical models of the deployable reflector have been constructed to aid in antenna design. The ultimate goal is a deployable mesh reflector antenna with 30-m diameter. The measured performance of the scale models corresponds closely to the calculated performance. These results will be extremely useful for designing large deployable mesh reflector antennas for mobile communication satellites. Author

A92-31076
THE CURRENT STATE OF THE REFLECTOR ANTENNA ART - ENTERING THE 1990'S
WILLARD V. T. RUSCH (Southern California, University, Los Angeles, CA) IEEE, Proceedings (ISSN 0018-9219), vol. 80, Jan. 1992, p. 113-126. Jan. 1992 14 p refs
Copyright

Modern reflector theory and practice with emphasis on the recent past are reviewed. Included are a brief historical review and performance definitions for the nonspecialist. Special sections are devoted to shaped multiple reflectors, reflector-surface metrology, and reflectors for the next decade and beyond. In spite of decreasing budgets for scientific, commercial, and military space programs, the 1990s promise to be a true golden age for the reflector antenna art. I.E.

N92-10122*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACECRAFT ANTENNAS
VAHRAZ JAMNEJAD, FARZIN MANSHADI, YAHYA RAHMAT-SAMII, and PAUL CRAMER *In its* Personal Access Satellite System (PASS) Study. Fiscal Year 1989 Results 52 p Sep. 1990
Avail: CASI HC A04/MF A03

Some of the various categories of issues that must be considered in the selection and design of spacecraft antennas for a Personal Access Satellite System (PASS) are addressed, and parametric studies for some of the antenna concepts to help the system designer in making the most appropriate antenna choice with regards to weight, size, and complexity, etc. are provided. The question of appropriate polarization for the spacecraft as well as for the User Terminal Antenna required particular attention and was studied in some depth. Circular polarization seems to be the favored outcome of this study. Another problem that has generally been a complicating factor in designing the multiple beam reflector antennas, is the type of feeds (single vs. multiple element and overlapping vs. non-overlapping clusters) needed for generating the beams. This choice is dependent on certain system design factors, such as the required frequency reuse, acceptable interbeam isolation, antenna efficiency, number of beams scanned, and beam-forming network (BFN) complexity. This issue is partially addressed, but is not completely resolved. Indications are that it may be possible to use relatively simple non-overlapping clusters of only a few elements, unless a large frequency reuse and very stringent isolation levels are required. Author

N92-10123*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PASS SPACECRAFT ANTENNA TECHNOLOGY ASSESSMENT
R. E. FREELAND *In its* Personal Access Satellite System (PASS) Study. Fiscal Year 1989 Results 18 p Sep. 1990
Avail: CASI HC A03/MF A03

The purpose was to generate estimates of mechanical performance for the classes of spacecraft antenna under construction for application to the Personal Access Satellite System (PASS). These performance data are needed for the support of trade studies involving antenna system development. The classes of antenna considered included: (1) rigid non-deployable antenna structures; (2) mechanical deployable antenna concepts; (3) inflatable deployable antenna concepts; and (4) mesh deployable antenna concepts. The estimates of mechanical performance are presented in terms of structural weight and cost as a function of the reflector size. Estimates of aperture surface precision are presented for a few discrete antenna sizes. The range of reflector size is 1 to 4 meters for non-deployable structures and 2 to 8 meters for deployable structures. The range of reflector surface precision is lambda/30 to lambda/50 for 20 and 30 GHz, respectively. Author

N92-11036*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
LARGE DEPLOYABLE ANTENNA PROGRAM. PHASE 1: TECHNOLOGY ASSESSMENT AND MISSION ARCHITECTURE
CRAIG A. ROGERS and WARREN L. STUTZMAN Washington NASA Oct. 1991 87 p
(Contract NAS1-18471; RTOP 590-41-14-03)
(NASA-CR-4410; NAS 1.26:4410) Avail: CASI HC A05/MF A01

The program was initiated to investigate the availability of critical large deployable antenna technologies which would enable microwave remote sensing missions from geostationary orbits as required for Mission to Planet Earth. Program goals for the large antenna were: 40-meter diameter, offset-fed paraboloid, and surface precision of 0.1 mm rms. Phase 1 goals were: to review the state-of-the-art for large, precise, wide-scanning radiometers up to 60 GHz; to assess critical technologies necessary for selected concepts; to develop mission architecture for these concepts; and to evaluate generic technologies to support the large deployable reflectors necessary for these missions. Selected results of the study show that deployable reflectors using furlable segments are limited by surface precision goals to 12 meters in diameter, current launch vehicles can place in geostationary only a 20-meter class antenna, and conceptual designs using stiff reflectors are possible with areal densities of 2.4 deg/sq m. Author

N92-11079*# Alabama Univ., Tuscaloosa. Dept. of Engineering Mechanics.
MLITEMP: A COMPUTER PROGRAM TO PREDICT THE THERMAL EFFECTS ASSOCIATED WITH HYPERVELOCITY IMPACT DAMAGE TO SPACE STATION MLI
W. K. RULE and V. GIRIDHARAN Sep. 1991 79 p
(Contract NAS8-38555)
(NASA-CR-184245; NAS 1.26:184245) Avail: CASI HC A05/MF A01

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 are described. Spacecraft wall temperatures and condensate formation is also predicted. The spacecraft wall configuration is assumed to consist of multilayered insulation (MLI) placed between a Whipple style bumper and the pressure wall. Impact damage 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 database of experimental results that is used by the damage prediction modules to predict damage to the bumper, the MLI, and the pressure wall. A finite difference technique is used to predict temperature distributions in the pressure wall, the MLI, and the bumper. Condensate layer thickness is predicted for the

case where the pressure wall temperature drops below the dew point temperature of the spacecraft atmosphere. Author

N92-11371 Colorado Univ., Boulder.
A COMPUTATIONAL PROCEDURE FOR THE DYNAMICS OF FLEXIBLE BEAMS WITHIN MULTIBODY SYSTEMS Ph.D. Thesis
JANICE DIANE DOWNER 1990 217 p
Avail: Univ. Microfilms Order No. DA9123442

The dynamic analysis of 3-D elastic beams which experience large rotational and deformational motions are examined. The beam motion is modeled using an inertial reference for the translational displacements and a body fixed reference for the rotational quantities. Finite strain rod theories are then defined in conjunction with the beam kinematic description which accounts for the effects of stretching, bending, torsion, and transverse shear deformations. A convected coordinate representation of the Cauchy stress tensor and a conjugate strain definition is introduced to model the beam deformation. To treat the beam dynamics, a two stage change of the central difference algorithm is presented to integrate the translational coordinates and the application of an implicit integration algorithm to the Euler parameter/angular velocity kinematical relation. The combined developments of the objective internal force computation with the dynamic solution procedures result in the computational preservation of total energy for undamped systems. The present method is also intended to model the dynamics of deployment or retrieval of the flexible members. Dissert. Abstr.

N92-12269*# Alabama Univ., Huntsville. Materials Processing Lab.
WELDING IN SPACE WORKSHOP Final Report
GARY L. WORKMAN 1 Mar. 1990 85 p Workshop held in Huntsville, AL, 8-9 Nov. 1989
(Contract NAS8-36955)
(NASA-CR-184234; NAS 1.26:184234) Avail: CASI HC A05/MF A01

The potential was discussed for welding in space, its advantages and disadvantages, and what type of programs can benefit from the capability. Review of the various presentations and comments made in the course of the workshop suggests several routes to obtaining a better understanding of how welding processes can be used in NASA's initiatives in space. They are as follows: (1) development of a document identifying well processes and equipment requirements applicable to space and lunar environments; (2) more demonstrations of welding particular hardware which are to be used in the above environments, especially for space repair operations; (3) increased awareness among contractors responsible for building space equipment as to the potential for welding operations in space and on other planetary bodies; and (4) continuation of space welding research projects is important to maintain awareness within NASA that welding in space is viable and beneficial. Author

N92-13263# Nippon Electric Co. Ltd., Tokyo (Japan).
SFU SOLAR ARRAY DEVELOPMENT TEST
Y. SHIBAYAMA (Tokyo Univ. (Japan).), K. HAMA (Tokyo Univ. (Japan).), H. IRIKADO (Tokyo Univ. (Japan).), T. OKUDAIRA (Institute for Unmanned Space Experiments Free Flyer, Tokyo (Japan).), H. TAKE, A. USHIROKAWA, M. NATORI, K. TAKAHASHI, N. WAKASUGI, and T. ANZAI (Institute for Unmanned Space Experiments Free Flyer, Tokyo, Japan) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 735-740 Aug. 1991 Sponsored by New Energy and Industrial Technology Development Organization
Copyright Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Space Flyer Unit (SFU) solar array is a 3 kW, flexible fold out, and retractable solar array on board a Japanese free flyer scheduled to be launched at the end of 1993. Extensive development tests were successfully completed on a SFU solar array engineering model to verify the design requirements. Manufacturing and assembly of the solar array protoflight models have been completed, and acceptance testing will start in May 1991. The development test results for the SFU solar array are outlined. ESA

N92-13264# Nippon Electric Co. Ltd. (Japan).
THE SOLAR ARRAY OF ASTRO-D SPACECRAFT
Y. OKADA (*Nippon Electric Co. Ltd. (Japan).*), J. TAKAHASHI (Tokyo Univ. (Japan).), Y. SHIBAYAMA (Tokyo Univ. (Japan).), M. TAJIMA, J. ONODA, and M. KOHBATA (Tokyo Univ., Japan) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 741-746 Aug. 1991
Copyright Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

The 15th scientific satellite, ASTRO-D, is being developed. The ASTRO-D X-ray observatory spacecraft, will be launched by a Mu booster in February, 1993. The electrical power for the ASTRO-D is supplied by two deployable solar array wings. The structural and technical design of the ASTRO-D solar array and the test results of an engineering model are outlined. ESA

N92-13865*# Old Dominion Univ., Norfolk, VA. Dept. of Engineering Management.
SPACECRAFT DESIGN OPTIMIZATION USING TAGUCHI ANALYSIS
RESIT UNAL *In its* NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1991 p 227-228 Sep. 1991
Avail: CASI HC A01/MF A03

The quality engineering methods of Dr. Genichi Taguchi, employing design of experiments, are important statistical tools for designing high quality systems at reduced cost. The Taguchi method was utilized to study several simultaneous parameter level variations of a lunar aerobrake structure to arrive at the lightest weight configuration. Finite element analysis was used to analyze the unique experimental aerobrake configurations selected by Taguchi method. Important design parameters affecting weight and global buckling were identified and the lowest weight design configuration was selected. Author

N92-14104*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
COMPUTATIONAL DETERMINATION OF BALLISTIC LIMITS FOR A SIMPLE WHIPPLE BUMPER SHIELD
E. S. HERTEL (Sandia National Labs., Albuquerque, NM.), L. C. CHHABILDAS (Sandia National Labs., Albuquerque, NM.), L. YARRINGTON (Sandia National Labs., Albuquerque, NM.), and S. A. HILL 1991 10 p Presented at the Workshop on Hypervelocity Impacts in Space, Canterbury, England, 1-5 Jul. 1991
(Contract DE-AC04-76DP-00789)
(NASA-TM-105455; NAS 1.15:105455; DE92-000951; SAND-91-0876C; CONF-9107182-2) Avail: CASI HC A02/MF A01

A series of numerical simulations has been performed using the multi-dimensional hydrodynamics code CTH to computationally determine a ballistic limit for a Whipple bumper shield. The ballistic limit is generally characterized as a critical diameter such that particle diameters greater than the ballistic limit will generate debris clouds that will penetrate the rear wall and particle diameters less than the ballistic limit will not. The particular shield design used for these analyses is defined as a 1.27 mm bumper, a 102 mm void space, and a 3.18 mm rear wall. Since debris shape is expected to be a contributing factor in the impact phenomena, two different shapes are considered for the numerical simulations. The particle shapes considered were flat plates of constant 1 mm thickness and varying diameters and spheres of varying diameters. The critical diameter (ballistic limit) was determined over the velocity range 4 km/s to 15 km/s for both geometries. DOE

N92-14105*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
EXPERIMENTAL AND NUMERICAL SIMULATIONS OF ORBITAL DEBRIS IMPACT ON A SIMPLE WHIPPLE BUMPER SHIELD

L. C. CHHABILDAS (Sandia National Labs., Albuquerque, NM.), E. S. HERTEL (Sandia National Labs., Albuquerque, NM.), and S. A. HILL 1991 5 p Presented at the Workshop on Hypervelocity Impacts in Space, Canterbury, England, 1-5 Jul. 1991
(Contract DE-AC04-76DP-00789)
(NASA-TM-105456; NAS 1.15:105456; DE92-000988; SAND-91-0889C; CONF-9107182-1) Avail: CASI HC A01/MF A01

A series of experiments has been performed on the Sandia HyperVelocity Launcher (HVL) to evaluate the effectiveness of thin Whipple bumper shield at impact velocities up to 10.4 km/s by orbital space debris. Upon impact by a 0.67 gm (0.87 mm thick) flier plate, the thin aluminum bumper shield completely disintegrates into a debris cloud. The debris cloud front propagates axially at velocities of approx. 14 km/s and expands radially at a velocity of approx. 7 km/s. Subsequent loading on a 3.2 mm thick aluminum substructure by the debris penetrates the substructure completely. Numerical simulations performed using the multi-dimensional hydrodynamics code CTH also predict complete penetration of the substructure by the subsequent debris cloud. DOE

N92-14790*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE PROPAGATION CHARACTERISTICS OF THE PLATE MODES OF ACOUSTIC EMISSION WAVES IN THIN ALUMINUM PLATES AND THIN GRAPHITE/EPOXY COMPOSITE PLATES AND TUBES Ph.D. Thesis - Johns Hopkins Univ., 1991
WILLIAM H. PROSSER Nov. 1991 178 p
(Contract RTOP 323-51-66-01)
(NASA-TM-104187; NAS 1.15:104187) Avail: CASI HC A09/MF A02

Acoustic emission was interpreted as modes of vibration in plates. Classical plate theory was used to predict dispersion curves for the two fundamental modes and to calculate the shapes of flexural waveforms produced by vertical step function loading. There was good agreement between theoretical and experimental results for aluminum. Composite materials required the use of a higher order plate theory (Reissner-Mindlin) to get good agreement with the measured velocities. Four composite plates with different laminate stacking sequences were studied. The dispersion curves were determined from phase spectra of the time dependent waveforms. Plate modes were shown to be useful for determining the direction of source motion. Aluminum plates were loaded by breaking a pencil lead against their surface. By machining slots at angles to the plane of a plate, the direction in which the force acted was varied. Changing the source motion direction produced regular variations in the waveforms. To demonstrate applicability beyond simple plates, waveforms produced by lead breaks on a thin walled composite tube were also shown to be interpretable as plate modes. The tube design was based on the type of struts proposed for Space Station Freedom's trussed structures.
Author

N92-15114* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
HYPERVELOCITY IMPACT SHIELD Patent
BURTON G. COUR-PALAIS, inventor (to NASA) and JEANNE LEE CREWS, inventor (to NASA) 26 Nov. 1991 12 p Filed 30 Apr. 1990 Supersedes N90-26858 (28 - 21, p 2966)
(NASA-CASE-MSC-21420-1; US-PATENT-5,067,388; US-PATENT-APPL-SN-516573; US-PATENT-CLASS-89-36.02; US-PATENT-CLASS-89-36.11; US-PATENT-CLASS-244-158R; INT-PATENT-CLASS-F41H-5/04) Avail: US Patent and Trademark Office

A hypervelocity impact shield and method for protecting a wall structure, such as a spacecraft wall, from impact with particles of debris having densities of about 2.7 g/cu cm and impact velocities up to 16 km/s are disclosed. The shield comprises a stack of ultra thin sheets of impactor disrupting material supported and arranged by support means in spaced relationship to one another and mounted to cover the wall in a position for intercepting the particles. The sheets are of a number and spacing such that the impacting particle and the resulting particulates of the impacting particle and sheet material are successively impact-shocked to a thermal state of total melt and/or vaporization to a degree as precludes perforation of the wall. The ratio of individual sheet thickness to the theoretical diameter of particles of debris which may be of spherical form is in the range of 0.03 to 0.05. The spacing between adjacent sheets is such that the debris cloud plume of liquid and vapor resulting from an impacting particle penetrating a sheet does not puncture the next adjacent sheet prior to the arrival thereat of fragment particulates of sheet material and the debris particle produced by a previous impact.
Official Gazette of the U.S. Patent and Trademark Office

N92-15257# Dornier System G.m.b.H., Friedrichshafen (Germany).
DEPLOYABLE 20/30 GHZ REFLECTOR FOR FUTURE COMMUNICATIONS SATELLITES
DIETMAR SCHEULEN *In* ESA, Second European Conference on Satellite Communications (ECSC-2) p 315-319 Oct. 1991
(Contract BMFT-01-YH-85070; BMFT-01-YH-85082; BMFT-01-YH-90015)
 Avail: CASI HC A01/MF A04; ESA, EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

In order to provide the technology required for future communications satellites, a new antenna system was developed. The antenna requirements and system design are considered. The deployment system and structural design of the 4.7 m deployable reflector are discussed. The panel manufacturing assembly as well as the adjustment of the reflector are dealt with. Electrical tests of the antenna system and mechanical tests of the reflector are discussed. A functional model in original size and technology was built and tested successfully. ESA

N92-15258# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany). Space Communications and Propulsion Systems.
ANTENNA SYSTEMS FOR FUTURE EUROPEAN BROADCASTING SATELLITES
M. LIEKE, N. SCHROEDER, and CH. HUNSCHER *In* ESA, Second European Conference on Satellite Communications (ECSC-2) p 321-325 Oct. 1991
 Avail: CASI HC A01/MF A04; ESA, EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

Future European broadcasting satellite systems call for higher system capacities and lower costs per channel than today's operating direct broadcasting satellites. Highly efficient illumination of the service areas has to be performed by well contoured antenna beams in order to use the spacecraft power resources economically. Several antenna systems for these purposes are presented. For elliptical beams the elliptically contoured reflector fed by an elliptical corrugated horn is the preferred single reflector solution. Special surface shaping of main and subreflector is an attractive alternative for an elliptical beam, if a dual reflector antenna can be accommodated on the spacecraft. Multifeed antennas with single or dual mode beam forming networks have to be employed for high gain illumination of contoured, overlapping multibeam coverages. ESA

N92-15470*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HOOP COLUMN SOIL MOISTURE SPACECRAFT IN LOW EARTH ORBIT FOR GLOBAL CHANGE MONITORING
MELVIN J. FEREBEE, JR. *In its* Global Change Technology Architecture Trade Study p 271-280 Sep. 1991
Avail: CASI HC A02/MF A04

A subset of the total Global Change Technology Initiative instruments are required to be in low Earth, sunsynchronous orbits. There is one instrument, however, that requires its own specialized spacecraft; the Soil Moisture Microwave Radiometer (SMMR). The characteristic structure of the instrument is the 118 m hoop column support structure. The hoop is supported by an axially placed column. Tension cables support and shape an electromagnetically reflective mesh surface. The instrument is capable of detecting

frequencies in the 1.4 GHz range (Soil Moisture and Sea Salinity). Three apertures are used to reduce the degree of paraboloid offset and improve the beam quality. The spacecraft configuration is determined by the instrument support requirements and the requirement that it can fit into the Titan IV cargo bay. The configuration is derived by cross referencing the instrument performance requirements with the performance of the spacecraft. The spacecraft design is similar with the Multi-mission Modular Spacecraft in terms of size and packaging. A description of the spacecraft's features will yield a summary of the technologies needed for the SMMR spacecraft. Author

N92-16007* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
LOAD LIMITING ENERGY ABSORBING LIGHTWEIGHT DEBRIS CATCHER Patent
JON B. KAHN, inventor (to NASA) and WILLIAM C. SCHNEIDER, inventor (to NASA) 10 Dec. 1991 11 p Filed 22 Feb. 1991 Supersedes N91-24216 (29 - 16, p 2564)
(NASA-CASE-MSC-21562-1; US-PATENT-5,071,091; US-PATENT-APPL-SN-658911; US-PATENT-CLASS-244-121; US-PATENT-CLASS-244-129.4; US-PATENT-CLASS-244-158R; INT-PATENT-CLASS-B64G-1/14) Avail: US Patent and Trademark Office

In the representative embodiment of the invention disclosed, a load limiting, energy absorbing net is arranged to overlay a normally-covered vent opening in the rear bulkhead of the space orbiter vehicle. Spatially-disposed flexible retainer straps are extended from the net and respectively secured to bulkhead brackets spaced around the vent opening. The intermediate portions of the straps are doubled over and stitched together in a pattern enabling the doubled-over portions to progressively separate at a predicable load designed to be well below the tensile capability of the straps as the stitches are successively torn apart by the forces imposed on the retainer members whenever the cover plate is explosively separated from the bulkhead and propelled into the net. By arranging these stitches to be successively torn away at a load below the strap strength in response to forces acting on the retainers that are less than the combined strength of the retainers, this tearing action serves as a predictable compact energy absorber for safely halting the cover plate as the retainers are extended as the net is deployed. The invention further includes a block of an energy-absorbing material positioned in the net for receiving loose debris produced by the explosive release of the cover plate.
Official Gazette of the U.S. Patent and Trademark Office

N92-16011# Pacific Northwest Lab., Richland, WA.
ACOUSTIC EMISSIONS APPLICATIONS ON THE NASA SPACE STATION
M. A. FRIESEL, J. F. DAWSON, R. J. KURTZ, R. S. BARGA, P. H. HUTTON, and D. K. LEMON Aug. 1991 9 p Presented at the Review of Progress in Quantitative Nondestructive Evaluation (NDE), Brunswick, ME, 28 Jul. - 2 Aug. 1991
(Contract DE-AC06-76RL-01830)
(DE92-000137; PNL-SA-19449; CONF-9107112-1) Avail: CASI HC A02/MF A01

Acoustic emission is being investigated as a way to continuously monitor the space station Freedom for damage caused by space debris impact and seal failure. Experiments run to date focused on detecting and locating simulated and real impacts and leakage. These were performed both in the laboratory on a section of material similar to a space station shell panel and also on the full scale common module prototype at Boeing's Huntsville facility. A neural network approach supplemented standard acoustic emission detection and analysis techniques. DOE

N92-16480*# Acurex Corp., Mountain View, CA.
CONCEPTUAL DESIGN OF A SELF-DEPLOYABLE, HIGH PERFORMANCE PARABOLIC CONCENTRATOR FOR ADVANCED SOLAR-DYNAMIC POWER SYSTEMS Final Technical Report
HANS J. DEHNE May 1991 76 p
(Contract NAS3-25341)
(NASA-CR-187061; NAS 1.26:187061) Avail: CASI HC A05/MF A01

NASA has initiated technology development programs to develop advanced solar dynamic power systems and components for space applications beyond 2000. Conceptual design work that was performed is described. The main efforts were the: (1) conceptual design of self-deploying, high-performance parabolic concentrator; and (2) materials selection for a lightweight, shape-stable concentrator. The deployment concept utilizes rigid gore-shaped reflective panels. The assembled concentrator takes an annular shape with a void in the center. This deployable concentrator concept is applicable to a range of solar dynamic power systems of 25 kW sub e to in excess of 75 kW sub e. The concept allows for a family of power system sizes all using the same packaging and deployment technique. The primary structural material selected for the concentrator is a polyethyl ethylketone/carbon fiber composite also referred to as APC-2 or Vitrex. This composite has a nearly neutral coefficient of thermal expansion which leads to shape stable characteristics under thermal gradient conditions. Substantial efforts were undertaken to produce a highly specular surface on the composite. The overall coefficient of thermal expansion of the composite laminate is near zero, but thermally induced stresses due to micro-movement of the fibers and matrix in relation to each other cause the surface to become nonspecular. Author

N92-16682*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
SINGLE WALL PENETRATION EQUATIONS
K. B. HAYASHIDA and J. H. ROBINSON Dec. 1991 28 p
(NASA-TM-103565; NAS 1.15:103565) Avail: CASI HC A03/MF A01

Five single plate penetration equations are compared for accuracy and effectiveness. These five equations are two well-known equations (Fish-Summers and Schmidt-Holsapple), two equations developed by the Apollo project (Rockwell and Johnson Space Center (JSC), and one recently revised from JSC (Cour-Palais). They were derived from test results, with velocities ranging up to 8 km/s. Microsoft Excel software was used to construct a spreadsheet to calculate the diameters and masses of projectiles for various velocities, varying the material properties of both projectile and target for the five single plate penetration equations. The results were plotted on diameter versus velocity graphs for ballistic and spallation limits using Cricket Graph software, for velocities ranging from 2 to 15 km/s defined for the orbital debris. First, these equations were compared to each other, then each equation was compared with various aluminum projectile densities. Finally, these equations were compared with test results performed at JSC for the Marshall Space Flight Center. These equations predict a wide variety of projectile diameters at a given velocity. Thus, it is very difficult to choose the 'right' prediction equation. The thickness of a single plate could have a large variation by choosing a different penetration equation. Even though all five equations are empirically developed with various materials, especially for aluminum alloys, one cannot be confident in the shield design with the predictions obtained by the penetration equations without verifying by tests. Author

N92-16693# Los Alamos National Lab., NM.
SURVIVABILITY OF LARGE DIRECTED-ENERGY PLATFORMS
G. H. CANAVAN Oct. 1991 10 p
(Contract W-7405-ENG-36)
(DE92-002603; LA-12078-MS) Avail: CASI HC A02/MF A01

There are adequate discussions in the literature of the survivability of space platforms that are small. Discussions of the survivability of large space platforms are less developed. In part that is because the large directed-energy platforms are thought to be useful in the long term; in part it is because of a rough concept that they are vulnerable simply because they are large. Size does matter for passive survivability techniques such as hardening, maneuver, and decoys. Both initial- and life-cycle mass and cost trades strongly favor lasers that are attacked. Their advantage is

shielding, which is independent of platform size. The analysis of NPBs is more complex, but again reduces to the greater ease of shielding. Thus, in the most stressing attacks size plays no role. These results are generic. They show the advantage of shielding for any attacked platform. DOE

N92-17200*# Texas Univ., Austin. Dept. of Mechanical Engineering.
HYPERVELOCITY IMPACT SIMULATION FOR MICROMETEORITE AND DEBRIS SHIELD DESIGN Final Report
ERIC P. FAHRENTHOLD 27 Jan. 1992 81 p
(Contract NAG9-444)
(NASA-CR-189807; NAS 1.26:189807) Avail: CASI HC A05/MF A01

A new capability has been developed for direct computer simulation of hypervelocity impacts on multi-plate orbital debris shields, for combinations of low shield thickness and wide shield spacing which place extreme demands on conventional Eulerian analysis techniques. The modeling methodology represents a novel approach to debris cloud dynamics simulation, a problem of long term interest in the design of space structures. Software implementation of the modeling methodology provides a new design tool for engineering analysis of proposed orbital debris protection systems. Author

N92-17772*# Lockheed Missiles and Space Co., Huntsville, AL.
SPACE STATION FREEDOM SOLAR ALPHA JOINT GROWTH CAPABILITY
DAVID SNYDER *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 2: Space Station Freedom, Part 1 p 835-852 Sep. 1991 Avail: CASI HC A03/MF A03

The Solar Alpha Rotary Joint (SARJ) helps to align the power generation system, onboard the Space Station Freedom, with the sun. The SARJ is responsible for providing structural continuity and controlled rotation to the outboard transverse booms. The SARJ also provides continuous power, data, and video transfer across the joint. D.R.D.

N92-18383*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
SUNSPOT: A PROGRAM TO MODEL THE BEHAVIOR OF HYPERVELOCITY IMPACT DAMAGED MULTILAYER INSULATION IN THE SUNSPOT THERMAL VACUUM CHAMBER OF MARSHALL SPACE FLIGHT CENTER
W. K. RULE (Alabama Univ., Tuscaloosa.) and K. B. HAYASHIDA Jan. 1992 50 p
(NASA-TM-103570; NAS 1.15:103570) Avail: CASI HC A03/MF A01

The development of a computer program to predict the degradation of the insulating capabilities of the multilayer insulation (MLI) blanket of Space Station Freedom due to a hypervelocity impact with a space debris particle is described. A finite difference scheme is used for the calculations. The computer program was written in Microsoft BASIC. Also described is a test program that was undertaken to validate the numerical model. Twelve MLI specimens were impacted at hypervelocities with simulated debris particles using a light gas gun at Marshall Space Flight Center. The impact-damaged MLI specimens were then tested for insulating capability in the space environment of the Sunspot thermal vacuum chamber at MSFC. Two undamaged MLI specimens were also tested for comparison with the test results of the damaged specimens. The numerical model was found to adequately predict behavior of the MLI specimens in the Sunspot chamber. A parameter, called diameter ratio, was developed to relate the nominal MLI impact damage to the apparent (for thermal analysis purposes) impact damage based on the hypervelocity impact conditions of a specimen. Author

N92-18844*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
A COMPARISON OF WHIPPLE SHIELD HYPERVELOCITY IMPACT TESTS TO PENETRATION PREDICTORS
S. A. HILL (Snelgrove (C. R.) Co. Ltd., Don Mills (Ontario).), L. C. CHHABILDAS (Snelgrove (C. R.) Co. Ltd., Don Mills (Ontario).), and E. S. HERTEL (Sandia National Labs., Albuquerque, NM.) 1991 4 p Presented at the 42nd International Aeronautical Federation Congress (IAEFC), Montreal, Quebec, 7-11 Oct. 1991
(Contract NASA ORDER H-99071-B; DE-AC04-76DP-00789)
(NASA-TM-105107; NAS 1.15:105107; DE92-004740; SAND-91-2399C; CONF-9110217-6) Avail: CASI HC A01/MF A01

The purpose of this paper is to develop an analytical model to convert ballistic limit curves obtained from flat projectile experiments to ballistic limit curves based on equivalent diameter spheres. Results from a test program involving flat plate projectiles conducted at Sandia National Laboratories are compared against the predicted performance of equivalent spherical projectiles as determined from the Wilkinson and Cour-Palais penetration equations. The developed method demonstrates good correlation of the ballistic limit of the shield concept for the flat plate projectiles to the theoretical ballistic limit for equivalent spheres as predicted by the penetration equations. DOE

N92-19071# L'Garde, Inc., Tustin, CA.
INFLATABLE TORUS SOLAR ARRAY TECHNOLOGY PROGRAM, PHASE 1 Final Report, Mar. 1990 - Oct. 1991
BILLY DERBIS, KOOROSH GUIDANEAN, PAT MALONE, ART PALISOC, and GORDON VEAL 15 Oct. 1991 208 p
(Contract F29601-90-C-0006)
(AD-A243996; LTR-91-V-022-PHASE-1) Avail: CASI HC A10/MF A03

This Phase 1 of the Inflatable Torus Solar Array Technology (ITSAT) Program demonstrated the feasibility of an inflatably deployed solar array. During the program, several array conceptual designs for various orbits and power levels were prepared. A flexible amorphous silicon solar array was fabricated and mounted in a lightweight inflatably deployed rigidizable structure. This prototype unit was successfully packaged and deployed. Author (GRA)

N92-20027*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
SHIELD SIZING AND RESPONSE EQUATIONS
ERIC L. CHRISTIANSEN 15 Feb. 1991 15 p
(NASA-TM-105527; NAS 1.15:105527) Avail: CASI HC A03/MF A01

A consolidated list is presented of meteoroid debris shield equations which have been given in the referenced memorandums. In some cases, equations have been updated; thus, this memorandum supersedes reference 1. The equations are presented in two parts: (1) shield sizing equations which are used to produce preliminary estimates of shielding weights; and (2) response equations to describe the impact conditions (projectile size as a function of velocity, density, and impact angle) causing failure of a given shield that are to be used for probability analyses (such as in the modified BUMPER program). Specific equations are given that are applicable for the following types of shields: aluminum Whipple shields; Nextel multishock (MS) shields; and mesh double bumper (MDB) shields. These equations will be updated in the future as warranted by the results of additional HVI tests, analyses, and shield modeling. Author

N92-20045*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
COLLAPSE ANALYSIS OF A WAFFLE PLATE STRONGBACK FOR SPACE STATION FREEDOM
FRANK F. MONASA (Michigan Technological Univ., Houghton.) and JOSEPH M. ROCHE Mar. 1992 36 p
(Contract RTOP 474-46-10)
(NASA-TM-105412; E-6817; NAS 1.15:105412) Avail: CASI HC A03/MF A01

The structural integrity was studied of the Integrated Equipment

Assembly (IEA) Strongback of the SSF for the launch environment. The strongback structure supports the electrical power system for SSF. To achieve minimum launch mass, it is essential that flight structures are designed as light as possible. A nonlinear structural analysis was conducted to determine the collapse load of the structure and the associated factor of safety against the service loads. A modeling technique is provided for simulating the load conditions and the buckling and post buckling (collapse) load is evaluated of the IEA Strongback structure, using the finite element computer code MARC. Two of four strongback panels were modeled and analyzed. The effects were examined of the following factors on the global behavior of the strongback panels: (1) load simplification and simulation; (2) type of support boundary conditions; and (3) the possibility of weight reduction of the original structure. For this purpose, several models of the two panels of the strongback were considered. The stress level and distribution in the panels for launch condition, the Eigenvalue critical buckling load and/or the collapse load were determined. Author

N92-20068*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
WHIPPLE SHIELD SIZING EQUATIONS
ERIC L. CHRISTIANSEN 1 Mar. 1991 23 p
(NASA-TM-105539; NAS 1.15:105539) Avail: CASI HC A03/MF A01

Wipple shield sizing equations are given for use in current Space Station Freedom (SSF) Work Package 2 (WP-2) trade study activities. These equations are modifications of the 1969 Cour-Palais predictor equations which were used by McDonnell Douglas to size WP-2 meteoroid and debris shielding for the SSF preliminary design review. Recent hypervelocity impact (HVI) test results have shown that the original 1969 Cour-Palais predictor improperly scales to the particle sizes that the WP-2 shields must be designed to protect against. The original equations have been redesigned to correct this scaling deficiency. Substantial increases to WP-2 shielding weight estimates are indicated by the modified equations. Several possibilities exist, however, to reduce the weight of WP-2 shielding. These equations will be updated in the future as warranted by the results of ultra-high speed (greater than 19 km/sec) HVI tests and further analysis. Author

N92-20671*# Sverdrup Technology, Inc., Brook Park, OH.
DESIGN AND OPTIMIZATION OF A SELF-DEPLOYING SINGLE AXIS TRACKING PV ARRAY Final Report
ANTHONY J. COLOZZA Mar. 1992 25 p
(Contract NAS3-25266; RTOP 591-14-11)
(NASA-CR-189132; E-6911; NAS 1.26:189132) Avail: CASI HC A03/MF A01

This study was performed in order to design a tracking photovoltaic (PV) array and optimize the design for maximum specific power. The design considerations were minimal deployment time, high reliability, and small stowage volume. The array design was self-deployable, from a compact stowage configuration, using a passive pressurized gas deployment mechanism. The array structural components consist of a combination of beams, columns, and cables used to deploy and orient a flexible PV blanket. Each structural component of the design was analyzed to determine the size necessary to withstand the various forces to which it would be subjected. An optimization was performed to determine the array dimensions and blanket geometry which produce the maximum specific power. The optimization was performed for both lunar and Martian environments with 4 types of PV blankets (silicon, GaAs/Ge, GaAs CLEFT, and amorphous silicon). For the lunar environment, the amorphous silicon array produced the highest specific power, whereas, for Mars the GaAs CLEFT array produced the highest specific power. A comparison was made to a fixed PV tent array of similar design. The tracking array produced a higher specific power with all types of the PV blankets examined except amorphous silicon at both locations. Author

N92-21306*# California Univ., San Diego, La Jolla. Dept. of AMES.
NONDESTRUCTIVE STRUCTURAL DAMAGE DETECTION IN FLEXIBLE SPACE STRUCTURES USING VIBRATION CHARACTERIZATION Final Report
JAMES M. RICLES *In* Texas A and M Univ., NASA/ASEE Summer Faculty Fellowship Program, 1991, Volume 2 17 p Dec. 1991
Avail: CASI HC A03/MF A02

Spacecraft are susceptible to structural damage over their operating life from impact, environmental loads, and fatigue. Structural damage that is not detected and not corrected may potentially cause more damage and eventually catastrophic structural failure. NASA's current fleet of reusable spacecraft, namely the Space Shuttle, has been flown on several missions. In addition, configurations of future NASA space structures, e.g. Space Station Freedom, are larger and more complex than current structures, making them more susceptible to damage as well as being more difficult to inspect. Consequently, a reliable structural damage detection capability is essential to maintain the flight safety of these structures. Visual inspections alone can not locate impending material failure (fatigue cracks, yielding); it can only observe post-failure situations. An alternative approach is to develop an inspection and monitoring system based on vibration characterization that assesses the integrity of structural and mechanical components. A methodology for detecting structural damage is presented. This methodology is based on utilizing modal test data in conjunction with a correlated analytical model of the structure to: (1) identify the structural dynamic characteristics (resonant frequencies and mode shapes) from measurements of ambient motions and/or force excitation; (2) calculate modal residual force vectors to identify the location of structural damage; and (3) conduct a weighted sensitivity analysis in order to assess the extent of mass and stiffness variations, where structural damage is characterized by stiffness reductions. The approach is unique from other existing approaches in that varying system mass and stiffness, mass center locations, the perturbation of both the natural frequencies and mode shapes, and statistical confidence factors for structural parameters and experimental instrumentation are all accounted for directly. Author

N92-21727* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
PRESSURE VESSEL FLEX JOINT Patent
JON B. KAHN, inventor (to NASA) 7 Apr. 1992 13 p Filed 19 Feb. 1991 Supersedes N91-25415 (29 - 17, p 2785)
(NASA-CASE-MSC-21748-1; US-PATENT-5,102,150; US-PATENT-APPL-SN-657598; US-PATENT-CLASS-277-3; US-PATENT-CLASS-277-34; US-PATENT-CLASS-277-34.3; US-PATENT-CLASS-285-97; US-PATENT-CLASS-285-223; US-PATENT-CLASS-285-346; US-PATENT-CLASS-285-910)
Avail: US Patent and Trademark Office

An airtight, flexible joint is disclosed for the interfacing of two pressure vessels such as between the Space Station docking tunnel and the Space Shuttle Orbiter bulkhead adapter. The joint provides for flexibility while still retaining a structural link between the two vessels required due to the loading created by the internal/external pressure differential. The joint design provides for limiting the axial load carried across the joint to a specific value, a function returned in the Orbiter/Station tunnel interface. The flex joint comprises a floating structural segment which is permanently attached to one of the pressure vessels through the use of an inflatable seal. The geometric configuration of the joint causes the tension between the vessels created by the internal gas pressure to compress the inflatable seal. The inflation pressure of the seal is kept at a value above the internal/external pressure differential of the vessels in order to maintain a controlled distance between the floating segment and pressure vessel. The inflatable seal consists of either a hollow torus-shaped flexible bladder or two rolling convoluted diaphragm seals which may be reinforced by a system of straps or fabric anchored to the hard structures. The joint acts as a flexible link to allow both angular motion and lateral displacement while it still contains the internal pressure and holds the axial

tension between the vessels.
Official Gazette of the U.S. Patent and Trademark Office

N92-22093# National Space Development Agency, Tokyo (Japan). Engineering Test Satellite Group.
DEVELOPMENT TEST RESULTS OF ETS-6 STRUCTURAL DEVELOPMENT MODEL
AKIO TSUJIHATA *In its* Preprints of NASDA's 5th Technical Symposium p 91-122 1 Jun. 1990 In JAPANESE; ENGLISH summary
Avail: CASI HC A03/MF A03
The Engineering Test Satellite-6 (ETS-6) is a two-ton-class three-axis-stabilized geostationary spacecraft and was developed to be launched in Summer 1993 by the H-2 Launch Vehicle. For the ETS-6 structural development, full-scale structural development models were fabricated in accordance with the basic design results and tests were performed. Those are Structural Development Model-Static (SDM-S) and Structural Development Model-Dynamic (SDM-D). The objective of the SDM-S is to verify the strength of structure and the SDM-D is to verify the evaluation of mechanical environments. This paper presents a summary of the ETS-6 SDM and the results of the development test. The results of the development test provided useful test data to evaluate the design, the manufacture, and the test procedure for the protoflight model.
Author (NASDA)

N92-22094# National Space Development Agency, Tokyo (Japan). Tsukuba Space Center.
RESEARCH AND DEVELOPMENT ON LARGE DEPLOYABLE ANTENNA
YASUMASA HISADA *In its* Preprints of NASDA's 5th Technical Symposium p 123-157 1 Jun. 1990 In JAPANESE; ENGLISH summary
Avail: CASI HC A03/MF A03
This paper describes the ground deployment test of a synthetic aperture radar (SAR) antenna and a five meter diameter petal deployable antenna under research and development by the National Space Development Agency of Japan (NASDA). The SAR antenna will be mounted on Earth Resources Satellite-1 (ERS-1) and the five meter diameter petal deployment antenna will be mounted on a Tracking and Data Relay (TDRS) Satellite. This paper especially describes the policy on research and development of a large deployable antenna in NASDA, and the ground deployment test results of these two antennas are also introduced.
Author (NASDA)

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.

A92-10127
DESIGN AND DEVELOPMENT OF PASSIVE DAMPING CONCEPTS IN ADVANCED COMPOSITE LARGE SPACE STRUCTURES
DONALD L. EDBERG and ANDREW S. BICOS (McDonnell Douglas Space Systems Co., Huntington Beach, CA) IN: International SAMPE Symposium and Exhibition, 36th, San Diego, CA, Apr. 15-18, 1991, Proceedings. Book 1 1991 12 p refs
Copyright
Two different concepts, one totally passive and the other using its own strain to enhance damping, are intended to improve the available damping created by structural members. For the passive damper, the tailoring of composite properties leads to a design where 45 deg lamination angles are utilized to magnify the Poisson contraction to its maximum level. The increased deformation created by this contraction may be used, with a viscoelastic material placed in parallel with the load path, to improve the damping over that available from a conventional structural member. R.E.P.

A92-10128
AN OPTIMUM METHOD FOR VIBRATION CONTROL WITH PASSIVE DAMPING
FRED AUSTIN and GARETH KNOWLES (Grumman Corporate Research Center, Bethpage, NY) IN: International SAMPE Symposium and Exhibition, 36th, San Diego, CA, Apr. 15-18, 1991, Proceedings. Book 1 1991 11 p refs
Copyright
To improve the accuracy of damping predictions for passively damped structures, a method is presented for incorporating damping models into the COMAP ASTRAL finite-element program. In addition, an optimality based method is developed to implement the desired damping by adding the minimum weight of damping material. The method provides the most effective location on the structure to apply the passive-damping treatment. The optimization procedure is demonstrated on a truss structure subject to multiple vibration frequency constraints.
Author

A92-11120
MODERN ADAPTIVE REAL-TIME CONTROLLERS FOR ACTIVELY REACTING FLEXIBLE STRUCTURES
J. MELCHER and R. WIMMEL (DLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) (Joint U.S./Japan Conference on Adaptive Structures, 1st, Maui, HI, Nov. 13-15, 1990) Journal of Intelligent Material Systems and Structures (ISSN 1045-389X), vol. 2, July 1991, p. 328-346. Jul. 1991 19 p refs
Copyright
This paper describes modern controllers, which are based on digital real-time filters, powerful adaptation algorithms and high speed signal processor systems. Such controllers are required for active shape and vibration control on large flexible space structures. Within the frameworks of the DLR program ARES (Actively Reacting Flexible Structures)-which is an attempt to develop systems capable of changing their characteristics in orbit in order to fulfill essential operational requirements, efforts are specially focused on adaptive signal processing. The hitherto achieved results are presented. The philosophy and capabilities of such controllers are demonstrated, referring to the process of adaptive system identification and inverse modeling. In addition, different types of filtering techniques and adaptation algorithms are theoretically and experimentally discussed concerning structural dynamic requirements.
Author

A92-11121
IDENTIFICATION AND ADAPTIVE CONTROL OF FLEXIBLE TRUSS STRUCTURES
KOJI SEKINE, YUZO SHIBAYAMA, NAOTOSHI IWASAWA, NORIO TAGAWA (NEC Corp., Space Development Div., Yokohama, Japan), SEI-ICHI SUNAHARA, SHIRO YOSHIDA, and TAKEO ARIKABE (Sumitomo Heavy Industries, Ltd., Aerospace Engineering Dept., Yokosuka, Japan) (Joint U.S./Japan Conference on Adaptive Structures, 1st, Maui, HI, Nov. 13-15, 1990) Journal of Intelligent Material Systems and Structures (ISSN 1045-389X), vol. 2, July 1991, p. 347-385. Jul. 1991 39 p refs
Copyright
This paper describes investigations on adaptive vibration control and shape adjustment of truss structures making use of the active member actuator. The actuator was manufactured in an attempt to achieve these functions by linear actuating. Fundamental characteristics were examined statically and dynamically. Numerical simulations of planar truss model with the configuration of one pair of collocated actuator and sensor shows that a state observer can estimate truncated modes well and the excited vibration can be controlled rapidly.
Author

A92-11125
ROBUST FAILURE DETECTION FOR LINEAR DISTRIBUTED PARAMETER SYSTEMS

SHELDON X. C. LOU and JIONG JIANG (Toronto, University, Canada) International Journal of Adaptive Control and Signal Processing (ISSN 0890-6327), vol. 5, Sept.-Oct. 1991, p. 293-311. Research supported by NSERC and URIF. Oct. 1991 19 p refs
Copyright

This paper discusses the robust failure detection methods in general separable Hilbert space using an operator approximation approach. It is simple and provides an intuitive geometric interpretation. The computational procedure required is the Schmit expansion of an operator. An example arising from the sensor failure detection design for space structures is given to illustrate the methodology suggested. Author

A92-11292
DUAL ACTIVE AND PASSIVE CONTROL OF LARGE FLEXIBLE STRUCTURES

T. S. PAN, S. S. RAO (Purdue University, West Lafayette, IN), and V. B. VENKAYYA (USAF, Wright-Patterson AFB, OH) ASME, Transactions, Journal of Vibration and Acoustics (ISSN 0739-3717), vol. 113, Oct. 1991, p. 469-475. Oct. 1991 7 p refs
(Contract F33615-87-C-3256)
Copyright

A unified passive damping design algorithm, using active control design techniques and least squares method, is developed to improve the stability and performance of closed-loop controlled structures. To achieve the stringent requirements of large flexible structures (LFS), dual active/passive control using interacting substructure decentralized control and unified passive damping design method is introduced. Physical coordinates are used in modeling: since no modal data is used, no modal errors are involved in the modeling process. Examples are presented to illustrate the design procedure and their effectiveness. Author

A92-11323
H(INFINITY)-OPTIMAL MIXED SENSITIVITY FOR GENERAL DISTRIBUTED PLANTS

DAVID S. FLAMM and HONG YANG (Princeton University, NJ) IN: IEEE Conference on Decision and Control, 29th, Honolulu, HI, Dec. 5-7, 1990, Proceedings. Vol. 1 1990 6 p refs
(Contract AF-AFOSR-89-0205)
Copyright

The authors show how the results and techniques presented by Zames and Mitter (1988) can be extended to a very general single-input/single-output (SISO) mixed sensitivity problem, in which the transfer function of the plant to be controlled has both irrational stable and irrational unstable parts. It is shown, as an extension of Fagnani (1987), how to transform the scalar mixed sensitivity problem into the 'standard form' which is the starting point from which Zames and Mitter computed the optimal norm of the mixed sensitivity. This transformation allows some new observations about this problem that have design significance. These developments are motivated by the computation of the infimal H(infinity)-norm of the mixed sensitivity for the irrational transfer function model developed by Flamm (1990). I.E.

A92-11334
NUMERICAL SOLUTION OF VERY LARGE, SPARSE LYAPUNOV EQUATIONS THROUGH APPROXIMATE POWER ITERATION

A. S. HODEL (Auburn University, AL) and KAMESHWAR POOLLA (Illinois, University, Urbana) IN: IEEE Conference on Decision and Control, 29th, Honolulu, HI, Dec. 5-7, 1990, Proceedings. Vol. 1 1990 6 p refs
(Contract NSF ECS-87-09265; N00014-84-C-0214)
Copyright

The authors present an algorithm for the solution of large order (1000 = n or less) Liapunov equations $AX + XA' + Q = 0$. The algorithm, approximate power iteration, attempts to compute directly an orthogonal basis of the dominant eigenspace of the solution X. It is shown that if the dominant eigenvalues lambda1 and lambda2 of X are sufficiently well separated (lambda1 much greater than lambda2), then a special case of the approximate power iteration algorithm has at least one fixed point v that is near to the dominant eigenvector mu1 of X, and that there is a small attractive region in IR super n containing both mu1 and v. I.E.

A92-11345
REAL PARAMETER UNCERTAINTY AND PHASE INFORMATION IN THE ROBUST CONTROL OF FLEXIBLE STRUCTURES

D. S. BERNSTEIN, E. G. COLLINS, JR., and D. C. HYLAND (Harris Corp., Melbourne, FL) IN: IEEE Conference on Decision and Control, 29th, Honolulu, HI, Dec. 5-7, 1990, Proceedings. Vol. 2 1990 2 p refs
(Contract F49620-89-C-0011; F49620-89-C-0029)
Copyright

Real parameter uncertainty and phase information play a key role in the analysis and synthesis of robust controllers for lightly damped flexible structures. The purpose of this study is to examine the impact of these issues on structural control, their interrelationship, and their manifestation within the analysis and synthesis of feedback systems. The discussion is illustrated by examining robust controllers designed for the ACES structure at Marshall Space Flight Center. These controllers were designed by means of the maximum entropy generalized LQG (linear quadratic Gaussian) methodology. I.E.

A92-11348
ORIENTATION AND CONTROL OF A FLEXIBLE SPACECRAFT - PLANAR MOTION

OMER MORGUL (Bilkent University, Ankara, Turkey) IN: IEEE Conference on Decision and Control, 29th, Honolulu, HI, Dec. 5-7, 1990, Proceedings. Vol. 2 1990 2 p refs
(Contract NSF ECS-85-00993)
Copyright

A flexible spacecraft modeled as a rigid body which rotates in an inertial frame is considered; a light flexible beam is clamped to the rigid body at one end and free at the other end. It is assumed that the flexible spacecraft performs only planar motions. Two control problems are posed, namely, the orientation and the stabilization of the system. It is shown that suitable boundary controls applied to the free end of the beam and suitable control torques applied to the rigid body solve the problems. I.E.

A92-11372
A METHOD FOR ROBUST IDENTIFICATION AND CONTROL OF A FLEXIBLE SPACE STRUCTURE

JAMES V. CARROLL (DOT, Transportation Systems Center, Cambridge, MA) IN: IEEE Conference on Decision and Control, 29th, Honolulu, HI, Dec. 5-7, 1990, Proceedings. Vol. 2 1990 6 p refs
(Contract F49620-87-C-0099)
Copyright

The author holds that the large space structure (LSS) control design problem, by its nature, has extra dimensions of interrelationship among the modeling, dynamics and control synthesis disciplines, in addition to those found in most other control design problems. The feasibility of applying robust identification and control techniques to the LSS control problem is explored. The identification module is a key control subsystem. The identification method applies a canonical variate analysis (CVA) technique to selected input and measurement signals of the process to be identified, and thereby extracts model parameters. Model order is statistically determined using built-in criteria. By using such computationally stable algorithms as singular value decomposition, CVA identification is well-suited to LSS applications. The results presented indicate clearly that CVA identification and model predictive control (MPC) are capable of providing robust control of flexible structures. This conclusion is the result of applying CVA and MPC to three flexible structure models: an 8th order disk-torsion bar system with one input and one output, collocated; a 12th order free-free beam with 2 inputs and 2 outputs; and a 24th order free-free beam with 4 inputs and 4 outputs. I.E.

A92-11438
DECENTRALIZED CONTROL EXPERIMENTS ON A TRUSS STRUCTURE
PETER DIX, UMIT OZGUNER (Ohio State University, Columbus), and ROBERT W. GORDON (USAF, Wright Research and Development Center, Wright-Patterson AFB, OH) IN: IEEE Conference on Decision and Control, 29th, Honolulu, HI, Dec. 5-7, 1990, Proceedings. Vol. 4 1990 6 p refs

The hardware, software, and control issues related to decentralized control experiments performed on a 12-m truss are described. The studies are related to modeling, model verification, and active vibration damping for laboratory-scale models of structures that are representative of future large, flexible space structures. I.E.

A92-11439
ADVENTURES OF THREE ANALYSTS IN THE WONDERFUL WORLD OF EXPERIMENTAL SPACECRAFT CONTROL
J. L. JUNKINS, Z. H. RAHMAN, and H. BANG (Texas A & M University, College Station) IN: IEEE Conference on Decision and Control, 29th, Honolulu, HI, Dec. 5-7, 1990, Proceedings. Vol. 4 1990 5 p refs

Analytical and experimental results are presented of a Liapunov approach to designing globally stabilizing controllers for large nonlinear motions of distributed parameter systems. The configuration studied is a nine-body, hub-appendage system consisting of five rigid bodies interconnected by four flexible beams. The control is designed such that a compromise is achieved between vibration suppression and maneuver time. The method allows the form of rigorously stabilizing control laws for a nonlinear distributed parameter system to be established before discretization and order-reduction approximations are introduced. I.E.

A92-11440* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PROGRESS ON CONTROL EXPERIMENTS OF FLEXIBLE STRUCTURES
JER-NAN JUANG (NASA, Langley Research Center, Hampton, VA) IN: IEEE Conference on Decision and Control, 29th, Honolulu, HI, Dec. 5-7, 1990, Proceedings. Vol. 4 1990 6 p refs

Progress at the NASA Langley Research Center in the area of control experiments for flexible structures is described. First the author presents the experimental results for a linear model which represents slewing maneuvers of a generic space station solar panel carried out to evaluate experimentally some control technologies. Then the status of the rotational/translational maneuvering experiment of a flexible steel panel carried by a translation cart is presented. Finally, experimental results of the NASA minimast testbed using velocity command stepper motors as reaction mass reactors are shown. All the test configurations are briefly described, including actuator and sensor, test setup, and test software. The status of some research activities oriented primarily to the experimental methods for control of flexible structures is presented. I.E.

A92-11441
ASTREX - A UNIQUE TEST BED FOR CSI RESEARCH
ALOK DAS, JOEL L. BERG, GREGORY A. NORRIS, DEREK F. COSSEY, TIM J. STRANGE, III, and WAID T. SCHLAEGEL (USAF, Astronautics Laboratory, Edwards AFB, CA) IN: IEEE Conference on Decision and Control, 29th, Honolulu, HI, Dec. 5-7, 1990, Proceedings. Vol. 4 1990 6 p refs

The Astronautics Laboratory, Air Force Systems Command, has developed the Advanced Space Structure Technology Research Experiments (ASTREX) facility as a test bed for validation and integration of emerging controls/structure interaction (CSI) technologies. This unique national test bed provides for large-angle slewing and vibration suppression of realistic spacecraft models. A detailed description of the ASTREX facility and its capabilities is given. Some of the on-going and planned technology validation experiments are discussed. I.E.

A92-11442* Harris Government Aerospace Systems Div., Melbourne, FL.
EXPERIMENTAL DEMONSTRATION OF ACTIVE VIBRATION CONTROL FOR FLEXIBLE STRUCTURES
DOUGLAS J. PHILLIPS, DAVID C. HYLAND, and EMMANUEL G. COLLINS, JR. (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: IEEE Conference on Decision and Control, 29th, Honolulu, HI, Dec. 5-7, 1990, Proceedings. Vol. 4 1990 6 p refs
(Contract F49620-87-C-0108; NAS1-18872)

Active vibration control of flexible structures for future space missions is addressed. Three experiments that successfully demonstrate control of flexible structures are described. The first is the pendulum experiment. The structure is a 5-m compound pendulum and was designed as an end-to-end test bed for a linear proof mass actuator and its supporting electronics. Experimental results are shown for a maximum-entropy/optimal-projection controller designed to achieve 5 percent damping in the first two pendulum modes. The second experiment was based upon the Harris Multi-Hex prototype experiment (MHPE) apparatus. This is a large optical reflector structure comprising a seven-panel array and supporting truss which typifies a number of generic characteristics of large space systems. The third experiment involved control design and implementation for the ACES structure at NASA Marshall Space Flight Center. The authors conclude with some remarks on the lessons learned from conducting these experiments. I.E.

A92-11443
CONTROLLER DESIGN FOR MSAT - A THIRD GENERATION SPACECRAFT
E. J. DAVISON (Toronto, University, Canada) IN: IEEE Conference on Decision and Control, 29th, Honolulu, HI, Dec. 5-7, 1990, Proceedings. Vol. 4 1990 7 p refs

The control of a large flexible space structure (LFSS) as modeled by the Msat (mobile communications satellite) configuration is considered. In this problem, the MSAT vehicle is highly unsymmetric and highly flexible, with noncollocated sensors/actuators. It is desired to find a controller, based on a design model of Msat, which, when applied to an unspecified evaluation model of Msat, solves the following problems: regulating the orientation of Msat (three outputs), regulating the horn/reflector relative position (six outputs) in the presence of unknown disturbances, stabilizing rigid body and elastic body modes of the system, and avoiding undesirable spillover effects caused by the controller (robustness). A summary of results obtained in designing a controller to solve the above problem, together with some representative output simulations, is given. I.E.

A92-11496
TIME-OPTIMAL CONTROL OF FLEXIBLE STRUCTURES
L. Y. PAO and G. F. FRANKLIN (Stanford University, CA) IN: IEEE Conference on Decision and Control, 29th, Honolulu, HI, Dec. 5-7, 1990, Proceedings. Vol. 5 1990 2 p refs

It is shown that the time-optimal control for rest-to-rest maneuvers of a one-bending-mode model of a flexible structure is bang-bang with at most three switches and is symmetric about the second switch. For the case with damping, optimal reversal and maneuver times are calculated for a normalized system for several damping ratios. Since these times can be scaled for frequency and control authority, these results can be used to interpolate for times of any damping ratio. The variation of the optimal slewing times with structural frequency and damping ratio is presented. I.E.

A92-11497
OPTIMAL TENDON PLACEMENT OF A TENDON CONTROL SYSTEM FOR LARGE FLEXIBLE STRUCTURES
JIN LU, JAMES S. THORP, BRIAN H. AUBERT, and LAURAN LARSON (Cornell University, Ithaca, NY) IN: IEEE Conference on Decision and Control, 29th, Honolulu, HI, Dec. 5-7, 1990, Proceedings. Vol. 5 1990 6 p refs
Copyright
The optimal tendon placement of a tendon control system for a 2-D N-bay truss is considered. With the criterion of optimality for optimal tendon placement being controllability and robustness of the tendon control system, the optimal tendon placement problem can be formulated as a constrained optimization problem which can be solved using dynamic programming; therefore, the globally optimal solution to the optimal tendon problem can be obtained efficiently. A tendon control system is designed for a 2-D 11-bay truss using this technique. I.E.

A92-11498 Virginia Polytechnic Inst. and State Univ., Blacksburg.
MEASUREMENT AND CONTROL OF FLEXIBLE STRUCTURES USING DISTRIBUTED SENSORS
DOUGLAS K. LINDNER, KARL M. REICHARD, WILLIAM T. BAUMANN (Virginia Polytechnic Institute and State University, Blacksburg), and MICHAEL F. BARSKY (Hughes Aircraft Co., Los Angeles, CA) IN: IEEE Conference on Decision and Control, 29th, Honolulu, HI, Dec. 5-7, 1990, Proceedings. Vol. 5 1990 5 p refs
(Contract NAG1-1006; NAG1-1043; NGT-5004; N00014-89-J-3123)
Copyright
The use of distributed filtering to realize arbitrary scalar system outputs from the output of a distributed sensor is described. The set of scalar position measurements realizable using traditional point sensors is a subset of the set of scalar outputs realizable using distributed sensing over point sensing. Several examples are provided to illustrate applications of distributed filtering. It is shown that distributed-effect sensors can be used to implement functional observers, providing a significant reduction in compensator order. I.E.

A92-11832
MECHANICAL IMPEDANCE OF A MULTIBODY SYSTEM - COMPOSITE IMPEDANCE MATRIX
A. CAMPBELL (Caen, Universite; Paris VI, Universite, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 3, 1991, p. 49-57. 1991 9 p refs
Copyright
Under the assumption of an undeformable interface, the composite impedance matrix is computed using the impedance matrix of the first and second elastic bodies of the structure (C1 and C2) and the matrices which depend only on C1. This result, obtained for 3D solids, can be generalized to other types of behavior. In particular, it can easily be verified in the case where C1 is a homogeneous beam for which an explicit expression of the impedance matrix is known and C2 is an arbitrary beam. C.D.

A92-12303
DIRECT POSITION PLUS VELOCITY FEEDBACK CONTROL OF LARGE FLEXIBLE SPACE STRUCTURES
IZHAK BAR-KANA, ROBERT FISCHL, and PAUL KALATA (Drexel University, Philadelphia, PA) IEEE Transactions on Automatic Control (ISSN 0018-9286), vol. 36, Oct. 1991, p. 1186-1188. Oct. 1991 3 p refs
Copyright
The authors demonstrate the feasibility of shape and position control of large flexible structures with collocated sensors and actuators using direct position-plus-velocity feedback. This result is important for large space structures where the number of modes is very large and eventually unknown. When the number of inputs equals the number of outputs, the stabilizing feedback gain stands for any positive definite matrix, including diagonal matrices. This result may explain the success of decentralized adaptive controllers when a reasonable number of sensors is used to satisfy the observability assumption. I.E.

A92-12361
BAND LANCZOS VIBRATION ANALYSIS OF AEROSPACE STRUCTURES
V. K. GUPTA, J. F. NEWELL (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA), and W. H. ROBERTS (FAA, Los Angeles Aircraft Certification Office, Long Beach, CA) (Parallel methods on large-scale structural analysis and physics applications; Symposium, Hampton, VA, Feb. 5, 6, 1991, Selected Papers. A92-12351 02-61) Computing Systems in Engineering (ISSN 0956-0521), vol. 2, no. 2-3, 1991, p. 231-241. 1991 11 p refs
Copyright
Band Lanczos dynamic reduction is employed to effectively solve the large-scale structural eigenproblem. Superelement (SE) formulation is adapted to exploit parallel computation for timely solution of real-time applications. The Band Lanczos algorithm coupled with SE modal synthesis permits rapid optimization for efficient use of processors in parallel and memory. Direct numerical time integration of the reduced equations of motion in both Lanczos and physical coordinates is employed based on the Lanczos-modified Craig-Bampton transform. Van de Vooren formulas are used to compute sensitivity derivatives of frequency, mode shape, and flutter speed for potential use in vibration-sensitive design optimization and flutter optimization of the hypersonic aerospace plane, MD90 Aircraft, Space Shuttle, and Space Station types of projects. Author

A92-12370* California Univ., Los Angeles.
STOCHASTIC REGULATOR THEORY FOR A CLASS OF ABSTRACT WAVE EQUATIONS
A. V. BALAKRISHNAN (California, University, Los Angeles) SIAM Journal on Control and Optimization (ISSN 0363-0129), vol. 29, Nov. 1991, p. 1288-1299. Nov. 1991 12 p refs
(Contract NAS1-18585)
Copyright
A class of steady-state stochastic regulator problems for abstract wave equations in a Hilbert space - of relevance to the problem of feedback control of large space structures using co-located controls/sensors - is studied. Both the control operator, as well as the observation operator, are finite-dimensional. As a result, the usual condition of exponential stabilizability invoked for existence of solutions to the steady-state Riccati equations is not valid. Fortunately, for the problems considered it turns out that strong stabilizability suffices. In particular, a closed form expression is obtained for the minimal (asymptotic) performance criterion as the control effort is allowed to grow without bound. Author

A92-12606
ACTIVE VIBRATION ISOLATION FOR SPACECRAFT
SIMON A. COLLINS and ANDREAS H. VON FLOTOW (MIT, Cambridge, MA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Research supported by California Institute of Technology. Oct. 1991 9 p refs
(IAF PAPER 91-289) Copyright
Vibration isolation for spacecraft is reviewed focusing on active isolation of noisy machines and sensitive instruments. Three cases are considered: isolation of noisy machinery, isolation of sensitive payloads, and disturbance cancelling when isolation is not possible. It is concluded that, while work in the final scenario is just beginning, the technology for the first two has been demonstrated a number of times, indicating that active vibration isolation will be available as stricter performance requirements demand it. O.G.

A92-12607
DYNAMICS OF CLOSED LINKED VARIABLE GEOMETRY TRUSS MANIPULATORS
HIROSHI FURUYA (Nagoya University, Japan) and KENICHI HIGASHIYAMA (All Nippon Airways, Tokyo, Japan) IAF,

International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 8 p. Oct. 1991 8 p refs
(IAF PAPER 91-291) Copyright

This paper presents dynamical characteristics of a variable geometry truss manipulator system which consists of a two-dimensional statically determinate truss or space applications. A formulation takes into account geometrical effects of closed-link constraints, variable length mechanisms, rotational degrees of freedom at the joints, and internal control forces developed by Kane's dynamical equations. The conventional formulas of tree-like truss structures are extended to the procedure, which is adapted to statically determine truss structures using a Jacobian matrix derived by geometric considerations. Inverse kinetics of the variable geometry truss have been formulated considering the minimum norm solution to the equations of motion. A two-dimensional variable geometry truss manipulator is simulated numerically as an example of activities on Space Station. Results show the effects of internal control forces on the attitude of the manipulator system in space environment, and the characteristics of the inverse kinetics of the manipulator are investigated. Author

A92-12608* Draper (Charles Stark) Lab., Inc., Cambridge, MA.
DYNAMICS MODELING OF MULTIBODY FLEXIBLE SYSTEMS WITH TRAVELING MULTI-POINT JOINTS
ACHILLE MESSAC (Charles Stark Draper Laboratory, Inc., Cambridge, MA) and DEBORAH HERMAN (MIT, Cambridge, MA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 17 p. Research sponsored by NASA. Oct. 1991 17 p refs
(IAF PAPER 91-292) Copyright

This paper presents a general methodology for modeling the dynamics of a flexible structure which moves on the surface of another flexible structure. The relative motion of the two bodies need not follow a straight line, nor need the contact surfaces be planar in their undeformed state. A model reduction approach is also developed, which makes the methodology applicable to large structural systems. The Space Station Freedom Mobile Transporter represents one such system, when attached to the Shuttle Orbiter. Numerical examples are provided. Author

A92-12609
AN APPROACH TO DYNAMICS OF FLEXIBLE ORBITING SYSTEMS WITH APPLICATION TO THE PROPOSED SPACE STATION
V. J. MODI and A. SULEMAN (British Columbia, University, Vancouver, Canada) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 15 p. Research supported by Centers of Excellence Program. Oct. 1991 15 p refs
(Contract NSERC-A-2181)
(IAF PAPER 91-293) Copyright

Consideration is given to a relatively general approach for studying dynamics of complex multibody time-varying systems, characterized by interconnected beam and plate type members, forming the open tree topology. The equations of motion make it possible to gain physical appreciation of the contributing forces and coupling effects. Computer implementation of these equations through symbolic manipulation enables the user to obtain tailor-made equations of motion for the particular configuration with optimum allocation of computer sources. Versatility of the formulation is illustrated through its application to major configurations of the SSF. The versatile dynamics algorithm is found to be ideally suited for parametric response analysis. It can provide information concerning critical displacement, velocity, and acceleration fields. O.G.

A92-12810
DYNAMICS OF A SPACECRAFT WITH ELASTIC OSCILLATING MASSES [K DINAMIKE KOSMICHESKOGO APPARATA S UPRUGIMI KOLEBLIUSHCHIMISIA MASSAMI]
IU. G. MARKOV and I. S. MINIAEV Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, Sept.-Oct. 1991, p. 685-694. In Russian. Oct. 1991 10 p In RUSSIAN refs
Copyright

Transient processes associated with oscillations of an elastic satellite moving about the center of mass under the effect of a controlling moment are examined. Analytical expressions are obtained for the deviation of the angular velocity from the programmed one. L.M.

A92-14067
THE ASTRO-1 STAR SENSOR SYSTEM ABOARD THE MIR ORBITAL STATION
CHRISTIAN ELSTNER, GERT LICHTENAUER, and WALDEMAR SKARUS Jena Review (ISSN 0448-9497), vol. 36, no. 3, 1991, p. 137-139. 1991 3 p
Copyright

The performance of the ASTRO-1 system for autonomous attitude determination, launched on November 26th, 1989 aboard the Mir space station, is briefly discussed. The system consists of three star sensors, three image processing units, an attitude determination unit, and a manager and interface unit. Test results indicate that the in-orbit performance of the ASTRO-1 is better than specified and all technical requirements are satisfied. O.G.

A92-14201* National Cheng Kung Univ., Tainan (Taiwan).
CONTROL OF LARGE FLEXIBLE STRUCTURES - AN EXPERIMENT ON THE NASA MINI-MAST FACILITY
CHEN HSIEH (National Cheng Kung University, Tainan, Republic of China), JAE H. KIM, KETAO LIU, GUOMING ZHU, and ROBERT E. SKELTON (Purdue University, West Lafayette, IN) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 11, Oct. 1991, p. 13-21. Oct. 1991 9 p refs
(Contract NAG1-958)
Copyright

The output variance constraint controller design procedure is integrated with model reduction by modal cost analysis. A procedure is given for tuning MIMO controller designs to find the maximal rms performance of the actual system. Controller designs based on a finite-element model of the system are compared with controller designs based on an identified model (obtained using the Q-Markov Cover algorithm). The identified model and the finite-element model led to similar closed-loop performance, when tested in the Mini-Mast facility at NASA Langley. Author

A92-14714
A PREDICTION METHOD TO EVALUATE THE ACOUSTIC RESPONSE OF SPACECRAFT EXTERNAL PANELS - AN APPLICATION TO THE ITALSAT STRUCTURE DEVELOPMENT
F. MORGANTI (Alenia Spazio S.p.A., Rome, Italy) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 14 p. Oct. 1991 14 p refs
(IAF PAPER 91-288) Copyright

Applications of a prediction method development during the Italsat F1 structural design phase are discussed. The method had the main purpose to finalize some structural modifications capable of reducing the random vibrations on the east and west panels of the spacecraft. Starting from an experimental data base, an analytical method, based on the structural modes superposition, has been applied to predict the response of the flight model spacecraft. The method has been validated with acoustic tests on panel specimens having different structural design and mass distribution, with the purpose of discerning the effects of the structure alone (in terms of mass and stiffness) and of the units lumped mass. Author

A92-14715
DYNAMICS ANALYSIS OF COMPLEX SPACE STRUCTURES USING NATURAL ORTHOGONAL COMPLEMENT
XAVIER CYRIL (CAE Electronics, Ltd., St. Laurent, Canada) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Research supported by Canadian Space Agency. Oct. 1991 9 p refs
(IAF PAPER 91-295) Copyright

Presented in this paper is a methodology to derive a general dynamics model of complex multibody systems. This method is applied here to complex architectures, namely, one that consists

of serial-, parallel-, and tree-type kinematic chains. In this method, the derivation of the unconstrained equations of motion of the multibody system is carried out using a hybrid Newton-Euler/Euler-Lagrange formulation. Later the nonworking constrained forces of the system are eliminated using the natural orthogonal complement to obtain the constrained dynamical equations. Author

A92-14734* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DYNAMICS AND CONTROL OF THE SPACE STATION FREEDOM DOCKING/ARRAY FEATHERING MANEUVER
RONALD E. GRAHAM (NASA, Lewis Research Center, Cleveland, OH) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p refs
(IAF PAPER 91-321) Copyright

Analysis performed at Lewis Research Center has indicated that it is possible to fail a photovoltaic array of the Space Station Freedom during a Shuttle approach, due to impingements by Shuttle attitude jet firing plumes. A solution to this potential problem is the feathering of the arrays. This study deals with fine adjustments in feathered position for extra plume load relief. A mathematical model for fine feathering is described. The Shuttle is treated as a single rigid body, with prescribed jet firings. Freedom is treated as a system of rigid bodies, with high-fidelity gimbal dynamics. Uncertainty is found in disturbances, plume dynamic pressure, gimbal friction and misalignments. Assumptions, model structure and analysis test plan are presented. Author

A92-14756
EXPERIMENTAL VERIFICATION OF ATTITUDE CONTROL TECHNIQUES FOR FLEXIBLE SPACECRAFT
BRIJ AGRAWAL (U.S. Naval Postgraduate School, Monterey, CA) and R. J. WATKINS, JR. IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p refs
(IAF PAPER 91-354) Copyright

This paper presents experimental verification of control techniques for flexible spacecraft. The experimental setup simulates pitch axis motion of a flexible spacecraft consisting of a rigid central body and a flexible reflector. The primary actuator is a reaction wheel mounted on the central body. The spacecraft simulator floats on airpads above a granite table. The experimental and analytical simulation results are in good agreement. Author

A92-15258
DYNAMICAL ANALYSIS OF THE DEPLOYABLE WIRE AND PROBE ANTENNA SYSTEMS ABOARD THE DUAL-SPIN SATELLITE GEOTAIL
Y. MORITA, M. HINADA (Institute of Space and Astronautical Science, Sagamihara, Japan), A. KITSUI, and Y. TAKEMOTO (Hitachi, Ltd., Yokohama, Japan) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. Oct. 1991 12 p refs
(IAF PAPER 91-352) Copyright

In order to investigate the geomagnetic tail region of the magnetosphere, a joint project, called Geotail, is planned between Japan and NASA. The high degree of flexibility of the wire antennas and their dimensions can lead to undesirable wire vibrations as well as satellite-attitude perturbations through in-orbit events such as antenna deployment, satellite spinup, despun motor operation, attitude and orbital maneuvers, resulting in distortion of the attitude-control accuracy and the scientific observation environment. In the study, the dynamics of dual spinning systems with highly flexible deployable wire antennas has been formulated in a relatively general manner. The associated extensive parametric analysis reveals the interactions among the attitude, orbital, and vibrational dynamics as affected by wire deployment, mast extension, and despun antenna operation as well as attitude and orbit maneuvers. Author

A92-15376
DYNAMICS OF FLEXIBLE STRUCTURES IN SPACE; PROCEEDINGS OF THE 1ST INTERNATIONAL CONFERENCE, CRANFIELD INSTITUTE OF TECHNOLOGY, ENGLAND, MAY 15-18, 1990
C. L. KIRK, ED. (Cranfield Institute of Technology, England) and J. L. JUNKINS, ED. (Texas A & M University, College Station) Southampton, England/Berlin and New York, Computational Mechanics Publications/Springer-Verlag, 1990, 668 p. For individual items see A92-15377 to A92-15411. 1990 668 p
Copyright

Consideration is given to dynamic modeling and control techniques; multibody dynamics, robotics and design; numerical analysis and finite element methods; and tethers and tethered satellites, on-orbit system identification, and Space Station dynamics. Particular attention is given to optimal large angle manuevers of a flexible spacecraft, a dynamics parameter invariant attitude control system for flexible spacecraft, dynamics of systems with interconnected flexible members in the presence of thermal deformations, recent developments in learning control and system identification for robots and structures, experimental verification of structural control, 2D continuous elements, the offset control of tethered systems, and the modeling and identification of large flexible spacecraft structures. O.G.

A92-15377
ON THE MANEUVERING AND CONTROL OF SPACE STRUCTURES
L. MEIROVITCH and M. K. KWAK (Virginia Polytechnic Institute and State University, Blacksburg) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 15 p refs
(Contract F49620-89-C-0049)
Copyright

Recent advancements in flexible single-body and multibody maneuvers are reviewed, and the problem of maneuvering and control of a space structure consisting of a central substructure and several articulated substructures is discussed in detail. The problem is characterized by time-varying coefficients and persistent disturbances. The control design consists of the substructure decentralized control, whereby the actuator forces acting on a given substructure depend only on the sensor output signals from the same substructure. O.G.

A92-15378
STABLE MANEUVER CONTROL LAWS FOR DISTRIBUTED PARAMETER SYSTEMS
J. L. JUNKINS, Z. H. RAHMAN, and H. BANG (Texas A & M University, College Station) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 24 p refs
(Contract F49620-87-C-0078)
Copyright

An approach for designing globally stable feedback control laws for maneuvers of distributed parameter structural systems is proposed. Tracking-type control laws have been developed to suppress the departure of the system state from an a priori determined smooth target trajectory. The approach is used to generate a family of near-minimum-time feedback controllers which accommodates general 'torque-shaping'. It is shown how to establish path-type stability-in-the-large during the maneuver, in the sense that the motion is globally attracted to a small region near the target trajectory. The flexibility of the approach makes it possible to achieve a compromise beween near-minimum-time and competing performance indices including levels of vibration during the maneuver, sensitivity to model errors, disturbances, and control implementation errors. O.G.

A92-15379
DYNAMICS AND CONTROL OF FLEXIBLE INTERCONNECTED BODIES - A FORMULATION WITH APPLICATION
V. J. MODI and Y. MORITA (British Columbia, University,

Vancouver, Canada) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 15 p refs
Copyright

A relatively general formulation for studying dynamics of a large class of interconnected chain-type structures is applied to the Shuttle based large reflector antenna system as proposed in the NASA's design challenge. The Shuttle attitude and the antenna mast vibration are controlled through the Shuttle's primary and vernier thrusters, a set of actuators located on the mast, and joint rotation. Three different control strategies of centralized and decentralized forms are developed in which the optimal linear quadratic regulator theory and the direct velocity feedback principle are employed. The results reveal the uncontrolled system to be unstable and demonstrates relative effectiveness of the proposed control strategies in gaining the fine antenna pointing. Author

A92-15380
INTEGRATED STRUCTURAL/CONTROL DESIGN VIA MULTIOBJECTIVE OPTIMIZATION
G. L. SCHNEIDER and R. A. CALICO, JR. (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 15 p refs
Copyright

A vector minimum correction homotopy approach is used to obtain the simultaneous/integrated optimal design of a large flexible structure (Draper/RPL configuration) and its active control system (direct output feedback). Instead of the usual method of weighting and summing all desired objectives to form a constrained scalar optimization problem, a vector of objective functions is directly dealth with. Design variables are the arm dimensions, control system gains, and sensor and actuator locations. Up to 50 percent reductions in mass and/or control energy are simultaneously obtained while achieving desired closed-loop eigenvalues. Since reduced-order models were used for the structural/control design, the resultant configurations are easily driven unstable by spillover from higher-order unmodeled modes. A modal suppression technique is applied to eliminate observation spillover and provide a decade of deadband above the controller bandwidth. Author

A92-15381
VIBRATION CONTROL IN LARGE SYSTEMS WITH UNMODELED DYNAMICS
C. J. MADAY and N. H. JOHNSON (North Carolina State University, Raleigh) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 12 p refs
Copyright

A control algorithm is developed which is based upon a reduced order model that has certain features of model followers but differs in that the plant is of higher order than the model. The control is based on an incomplete state feedback. The effects of dynamic coupling are reduced since the compensation algorithm introduces strong uncoupling effects. The compensator is a decentralized controller characterized by autonomous elements that control their immediate neighborhood while treating coupling effects as disturbances. The compensater is considered to be an effective low-pass filter that rejects frequencies of about seven times the lowest natural frequency of a plant. O.G.

A92-15382
CONTROLLER ORDER REDUCTION FOR FLEXIBLE SPACECRAFT USING CLOSED-LOOP BALANCING METHODS
K. A. CARROLL and P. C. HUGHES (Toronto, University, Downsview, Canada) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 16 p refs
Copyright

This paper discusses a method of order reduction for dynamic controller, called 'balanced augmented controller reduction'. A basis in theory for this method is developed; in doing so, the new concepts of 'substate controllability' and 'substate observability' are introduced. Substate controllable and observable subspaces are defined and are shown to be related to the eigenvalues of partitions of certain balanced Gramian matrices. Numerical comparisons between this and other controller order reduction methods are presented based on two examples: a flexible spacecraft (called ZSAT) and a four-disk system. The present method is found to perform well. Author

A92-15383
A REVIEW OF MODEL REDUCTION METHODS FOR STRUCTURAL CONTROL DESIGN
R. R. CRAIG, JR. and T.-J. SU (Texas, University, Austin) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 14 p refs
Copyright

This paper presents a review and comparison of several frequently used model reduction methods for flexible structures. The methods reviewed are: modal truncation, balanced reduction, balanced gain approach, Krylov model reduction, and mixed-mode method. A 24 degree-of-freedom plane truss structure with closely-spaced frequencies and small modal damping is used for dynamic analysis and control design comparison. Author

A92-15384
A DYNAMICS PARAMETER INVARIANT ATTITUDE CONTROL SYSTEM FOR FLEXIBLE SPACECRAFT
S. J. DODDS (East London, Polytechnic, Dagenham, England) and R. P. G. HEATH (Integrated Systems, Inc., Cambridge, England) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 25 p refs
Copyright

A universal control system is presented which is applicable to a wide range of spacecraft with collocated sensors and continuous actuators mounted on a rigid center-body. Attitude acquisition from relatively large initial errors is performed near-time-optimally without a detailed knowledge of the spacecraft dynamics. This includes large angle slewing about all three control axes simultaneously with the aid of the quaternion attitude representation and the associated kinematic differential equations. A parameter invariant closed-loop performance is achieved for small attitude errors together with extreme stiffness with respect to disturbance torques. The control system embodies a sliding-mode control law with curved switching boundaries used in conjunction with an on-line center-body moment of inertia matrix estimator. Embodiment of active flexure mode damping using a 'posicast' approach is investigated together with the associated trade-off with center-body attitude control performance. Digital computer simulations with several spacecraft dynamics models are presented. Author

A92-15385
A HIERARCHICAL APPROACH TO LARGE SPACE STRUCTURE CONTROL
K. D. YOUNG (California, University, Livermore) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 14 p refs
Copyright

A hierarchical approach to large space structure control which utilizes the controlled component synthesis (CCS) process repeatedly in a multilevel setting is presented. It is shown that, for a planar truss with a closed kinematic chain configuration, the hierarchical CCS is an effective multilevel decentralized control framework for large space truss. The characteristic robustness of CCS is manifested in this hierarchical setting as a multilevel control reliability. O.G.

A92-15386
DYNAMICS OF SYSTEMS WITH INTERCONNECTED FLEXIBLE MEMBERS IN THE PRESENCE OF THERMAL DEFORMATIONS
V. J. MODI and A. C. NG (British Columbia, University, Vancouver,

Canada) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 15 p refs
(Contract NSERC-STR-32682)
Copyright

A relatively general formulations for studying the dynamics of spacecraft with interconnected flexible bodies is developed accounting for solar radiation induced flexural deformations. Versatility of the formulation is illustrated through simulation of the dynamics of an evolving Space Station configuration. The results suggest nominal equilibrium orientation of the configuration to be inherently unstable in librations. Of some interest is the beat response of the power boom and stinger. The information is fundamental to the design of damping devices, control system and desired locations for the payloads. Author

A92-15387
LUMPED MASS COMPUTATIONS FROM CONSISTENT ELEMENTS WITH APPLICATIONS IN FLEXIBLE MULTIBODY DYNAMICS-LINKING FEM CODES AND DADS
O. FRIBERG and V. KARHU (Chalmers University of Technology, Goteborg, Sweden) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 17 p refs
Copyright

The accuracy of lumping procedures with respect to mass moments of inertia computations has been studied. It is noted that in 'standard' FEM formulations simple lower-order elements are used for nonlinear problems. In flexible multibody dynamics higher-order elements which are exactly lumped are used in conjunction with a modal superposition technique. It is concluded that whether lower or higher elements are used the number of modes may be the same, but the number of nodes and degrees of freedom in the FEM model can be kept lower in the case of higher order elements. The intermediate processor in the Dynamic Analysis and Design System (DADS) has been updated in terms of lumping procedures. O.G.

A92-15388
SUPERPOSITION METHOD FOR STRESS STIFFENING IN FLEXIBLE MULTIBODY DYNAMICS
O. WALLRAPP (DLR, Institut fuer Dynamik der Flugsysteme, Wessling, Federal Republic of Germany), J. SANTOS (Instituto Superior Tecnico, Lisbon, Portugal), and J. RYU (Iowa, University, Iowa City) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 15 p refs
Copyright

For dynamics of flexible multibody systems the deformation of the bodies is described by global assumed modes. The development of geometric stiffness terms due to steady state (nominal) loads is presented. In particular, the stress stiffening matrix with respect to nominal stresses is derived by superposition of unit stress stiffening matrices and scaling them by actual nominal loads. The method is applied to a flexible pendulum and a helicopter rotor blade. The results are compared with those obtained by a finite element analysis. Author

A92-15389
LYAPUNOV STABLE PENALTY METHODS FOR IMPOSING HOLONOMIC CONSTRAINTS IN MULTIBODY SYSTEM DYNAMICS
A. J. KURDILA, J. L. JUNKINS, and S. HSU (Texas A & M University, College Station) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 15 p refs
Copyright

This paper presents a novel approach for imposing holonomic constraints for a class of multibody system dynamics. As opposed to some recent techniques that employ a penalty functional to approximate the Lagrange multipliers, the method herein defines a penalized dynamical system using penalty-augmented kinetic and potential energies, as well as a penalty dependent constraint violation dissipation function. The approach can be shown to reduce to a standard penalty method for a special choice of penalty parameters. Numerical results for some typical simulations shows that the method can be less sensitive to singular configurations than those that require the factorization of a 'constraint metric' matrix. Author

A92-15390
ON STRUCTURAL DESIGN OF ACTIVE STRUCTURES
W. CHARON, U. BUCK (Dornier GmbH, Friedrichshafen, Federal Republic of Germany), and A. NEWERLA (ESTEC, Noordwijk, Netherlands) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 15 p refs
(Contract ESTEC-6922/86)
Copyright

The concept of active control for future space structures is presented with emphasis placed on the modal cost analysis as an essential means for selecting efficient sensor and actuator positions and performing model reduction. The modal cost analysis is shown to be a good tool for designing the structural part of active structures, choosing the transducer types, and positioning them a priori. Actuator/sensor types and location are found to have a strong influence on the system properties. The physical meaning of the most important matrices describing the correlations between states, inputs, disturbances, outputs, and sensors are pointed out. O.G.

A92-15393* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RECENT DEVELOPMENTS IN LEARNING CONTROL AND SYSTEM IDENTIFICATION FOR ROBOTS AND STRUCTURES
M. PHAN, J.-N. JUANG (NASA, Langley Research Center, Hampton, VA), and R. W. LONGMAN (Columbia University, New York) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 14 p refs
Copyright

This paper reviews recent results in learning control and learning system identification, with particular emphasis on discrete-time formulation, and their relation to adaptive theory. Related continuous-time results are also discussed. Among the topics presented are proportional, derivative, and integral learning controllers, time-domain formulation of discrete learning algorithms. Newly developed techniques are described including the concept of the repetition domain, and the repetition domain formulation of learning control by linear feedback, model reference learning control, indirect learning control with parameter estimation, as well as related basic concepts, recursive and non-recursive methods for learning identification. Author

A92-15395
FLEXIBLE MULTIBODY DYNAMICS BASED ON A FULLY CARTESIAN SYSTEM OF SUPPORT COORDINATES
N. VUKASOVIC, J. T. CELIGUETA, J. GARCIA DE JALON (CEIT; Navarra, Universidad, San Sebastian, Spain), and E. BAYO (California, University, Santa Barbara) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 13 p refs
(Contract NATO-0877/87)
Copyright

A multirigid body method based on a fully Cartesian system of coordinates has been extended to flexible multibody systems. The method combines rigid and deformable elements with a simple and efficient formulation. The moving local frames are attached to a set of points and vectors which move according to the rigid body condition. The differential equations of motions are integrated by a single-step Newmark method combined with fixed point iteration to cope with the equation's nonlinearity. It is concluded that the method performs well with numerical stiffness and allows discontinuities on external forces or prescribed motion variables. O.G.

A92-15397
EXPERIMENTAL VERIFICATION OF STRUCTURAL CONTROL
L. D. PETERSON (Purdue University, West Lafayette, IN) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 14 p refs
(Contract DE-AC04-76DP-00789)
Copyright

The effect of experimental structural dynamic measurements on the design of a controlled structure is reviewed. The optimal projection reduced order control theory is compared to a suboptimal reduced order control design method on a controlled truss structure. Experimental modal testing for updating the finite element model is considered to be a critical link in achieving stable, high-performance control. It is suggested that experimental measurements should be formally integrated into the control design formulation. O.G.

A92-15398
GROUND BASED DYNAMIC TESTING OF FLEXIBLE COMPOSITE SATELLITE STRUCTURES
D. A. C. SPARRY and L. HOLLAWAY (Surrey, University, Guildford, England) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 13 p refs
Copyright

Methods and materials used in the modeling of a skeletal satellite system are briefly discussed, and the techniques used in the ground testing of a basic building block which is a triangular-based pyramidal system are examined. A series of dynamic tests carried out on the unit supported in a near 'free-free' condition is described. It is concluded that the use of simple beam elements instead of shell elements for the finite element models of the composite structures has been successful. Perspex has proved to be the best model material. It is important to develop the accurate analysis of the unit structure so that it could be incorporated into the substructuring technique. O.G.

A92-15400
NON-LINEAR VIBRATION OF LARGE, IMPERFECT SPACE STRUCTURES
H. OERY, A. RITTWEGER (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany), E. HORNUNG, and E. ERBEN (ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 24 p
Copyright

The fundamental dynamic behavior of a large framework structure with imperfect struts is investigated under shock loads and periodic excitations. Beside the expected large overall deformations more dramatic nonlinear influences are shown to occur from the inevitable imperfections of the struts. The conclusion also is that an active shape control, ensuring the straightness of the struts, seems to be mandatory for large space structures.
Author

A92-15403
A TIME DOMAIN IDENTIFICATION APPROACH FOR LOW NATURAL FREQUENCIES AND LIGHT DAMPING STRUCTURES
A. AGNENI and L. B. CREMA (Roma I, Universita, Rome, Italy) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 13 p refs
(Contract CNR-88,03112,11)
Copyright

To save memory storage and computational time the Hartley approach was used for obtaining the Hilbert transform. The approach is considered to be useful for large-scale space structure modal analysis, where it is necessary to work on responses with observation times much shorter than those in general required by the frequency domain approach. O.G.

A92-15404
A RECURSIVE COMPUTATIONAL METHOD FOR THE DYNAMIC ANALYSIS OF BEAM-LIKE PERIODIC STRUCTURES
A. AGNENI and S. SGUBINI (Roma I, Universita, Rome, Italy) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 13 p refs
Copyright

A recursive algorithm for obtaining the displacements of clamped-clamped periodic structures is presented. Using a stepped-sine excitation, it is possible to get the frequency response with the desired resolution, so that precise evaluations of the natural frequencies can be obtained. The method was applied to longitudinal and transverse vibrations of pin-jointed clamped-clamped structures, made up of equal elements. High reductions of computing time have been achieved in both cases. O.G.

A92-15409
MODELLING AND IDENTIFICATION OF FLEXIBLE SPACECRAFT
P. PH. VAN DEN BROEK, J. A. MULDER (Delft University of Technology, Netherlands), and Q. P. CHU (Chinese Academy of Sciences, Space Science and Technology Center, Beijing, People's Republic of China) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 11 p refs
Copyright

A new approach to spacecraft parameter estimation is proposed which reduces the number of unknown parameters to a manageable level. The approach is based on the finite element method for generating a high-order dynamical model of the spacecraft. Quasi-static approximations of the low-frequency characteristic modes resulted in an order reduction of the dynamical finite element model. Stochastic model disturbances are introduced to account for model errors resulting from the structural discretization and the quasi-static approximations. The model order reduction is used to improve the numerical efficiency of a maximum likelihood prediction error estimator. O.G.

A92-15410
EIGENVALUE REALISATION METHODS FOR THE IN-ORBIT IDENTIFICATION OF LARGE FLEXIBLE SPACECRAFT STRUCTURES
J. E. COOPER and J. R. WRIGHT (Manchester, Victoria University, England) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 15 p refs
Copyright

In this paper two Multi-Input Multi-Output state space methods suitable for the in-orbit system identification of space structures are considered. The ERA (Eigensystem Realization Algorithm) method, which has already been used successfully on the Solar Array Flight Experiment, is compared to the ERA/DC (ERA using Data Correlations) method in terms of the formulation and computational effort. The methods are applied to simulated data from a space station type model. The ERA/DC method requires less model overspecification in the presence of noise than the ERA method for similar quality of results. A revision of the ERA/DC method is suggested. Author

A92-15411
SYSTEM MODES AND DYNAMICS OF THE PROPOSED SPACE STATION TYPE CONFIGURATIONS
V. J. MODI and A. SULEMAN (British Columbia, University, Vancouver, Canada) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 15 p refs
(Contract NSERC-STR-32682) .
Copyright

A preliminary libration/vibration interaction dynamics study of the Space Station Freedom is presented. System modes, obtained through the finite element analysis, are employed in the

discretization process, and the response study is confined to the orbital plane to emphasize interactions between vibrational dynamics and flexibility. A closed-form analytical solution of the simplified, nonlinear equations of motion is obtained using the variation of the parameter method. The finite element analysis suggests that the main truss exhibits a transition from a predominantly torsional character to a bending behavior. The acceleration reached at certain locations on the Space Station were high enough to interfere with the microgravity experiments onboard. To evaluate the effects of system parameters on libration/vibration interaction dynamics, the system was considered uncontrolled and undamped. O.G.

A92-16068* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AUTOMATED ON-ORBIT FREQUENCY DOMAIN IDENTIFICATION FOR LARGE SPACE STRUCTURES
D. S. BAYARD, F. Y. HADAEGH, Y. YAM, R. E. SCHEID, E. METTLER, and M. H. MILMAN (JPL, Pasadena, CA) Automatica (ISSN 0005-1098), vol. 27, Nov. 1991, p. 931-946. Nov. 1991 16 p refs
Copyright

Recent experiences in the field of flexible structure control in space have indicated a need for on-orbit system identification to support robust control redesign to avoid in-flight instabilities and maintain high spacecraft performance. This paper highlights an automated frequency domain system identification methodology recently developed to fulfill this need. The methodology is focused to support (1) the estimation of system quantities useful for robust control analysis and design; (2) experiment design tailored to performing system identification in a typically constrained on-orbit environment; and (3) the automation of operations to reduce 'human in the loop' requirements. Author

A92-17913
GRAPH-THEORY APPROACH TO EIGENVALUE PROBLEM OF LARGE SPACE STRUCTURES
A. S. S. R. REDDY (City College, New York) Journal of Aerospace Engineering (ISSN 0893-1321), vol. 5, Jan. 1992, p. 70-78. Jan. 1992 9 p refs
Copyright

The dynamic analysis and control system design of large space structures involve the solution of the large-dimensional generalized matrix eigenvalue problem. The computational effort involved is proportional to the third power of the dimension of the matrices involved. To minimize the computational time a graph-theory approach to reduce a matrix to lower-ordered submatrices is proposed. The matrix-reduction algorithm uses the Boolean matrices corresponding to the original numerical matrices and, thus, the computational effort to reduce the original matrix is nominal. The computational savings directly depend upon the number of submatrices into which the original matrix is reduced. A free-free square plate is considered as an example to illustrate the technique. In this example a matrix of 16th order is reduced to three scalars corresponding to three rigid-body modes, and three matrices of order three and one matrix of order four. Author

A92-17916
DESIGN/CONTROL OPTIMIZATION OF CROSS-PLY LAMINATES UNDER BUCKLING AND VIBRATION
J. M. SLOSS, J. C. BRUCH, JR. (California, University, Santa Barbara), I. S. SADEK (North Carolina, University, Wilmington), and S. ADALI (California, University, Santa Barbara; Natal, University, Durban, Republic of South Africa) Journal of Aerospace Engineering (ISSN 0893-1321), vol. 5, Jan. 1992, p. 127-137. Research supported by University of North Carolina. Jan. 1992 11 p refs
Copyright

The optimal layer thicknesses and optimal feedback control function are determined for a symmetric, cross-ply laminate. The objectives of the optimization are to maximize the biaxial buckling load (design objective) and to minimize the dynamic response to external disturbances (control objective) subject to a constraint on the expenditure of control energy. The design/control problem is formulated as a multiobjective optimization problem by employing a performance index that combines the design and control objectives in a weighted sum. Numerical results are given for a laminate made of an advanced composite material. Comparisons of controlled and uncontrolled laminates as well as optimally designed and nonoptimal laminates indicate the benefits of treating the design and control problems in unified formulation. The implications of solving these two problems are discussed. The values of optimal design and control variables are given for a number of problem parameters. Author

A92-18379
DIAGNOSTIC MONITORING AND SENSITIVITY ANALYSIS OF CONTACT DYNAMICS IN JOINTED STRUCTURES
YIMING RONG (Southern Illinois University, Carbondale, IL) and HORN-SEN TZOU (Kentucky, University, Lexington) AIAA Journal (ISSN 0001-1452), vol. 29, Dec. 1991, p. 2215-2221. Dec. 1991 7 p refs
Copyright

The operation and performance of elastically jointed structures can be degraded by dynamic contacts arising from a number of factors including excessive levels of vibration, inadequate lubrication, and improper joint clearance. In many applications, such as a space structure, periodic disassembly and inspection are impractical; thus, a monitoring and diagnosis system is desired to automatically detect and diagnose significant changes in the dynamic contact state of jointed structures. A time-series-based monitoring and diagnosis system has been formulated to address this need. The system incorporates a cross-entropy minimization method, based on the nearest neighbor classification rule, and a cross-entropy dissimilarity measure to classify a new observation of vibration states into one of a set of prestudied 'standard' vibration patterns. The approach is applied to a unit truss cell, representative of space structures, and laboratory experiments are conducted to evaluate its performance and assess its sensitivities. The experimental results indicate that the system can satisfactorily detect and classify changes in the vibration states of such structures. Author

A92-18380
STRUCTURAL MODEL CORRELATION USING LARGE ADMISSIBLE PERTURBATIONS IN COGNATE SPACE
MICHAEL M. BERNITSAS and RICKY L. TAWEKAL (Michigan, University, Ann Arbor) AIAA Journal (ISSN 0001-1452), vol. 29, Dec. 1991, p. 2222-2232. Research supported by University of Michigan. Dec. 1991 11 p refs
(Contract NOAA-NA-85AADSG045C)
Copyright

A nonlinear perturbation method is developed to solve the problem of correlating a finite element model (FEM) to a structure for which an incomplete set of natural frequencies and mode shapes and/or some static deflections have been measured. The solution algorithm can handle differences between FEM and structure, in design variables and response, as large as 100-300 percent, depending on the scale of the structure and correlation measures. This is achieved incrementally by making inadmissible predictions, identifying the modal cognate space relevant to the correlation measures, and making admissible corrections in the cognate space. The developed computer code postprocesses results of the FEM modal and/or static analyses of the initial model only. Lagrange multipliers reveal the dominant correlation requirements and the active admissible cognate subspace. Depending on the number of correlation variables and measures, an optimal, a unique, or an inadmissible minimal error solution may be produced. Beam and offshore tower examples are used to test the algorithm and investigate conflicting requirements, definition of admissible cognate space, limits of allowable differences between FEM and structure, accuracy, and cost of the nonlinear perturbation method. Author

A92-18389
ENHANCEMENT OF FREQUENCY AND DAMPING IN LARGE SPACE STRUCTURES WITH EXTENDIBLE MEMBERS
C. T. SUN (Purdue University, West Lafayette, IN) and R. T. WANG (National Cheng Kung University, Tainan, Republic of China) (Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Pt. 3, p. 1774-1780) AIAA Journal (ISSN 0001-1452), vol. 29, Dec. 1991, p. 2269-2271. Abridged. Previously cited in issue 12, p. 1911, Accession no. A88-32363. Dec. 1991 3 p refs
Copyright

A92-18390
STRUCTURAL DAMAGE DETECTION USING MODAL TEST DATA
TAE W. LIM (Lockheed Engineering and Sciences Co., Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 29, Dec. 1991, p. 2271-2274. Dec. 1991 4 p refs
Copyright
Attention is given to a systematic method, based on the stiffness matrix correction technique employing submatrices, that furnishes precise identification of damage-location and extent, when the exact measured modes at every finite element DOF are used. Also given is a procedure which performs damage detection with inaccurate, incomplete measured modes. The stiffness-reduction factor for each submatrix revealing the location and degree of stiffness damage is obtained by a computationally efficient pseudoinverse solution. O.C.

A92-18587
OPTIMUM DESIGN OF GEOMETRICALLY NONLINEAR SPACE TRUSSES
M. P. SAKA (University of Bahrain, Isa Town) and M. ULKER (Euphrates University, Elazig, Turkey) Computers and Structures (ISSN 0045-7949), vol. 41, no. 6, 1991, p. 1387-1396. 1991 10 p refs
Copyright
An optimum design algorithm developed for geometrically nonlinear 3D space trusses which considers the geometrical nonlinearity resulting from large displacements is presented. This is achieved by coupling the optimality criteria approach with the tangent stiffness method. The post-buckling and post-yielding behavior of truss members are not included in the design algorithm. As a result, members are loaded up to their yielding stress or critical stress. It is shown that further reduction can be achieved in the weight of the space truss considering the geometrical nonlinearity while keeping the member's behavior elastic. The optimality criteria approach is shown to be effective in the design of nonlinear structures. It provides simplicity in the formulation of design problems and facilitates the programming of algorithms. P.D.

A92-18602* Massachusetts Inst. of Tech., Cambridge.
EXPERIMENTAL INVESTIGATION INTO PASSIVE DAMPING ENHANCEMENT FOR SPACE STRUCTURES
NESBITT W. HAGOOD and EDWARD F. CRAWLEY (MIT, Cambridge, MA) Dec. 1991 10 p refs
(Contract NAGW-21)
Copyright

A92-18603
EXPERIMENTAL ANALYSIS OF A PASSIVELY TUNED ACTUATOR ON A LOW-ORDER STRUCTURE
STEVEN G. WEBB and JEFFREY S. TURCOTTE (U.S. Air Force Academy, Colorado Springs, CO) Dec. 1991 5 p refs

A92-18604* Arizona State Univ., Tempe.
ROBUST H(INFINITY) CONTROL DESIGN FOR THE SPACE STATION WITH STRUCTURED PARAMETER UNCERTAINTY
KUK-WHAN BYUN (Dynacs Engineering Co., Inc., Palm Harbor, FL), BONG WIE (Arizona State University, Tempe), DAVID GELLER, and JOHN SUNKEL (NASA, Johnson Space Center, Houston, TX) Dec. 1991 8 p refs
Copyright

A92-18605
DYNAMICS OF AN ANTENNA POINTING CONTROL SYSTEM WITH FLEXIBLE STRUCTURES
MASAZUMI UEBA (NTT, Yokosuka, Japan) Dec. 1991 6 p refs
Copyright

A92-18628* Texas Univ., Austin.
KRYLOV MODEL REDUCTION ALGORITHM FOR UNDAMPED STRUCTURAL DYNAMICS SYSTEMS
ROY R. CRAIG, JR. (Texas, University, Austin) and TZU-JENG SU Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Nov.-Dec. 1991, p. 1311-1313. Dec. 1991 3 p refs
(Contract NAS9-17254)
Copyright
Krylov vectors furnish an efficient basis for eigenvalue analysis and model reduction of structural dynamics systems. The reduced-order model obtained by the present Krylov model-reduction algorithm for an undamped structural-dynamics system is found to match low-frequency moments. The transformed system equation in Krylov coordinates reflects the structure of a tandem system. O.C.

A92-18629
OPTIMAL FEEDBACK GAINS FOR THREE-DIMENSIONAL LARGE ANGLE SLEWING OF SPACECRAFT
ARUN K. BANERJEE (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Nov.-Dec. 1991, p. 1313-1315. Dec. 1991 3 p refs
Copyright
Feedback control based on Euler parameters and angular velocity components for the large-angle, 3D slewing of spacecraft requires careful selection of feedback gains, due to strongly nonlinear dynamics. A systematic procedure is presented from the determination of these feedback control gains on the basis of optimal control theory, as well as the application of a state-of-the-art optimization technique. The method is applied to a problem in which a rigid body is simultaneously rotated in three axes in order to capture the desired orientation, using feedback-control torques with saturation constraints. O.C.

A92-19023
COMBINED DESIGN OF STRUCTURES AND CONTROLLERS FOR OPTIMAL MANEUVERABILITY
J. LING, P. KABAMBA, and J. TAYLOR (Michigan, University, Ann Arbor) Structural Optimization (ISSN 0934-4373), vol. 3, Dec. 1991, p. 214-230. Dec. 1991 17 p refs
Copyright
The paper treats the problem of the combined design of structure/control systems for achieving optimal maneuverability. A maneuverability index which directly reflects the time required to perform a given maneuver or set of maneuvers is introduced. By designing the flexible appendages of a spacecraft, its maneuverability is optimized under the constraints of structural properties, and of the postmaneuver spill-over being within a specified bound. The spillover reduction is achieved by making use of an appropriate control design model. The distributed parameter design problem is approached using assumed shape functions and finite-element analysis with dynamic reduction. Characteristics of the problem and problem-solving procedures are investigated. Adaptive approximate design methods are developed to overcome computational difficulties. It is shown that the global optimal design can be obtained by tuning the natural frequencies of the spacecraft to satisfy specific constraints. The difference is quantified between a lower bound to the objective function associated with the original problem and the estimate obtained from the modified problem as the index for the adaptive refinement procedure. Numerical examples show that the results of the design can provide substantial improvement. Author

A92-19049
LINEAR SUBSTRUCTURE SYNTHESIS VIA LYAPUNOV STABLE PENALTY METHODS
A. J. KURDILA, J. L. JUNKINS, and R. G. MENON (Texas A & M University, College Station) Finite Elements in Analysis and Design (ISSN 0168-874X), vol. 10, Nov. 1991, p. 101-123. Nov. 1991 23 p refs

Component mode synthesis theories in structural dynamics are comprised of two fundamental steps: (1) substructure order reduction and (2) synthesis of the reduced order substructure models to achieve approximate full-order response. The most common criticism of component mode synthesis procedures in general is that they require heuristic decision based upon physical insight of the analyst to insure accurate results. This paper introduces a novel approach for the problem of coupling reduced order models based upon recent work by the authors in nonlinear multibody dynamics. It is attractive in its simplicity, and in the fact that some theoretical results regarding the accuracy of the coupling procedure have been derived. The method enforces constraints between substructures by approximating the constrained governing system of differential-algebraic equations by a penalty-parameterized system of ordinary differential equations. The resulting formulation has several advantages: (1) explicit time-domain constraint violation bounds are available for the approximate full-order system; (2) under relatively mild sufficient conditions, the approximate governing equations are guaranteed to be Liapunov (asymptotically) stable; (3) the approximate method is equivalent to a linear quadratic feedback control formulation to minimize the constraint work; (4) the method retains a high degree of sparsity in the full order, approximate system; and (5) the approach is simple to implement compared to many other alternative techniques of substructure coupling. Author

A92-19083
SIMULATING THE ATTITUDE DYNAMICS OF A MULTIBODY SPACECRAFT
J. W. HUNT, JR. and H. L. FISHER (Johns Hopkins University, Laurel, MD) IN: 1990 Annual Summer Computer Simulation Conference, 22nd, Calgary, Canada, July 16-18, 1990, Proceedings 1990 6 p refs

A general simulation of the attitude dynamics of a spacecraft composed of a collection of interconnected rigid bodies is presented. The rotational motion between bodies is coupled at the joints through the inclusion of linear springs and dampers. Forces and torques typically encountered by earth-orbiting spacecraft are modeled, including: gravity-gradient effects, aerodynamic and solar pressure effects, magnetic dipole torques, magnetic eddy current damping torques, and wheel torques. This program, coded in FORTRAN, is compiled to run on a 32-bit, 80386-based personal computer. A flexible, easily-configured, user-friendly input system using NAMELIST input is employed with extensive error checking of data and helpful diagnostic messages. User-configured output files with automatically generated text headers, enable file sizes to be minimized. An example demonstrates the utility and flexibility of the program. Author

A92-19454
MODELLING OF SUPERELEMENTS IN MECHANISM ANALYSIS
ALBERTO CARDONA (Universidad Nacional del Litoral, Santa Fe, Argentina) and MICHEL GERADIN (Liege, Universite, Belgium) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 32, Dec. 1991, p. 1565-1593. Dec. 1991 29 p refs

The paper deals with substructuring for dynamic analysis of flexible multibody systems. Three different techniques based on component synthesis are discussed, corresponding respectively to fully consistent mass discretization, lumped mass discretization and corotational approximation of inertia forces. To simplify the computer implementation, only the the lumped mass and corotational approximations have been considered in detail and programmed. Both approaches are validated on simple examples of rotating beams for which a full elastic model is available using a fully nonlinear beam element. The computational efficiency of the corotational inertia approach is also demonstrated on the deployment of a large flexible satellite antenna. Author

A92-19457
COMPUTER METHODS IN FLEXIBLE MULTIBODY DYNAMICS
RONALD L. HUSTON (Cincinnati, University, OH) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 32, Dec. 1991, p. 1657-1668. Dec. 1991 12 p refs
(Contract NSF MSS-89-12521)

It is suggested that nonlinear dynamics in large flexible systems can give rise to chaotic effects where a small change in initial movement and configuration can cause significant changes in the motion at subsequent times. A method of analysis and computation is described which can account for these nonlinear and chaotic effects. It is a lumped parameter method with the flexibility and damping modeled at the joints; it uses relative coordinates, Euler parameters, and generalized speeds. Particular attention is given to the incorporation of flexibility effects, with application to long, slender members. A closed-loop spatial robot consisting of two flexible and three rigid bodies is considered as an example. L.M.

A92-19460
AN APPROACH TO DYNAMICS AND CONTROL OF ORBITING FLEXIBLE STRUCTURES
V. J. MODI (British Columbia, University, Vancouver, Canada), Y. MORITA (Institute of Space and Astronautical Science, Sagamihara, Japan), A. SULEMAN, and A. C. NG International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 32, Dec. 1991, p. 1727-1748. Research supported by Centers of Excellence Program. Dec. 1991 22 p refs
(Contract NSERC-A-2181)

A relatively general formulation for studying the dynamics of an arbitrary spacecraft with interconnected flexible bodies is developed accounting for thermal deflection, transient system inertias, shift in the center of mass, shear deformations, rotary inertias and geometric nonlinearities. The computer implementation has been carried out through symbolic manipulation of the equations of motion. Versatility of the formulation is indicated through application to problems of contemporary interest. Author

A92-19462
CONSTRAINED MOTION OF DEFORMABLE BODIES
A. A. SHABANA (Illinois, University, Chicago) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 32, Dec. 1991, p. 1813-1831. Research supported by U.S. Army. Dec. 1991 19 p refs

In this paper, issues related to the dynamic modeling of constrained deformable bodies that undergo large rigid body displacements are discussed. Particular attention is focused on finite element formulations. It is shown that the use of nodal coordinates and shape functions to describe the finite rotation of some of the commonly used finite elements leads to a linearization of the kinematics and dynamic relationships. The structure of the nonlinear dynamic equations that govern the motion of deformable bodies that undergo large displacements is examined. Comments on the finite element formulation of the invariants of motion, the definition of the generalized forces and moments in flexible body dynamics and the computational strategy used for the automatic generation of the equations of motion are made. The computer formulation of the joint constraints between deformable bodies as well as the numerical algorithms currently used in many of the general purpose computer programs that are based on the augmented formulation are discussed. A decoupled joint-elastic acceleration recursive formulation is also presented. This formulation leads to a small system of acceleration equations whose dimensions are independent of the number of the elastic

degrees of freedom of the system. In this paper, the coupling between the displacements of the deformable bodies is classified as kinematic, inertia and elastic. In view of this classification, comments on the validity of using the updated finite element Lagrangian formulation and the 4 x 4 transformation matrix in the dynamic analysis of flexible multibody systems are made. The coupling between the finite rotation and the wave motion in constrained deformable bodies is also discussed Author

A92-20376* National Aeronautics and Space Administration Langley Research Center, Hampton, VA
STRUCTURAL DYNAMIC PERFORMANCE OF A GEOSTATIONARY MICROWAVE RADIOMETER
DEBORAH M. WAHLS, JEFFERY T FARMER (NASA, Langley Research Center, Hampton, VA), and DAVID W. SLEIGHT Dec. 1991 2 p refs
Copyright

A92-20679
ANALYSIS MODELLING AND SPACE-SPECIFIC ANALYSES USING 'ESABASE'
J. DE KRUYF (ESTEC, Noordwijk, Netherlands) ESA Journal (ISSN 0379-2285), vol. 15, no. 3-4, 1991, p 229-236 1991 8 p refs
Copyright

The ESABASE engineering tool supports a wide variety of space-specific analyses It includes data management, processing and application steering utilities, as well as computer-graphics facilities to verify analysis models and to analyze calculated results, and a gateway to commercial CAD/CAE packages. ESABASE has a number of space-specific applications associated with it, including outgasing contamination analysis The ESABASE software, which is now installed at more than 60 companies and institutes throughout Europe, is continually being extended with new analysis capabilities (e.g , for space debris, micrometeoroids) and updated with the latest computing tools (e g., X-Windows, Postscript) ESABASE has recently been exploited for the design of the Agency's future Solar and Heliospheric Observatory (Soho) scientific mission. Author

A92-20748* California Univ , Los Angeles
IMPROVED APPROXIMATIONS FOR CONTROL AUGMENTED STRUCTURAL SYNTHESIS
H. L. THOMAS, A. E. SEPULVEDA, and L. A SCHMIT (California, University, Los Angeles) Jan 1992 9 p refs
(Contract NSG-1490)
Copyright

A92-20754* Jet Propulsion Lab , California Inst of Tech , Pasadena
IMPROVEMENT OF STRUCTURAL MODELS USING COVARIANCE ANALYSIS AND NONLINEAR GENERALIZED LEAST SQUARES
R. J. GLASER, C. P KUO, and B K. WADA (JPL, Pasadena, CA) AIAA Journal (ISSN 0001-1452), vol. 30, Jan 1992, p 226-233 Jan 1992 8 p refs
Copyright

The next generation of large, flexible space structures will be too light to support their own weight, requiring a system of structural supports for ground testing. The authors have proposed multiple boundary-condition testing (MBCT), using more than one support condition to reduce uncertainties associated with the supports. MBCT would revise the mass and stiffness matrix, analytically qualifying the structure for operation in space The same procedure is applicable to other common test conditions, such as empty/loaded tanks and subsystem/system level tests This paper examines three techniques for constructing the covariance matrix required by nonlinear generalized least squares (NGLS) to update structural models based on modal test data The methods range from a complicated approach used to generate the simulation data (i e , the correct answer) to a diagonal matrix based on only two constants The results show that NGLS is very insensitive to assumptions about the covariance matrix, suggesting that a workable NGLS procedure is possible The examples also indicate that the multiple boundary condition procedure more accurately reduces errors than individual boundary condition tests alone Author

A92-20755
NONLINEAR DYNAMIC RESPONSE OF FRAME-TYPE STRUCTURES WITH HYSTERETIC DAMPING AT THE JOINTS
G SHI (Dalian University of Technology, People's Republic of China) and S. N ATLURI (Georgia Institute of Technology, Atlanta) AIAA Journal (ISSN 0001-1452), vol 30, Jan 1992, p 234-240. Research supported by USAF Jan 1992 7 p refs
Copyright

The dynamic response of frame-type structures with hysteretic damping at the structural joints, resulting from slipping and nonlinear flexible connections, is investigated in this paper The slipping at a structural joint is represented by the modified Coulomb joint model The behavior of a nonlinear flexible connection is modeled by the Ramberg-Osgood function. A simple computational model for the dynamic analysis of frames with the hysteretic damping is presented here Several numerical examples are included, to illustrate the usefulness of the approach in analyzing large space structures. Author

A92-20766
ANALYTICAL EVALUATION OF LATTICE SPACE STRUCTURES FOR ACCURACY
HIROSHI FURUYA (Nagoya University, Japan) AIAA Journal (ISSN 0001-1452), vol 30, Jan 1992, p 280-282 Jan 1992 3 p refs
Copyright

An effort is made to analytically formulate the arbitrary stochastic effects of member-length errors on lattice space structures' accuracy. The comprehensive formulation presented is based on the vector subspaces associated with the dominant matrix derived from the equilibrium and covariance matrices of the structure. It is shown that the stochastic analysis of the lattice-type structures can be treated as a simple eigenvalue problem, and that the invariant of the dominant matrix plays an important role in estimating the structural errors. O.C.

A92-21020
A FORMULATION AND TRANSIENT DYNAMICS OF THE EVOLVING SPACE STATION
V J. MODI (British Columbia, University, Vancouver, Canada), A C. NG, and A SULEMAN Journal of the Astronautical Sciences (ISSN 0021-9142), vol 39, Oct.-Dec 1991, p 393-410 Research supported by Centers of Excellence Program Dec 1991 18 p refs
(Contract NSERC-A-2181)
Copyright

A relatively general Lagrangian formulation for studying the dynamics of spacecraft with interconnected flexible bodies is developed accounting for solar radiation induced flexural deformations The approach satisfies the holonomic constraints implicitly and provides better physical insight into the contributing forces Versatility of the formulation is illustrated through simulation of the dynamics of two evolving Space Station configurations The results suggest nominal equilibrium orientations of the configurations to be inherently unstable in librations Of some interest is the beat response of the power boom and stinger The information is fundamental to the design of damping devices, control system and desired locations for the payloads Author

A92-21128
ADAPTABLE OPTIMALITY CRITERION TECHNIQUES FOR LARGE-SCALE SPACE FRAMES WITH MULTIPLE FREQUENCY CONSTRAINTS
O G. MCGEE and K F. PHAN (Ohio State University, Columbus) (U S Air Force/NASA Symposium, 3rd on Recent Advances in Multidisciplinary Analysis and Optimization, San Francisco, CA, Sept 24-26, 1990) Computers and Structures (ISSN 0045-7949),

vol 42, Jan 17, 1992, p 197-210 17 Jan 1992 14 p refs
(Contract NSF MSM-88-21143)
Copyright

This paper presents an adaptive optimality criteria (OC) approach for frequency-constrained weight minimization of large-scale space frames supporting nonstructural mass and subjected to minimum and maximum gauge restrictions The iterative procedure involves alternately satisfying the constraints (scaling) and applying the Kuhn-Tucker (optimality) condition (resizing) The primary sizing variables (cross-sectional areas), and indirectly the secondary ones (i e., two principal moments of inertia and a torsional constant) are uniformly scaled to the constraint surfaces using a closed-form formulation The closed-form scaling procedure is united with an adaptable redesign strategy in which linear extrapolates of past scaled design vectors are coupled with automatically tuned OC recursive formulas Several practical design examples are presented to demonstrate the method On the average, the method achieves a smooth upper-bound convergence of weight minima, as it quickly dissolves the (sometimes violent) oscillations of scaled weights in the iteration history. Most of all, the present design strategy eliminates the need for adjustments of internal parameters during the redesign phase Author

A92-21152* Houston Univ., TX
SELF-TUNING CONTROL OF ATTITUDE AND MOMENTUM MANAGEMENT FOR THE SPACE STATION
L S SHIEH (Houston, University, TX), J W SUNKEL (NASA, Johnson Space Center, Houston, TX), Z Z YUAN (Nankai University, Tianjin, People's Republic of China), and X M ZHAO Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol 15, Jan -Feb 1992, p 17-27 Feb. 1992 11 p refs
(Contract DAAL03-91-G-0106, NAG9-380, NAG9-385)
Copyright

This paper presents a hybrid state-space self-tuning design methodology using dual-rate sampling for suboptimal digital adaptive control of attitude and momentum management for the Space Station This new hybrid adaptive control scheme combines an on-line recursive estimation algorithm for indirectly identifying the parameters of a continuous-time system from the available fast-rate sampled data of the inputs and states and a controller synthesis algorithm for indirectly finding the slow-rate suboptimal digital controller from the designed optimal analog controller The proposed method enables the development of digitally implementable control algorithms for the robust control of Space Station Freedom with unknown environmental disturbances and slowly time-varying dynamics Author

A92-21155
ACTUATOR PLACEMENT IN STRUCTURAL CONTROL
K CHOE and H BARUH (Rutgers University, New Brunswick, NJ) Feb 1992 9 p refs
Copyright

A92-21156* National Aeronautics and Space Administration Langley Research Center, Hampton, VA.
METHOD FOR OPTIMAL ACTUATOR AND SENSOR PLACEMENT FOR LARGE FLEXIBLE STRUCTURES
K B LIM (NASA, Langley Research Center, Hampton, VA) Feb 1992 9 p refs
Copyright

A92-21157
ROBUSTNESS OF POSITIVE REAL CONTROLLERS FOR LARGE SPACE STRUCTURES
G. L SLATER, ALBERT B BOSSE, and Q ZHANG (Cincinnati, University, OH) Feb 1992 7 p refs
Copyright

A92-21159* Arizona State Univ , Tempe
CONTROL SYNTHESIS FOR FLEXIBLE SPACE STRUCTURES EXCITED BY PERSISTENT DISTURBANCES
BONG WIE (Arizona State University, Tempe) and MARCELO GONZALEZ Feb 1992 8 p refs
Copyright

A92-21161* Old Dominion Univ , Norfolk, VA
INTEGRATED SYSTEM IDENTIFICATION AND STATE ESTIMATION FOR CONTROL OF FLEXIBLE SPACE STRUCTURES
CHUNG-WEN CHEN, JEN-KUANG HUANG (Old Dominion University, Norfolk, VA), MINH PHAN, and JER-NAN JUANG (NASA, Langley Research Center, Hampton, VA) Feb 1992 8 p refs
Copyright

A92-21162
CLOSED-LOOP SOFT-CONSTRAINED TIME-OPTIMAL CONTROL OF FLEXIBLE SPACE STRUCTURES
E M CLIFF, A H NAYFEH (Virginia Polytechnic Institute and State University, Blacksburg), and M BIKDASH Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol 15, Jan -Feb 1992, p 96-103 Feb 1992 8 p refs
Copyright

Numerically efficient solutions are proposed for the open- and closed-loop time-optical soft-constrained control of a linear system representing a large flexible space structure The open-loop solution is expressed in terms of the controllability Grammian matrix, for which a closed-form expression has been obtained for the undamped system The qualitative dependence of the control on the initial state and the existence of many solutions satisfying the necessary conditions are shown A nominal closed-loop control policy is shown to be numerically expensive due to the nonuniqueness of extremal solutions A continuation-based algorithm is proposed to alleviate the computational problem Finally, the open- and closed-loop controls are shown to exhibit a saturation property reminiscent of the hard-constrained problem Author

A92-21163
ZERO-RESIDUAL-ENERGY, SINGLE-AXIS SLEW OF FLEXIBLE SPACECRAFT USING THRUSTERS - DYNAMICS APPROACH
HARI B. HABLANI (Rockwell International Corp , Seal Beach, CA) Feb 1992 10 p refs
Copyright

A92-21164 North Carolina State Univ , Raleigh
LIGHT IMPULSIVE DAMPING OF SPACECRAFT EXHIBITING NORMAL MODE BEHAVIOR
LARRY SILVERBERG (North Carolina State University, Raleigh) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol 15, Jan -Feb 1992, p. 114-120 Feb 1992 7 p refs
(Contract NAGW-1331, NAG1-977)
Copyright

This paper develops an impulsive damping control algorithm suitable for spacecraft The fuel optimal solutions to the problem of damping the motion of spacecraft consists of impulsive control forces applied at repeated instances in time The instances in time occur when the spacecraft undergoes maximum absolute velocities and minimum absolute displacements This paper approximates impulses by short duration pulses Maximum absolute velocities and minimum absolute displacements are then approximated by transient values of their respective standard deviations Impulsive damping is achieved by applying either a large single pulse or smaller repeated pulses A near fuel optimal mode preserving impulsive damping control algorithm is developed next The algorithm exhibits the following properties (1) the impulsive damping control algorithm is independent of spacecraft stiffness, (2) the associated control forces are proportional to spacecraft inertia, and (3) the impulsive damping control algorithm is decentralized The impulsive damping of a cantilever beam demonstrates the results Author

A92-21187
USE OF THE WORK-ENERGY RATE PRINCIPLE FOR DESIGNING FEEDBACK CONTROL LAWS

S. R. VADALI, J. L. JUNKINS (Texas A & M University, College Station), and H.-S. OH Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 15, Jan.-Feb. 1992, p. 275-277. Feb. 1992 3 p refs
Copyright

For a class of physical systems, it is presently shown that feedback control laws are naturally obtained from the system dynamics via the work-energy rate principle. The method is applicable to a wide variety of linear/nonlinear and discrete/continuous systems. By obtaining the time derivative of the Liapunov function without substituting the equations of motion, control-design efforts can be drastically reduced. Two illustrative examples are given. O.C.

A92-21189
STABILIZING CONTROL FOR SECOND-ORDER MODELS AND POSITIVE REAL SYSTEMS
JUDITH D. GARDINER (Ohio State University, Columbus) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 15, Jan.-Feb. 1992, p. 280-282. Feb. 1992 3 p refs
(Contract NSF ECS-90-09483)
Copyright

Some stability properties of second-order models are presently established, in conjunction with an easily computed stabilizing control law. The results thus obtained bear on the concept of a positive real system, for which it is also demonstrated that negative-output feedback with any positive definite gain matrix satisfies a linear-quadratic optimality criterion. O.C.

A92-21639
MOTION OF A SATELLITE WITH FLEXIBLE VISCOELASTIC BOOMS IN A NONCENTRAL GRAVITATIONAL FIELD [DVIZHENIE SPUTNIKA S GIBKIMI VIAZKOUPRUGIMI STERZHNIAMI V NETSENTRAL'NOM POLE TIAGOTENIIA]
A. V. SHATINA Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, Nov.-Dec. 1991, p. 815-821. In Russian. Dec. 1991 7 p In RUSSIAN refs
Copyright

The motion of an artificial satellite having the form of a plane disk with rigid and viscoelastic booms in the gravitational field of an asymmetric planet is investigated. The equations of satellite motion are derived by means of averaging in Delaunay's canonical variables. L.M.

A92-21641
STABILIZATION OF A SATELLITE WITH FLEXIBLE RODS. II [O STABILIZATSII SPUTNIKA S GIBKIMI STERZHNIAMI. II]
S. I. ZLOCHEVSKII and E. P. KUBYSHKIN Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, Nov.-Dec. 1991, p. 828-839. In Russian. Dec. 1991 12 p In RUSSIAN refs
Copyright

The paper examines the stabilization of the angular position of a satellite with two flexible rods with respect to its center of mass using jet engines, taking the entire frequency spectrum of the flexible rods into account. The rod material is considered to be viscoelastic. An analysis is made of the stability region of the stabilization system in the feedback-coefficient space. Two models for the rod viscoelasticity are considered: the Foecht model and the linear model of hereditary viscoelasticity. L.M.

A92-21642
ATTITUDE CONTROL SYSTEM WITH A NONLINEAR CORRECTING DEVICE FOR A FLEXIBLE SPACECRAFT [SISTEMA ORIENTATSII DEFORMIRUEMOGO KOSMICHESKOGO APPARATA S NELINEINYM KORREKTIRUIUSHCHIM USTROISTVOM]
G. IA. LEDENEV Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, Nov.-Dec. 1991, p. 840-848. In Russian. Dec. 1991 9 p In RUSSIAN refs
Copyright

It is shown that stable control of a flexible spacecraft can be achieved through proper selection of the parameters of the nonlinear correcting device. System stability conditions are found which make it possible to determine the parameters of the correcting device and the controller. Compared to a system without a nonlinear correcting device, this attitude control system preserves stability for the case of significantly large amplitudes of the angular velocity of the elastic oscillations. L.M.

A92-22858* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DAMPING AND VIBRATION CONSIDERATIONS FOR THE DESIGN OF OPTICAL SYSTEMS IN A LAUNCH/SPACE ENVIRONMENT
RALPH M. RICHARD (Arizona, University, Tucson) IN: Cryogenic optical systems and instruments IV; Proceedings of the Meeting, San Diego, CA, July 10-12, 1990 1990 14 p refs
(Contract NCC2-426)
Copyright

Engineering philosophies for the design of optical systems launched into space and operating in a vacuum or cryovacuum environment are reviewed. Particular attention is given to sources of energy dissipation which are usually lumped under a single modal parameter denoted as the equivalent viscous damping coefficient. Caging and/or damping system components or application of viscoelastic materials and/or dry friction devices are considered to be alternative methods for stabilizing instruments sensitive to motion. O.G.

A92-23431
INVESTIGATION OF AN AUTOMATIC ATTITUDE CONTROL SYSTEM FOR ORBITAL STATIONS [IZSLEDVANE NA SISTEMI ZA AVTOMATICHNO UPRAVLENIE NA ORIENTATSIIATA NA ORBITALNI STANTSII]
KH. ZH. PETEV (Institut Elektron, Pleven, Bulgaria) Aerokosmicheski Izsledvaniia v B'lgaria (ISSN 0861-1432), vol. 7, 1991, p. 61-65. In Bulgarian. 1991 5 p In BULGARIAN refs
Copyright

Systems for attitude control using an instantaneous magnetic actuator with three control algorithms are discussed. The first algorithm is characteristic for a constant-structure linear control system representing a fixed focus or unit. For the control of the second algorithm, a sliding mode between two constant structures differing qualitatively is organized, i.e., focus or unit and saddle. The third control algorithm provides a sliding mode with minimum control-effect change, and sliding is realized between two unstable qualitatively similar structures, i.e., saddles. P.D.

•

A92-24664
SHAPE DETERMINATION FOR LARGE FLEXIBLE SATELLITES VIA STEREO VISION
D. N. C. TSE and G. R. HEPPLER (Waterloo, University, Canada) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 29, Jan.-Feb. 1992, p. 108-116. Feb. 1992 9 p refs
Copyright

The use of stereo vision to determine the deformed shape of an elastic plate is investigated. The quantization error associated with using discrete charge coupled device camera images for this purpose is examined. An upper bound on the error is derived in terms of the stationary configuration parameters. An expression for the average (root mean square) error is also developed. The issue of interpolating the shape of the plate through erroneous data is addressed. The vibratory mode shapes are used as interpolation functions and two cases are considered: the case when the number of interpolation points (targets) is the same as the number of modes used in the interpolation, and the case when the number of targets exceeds the number of the modes used. Error criteria are established for both cases and they provide a means of establishing the best fit to the measured data.
Author

A92-24815
HYBRID ADAPTIVE CONTROL OF SPACE STATION
PINGAN BAO and ZHONGJUN ZHANG (Shanghai Jiao Tong University, People's Republic of China) Chinese Society of

Astronautics, Journal (ISSN 1000-1328), no. 3, 1991, p. 31-38. In Chinese. 1991 8 p In CHINESE refs

The left factorization model of transfer function matrix or a two-panel space station is derived. Based on this model, a pole assignment hybrid adaptive control scheme for the station has been proposed and illustrated to be effective and robust through computer simulation results. Author

A92-25507
A NEW CONTROL TECHNIQUE BASED ON THE LAC/HAC CONCEPT FOR FLEXIBLE STRUCTURES
SHINJI HOKAMOTO and NORIHIRO GOTO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 39, no. 455, 1991, p. 686-693. In Japanese. 1991 8 p In JAPANESE refs

In this paper a new control technique based on the LAC/HAC concept is proposed to suppress the vibration of flexible space structures. The new technique employs the mechanism to turn on or off the HAC part of the LAC/HAC system in such a manner as to suppress the spillover effects as quickly as possible. The control system designed by the new technique has global stability and is more effective than a pure LAC system, even when an ordinary LAC/HAC system results in failure because of spillover instability. To show the characteristic features of the new technique and how to implement the system, computer simulation examples are given. Finally, the technique is applied to the transversal vibration control of a cantilever beam to show its effectiveness and practicality. Author

A92-25579
ACTIVE VIBRATION CONTROL DURING DEPLOYMENT OF SPACE STRUCTURES
K. KRISHNAMURTHY and M.-C. CHAO (Missouri-Rolla, University, Rolla) Journal of Sound and Vibration (ISSN 0022-460X), vol. 152, Jan. 22, 1992, p. 205-218. 22 Jan. 1992 14 p refs
Copyright

Active vibration control during deployment of the NASA Solar Array Flight Experiment (SAFE) structure is considered. The equations of motion of the SAFE structure are derived using Hamilton's principle. The approach to damp out the deployment-induced vibration is to use a force actuator located at the tip of the structure. Two different control strategies are investigated. In the first, the deployment-induced vibration is actively controlled from 70 percent to 100 percent deployment. In the second, the force actuator is turned on for a short period of time when the deployment reaches 70 and 100 percent. Both strategies make use of the linear regulator theory with a prescribed degree of stability. Simulated results presented show that both strategies damp out the deployment-induced vibration effectively. However, the second control system is simpler to design and implement and is, therefore, a more practical choice. Author

A92-25881
MODAL CONTROL OF LARGE FLEXIBLE SPACE STRUCTURES USING COLLOCATED ACTUATORS AND SENSORS
JIN LU, JAMES S. THORP, and HSIAO-DONG CHIANG (Cornell University, Ithaca, NY) IEEE Transactions on Automatic Control (ISSN 0018-9286), vol. 37, Jan. 1992, p. 143-148. Research supported by USAF and K.C. Wong Educational Foundation of Hong Kong. Jan. 1992 6 p refs
Copyright

The authors consider the problem of assigning the eigenvalues associated with critical modes of a large flexible space structure into a specified region in the left-half plane via direct velocity feedback control (DVFC) using collocated actuators and sensors. Conditions for the existence of a DVFC using collocated actuators and sensors that can achieve the eigenvalue assignment are derived. When there exist nonunique feasible DVFCs, the one with least Frobenius norm feedback gain is determined. An experimental four-bay truss is used to illustrate the results. I.E.

A92-26434
VARIATIONAL PRINCIPLE FOR SHAPE DESIGN SENSITIVITY ANALYSIS
JASBIR S. ARORA and J. B. CARDOSO (Iowa, University, Iowa City) Feb. 1992 10 p refs
(Contract NSF MSM-89-13218)
Copyright

A92-27672
ADAPTIVE STRUCTURES RESEARCH AT ISAS - 1984-1990
KORYO MIURA (Institute of Space and Astronautical Science, Sagamihara, Japan) Journal of Intelligent Material Systems and Structures (ISSN 1045-389X), vol. 3, Jan. 1992, p. 54-74. Jan. 1992 21 p refs
Copyright

This article reviews the research and development on adaptive structures and intelligent structural systems done by the structures and structural dynamic group at the Institute of Space and Astronautical Science (ISAS) from 1984 to 1990. Activity is closely linked to the practical needs for actively controlled structures on board scientific satellites and interplanetary vehicles which ISAS launches annually. The subjects described are: the proposal of novel structural concepts such as the variable geometry truss, the adaptive structure and the tension truss antenna; the proposal of vibration control schemes for flexible structures and the shape control scheme for precision antenna reflectors; and the study on construction of large space structures by assembling adaptive structures. Author

A92-28057
EFFECT OF STRUCTURAL DAMPING ON FLUTTER OF PLATES WITH A FOLLOWER FORCE
KEN HIGUCHI (Tokyo Denki University, Saitama, Japan) and EARL H. DOWELL (Duke University, Durham, NC) Mar. 1992 6 p refs
Copyright

A92-28129
CONTROL OF FLEXIBLE SPACECRAFT WITH TIME-VARYING CONFIGURATION
LEONARD MEIROVITCH and MOON K. KWAK (Virginia Polytechnic Institute and State University, Blacksburg) Apr. 1992 11 p refs
(Contract F49620-89-C-0049)
Copyright

A92-28130
ADAPTIVE CONTROL APPLIED TO MOMENTUM UNLOADING USING THE LOW EARTH ORBITAL ENVIRONMENT
T. F. BURNS (TRW, Inc., Space and Technology Group, Redondo Beach, CA) and H. FLASHNER (Southern California, University, Los Angeles, CA) Apr. 1992 9 p refs
Copyright

A92-28131
EFFECT OF MODEL ERROR ON SENSOR PLACEMENT FOR ON-ORBIT MODAL IDENTIFICATION OF LARGE SPACE STRUCTURES
DANIEL C. KAMMER (Wisconsin, University, Madison) Apr. 1992 8 p refs
Copyright

A92-28132* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ROBUST MOMENTUM MANAGEMENT AND ATTITUDE CONTROL SYSTEM FOR THE SPACE STATION
IHNSEOK RHEE and JASON L. SPEYER (Texas, University, Austin) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 15, Mar.-Apr. 1992, p. 342-351. Research supported by NASA. Previously announced in STAR as N91-20202. Apr. 1992 10 p refs
Copyright

A game theoretic controller is synthesized for momentum management and attitude control of the Space Station in the

presence of uncertainties in the moments of inertia. Full state information is assumed since attitude rates are assumed to be very accurately measured. By an input-output decomposition of the uncertainty in the system matrices, the parameter uncertainties in the dynamic system are represented as an unknown gain associated with an internal feedback loop (IFL). The input and output matrices associated with the IFL form directions through which the uncertain parameters affect system response. If the quadratic form of the IFL output augments the cost criterion, then enhanced parameter robustness is anticipated. By considering the input and the input disturbance from the IFL as two noncooperative players, a linear-quadratic differential game is constructed. The solution in the form of a linear controller is used for synthesis. Inclusion of the external disturbance torques results in a dynamic feedback controller which consists of conventional PID (proportional integral derivative) control and cyclic disturbance rejection filters. It is shown that the game theoretic design allows large variations in the inertias in directions of importance. Author

A92-28134
TIME-OPTIMAL SLEWING OF FLEXIBLE SPACECRAFT
JOSEPH BEN-ASHER, JOHN A. BURNS, and EUGENE M. CLIFF (Virginia Polytechnic Institute and State University, Blacksburg) (IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Vol. 1, p. 524-528) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 15, Mar.-Apr. 1992, p. 360-367. Research supported by DARPA and SDIO. Previously cited in issue 13, p. 2154, Accession no. A88-34736. Apr. 1992 8 p refs
(Contract AF-AFOSR-85-0287; F49620-87-C-0116; F49620-87-C-0088)
Copyright

A92-28135* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SENSITIVITY OF THE TRANSMISSION ZEROS OF FLEXIBLE SPACE STRUCTURES
TREVOR WILLIAMS (Cincinnati, University, OH) and JER-NAN JUANG (NASA, Langley Research Center, Hampton, VA) Apr. 1992 8 p refs
Copyright

A92-28138
ACTIVE DAMPING BY A LOCAL FORCE FEEDBACK WITH PIEZOELECTRIC ACTUATORS
ANDRE PREUMONT, JEAN-PAUL DUFOUR, and CHRISTIAN MALEKIAN (Bruxelles, Universite Libre, Brussels, Belgium) Apr. 1992 6 p refs
Copyright

A92-28144
WAVE-ABSORBING CONTROL FOR FLEXIBLE STRUCTURES WITH NONCOLLOCATED SENSORS AND ACTUATORS
HIRONORI FUJII, TOSHIYUKI OHTSUKA, and TSUTOMO MURAYAMA (Tokyo Metropolitan Institute of Technology, Hino, Japan) Apr. 1992 9 p refs
Copyright

A92-28145
PARAMETER SENSITIVITY REDUCTION IN FIXED-ORDER DYNAMIC COMPENSATION
ANTHONY J. CALISE and EDWARD V. BYRNS, JR. (Georgia Institute of Technology, Atlanta) Apr. 1992 8 p refs
(Contract DAAL03-88-C-0003)
Copyright

A92-28147
REDUCED-BANDWIDTH COMPENSATOR DESIGN VIA CONTROL AND OBSERVATION NORMALIZATION
JOHN R. SESAK and KRISTIN M. STRONG (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Apr. 1992 4 p refs
Copyright

A92-28158
DEPLOYMENT OF A FLEXIBLE BEAM FROM AN OSCILLATING BASE
NELSON G. CREAMER (Swales and Associates, Inc., Beltsville, MD) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 15, Mar.-Apr. 1992, p. 527-529. Apr. 1992 3 p refs
Copyright

The dynamic interaction of a flexible appendage and its deployment mechanism may result in large flexural deformations and possible damage to the deploying boom, as was observed during deployment and retraction of the Shuttle-based solar array flight experiment. These structural deformations are attributed to a resonant interaction of the instantaneous appendage natural frequencies and a slight oscillatory motion within the deployment mechanism. This resonant interaction is examined here using Timoshenko beam theory in conjunction with base oscillatory motion. C.D.

A92-28163
MODEL ORDER EFFECTS ON THE TRANSMISSION ZEROS OF FLEXIBLE SPACE STRUCTURES
TREVOR WILLIAMS (Cincinnati, University, OH) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 15, Mar.-Apr. 1992, p. 540-543. Apr. 1992 4 p refs
Copyright

It is shown that the zeroes of finite-dimensional models for a flexible structure with compatible sensors and actuators exhibit precisely the same Rayleigh-Ritz convergence properties as do the poles of such models. In particular, the model zeroes always converge monotonically from above to the true values, with the low-frequency zeroes being the first to converge. If noncollocated sensors and actuators are used, the fundamental zeroes still converge fastest, but monotonicity is no longer guaranteed. These results are illustrated by a cantilever beam example. C.D.

A92-29062
COMPLICATED DYNAMICS IN SPACECRAFT ATTITUDE CONTROL SYSTEMS
GEORGE E. PIPER (General Electric Co., Astro-Space Div., Princeton, NJ) and HARRY G. KWATNY (Drexel University, Philadelphia, PA) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 1 1991 6 p refs
Copyright

It is shown that a commonly used momentum exchange spacecraft attitude control configuration gives rise to complex nonlinear behavior involving multiple limit cycles and strange attractors. However, if the momentum wheel assembly performance parameters are adequately matched to the spacecraft it is possible to achieve a globally stable equilibrium. The results are based on the analysis of a simple single-axis problem. I.E.

A92-29069
ON MULTIPLE-OBJECTIVE DESIGN OPTIMIZATION BY GOAL METHODS
JIGUAN G. LIN (Control Research Corp., Lexington, MA) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 1 1991 2 p refs
Copyright

Goal methods have a common drawback of mistaking inferior solutions to be the optimal solutions of the original multiple-objective problem. One possible way to improve the goal-attainment method is to check the Pareto optimality of the solutions. Alternatively, a new method, or an improved goal-attainment method, is needed such that the resulting solutions are automatically Pareto optimal as well as closest possible to the set goals. I.E.

A92-29092* National Aeronautics and Space Administration, Washington, DC.
THE PROCESS OF CONTROL DESIGN FOR THE NASA LANGLEY MINIMAST STRUCTURE

GARY J. BALAS (Minnesota, University, Minneapolis), PETER YOUNG, and JOHN C. DOYLE (California Institute of Technology, Pasadena) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 1 1991 6 p refs
Copyright

The design process used to select sensors for feedback and performance weights on the Minimast facility is discussed. Initially, a series of controllers are synthesized using H2 optimal control techniques for the given structural model, a variety of sensor locations and performance criteria to determine the best displacement sensor and/or accelerometers to be used for feedback. Upon selection of the sensors, controllers are formulated to determine the affect of using a reduced-order model of the Minimast structure instead of the higher-order structural analysis model for control design and the relationship between the actuator torque level and the closed-loop performance. Based on this information, controllers are designed using micro-synthesis techniques and implemented on the Minimast structure. Results of the implementation of these controllers on the Minimast experimental facility are presented. I.E.

A92-29161
FEEDBACK LINEARIZATION AND CONTROL OF NASA SCOLE SYSTEM BY OUTPUT FEEDBACK
MISBAHUL AZAM, SAHJENDRA N. SINGH, ASHOK IYER (Nevada, University, Las Vegas), and Y. P. KAKAD (North Carolina, University, Charlotte) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 1 1991 6 p refs
Copyright

The question of large rotation maneuver and vibration stabilization of NASA Spacecraft Control Laboratory Experiment system (SCOLE) is addressed. The mathematical model of SCOLE system includes the dynamical equations for rigid body slew maneuver and three-dimensional vibration of the rigid shuttle, the flexible beam, and the reflector with an offset mass. The design approach taken is to decompose the rigid model control from vibration stabilization. The feedback input (Shuttle torque)-output (attitude angles) map linearization technique is used for designing attitude control system for large-angle slewing. Linearization of the input-output map is accomplished by nonlinear inversion theory. It is shown that attitude control system asymptotically decouples the flexible dynamics and a linear feedback law is easily designed for vibration suppression. For the synthesis of the control law an observer is designed. I.E.

A92-29191* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A COMPARISON OF CONTROLLER DESIGNS FOR AN EXPERIMENTAL FLEXIBLE STRUCTURE
K. B. LIM, P. G. MAGHAMI, and S. M. JOSHI (NASA, Langley Research Center, Hampton, VA) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 2 1991 10 p refs
Copyright

Control systems design and hardware testing are addressed for an experimental structure that displays the characteristics of a typical flexible spacecraft. The results of designing and implementing various control design methodologies are described. The design methodologies under investigation include linear quadratic Gaussian control, static and dynamic dissipative controls, and H-infinity optimal control. Among the three controllers considered, it is shown, through computer simulation and laboratory experiments on the evolutionary structure, that the dynamic dissipative controller gave the best results in terms of vibration suppression and robustness with respect to modeling errors. I.E.

A92-29202
SUBOPTIMAL CONTROL OF FLEXIBLE STRUCTURES WITH CLEARANCES IN THE CONNECTING JOINTS
ALDO A. FERRI and GREGORY P. LINK (Georgia Institute of Technology, Atlanta) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 2 1991 7 p refs
(Contract NSF MSM-87-07846)
Copyright

An examination is made of the effects of clearances on the performance of a linear state-feedback and estimated state-feedback control design. The control laws are designed using linear quadratic optimal control theory and using a linear plant model. The closed-loop behavior of the linear plant is compared to that of the nonlinear plant under the action of the same control laws. It is seen that, relative to the linear plant, clearances can have detrimental or beneficial effects on the closed-loop performance depending on the nature of the clearances and depending on the system initial conditions. I.E.

A92-29208* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
OPTIMAL SIMULTANEOUS CONTROL AND STRUCTURE DESIGN
YWH-PYNG HARN, GUENTEKIN M. KABULI, and ROBERT L. KOSUT (*Integrated Systems, Inc., Santa Clara, CA*) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 2 1991 6 p refs
(Contract NAS1-19096)
Copyright

Optimization-based control/structure design methodologies are presented for large space structures with the H2 cost function. The order and/or structure of the compensator can be chosen in advance. It is assumed that the compensator parameters can vary freely, but the structural parameters are constrained. In addition, the CSI model is presented. The problem is stated, and algorithms are developed in MATRIXx software. Finally, the tools that are developed are tested using an 11-beam truss example. I.E.

A92-29210
THE OPTIMAL MIX OF PASSIVE AND ACTIVE CONTROL IN STRUCTURES
M. J. SMITH, K. M. GRIGORIADIS, and R. E. SKELTON (Purdue University, West Lafayette, IN) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 2 1991 6 p refs
Copyright

An examination is presented of the redesign of a structure to make it easier to control. Beginning with any active controller, the treatment consists of dividing this controller into two parts: one that can be synthesized simply by structure redesign (called the passive control) and one that is synthesized as an active controller. Given that the total closed-loop response must not be changed from the ideal, the passive part of the controller is designed so as to minimize the amount of control power needed for the active part. Necessary and sufficient conditions for a globally optimum structure are given, and gradient calculations are not required. The algorithm converges to the globally optimum in a finite number of iterations. I.E.

A92-29211* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INTEGRATED CONTROLS-STRUCTURES DESIGN - A PRACTICAL DESIGN TOOL FOR MODERN SPACECRAFT
P. G. MAGHAMI, S. M. JOSHI, and K. B. LIM (NASA, Langley Research Center, Hampton, VA) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 2 1991 9 p refs
Copyright

An integrated controls-structures design approach is developed for a class of flexible spacecraft. The integrated design problem is posed in the form of simultaneous optimization of both the structural and the control design variables. The approach is demonstrated by application to the integrated design of a geostationary platform and to a ground-based flexible structure experiment. The numerical results obtained indicate that the integrated design approach can yield spacecraft designs that have substantially superior performance over the conventional design

approach wherein the structural design and control design are performed sequentially. I.E.

A92-29251* National Aeronautics and Space Administration, Washington, DC.
SOME EXPERIENCE WITH IDENTIFICATION OF THE CALTECH EXPERIMENTAL SPACE STRUCTURE
A. N. MOSER and T. K. CAUGHEY (California Institute of Technology, Pasadena) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 2 1991 6 p refs
Copyright
It is shown that identification of modes with practically the same frequency but with different mode shapes can be carried out in experimental settings. Using multiple-input multiple-output data, distinct modes whose FRFs (frequency response functions) appear as single peaks can be distinguished from their input and output weights. When the peak is modeled with a single mode, some input/output channels may have good peaks, but others will not. Addition of more modes and use of multiple input data result in good fits for all channels if the system behaves in a linear modal manner. I.E.

A92-29265
DESIGN OF H(INFINITY) CONTROLLER FOR A LIGHTLY DAMPED SYSTEM USING A BILINEAR POLE SHIFTING TRANSFORM
R. Y. CHIANG and M. G. SAFONOV (Southern California, University, Los Angeles, CA) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 2 1991 2 p refs
Copyright
An H(infinity) control law design is presented for a benchmark problem consisting of an undamped pair of spring-coupled masses with a sensor and actuator which are not co-located. This simple mechanical system captures many of the salient features of more complex aircraft and space structure vibration control problems. The H(infinity) problem formulation enables the issue of stability robustness in the face of large mass and spring constant variation to be directly addressed. Constraints on closed-loop dominant pole locations and settling time are accommodated via a simple s-plane bilinear transform. I.E.

A92-29328
TRANSMISSION ZEROS OF FLEXIBLE SPINNING SPACECRAFT
TREVOR WILLIAMS (Cincinnati, University, OH) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 3 1991 2 p refs
Copyright
It is shown that the transmission zeros of flexible spinning spacecraft exhibit properties entirely analogous to those of undamped, nonspinning flexible space structures. Thus, the extensive results concerning the zeros in the undamped case (relationships to the poles, sensitivities, computation) apply without change to the zeros of spinning flexible aircraft. I.E.

A92-29329
A CONTROL FORMULATION FOR VIBRATION ABSORBERS
T. A. POSBERGH (Minnesota, University, Minneapolis), M. S. TRIMBOLI (U.S. Air Force Academy, Colorado Springs, CO), and J. P. DUKE (USAF, Frank J. Seiler Research Laboratory, Colorado Springs, CO) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 3 1991 2 p refs
(Contract F49620-88-C-0053)
Copyright
The problem of multiple passive damping of large flexible space structures is addressed by reformulating the classical Den Hartog absorber problem as a feedback control problem. With this reformulation recent algorithms developed for H(infinity) control problems can be applied to determine the optimal tuning of the damping devices. Extensions to multiple degree of freedom systems are straightforward. I.E.

A92-29363* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
IDENTIFICATION AND CONTROL OF NASA'S ACES STRUCTURES
K. LIU and R. E. SKELTON (Purdue University, West Lafayette, IN) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 3 1991 7 p refs
(Contract NAG1-958)
Copyright
Results are presented of identification and control experiments on NASA's ACES structure at the Marshall Space Flight Center. The models used for controller design were obtained from identification experiments employing the algorithm Q-Markov cover. The OVC algorithm used for control design produces a controller minimizing the control energy of the closed-loop system, subject to inequality constraints on each of the output variances. The identified model matches the experimental data for the ACES structure reasonably well. The line of sight pointing errors of the structure are substantially reduced by the controllers. I.E.

A92-29365* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
VARIANCE AND BIAS COMPUTATIONS FOR IMPROVED MODAL IDENTIFICATION USING ERA/DC
RICHARD W. LONGMAN (Columbia University, New York), JIANN-SHIUN LEW (Old Dominion University, Norfolk, VA), DONG-HUEI TSENG (Columbia University, New York), and JER-NAN JUANG (NASA, Langley Research Center, Hampton, VA) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 3 1991 6 p refs
(Contract NAG1-649; NAG1-1117)
Copyright
Variance and bias confidence criteria were recently developed for the eigensystem realization algorithm (ERA) identification technique. These criteria are extended for the modified version of ERA based on data correlation, ERA/DC, and also for the Q-Markov cover algorithm. The importance and usefulness of the variance and bias information are demonstrated in numerical studies. The criteria are shown to be very effective not only by indicating the accuracy of the identification results, especially in terms of confidence intervals, but also by helping the ERA user to obtain better results by seeing the effect of changing the sample time, adjusting the Hankel matrix dimension, choosing how many singular values to retain, deciding the model order, etc. I.E.

A92-29366* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DISTRIBUTED PARAMETER ESTIMATION FOR NASA MINI-MAST TRUSS USING TIMOSHENKO BEAM MODEL
JI-YAO SHEN, JEN-KUANG HUANG (Old Dominion University, Norfolk, VA), and LAWRENCE W. TAYLOR, JR. (NASA, Langley Research Center, Hampton, VA) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 3 1991 2 p refs
Copyright
A more accurate Timoshenko beam model is used to characterize the bending behavior of the truss. A maximum likelihood estimator for the Timoshenko beam model has been formulated. A closed-form solution of the Timoshenko beam equation, for a uniform cantilevered beam with two concentrated masses, is derived so that the procedure for the estimation of modal characteristics is much improved. The updated model to the NASA Mini-Mast test data is demonstrated. I.E.

A92-29367* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
FREQUENCY DOMAIN IDENTIFICATION FOR ROBUST LARGE SPACE STRUCTURE CONTROL DESIGN
Y. YAM, D. S. BAYARD, and R. E. SCHEID (JPL, Pasadena, CA) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 3 1991 3 p refs
Copyright
A methodology is demonstrated for frequency domain

identification of large space structures which systematically transforms experimental raw data into a form required for synthesizing H(infinity) controllers using modern robust control design software (e.g., Matlab Toolboxes). A unique feature of this approach is that the additive uncertainty is characterized to a specified statistic confidence rather than with hard bounds. In this study, the difference in robust performance is minimal between the two levels of confidence. In general cases, the present methodology provides a tool for performance/confidence level tradeoff studies. For simplicity, the additive uncertainty on a frequency grid is considered and the interpolation error in between grid points is neglected. I.E.

A92-29370* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
H2-OPTIMAL CONTROL WITH GENERALIZED STATE-SPACE MODELS FOR USE IN CONTROL-STRUCTURE OPTIMIZATION
MATT WETTE (JPL, Pasadena, CA) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 3 1991 2 p refs
Copyright

Several advances are provided solving combined control-structure optimization problems. The author has extended solutions from H2 optimal control theory to the use of generalized state space models. The generalized state space models preserve the sparsity inherent in finite element models and hence provide some promise for handling very large problems. Also, expressions for the gradient of the optimal control cost are derived which use the generalized state space models. I.E.

A92-29519
A FEATURE OF THE MISSION-FUNCTION CONTROL
HIRONORI FUJII Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 40, no. 457, 1992, p. 103-110. In Japanese. 1992 8 p In JAPANESE refs

A feature of the mission-function (MF) control is studied. The MF control is a control algorithm compatible with the fundamentals of mechanics of flexible structures and employs the mission function. The mission function is a Liapunov function which includes such mechanical information of the system as the Hamiltonian and also a generalized energy to improve the performance of the controller. This paper presents the necessary conditions for the MF control in a general form. Another purpose of the paper is to present a feature belonging to the MF control, namely, that application of the control algorithm reduces to the design of an optimal regulator for the flexible structural system. Two examples for application of the MF control are shown through the use of the numerical simulation. Author

A92-30660
MINIMIZING DISTORTION AND INTERNAL FORCES IN TRUSS STRUCTURES VIA SIMULATED ANNEALING
R. K. KINCAID (College of William and Mary, Williamsburg, VA) Structural Optimization (ISSN 0934-4373), vol. 4, March 1992, p. 55-61. Mar. 1992 7 p refs
Copyright

Inaccuracies in the length of members and the diameters of joints of large space structures may produce unacceptable levels of surface distortion and internal forces. Two discrete optimization problems, one to minimize surface distortion (DRMS) and the other to minimize internal forces (FRMS), are formulated. Both of these problems are based on the influence matrices generated by a small deformation linear analysis. Good solutions are obtained for DRMS and FRMS through the use of a simulated annealing heuristic. Results based on two biobjective (DRMS and FRMS) optimization models are discussed. Author

A92-30694* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INTEGRATED CONTROLS-STRUCTURES OPTIMIZATION OF A LARGE SPACE STRUCTURE
S. L. PASULA (NASA, Langley Research Center, Hampton, VA), C. A. SANDRIDGE (Virginia Polytechnic Institute and State University, Blacksburg), J. L. WALSH (NASA, Langley Research Center, Hampton, VA), and R. T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg) Computers and Structures (ISSN 0045-7949), vol. 42, March 3, 1992, p. 725-732. 3 Mar. 1992 8 p refs
(Contract NAG1-603)
Copyright

General-purpose control and structural codes are applied to a large detailed structural model including objective and constraint functions derived from actual design specifications. The approach is to divide the problem into a controls optimization step, a structural optimization step, and a system level coordination step. The objective is to minimize mass and power consumption with constraints on vibration characteristics, strength, and damping. This decomposition and optimization approach significantly enhances the design of a structure based on the COFS-I Mast Flight System, which is selected as a demonstration problem. R.E.P.

A92-31428
ROBUST LOW ORDER DYNAMIC CONTROLLER FOR FLEXIBLE SPACECRAFT
M. SEETHARAMA BHAT, A. G. SREENATHA, and S. K. SHRIVASTAVA (Indian Institute of Science, Bangalore, India) IEE Proceedings, Part D - Control Theory and Applications (ISSN 0143-7054), vol. 138, Sept. 1991, p. 460-468. Sep. 1991 9 p refs
Copyright

The design of an optimal low-order dynamic controller with a-shift (alpha-shift) for attitude control is attempted for a flexible satellite which is a solar electric propulsion spacecraft (SEPS). The satellite consists of a central rigid body to which two flexible solar panels are attached. The design of a third-order dynamic controller is accomplished using modified linear quadratic Gaussian theory. The improvement in the satellite attitude response with a small uniform alpha-shift is demonstrated by numerical simulation. A novel concept of block-shift is introduced to move different sets of closed-loop eigenvalues by different amounts. The advantages of this type of block-shift in the design of the controller are shown by simulation. The robustness of the controller with respect to parameter variations is shown to be ample. Author

A92-31575
CONTROL OF MOBILE LINKED FLEXIBLE SYSTEM
TOSHIO FUKUDA (Nagoya University, Japan), HIDEMI HOSOKAI, and AKIHIKO HIROTSU (Tokyo, Science University, Japan) JSME International Journal, Series III (ISSN 0914-8825), vol. 35, March 1992, p. 96-101. Mar. 1992 6 p refs
Copyright

Mobile control and vibration-damping methods are proposed for large space structures derived from the linking of flexible substructures; the control/damping system employs compressed-air jet nozzles at each of the structure's floating pads, as well as a dc motor at the linkage joint between adjacent structural elements. The system is modeled by a lumped-parameter system; the control method is applied to the present simulation in such a way that the flexible structure is entirely floated by the air-jet bearings at the joints, and reaction forces from the ground to the floating system are precluded. O.C.

A92-32188* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SENSOR PLACEMENT FOR ON-ORBIT MODAL TESTING
TAE W. LIM (Lockheed Engineering and Sciences Co., Hampton, VA) Apr. 1992 8 p refs
(Contract NAS1-19000)
Copyright

A92-32192* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PRACTICAL ASPECTS OF ON-ORBIT MODAL IDENTIFICATION USING FREE-DECAY DATA
AXEL SCHENK (DLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) and RICHARD S. PAPPA (NASA, Langley

Research Center, Hampton, VA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 29, Mar.-Apr. 1992, p. 264-270. Apr. 1992 7 p refs
Copyright

This paper discusses practical aspects of performing on-orbit modal identification using time domain analysis of free-decay data. The effects of environmental constraints, structural characteristics, excitation, and sensing are reviewed. In a recent laboratory application, an on-orbit experiment is simulated using a limited number of excitation and measurement points. The identified modal parameters correlate well, though not uniquely, with those obtained in a complete modal survey. Practical difficulties in performing the correlation are illustrated. Author

N92-10220*# Cleveland State Univ., OH. Dept. of Engineering Technology.
DEVELOPMENT OF A MODEL OF SPACE STATION SOLAR ARRAY Final Report, 15 Sep. 1989 - 15 Mar. 1990
PAUL A. BOSELA 15 Mar. 1990 228 p
(Contract NAG3-1008)
(NASA-CR-188911; NAS 1.26:188911) Avail: CASI HC A11/MF A03

Space structures, such as the space station solar arrays, must be extremely lightweight, flexible structures. Accurate prediction of the natural frequencies and mode shapes is essential for determining the structural adequacy of components, and designing a control system. The tension preload in the blanket of photovoltaic solar collectors, and the free/free boundary conditions of a structure in space, causes serious reservations on the use of standard finite element techniques of solution. In particular, a phenomena known as grounding, or false stiffening, of the stiffness matrix occurs during rigid body rotation. The grounding phenomena is examined in detail. Numerous stiffness matrices developed by others are examined for rigid body rotation capability, and found lacking. Various techniques are used for developing new stiffness matrices from the rigorous solutions of the differential equations, including the solution of the directed force problem. A new directed force stiffness matrix developed by the author provides all the rigid body capabilities for the beam in space. Author

N92-11018# Honeywell, Inc., Minneapolis, MN. Systems and Research Center.
NEW METHODS IN ROBUST CONTROL Final Draft Technical Report, Mar. 1988 - Aug. 1991
JOHN DOYLE, BLAISE MORTON, and MIKE ELGERSMA 14 Aug. 1991 86 p
(Contract F49620-88-C-0077)
(AD-A240221; HSRC-C910684; AFOSR-91-0740TR) Avail: CASI HC A05/MF A01

This report describes advances in robust control in three areas: Optimal H infinity control, singular values, and dynamic inversion. The H infinity results are a thorough treatment of the theory as it has been developed over the last three years. The structured singular value section describes an application of the technique to represent inertia parametric variations in the Space Station. The dynamic inversion section addresses global stability of aircraft pitch axis dynamics using a dynamic inversion control approach. This document is the first draft of the final report for the program New Methods in Robust Control. The emphasis of this program was to develop mathematical theory to help control system designers faced with challenging control problems associated with advanced aerospace vehicles. Relevant applications include flight control systems for new Air force fighter/bomber aircraft, the F-18 HARV research vehicle, the NASP vehicle, the next generation launch system (ALS or NLS), and the Space Station. GRA

N92-11080# Harris Corp., Melbourne, FL. Government Aerospace Systems Div.
OPUS: OPTIMAL PROJECTION FOR UNCERTAIN SYSTEMS. VOLUME 1 Final Report, 15 Oct. 1988 - 30 Sep. 1991
DENNIS S. BERNSTEIN and WASSIM M. HADDAD 1 Sep. 1991 368 p
(Contract F49620-89-C-0011)
(AD-A240372; AFOSR-91-0754TR) Avail: CASI HC A16/MF A03

The optimal projection for uncertain systems (OPUS) is a unified approach to control-system design and analysis for high-performance, multivariable applications such as large flexible space structures. The OPUS yields low-order, robust controllers that meet both time- and frequency-domain objectives. This final report discusses progress achieved during the previous three years in the areas of robust control, fixed-structure control, sampled-data control, tracking control, and nonlinear control. The appendices in this volume include reprints on the following topics: Optimal projection approach to robust fixed-structure control design; Combined L sub 2 H sub infinity model reduction; Robust stability and performance analysis for linear dynamic systems; Robust stability and performance via fixed-order dynamic compensation; Finite-dimensional approximation for optimal fixed-order compensation of distributed parameter systems; Minimal complexity control law synthesis; Singular linear-quadratic regulator problem; and the Goh-Riccati equation. GRA

N92-11081# Harris Corp., Melbourne, FL. Government Aerospace Systems Div.
OPUS: OPTIMAL PROJECTION FOR UNCERTAIN SYSTEMS, VOLUME 2 Final Report, 15 Oct. 1988 - 30 Sep. 1991
DENNIS S. BERNSTEIN and WASSIM M. HADDAD 1 Sep. 1991 425 p
(Contract F49620-89-C-0011)
(AD-A240373; AFOSR-91-0755TR) Avail: CASI HC A18/MF A04

The optimal projection for uncertain systems (OPUS) is a unified approach to control-system design and analysis for high-performance, multivariable applications such as large flexible space structures. The OPUS yields low-order, robust controllers that meet both time- and frequency-domain objectives. This final report discusses progress achieved during the previous three years in the areas of robust control, fixed-structure control, sampled-data control, tracking control, and nonlinear control. The appendices in this volume include reprints on the following topics: Controller design with regional pole constraints; Optimal output feedback for nonzero set point regulation; Inequalities for the trace of matrix exponentials; Reduced-order multirate estimation for stable and unstable plants; Nonquadratic cost and nonlinear feedback control; Some open problems in matrix theory arising in linear systems and controls; Small gain vs. positive real modeling of real parameter uncertainty; and Compartmental modeling and power flow analysis for state space systems. GRA

N92-11082# Naval Postgraduate School, Monterey, CA.
ATTITUDE CONTROL OF FLEXIBLE STRUCTURES M.S. Thesis
CHRISTINA C. WARD Sep. 1990 59 p
(AD-A240520) Avail: CASI HC A04/MF A01

The experimental set-up for laboratory study of spacecraft control/structural interaction have been designed. Design specifications have been derived, and all the actuators and sensors have been selected except the end-point displacement sensing of the arm. The mainbody and the flexible arm have been fabricated to meet design criteria. The equations of motion for the experimental model have been derived and natural frequencies determined. The natural frequencies of the flexible arm has been determined experimentally and compared with analytical predictions obtained by using the GIFTS finite element analysis program. The experimental and analytical results are in good agreement except the first mode. GRA

N92-11087*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MULTIDISCIPLINARY OPTIMIZATION OF CONTROLLED SPACE STRUCTURES WITH GLOBAL SENSITIVITY EQUATIONS
SHARON L. PADULA, BENJAMIN B. JAMES, PHILIP C. GRAVES (Vigyan Research Associates, Inc., Hampton, VA.), and STANLEY E. WOODARD Nov. 1991 39 p

(Contract RTOP 506-43-41-01)
(NASA-TP-3130; NAS 1.60:3130) Avail: CASI HC A03/MF A01

A new method for the preliminary design of controlled space structures is presented. The method coordinates standard finite element structural analysis, multivariable controls, and nonlinear programming codes and allows simultaneous optimization of the structures and control systems of a spacecraft. Global sensitivity equations are a key feature of this method. The preliminary design of a generic geostationary platform is used to demonstrate the multidisciplinary optimization method. Fifteen design variables are used to optimize truss member sizes and feedback gain values. The goal is to reduce the total mass of the structure and the vibration control system while satisfying constraints on vibration decay rate. Incorporating the nonnegligible mass of actuators causes an essential coupling between structural design variables and control design variables. The solution of the demonstration problem is an important step toward a comprehensive preliminary design capability for structures and control systems. Use of global sensitivity equations helps solve optimization problems that have a large number of design variables and a high degree of coupling between disciplines. Author

N92-11338*# Lockheed Engineering and Sciences Co., Hampton, VA.
ATTITUDE IDENTIFICATION FOR SCOLE USING TWO INFRARED CAMERAS Interim Report
JORAM SHENHAR Washington NASA Oct. 1991 64 p
(Contract NAS1-19000; RTOP 506-59-61-01)
(NASA-CR-4397; NAS 1.26:4397) Avail: CASI HC A04/MF A01

An algorithm is presented that incorporates real time data from two infrared cameras and computes the attitude parameters of the Spacecraft COntrol Lab Experiment (SCOLE), a lab apparatus representing an offset feed antenna attached to the Space Shuttle by a flexible mast. The algorithm uses camera position data of three miniature light emitting diodes (LEDs), mounted on the SCOLE platform, permitting arbitrary camera placement and an on-line attitude extraction. The continuous nature of the algorithm allows identification of the placement of the two cameras with respect to some initial position of the three reference LEDs, followed by on-line six degrees of freedom attitude tracking, regardless of the attitude time history. A description is provided of the algorithm in the camera identification mode as well as the mode of target tracking. Experimental data from a reduced size SCOLE-like lab model, reflecting the performance of the camera identification and the tracking processes, are presented. Computer code for camera placement identification and SCOLE attitude tracking is listed. Author

N92-11392*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SENSITIVITY OF SPACE STATION ALPHA JOINT ROBUST CONTROLLER TO STRUCTURAL MODAL PARAMETER VARIATIONS
RENJITH R. KUMAR, PAUL A. COOPER, and TAE W. LIM (Lockheed Engineering and Sciences Co., Hampton, VA.) Aug. 1991 12 p Presented at the AIAA Guidance, Navigation and Control Conference, 12-14 Aug. 1991 Previously announced in IAA as A91-49636
(Contract RTOP 590-14-31-02)
(NASA-TM-104153; NAS 1.15:104153) Avail: CASI HC A03/MF A01

The photovoltaic array sun tracking control system of Space Station Freedom is described. A synthesis procedure for determining optimized values of the design variables of the control system is developed using a constrained optimization technique. The synthesis is performed to provide a given level of stability margin, to achieve the most responsive tracking performance, and to meet other design requirements. Performance of the baseline design, which is synthesized using predicted structural characteristics, is discussed and the sensitivity of the stability margin is examined for variations of the frequencies, mode shapes and damping ratios of dominant structural modes. The design provides enough robustness to tolerate a sizeable error in the predicted modal parameters. A study was made of the sensitivity of performance indicators as the modal parameters of the dominant modes vary. The design variables are resynthesized for varying modal parameters in order to achieve the most responsive tracking performance while satisfying the design requirements. This procedure of reoptimization design parameters would be useful in improving the control system performance if accurate model data are provided. Author

N92-12038# Lawrence Livermore National Lab., CA.
HIERARCHICAL CONTROLLED COMPONENT SYNTHESIS OF LARGE SPACE STRUCTURES
K. D. YOUNG 1990 12 p Presented at the 11th International Federation of Automatic Control (IFAC) World Congress Conference, Tallinn, USSR, 13-17 Aug. 1990
(Contract W-7405-ENG-48)
(DE90-013476; UCRL-101639; CONF-9008118-1) Avail: CASI HC A03/MF A01

This paper describes a new framework called Controlled Component Synthesis for the design of multi-level decentralized for large flexible structures. In contrast to the existing decentralized control approach in which the design begins with a given dynamic model of the flexible structure, controlled components are built and assembled into a controlled flexible structure that meets performance specifications. A simple truss structural control problem is employed to illustrate the design procedures, as well as demonstrate the potentials of the developed method for controlling very large dimensional truss structures. DOE

N92-12042# Toronto Univ. (Ontario) Inst. for Aerospace Studies.
OPTIMAL CONTROL OF LARGE SPACE STRUCTURES USING DISTRIBUTED GYRICITY: A CONTINUUM APPROACH
CHRISTOPHER JOHN DAMAREN Oct. 1990 105 p
(ISSN 0082-5255)
(UTIAS-341; CTN-91-60252) Avail: CASI HC A06/MF A02

Continuum modeling is used for the analysis of large space structures (LSS) that employ a collection of control moment gyros (CMG's) for vibration control. The structure is modeled as a continuum in mass, stiffness, and gyricity (stored angular momentum) which is an effective model for lattice structures containing several small CMG's. A viscous damping model completes the dynamical description. In this model, a system of control moment gyros is replaced with the gyricity distribution (the density of stored angular momentum) and its associated distribution of gimbal angles. Point CMG's and the distributed analog are treated within the same framework. The latter description is interpreted as the limit of a sequence of point gyros. A first-order perturbation approach is presented for determining the changes in the modal characteristics due to light damping. The completeness properties of the damped, gyroelastic eigenfunctions are established, which permits the damped modal equations of motion to be derived. The introduction of an appropriate adjoint equation, which occurs naturally in optimal control problems, is instrumental in the analysis. Controllability and observability conditions for this class of structural model are found in terms of the modal information (frequencies and mode shapes). Author (CISTI)

N92-13140*# Astro Aerospace Corp., Carpinteria, CA.
CONCEPTS, ANALYSIS AND DEVELOPMENT FOR PRECISION DEPLOYABLE SPACE STRUCTURES
RICHARD K. MILLER, MARK THOMSON, and JOHN M. HEDGEPETH Jul. 1991 46 p
(Contract NAS1-18567; RTOP 506-43-41-02)
(NASA-CR-187622; NAS 1.26:187622; AAC-TN-1163) Avail: CASI HC A03/MF A01

Several issues surrounding the development of large Precision Segmented Reflector (PSR) designs are investigated. The concerns include nonlinear dynamics of large unruly masses such as the multi-layer thermal insulation of sunshades for instruments such as the precision pointing 20-m-diameter Large Deployable Reflector (LDR). A study of the residual oscillations after bang-bang reorientation maneuvers of a rigid satellite with a string appendage

is presented. Application is made to the design of a sunshade (thermal blanket) for the LDE satellite. Another concern is the development of a deployable truss that has minimum structural redundancy (such as the tetrahedral truss) and that can be configured with planar and doubly curved geometries. A kinematically synchronized articulation scheme for a deployable tetrahedral truss is presented. Called the Tetrapac, this truss is currently limited to a planar configuration that has two rings. The final concern is the development and demonstration of hardware that enables astronauts to attach large, cumbersome, and fragile precision reflector segments to an erectable truss structure. This task must be accomplished with a high degree of precision and with relative ease. A design for a Panel Attachment Device (PAD) was developed and manufactured for neutral buoyancy simulations to be performed by LaRC. Author

N92-13466# Wright Lab., Wright-Patterson AFB, OH.
PROCEEDINGS OF DAMPING 1991, VOLUME 1 Final Report, Feb. 1989 - Feb. 1991
Aug. 1991 393 p Conference held in San Diego, CA, 13-15 Feb. 1991
(Contract AF PROJ. 2401)
(AD-A241311; WL-TR-91-3078-VOL-1) Avail: CASI HC A17/MF A04

The topics covered include the following: viscoelastic material testing and characterization, passive damping concepts, passive damping analysis and design techniques, optimization, damped control/structure interaction, viscous dampers, friction damping, other vibration suppression techniques, damping identification and dynamic testing, applications to aircraft, space structures, marine structures, commercial products, defense applications, and payoffs of vibrational suppression. GRA

N92-13467# Wright Lab., Wright-Patterson AFB, OH.
PROCEEDINGS OF DAMPING 1991, VOLUME 2 Final Report, Feb. 1989 - Feb. 1991
Aug. 1991 560 p Conference held in San Diego, CA, 13-15 Feb. 1991
(Contract AF PROJ. 2401)
(AD-A241312; WL-TR-91-3078-VOL-2) Avail: CASI HC A24/MF A04

The topics covered include the following: viscoelastic material testing and characterization, passive damping concepts, passive damping analysis and design techniques, optimization, damped control/structure interaction, viscous dampers, friction damping, other vibration suppression techniques, damping identification and dynamic testing, applications to aircraft, space structures, marine structures, commercial products, defense applications, and payoffs of vibration suppression. GRA

N92-13860*# Kentucky Univ., Lexington. Dept. of Electrical Engineering.
FURTHER EVALUATION OF THE CONSTRAINED LEAST SQUARES ELECTROMAGNETIC COMPENSATION METHOD
WILLIAM T. SMITH *In* Old Dominion Univ., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1991 p 206-209 Sep. 1991
Avail: CASI HC A01/MF A03

Technologies exist for construction of antennas with adaptive surfaces that can compensate for many of the larger distortions caused by thermal and gravitational forces. However, as the frequency and size of reflectors increase, the subtle surface errors become significant and degrade the overall electromagnetic performance. Electromagnetic (EM) compensation through an adaptive feed array offers means for mitigation of surface distortion effects. Implementation of EM compensation is investigated with the measured surface errors of the NASA 15 meter hoop/column reflector antenna. Computer simulations are presented for: (1) a hybrid EM compensation technique, and (2) evaluating the performance of a given EM compensation method when implemented with discretized weights. Author

N92-13988# Toronto Univ., Downsview (Ontario). Inst. for Aerospace Studies.
SPACECRAFT DYNAMICS AND CONTROL
P. C. HUGHES, G. M. T. DELEUTERIO, G. B. SINCARSIN, V. PUGLIESE, T. CHERPILLOD, K. A. CARROLL, D. J. MCTAVISH, C. J. DAMAREN, G. W. CROCKER, T. HONG et al. *In its* Activities of the University of Toronto Institute for Aerospace Studies p 101-102 1989
Avail: CASI HC A01/MF A02

Progress in the study of spacecraft dynamics and control at the University of Toronto Institute for Aerospace Studies is reviewed. An upgrade to the Daisy Research Facility, designed to investigate control of flexible spacecraft, is underway. A multibus II real-time computer system, new reaction wheel controllers, and power amplifiers are being integrated into Daisy. The GHM (Golla, Hughes, McTavish) theory, a complete procedure for incorporating viscoelastic material properties into structural finite elements, is complete. This representation of material behavior provides a more realistic model of damping characteristics than current models and retains the matrix second order form of the equations of motion. Viscoelastic modulus data have been measured for use in a GHM finite element model of a truss structure. A study on the control of large space structures using a distribution of gyricity is complete. The resulting control systems are very successful in suppressing structural vibration. An analytical examination of the adverse effects of time delays introduced by a computer on the control of flexible space structures has been undertaken. Work aimed at reducing the order of both the structural model and the control system when controlling flexible structures is continuing. A technique has been developed in which balanced Grammian matrices provide the basis for deleting certain state variables associated with the controller. CISTI

N92-14088*# California Univ., Davis. Dept. of Mechanical, Aeronautical and Materials Engineering.
EFFECTIVENESS OF LARGE BOOMS AS NUTATION DAMPERS FOR SPIN STABILIZED SPACECRAFT
F. O. EKE *In* NASA. Goddard Space Flight Center, Flight Mechanics/Estimation Theory Symposium, 1991 p 321-331 Oct. 1991
Avail: CASI HC A03/MF A04

The issue of using long slender booms as pendulous nutation damping devices on spinning aircraft is discussed. Motivation comes from experience with the Galileo Spacecraft, whose magnetometer boom also serves as a passive nutation damper for the spacecraft. Performance analysis of a spacecraft system equipped with such systems are relatively insensitive to changes in the damping constant of the device. However, the size and arrangement of such a damper raises important questions concerning spacecraft stability in general. Author

N92-14092*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
QUATERNION NORMALIZATION IN ADDITIVE EKF FOR SPACECRAFT ATTITUDE DETERMINATION
I. Y. BAR-ITZHACK (Technion - Israel Inst. of Tech., Haifa.), J. DEUTSCHMANN, and F. L. MARKLEY *In its* Flight Mechanics/Estimation Theory Symposium, 1991 p 403-421 Oct. 1991
Avail: CASI HC A03/MF A04

This work introduces, examines, and compares several quaternion normalization algorithms, which are shown to be an effective stage in the application of the additive extended Kalman filter (EKF) to spacecraft attitude determination, which is based on vector measurements. Two new normalization schemes are introduced. They are compared with one another and with the known brute force normalization scheme, and their efficiency is examined. Simulated satellite data are used to demonstrate the performance of all three schemes. A fourth scheme is suggested for future research. Although the schemes were tested for spacecraft attitude determination, the conclusions are general and hold for attitude determination of any three dimensional body when

based on vector measurements, and use an additive EKF for estimation, and the quaternion for specifying the attitude. Author

N92-14100 Illinois Univ. at Urbana-Champaign, Savoy.
BANDWIDTH-LIMITED ROBUST NONLINEAR SPACECRAFT CONTROL Ph.D. Thesis
JINHO KIM 1991 117 p
Avail: Univ. Microfilms Order No. DA9124442

Robust large-angle spacecraft pointing and tracking by variable structure control (VSC) are developed. The control of multiaxial attitude dynamics is a highly nonlinear problem, which can be resolved by exact feedback linearization with respect to attitude variables. This requires exact measurements and perfect model parameters; however, spacecraft maneuver in uncertain circumstances. Thus, robust control is required. It is shown that asymptotic stability can be achieved by VSC, provided that the parasitics are assumed be bounded. Chattering from high gains is undesirable due to actuator limit and excitation of unmodeled high frequency dynamics. Allowance of tracking errors with guaranteed bounds around attractive sliding surfaces eliminates the discontinuity caused by chattering. it is found that the trade-off study can be easily performed with actuator band-width parameters and sliding surface characteristics. Numerical simulations are conducted to validate the results. Coupled with the elastic dynamics of the structure, the angular acceleration of spacecraft excites the unmolded elastic dynamics, which also interacts with the dynamics of the whole spacecraft. While the trajectory of the controlled variable is near or at the sliding surface, the differential equations of flexible generalized amplitudes and sliding surface dynamics are derived in the state space form within the boundary layer so that the robust stability constraint can be obtained form analyzing the system matrix. It is shown that the stability of the system is determined by the following factors: modeling error, control band-width, desired target history and flexible structure configuration, and its material characteristics. Numerical simulations are performed to show that the control band-width and the sliding surface characteristic are the main factors for steady state error and stability of flexible modes. To extend the stability range and vibration suppression capability, the active damping design method with a variational principle for distributed and discrete actuators is introduced. Dissert. Abstr.

N92-14384# Massachusetts Inst. of Tech., Cambridge. Artificial Intelligence Lab.
PHASE SPACE NAVIGATOR: TOWARDS AUTOMATING CONTROL SYNTHESIS IN PHASE SPACES FOR NONLINEAR CONTROL SYSTEMS
FENG ZHAO Apr. 1991 31 p
(Contract N00014-89-J-3202; NSF MIP-90-01651)
(AD-A241160; AI-M-1286) Avail: CASI HC A03/MF A01

We develop a novel autonomous control synthesis strategy called Phase Space Navigator for nonlinear control systems, with which a controller for a nonlinear system can be automatically synthesized in phase spaces. The Phase Space Navigator generates control laws by synthesizing flow shapes of dynamical systems and planning and navigating system trajectories in the phase spaces. More specifically, the control synthesis strategy consists of a global control path planner, a local trajectory generator, and a reference trajectory follower. The global path planner finds optimal paths from an initial state to the goal state in the phase space, consisting of a sequence of path segments connected at intermediate points where the control parameter changes. A brute-force, fine-grain search in high-dimensional phase spaces would be prohibitively expensive. Modeling and parsing phase spaces into trajectory flow pipes provide a way to efficiently reason about the phase space structures and search for global control paths. The local trajectory generator uses the flow information about the phase space trajectories to produce smoothed trajectories. The trajectory follower tracks the planned reference trajectory, reactively corrects deviations, and resynthesizes the reference trajectory if the dynamics of the system changes significantly. We have demonstrated the strategy with a program that automatically synthesizes global control paths for stabilizing a steel column buckling under compression. The Phase Space Navigator is particularly suitable for synthesizing high performance control systems that do not lend themselves to traditional design and analysis techniques. It can also assist control engineers in exploring much larger design spaces than otherwise possible. GRA

N92-14386# Wright Lab., Wright-Patterson AFB, OH.
PROCEEDINGS OF DAMPING 1991, VOLUME 3 Final Report, Feb. 1989 - Feb. 1991
Aug. 1991 517 p Conference held in San Diego, CA, 13-15 Feb. 1991
(Contract AF PROJ. 2401)
(AD-A241313; WL-TR-91-3078-VOL-3) Avail: CASI HC A22/MF A04

Individual papers are presented, and the topics covered include the following: viscoelastic material testing and characterization, passive damping concepts, passive damping analysis and design techniques, optimization, damped control/structure interaction, viscous dampers, friction damping, other vibration suppression techniques, damping identification and dynamic testing, applications to aircraft, space structures, marine structures, commercial products, defense applications, and payoffs of vibration suppression. GRA

N92-14394*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LANGLEY'S CSI EVOLUTIONARY MODEL: PHASE O
W. KEITH BELVIN (Lockheed Engineering and Sciences Co., Hampton, VA.), KENNY B. ELLIOTT (Lockheed Engineering and Sciences Co., Hampton, VA.), LUCAS G. HORTA (Lockheed Engineering and Sciences Co., Hampton, VA.), JIM P. BAILEY (Lockheed Engineering and Sciences Co., Hampton, VA.), ANNE M. BRUNER, JEFFREY L. SULLA, JOHN WON, and ROBERTO M. UGOLETTI (Lockheed Engineering and Sciences Co., Hampton, VA.) Nov. 1991 252 p
(Contract RTOP 590-14-21-01)
(NASA-TM-104165; NAS 1.15:104165) Avail: CASI HC A12/MF A03

A testbed for the development of Controls Structures Interaction (CSI) technology to improve space science platform pointing is described. The evolutionary nature of the testbed will permit the study of global line-of-sight pointing in phases 0 and 1, whereas, multipayload pointing systems will be studied beginning with phase 2. The design, capabilities, and typical dynamic behavior of the phase 0 version of the CSI evolutionary model (CEM) is documented for investigator both internal and external to NASA. The model description includes line-of-sight pointing measurement, testbed structure, actuators, sensors, and real time computers, as well as finite element and state space models of major components. Author

N92-15110# Naval Postgraduate School, Monterey, CA. Dept. of Mechanical Engineering.
STABILIZATION OF FREE-FLYING UNDERACTUATED MECHANISMS IN SPACE
RANJAN MUKHERJEE Sep. 1991 20 p
(AD-A242557; NPS-ME-91-03) Avail: CASI HC A03/MF A01

Underactuated mechanisms provide low cost automation and can overcome actuator failures. These mechanisms are more suitable for space applications mainly because of their lower weight and lower power consumption. Typical examples of useful underactuated mechanisms in space would be large space structures and robot manipulators. Such mechanisms are however difficult to control because of the fewer number of actuators in the system. In this paper we formulate the dynamics of an underactuated mechanism using Hamilton's canonical equations. Next, we develop a theorem that provides us with some necessary and some sufficient conditions for the asymptotic stability of autonomous systems. This theorem is more powerful than LaSalle's theorem when higher order derivatives of the Liapunov function can be easily computed. Finally, we use a Liapunov function approach to develop a control strategy that will stabilize an

underactuated mechanism in space to an equilibrium manifold. The effectiveness of such control is verified using our asymptotic stability theorem. GRA

N92-15405*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SPACE STATION FREEDOM SOLAR DYNAMIC MODULES STRUCTURAL MODELLING AND ANALYSIS
CHARLES LAWRENCE and RON MORRIS (Sverdrup Technology, Inc., Brook Park, OH.) Dec. 1991 25 p
(Contract RTOP 505-63-1B)
(NASA-TM-104506; E-6367; NAS 1.15:104506) Avail: CASI HC A03/MF A01

In support of the Space Station Freedom (SSF) Solar Dynamic Power Module effort, structural design studies were performed to investigate issues related to the design of the power module, its pointing capabilities, and the integration of the module into the SSF infrastructure. Of particular concern from a structural viewpoint are the dynamics of the power module, the impact of the power module on the Space Station dynamics and controls, and the required control effort for obtaining the specified Solar Dynamic Power Module pointing accuracy. Structural analyses were performed to determine the structural dynamics attributes of both the existing and the proposed structural dynamics module designs. The objectives of these analyses were to generate validated Solar Dynamic Power Module NASTRAN finite element models, combine Space Station and power module models into integrated system models, perform finite element modal analyses to assess the effect of the relocations of the power module center of mass, and provide modal data to controls designers for control systems design.
Author

N92-16010*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RECURSIVE DYNAMICS FOR FLEXIBLE MULTIBODY SYSTEMS USING SPATIAL OPERATORS
A. JAIN and G. RODRIGUEZ 15 Dec. 1990 64 p
(NASA-CR-189760; JPL-PUBL-90-26; NAS 1.26:189760) Avail: CASI HC A04/MF A01

Due to their structural flexibility, spacecraft and space manipulators are multibody systems with complex dynamics and possess a large number of degrees of freedom. Here the spatial operator algebra methodology is used to develop a new dynamics formulation and spatially recursive algorithms for such flexible multibody systems. A key feature of the formulation is that the operator description of the flexible system dynamics is identical in form to the corresponding operator description of the dynamics of rigid multibody systems. A significant advantage of this unifying approach is that it allows ideas and techniques for rigid multibody systems to be easily applied to flexible multibody systems. The algorithms use standard finite-element and assumed modes models for the individual body deformation. A Newton-Euler Operator Factorization of the mass matrix of the multibody system is first developed. It forms the basis for recursive algorithms such as for the inverse dynamics, the computation of the mass matrix, and the composite body forward dynamics for the system. Subsequently, an alternative Innovations Operator Factorization of the mass matrix, each of whose factors is invertible, is developed. It leads to an operator expression for the inverse of the mass matrix, and forms the basis for the recursive articulated body forward dynamics algorithm for the flexible multibody system. For simplicity, most of the development here focuses on serial chain multibody systems. However, extensions of the algorithms to general topology flexible multibody systems are described. While the computational cost of the algorithms depends on factors such as the topology and the amount of flexibility in the multibody system, in general, it appears that in contrast to the rigid multibody case, the articulated body forward dynamics algorithm is the more efficient algorithm for flexible multibody systems containing even a small number of flexible bodies. The variety of algorithms described here permits a user to choose the algorithm which is optimal for the multibody system at hand. The availability of a number of algorithms is even more important for real-time applications, where implementation on parallel processors or custom computing hardware is often necessary to maximize speed. Author

N92-17045*# DYNACS Engineering Co., Inc., Palm Harbor, FL.
MODES OF INTERCONNECTED LATTICE TRUSSES USING CONTINUUM MODELS, PART 1 Interim Report
A. V. BALAKRISHNAN Dec. 1991 49 p
(Contract NAS1-19158; RTOP 590-14-51-01)
(NASA-CR-189568; NAS 1.26:189568) Avail: CASI HC A03/MF A01

This represents a continuing systematic attempt to explore the use of continuum models--in contrast to the Finite Element Models currently universally in use--to develop feedback control laws for stability enhancement of structures, particularly large structures, for deployment in space. We shall show that for the control objective, continuum models do offer unique advantages. It must be admitted of course that developing continuum models for arbitrary structures is no easy task. In this paper we take advantage of the special nature of current Large Space Structures--typified by the NASA-LaRC Evolutionary Model which will be our main concern--which consists of interconnected orthogonal lattice trusses each with identical bays. Using an equivalent one-dimensional Timoshenko beam model, we develop an almost complete continuum model for the evolutionary structure. We do this in stages, beginning only with the main bus as flexible and then going on to make all the appendages also flexible-except for the antenna structure. Based on these models we proceed to develop formulas for mode frequencies and shapes. These are shown to be the roots of the determinant of a matrix of small dimension compared with mode calculations using Finite Element Models, even though the matrix involves transcendental functions. The formulas allow us to study asymptotic properties of the modes and how they evolve as we increase the number of bodies which are treated as flexible. The asymptotics, in fact, become simpler.
Author

N92-17602# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
CONTROL OF A LARGE FLEXIBLE SPACE STRUCTURE USING MULTIPLE MODEL ADAPTIVE ALGORITHMS M.S. Thesis
JOHN A. GUSTAFSON Dec. 1991 479 p
(AD-A243759; AFIT/GE/ENG/91D-22) Avail: CASI HC A21/MF A04

The development and performance of moving-bank multiple model adaptive estimation (MMAE) and control (MMAC) algorithms for quelling vibrations induced in the SPICE 2 space structure are analyzed in this thesis. The structure consists of a large platform and a smaller platform connected by three legs in a tripod fashion. The model supplied by Phillips Laboratory, Kirtland AFB is used to develop a truth model and multiple reduced ordered filter models. The filter models are developed from modal analysis and internally balanced techniques. Deviations of the line-of-sight vector from the center of the large platform to the center of the smaller platform are used for LQG controller performance evaluation. For use with the LQG controller, research results indicate the chosen reduced order models are of inadequate dimension and that the full ordered filter model should be implemented to quell vibrations introduced into the structure. The parameter estimator implemented the ME/I algorithm, the moving-bank logic employed parameter position monitoring and the controller used the modified MMAC method. Parameter variations of two percent caused instabilities in the single filter/controller design. The MMAE/MMAC algorithms provide an excellent method to estimate a wide range of parameter variations and to quell oscillations in the structure. GRA

N92-18241# National Aerospace Lab., Tokyo (Japan). Space Technology Research Group.
DAMPING ENHANCEMENT OF LARGE SPACE STRUCTURES BY PROOF-MASS-ACTUATORS
TAKASHI KIDA (Yokohama National Univ. (Japan).), ISAO YAMAGUCHI (Yokohama National Univ. (Japan).), SEIYA UENO

(Yokohama National Univ. (Japan).), and MASAKI TANAKA (Toshiba Corp., Tokyo, Japan) May 1991 23 p In JAPANESE; ENGLISH summary
(ISSN 0389-4010)
(NAL-TR-1114) Avail: CASI HC A03/MF A01

The enhancement of modal damping is a key technology in Large Space Structures (LSS) robust control. A controller design is examined which actively augments substantial damping factors to LSS. The stability analysis of the closed loop system is discussed, and was subsequently confirmed by a ground based control experiment which used a newly developed pivoted type Proof Mass Actuator (PMA). The controller uses a direct velocity feedback control. A multi-input multi-output control system was examined using two PMAs, in addition to the single-input single-output case. In both cases, the experimental results showed excellent vibration suppression capability. A sizing problem of the PMAs is also discussed. Author

N92-18299# Virginia Polytechnic Inst. and State Univ., Blacksburg.
ON-ORBIT STRUCTURAL DYNAMIC PERFORMANCE OF A LARGE-DIAMETER ANTENNA M.S. Thesis
DEBORAH M. WAHLS Jun. 1991 99 p
Avail: CASI HC A05/MF A02

An analysis of the structural vibrational performance of a 15-meter-diameter antenna subject to representative onboard dynamic disturbances is presented. Antenna performance parameter limits are defined for the root-mean-square surface roughness, pointing error, and defocus. The antenna concept is described, and the generation of the finite-element model is explained. A subreflector scanning scenario which represents an onboard disturbance to the system is modeled with orthogonal excitation functions. A modal analysis performed on the antenna in both free-flying and platform-mounted configurations is discussed. The resulting mode shapes and natural frequencies are then input to a forced-response analysis, which is performed for each configuration with the onboard scanning disturbance. The impact of the resulting dynamic distortions on the antenna performance parameters (i.e., errors) is assessed. The distortions in the surface are determined to contribute to all three errors, the displacement of the subreflector adds to the pointing error and defocus, and the displacement of the vertex is a component of the defocus. Based on the results of the analysis, the reflector support structure and feed mast of the low-frequency microwave radiometer as designed are capable of maintaining their shapes within specifications for the assumed on-orbit disturbance. This is particularly true for the platform-mounted configuration which exhibits errors within their respective limits by at least an order of magnitude. This is also true for the free-flyer configuration surface roughness and defocus; however, the free-flyer configuration maximum pointing error is significantly closer to, yet still within, its specified limit. Author

N92-19258*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL VALIDATION OF STRUCTURAL OPTIMIZATION METHODS
HOWARD M. ADELMAN Jan. 1992 36 p
(Contract RTOP 505-63-36-06)
(NASA-TM-104203; NAS 1.15:104203) Avail: CASI HC A03/MF A01

The topic of validating structural optimization methods by use of experimental results is addressed. The need for validating the methods as a way of effecting a greater and an accelerated acceptance of formal optimization methods by practicing engineering designers is described. The range of validation strategies is defined which includes comparison of optimization results with more traditional design approaches, establishing the accuracy of analyses used, and finally experimental validation of the optimization results. Examples of the use of experimental results to validate optimization techniques are described. The examples include experimental validation of the following: optimum design of a trussed beam; combined control-structure design of a cable-supported beam simulating an actively controlled space structure; minimum weight design of a beam with frequency constraints; minimization of the vibration response of helicopter rotor blade; minimum weight design of a turbine blade disk; aeroelastic optimization of an aircraft vertical fin; airfoil shape optimization for drag minimization; optimization of the shape of a hole in a plate for stress minimization; optimization to minimize beam dynamic response; and structural optimization of a low vibration helicopter rotor. Author

N92-19492*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EIGENSYSTEM REALIZATION ALGORITHM MODAL IDENTIFICATION EXPERIENCES WITH MINI-MAST
RICHARD S. PAPPA (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.).), AXEL SCHENK, and CHRISTOPHER NOLL (Lockheed Engineering and Sciences Co., Hampton, VA.) Feb. 1992 43 p
(Contract RTOP 590-14-61-01)
(NASA-TM-4307; NAS 1.15:4307) Avail: CASI HC A03/MF A01

This paper summarizes work performed under a collaborative research effort between the National Aeronautics and Space Administration (NASA) and the German Aerospace Research Establishment (DLR, Deutsche Forschungsanstalt fur Luft- und Raumfahrt). The objective is to develop and demonstrate system identification technology for future large space structures. Recent experiences using the Eigensystem Realization Algorithm (ERA), for modal identification of Mini-Mast, are reported. Mini-Mast is a 20 m long deployable space truss used for structural dynamics and active vibration-control research at the Langley Research Center. A comprehensive analysis of 306 frequency response functions (3 excitation forces and 102 displacement responses) was performed. Emphasis is placed on two topics of current research: (1) gaining an improved understanding of ERA performance characteristics (theory vs. practice); and (2) developing reliable techniques to improve identification results for complex experimental data. Because of nonlinearities and numerous local modes, modal identification of Mini-Mast proved to be surprisingly difficult. Methods were available, ERA, for obtaining detailed, high-confidence results. Author

N92-19513# Integrated Systems, Inc., Santa Clara, CA.
ADAPTIVE AND NONLINEAR CONTROL FOR RAPID MANEUVERING OF FLEXIBLE STRUCTURES Final Report, Sep. 1987 - Jun. 1991
ROBERT L. KOSUT and GUNTEKIN M. KABULI 1 Oct. 1991 90 p
(Contract F49620-88-C-0012)
(AD-A243991; ISI-5733-05; AFOSR-91-0971TR) Avail: CASI HC A05/MF A01

This report describes research results on the design of feedback controllers for rapid slewing of flexible space structures, such as optical tracking systems. Two approaches evolved during this research. The first approach modifies the exact rigid-body time-optimal control so as to account for chattering near zero tracking error and robustness to flexible modes close to the controller bandwidth. Efforts to make this controller adaptive are also presented. The second approach uses a combination of feed forward trajectory generation with a standard linear feedback in the inner loop. The feed-forward generator is designed by solving a convex optimization problem which is an approximation to the time-optimal problem. The latter approach is effective for multiple input multiple output systems with independent actuator saturation constraints. GRA

N92-19615 Auburn Univ., AL.
ACTIVE VIBRATION CONTROL Ph.D. Thesis
JIAWEI LU 1991 183 p
Avail: Univ. Microfilms Order No. DA9201244

Active vibration control is an important approach to vibration problems in large flexible space structures. These structures will probably be built from lightweight materials with low damping and they will be very flexible due to the thin, large-size elements from

which they will be constructed. Vibration in such large space structures may lead to fatigue, instability, and other destructive results. Modal space control and wave control are the two main approaches used in the active vibration control of a distributed parameter system. Herein, wave control approaches applied to a one-dimensional distributed (or lumped) parameter system are studied both experimentally and theoretically. The vibration isolation on a flexible beam undergoing periodic excitation was studied experimentally. The control was applied to isolate the disturbing source. The LMS (least mean squares) adaptive control approach was successfully used. The control model was also studied theoretically. Active vibration control was studied for a string model by applying boundary adsorption to suppress resonance in the string. Both theoretical and experimental results have shown that active vibration isolation and adsorption are good vibration control approaches. Dissert. Abstr.

N92-19632 Howard Univ., Washington, DC.
ISSUES IN CONTROL SYSTEM DESIGN OF LARGE SPACE STRUCTURES Ph.D. Thesis
MIFANG RUAN 1991 204 p
Avail: Univ. Microfilms Order No. DA9136273

The proposed large space structures (LSS) possess special characteristics, such as flexibility, low damping, and tightly grouped frequencies of vibration. Those characteristics lead to mathematical difficulties and special issues in the design of the control systems of the structures. The overall field in design of the control systems of LSS is discussed, and particular attention is paid to four special topics: model reduction of 'single input single output' (SISO) systems; model reduction of 'multi input multi output' (MIMO) systems; actuator placement; and spillover reduction. New methods are developed for each of the topics, and those methods can be applied not only to LSS but also to other control systems. A method is developed for model reduction of SISO systems by using an optimization approach. The method reduces the cost function to a quadratic form by presetting the poles of the reduced system, and the computational time is very small. The difficulties which prevent the use of SISO model reduction methods to MIMO systems are discussed. A new method is also developed, which overcomes the difficulties and reduces the cost function to a quadratic form by presetting the poles of the reduced system. Dissert. Abstr.

N92-19664*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTER OPTIMIZATION TECHNIQUES FOR NASA LANGLEY'S CSI EVOLUTIONARY MODEL'S REAL-TIME CONTROL SYSTEM
KENNY B. ELLIOTT (Lockheed Engineering and Sciences Co., Hampton, VA.), ROBERTO UGOLETTI, and JEFF SULLA (Lockheed Engineering and Sciences Co., Hampton, VA.) Feb. 1992 16 p Proposed for presentation at the 38th International Instrumentation Symposium, Instrument Society of America, Las Vegas, NV, 26-30 Apr. 1992
(Contract RTOP 590-14-61-01)
(NASA-TM-104223; NAS 1.15:104223) Avail: CASI HC A03/MF A01

The evolution and optimization of a real-time digital control system is presented. The control system is part of a testbed used to perform focused technology research on the interactions of spacecraft platform and instrument controllers with the flexible-body dynamics of the platform and platform appendages. The control system consists of Computer Automated Measurement and Control (CAMAC) standard data acquisition equipment interfaced to a workstation computer. The goal of this work is to optimize the control system's performance to support controls research using controllers with up to 50 states and frame rates above 200 Hz. The original system could support a 16-state controller operating at a rate of 150 Hz. By using simple yet effective software improvements, Input/Output (I/O) latencies and contention problems are reduced or eliminated in the control system. The final configuration can support a 16-state controller operating at 475 Hz. Effectively the control system's performance was increased by a factor of 3. Author

N92-19780*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SOLAR DYNAMIC MODULES FOR SPACE STATION FREEDOM: THE RELATIONSHIP BETWEEN FINE-POINTING CONTROL AND THERMAL LOADING OF THE APERTURE PLATE
ROGER D. QUINN (Case Western Reserve Univ., Cleveland, OH.) and THOMAS W. KERSLAKE 1992 20 p Proposed for presentation at the International Solar Energy Conference, Lahaina, HI, 5-9 Apr. 1992; sponsored by ASME
(Contract RTOP 474-52-10)
(NASA-TM-104498; E-6109; NAS 1.15:104498) Avail: CASI HC A03/MF A01

Dynamic simulations of Space Station Freedom (SSF) configured with solar dynamic (SD) power modules were performed. The structure was subjected to Space Shuttle docking disturbances, while being controlled with a 'natural' vibration and tracking control approach. Three control cases were investigated for the purpose of investigating the relationship between actuator effort, SD pointing, and thermal loading on the receiver aperture plate. Transient, one-dimensional heat transfer analyses were performed to conservatively predict temperatures of the multi-layered receiver aperture plate assembly and thermal stresses in its shield layer. Results indicate that the proposed aperture plate is tolerant of concentrated flux impingement during short-lived structural disturbances. Pointing requirements may be loosened and the requirement control torques lessened from that previously specified. Downsizing and simplifying the joint drive system should result in a considerable savings mass. Author

N92-20031*# Minnesota Univ., Minneapolis. Dept. of Aerospace Engineering and Mechanics.
VIBRATION ATTENUATION OF THE NASA LANGLEY EVOLUTIONARY STRUCTURE EXPERIMENT USING H(SUB INFINITY) AND STRUCTURED SINGULAR VALUE (MICRON) ROBUST MULTIVARIABLE CONTROL TECHNIQUES Midyear Report
GARY J. BALAS 9 Mar. 1992 55 p
(Contract NAG1-1254)
(NASA-CR-190080; NAS 1.26:190080) Avail: CASI HC A04/MF A01

The use is studied of active control to attenuate structural vibrations of the NASA Langley Phase Zero Evolutionary Structure due to external disturbance excitations. H sub infinity and structured singular value (mu) based control techniques are used to analyze and synthesize control laws for the NASA Langley Controls Structures Interaction (CSI) Evolutionary Model (CEM). The CEM structure experiment provides an excellent test bed to address control design issues for large space structures. Specifically, control design for structures with numerous lightly damped, coupled flexible modes, collocated and noncollocated sensors and actuators and stringent performance specifications. The performance objectives are to attenuate the vibration of the structure due to external disturbances, and minimize the actuator control force. The control design problem formulation for the CEM Structure uses a mathematical model developed with finite element techniques. A reduced order state space model for the control design is formulated from the finite element model. It is noted that there are significant variations between the design model and the experimentally derived transfer function data. Author

N92-20840# Applied Computing Enterprises, Nepean (Ontario).
LITERATURE SURVEY OF ACTIVE DAMPING USING PIEZOELECTRIC DEVICES
ANTHONY FARIA VAZ 12 Mar. 1991 34 p Sponsored by Canadian Space Agency
(ACE-R-CSA-91-3.0; CSA-DSM-CR-91-006; CTN-92-60414)
Avail: CASI HC A03/MF A01

Large flexible space structures have significant structural flexibility; meaning that elastic body modes, ranging from very low

to very high frequencies, will be very lightly damped. High frequency modes can be attenuated by using viscoelastic structural materials but low frequency modes cannot. A significant amount of research has shown that piezoelectric sensors and actuators can successfully damp structural vibrations. This report provides a literature survey on active damping using piezoelectric devices. A number of different piezoelectric devices have been successfully used to actively damp structural vibrations. The most promising have simple construction. Thin piezoelectric films can be bonded to structural members for use as either actuators or sensors. By geometrically shaping the piezoelectric films, individual modes of a structure can be sensed and controlled. This property can be used to implement a state feedback law in terms of a shaped film. In this manner, high fidelity dynamic models can be used for controller design without the typical penalty of excessive controller complexity. It is suggested that a flat beam cantilever is a suitable structure for initial active damping experimentation. CISTI

N92-20843# Applied Computing Enterprises, Nepean (Ontario).
MODELLING OF PIEZOELECTRIC BEHAVIOUR FOR ACTUATOR AND SENSOR APPLICATIONS
ANTHONY FARIA VAZ 25 Feb. 1991 40 p Sponsored by Canadian Space Agency
(ACE-R-CSA-91-2-0; CSA-DSM-CR-91-005; CTN-92-60416)
Avail: CASI HC A03/MF A01

A significant amount of research has shown that piezoelectric sensors and actuators can be used successfully to damp vibrations in large flexible space structures. In this report, the equations used to characterize the behavior of piezoelectric materials are developed. The equations are then used to develop electro mechanical models of piezoelectric actuator and sensor operations. The physics associated with the piezoelectric phenomena is explained and the relevant background in electro magnetics, mechanics of solids, and thermodynamics is briefly summarized. Electro magnetic models of piezoelectric sensor and actuator behavior are derived. The mechanical aspect of these models permits the analysis of the dynamics of the interactions between the structural members and piezoelectric elements. The electrical aspects of the models are required for determining appropriate interface electronics. The physical properties of piezoelectric materials that determine their suitability for use as a sensor or an actuator were determined. It was determined that poly vinylidene fluoride (PVDF) sensors are more sensitive than piezoceramic sensors. On the other hand, piezoceramic actuators are more efficient than PVDF actuators. Appropriate interface electronics for piezoelectric sensors and actuators are specified. CISTI

N92-21983*# Draper (Charles Stark) Lab., Inc., Cambridge, MA.
DISCRETE AND CONTINUOUS DYNAMICS MODELING OF A MASS MOVING ON A FLEXIBLE STRUCTURE
DEBORAH ANN HERMAN Jan. 1992 152 p
(Contract NAS9-18426)
(NASA-CR-189539; NAS 1.26:189539; CSDL-T-1111) Avail: CASI HC A08/MF A02

A general discrete methodology for modeling the dynamics of a mass that moves on the surface of a flexible structure is developed. This problem was motivated by the Space Station/Mobile Transporter system. A model reduction approach is developed to make the methodology applicable to large structural systems. To validate the discrete methodology, continuous formulations are also developed. Three different systems are examined: (1) simply-supported beam, (2) free-free beam, and (3) free-free beam with two points of contact between the mass and the flexible beam. In addition to validating the methodology, parametric studies were performed to examine how the system's physical properties affect its dynamics. Author

08

ASSEMBLY, MAINTENANCE, and EXTRAVEHICULAR ACTIVITY

Description of on-orbit deployment or assembly including tools. Includes space suits and other EVA equipment or support.

A92-12497* NASA Space Station Program Office, Reston, VA.
DESIGNING FOR ON-ORBIT MAINTENANCE
ANNE L. ACCOLA, GERALD E. JOHNSON, and RICHARD L. ROBBINS (NASA, Space Station Freedom Program Office, Reston, VA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 10 p. Oct. 1991 10 p refs
(IAF PAPER 91-091) Copyright

The history of conducting maintenance in space is outlined with particular emphasis on Skylab and shuttle missions to develop maintenance concepts for applications to maintaining the Space Station Freedom. In-flight maintenance (IFM) encompasses the activities of the crew alone or with robotic devices inside or outside the pressurized elements. The extravehicular activities (EVAs) and 141 on-orbit intravehicular activities (IVAs) related to space shuttle flights are discussed in terms of task and level of success. Skylab IFM procedures including IVA and EVA are similarly assessed, and two critical issues are identified. Coordination of flight crew, technicians, and other personnel is critical, and the efficient generation, collection, and storage of data is a key to IFM effectiveness. The overriding concern is that design guidelines for IFM learned from other programs are built into the development of technologies for the Space Station Freedom. C.C.S.

A92-14728
ROBOTIC ASSEMBLY OF TRUSS BEAMS FOR LARGE SPACE STRUCTURES
ANTHONY P. COPPA (General Electric Co., Astro Space Div., Philadelphia, PA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 11 p. Oct. 1991 11 p refs
(IAF PAPER 91-312) Copyright

The paper describes a robotic process and apparatus for constructing truss beams of square and equilateral triangular cross section within the context of the general Coppatruss erectable space structure system. The assembly system consists of: (1) a frame feeder (FF) which continuously feeds protoframes (the basic beam building block); (2) an IDSF feeder which feeds internal diagonal struts (IDS, required for square-section beams only); (3) a robot assembler (RA) which selects protoframes and IDSs from the FF and IDSF respectively and transfers and assembles them to the beam; and (4) a frame holding fixture (FHF) which fastens protoframes to the truss beam, holds the beams securely during construction, and advances it upon completion of the current beam bay. The construction of a square-section beam is described. Author

A92-14729
ACTIVE AND PASSIVE CABLE ELEMENTS IN DEPLOYABLE MASTS
S. PELLEGRINO (Cambridge, University, England) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 8 p. Research supported by SERC and Ministry of Defence. Oct. 1991 8 p refs
(IAF PAPER 91-313) Copyright

This paper describes a new type of deployable masts for use in space, which make use of the following elements. A deployable backbone, consisting of rods and/or plates, which can be folded or deployed freely. One or more active cables, following specially chosen routes along the mast, and running over small pulleys. The overall length of an active cable can vary between two extremes: when it has maximum length the mast is fully folded; when it has minimum length the mast is fully deployed. A set of passive cables, joining different points on the backbone. The

passive cables are all slack when the backbone is partially folded, and are taut when it is fully extended. Structural prestress, so that all of the cables are in a state of pretension and therefore are able to carry any tensile or compressive force changes induced by the external loads. An additional effect of this state of prestress is to remove backlash at the joints. Three deployable masts based on this approach are presented. Author

A92-14730
SCALE MODEL DEVELOPMENT OF ASSEMBLING TYPE SPACE ANTENNA
YOSHIAKI SUZUKI, TETSUO TAKAHASHI, MASATO TANAKA, TAKASHI IIDA (Communications Research Laboratory, Koganei, Japan), SEIJI YOKOTA (NEC Corp., Yokohama, Japan), and KAZUO OHSHIMA (Toshiba Corp., Komukai Works, Kawasaki, Japan) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 8 p. Oct. 1991 8 p refs
(IAF PAPER 91-314) Copyright

This paper describes the development of assembling type antenna scale models which are designed to be constructed by using manipulator arm. The assembling type antenna has possible advantages to achieve high accuracy in reflector surface construction and is appropriate for the high frequency application, comparing deployable type antenna. After some trade-off studies, two types of antennas which have unique coupling mechanisms were selected. Using these smart mechanisms, construction using manipulator instead of using dangerous extra vehicular operation became possible. Author

A92-14731
A MODULAR APPROACH TO BUILD A LARGE SPACE ANTENNA
JIN MITSUGI and TETSUO YASAKA (NTT, Radio Communication Systems Laboratory, Yokosuka, Japan) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 11 p. Oct. 1991 11 p refs
(IAF PAPER 91-315) Copyright

Large deployable mesh antenna composed of independently manufactured and tested modules is presented and its feasibility for a 10-m aperture, C-band application is examined from the surface accuracy point of view. The required accuracy of a module under possible imperfection between modules is derived. The tensions in the mesh surface to achieve the module accuracy is elicited by modeling the mesh with an equivalent cable network. Results gives a mesh surface that could be considered as flat among the shaping cable network. Author

A92-17784
APPLICATION OF EXPERT SYSTEM MODELING TO SPACE-BASED CONSTRUCTION AND MANUFACTURING
S. D. JOLLY (Colorado, University, Boulder) IN: Space manufacturing 8 - Energy and materials from space; Proceedings of the 10th Princeton/AIAA/SSI Conference, Princeton, NJ, May 15-18, 1991 1991 9 p refs
Copyright

This paper explores the issue of the assessment of constructability, specifically involving the creation and measurement of preferred assembly sequences in a computer aided design computing environment on Phase A space designs. A preliminary theoretical mathematical model is developed to try and explain the human planner's expert behavior, while simultaneously driving the consideration, selection, and development of a knowledge-based, domain-dependent prototype expert system. The possible assistance of the operations research algorithms and the fuzzy reasoning expert systems are briefly discussed in the context of model development. Author

A92-21808
HUMAN FACTORS IN AEROBRAKE DESIGN FOR EVA ASSEMBLY AND MAINTENANCE
LISA M. ROCKOFF, DAVID E. ANDERSON, and LISA K. EVELSIZER (McDonnell Douglas Space Systems Co., Space Station Div., Huntington Beach, CA) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 13 p. Jul. 1991 13 p refs
(SAE PAPER 911497) Copyright

Some EVA assembly techniques used in a neutral buoyancy test for an aerobrake designed to be launched in large pieces and then assembled on orbit are reviewed. Paper examines the need for crew restraint during assembly for torque reaction, familiar frame of reference, and assembly speed. Attention is also given to hardware interface requirements; EVA worksites, operations, and timelines; and recommendations based on results of the neutral buoyancy test. It is concluded that EVA tasks will be a necessary part of assembly and refurbishment. Vehicles and structures will have to be designed to accommodate not only the expanded long-term need of humans, but also crew interfaces for in-space assembly and maintenance. O.G.

A92-21863
APPLIED ETHOLOGICAL STUDY OF ASTRONAUT BEHAVIOR DURING EVA SIMULATIONS WITH A WET SUIT PROTOTYPE
C. TAFFORIN (Toulouse III, Universite, France) and L. DECRAMER (CNES, Toulouse, France) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 14 p. Jul. 1991 14 p refs
(SAE PAPER 911531) Copyright

An analytical method is applied to EVA training in which a Soviet flight suit serves as the basis for a wet-suit prototype that offers neutral buoyancy and a breathing apparatus. The simulations of weightlessness are described in terms of the zero-g test apparatus and the experimental protocol as well as the method of ethological analysis. Numerous donning/doffing tests are conducted with 11 subjects, and video recordings are analyzed in terms of body movements and orientations. The results of the observations are analyzed by quantitatively processing the data and calculating the frequency of occurrence of each item, the frequency of transitions between items, and activity durations. The descriptive and comparative analyses demonstrate that in parabolic flights there are diverse behavioral indicators of high performance levels. In immersion tests the data suggest more homogeneous and routine actions, and key differences are noted between male and female subjects. C.C.S.

A92-23670* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ASSEMBLY, DISASSEMBLY AND REPAIR OF LARGE TRUSS STRUCTURES IN SPACE
RAJIV S. DESAI and LUIZ S. HOMEM-DE-MELLO (JPL, Pasadena, CA) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

This paper addresses the problem of planning assembly, disassembly and repair sequences for large truss structures in space. First, the AND/OR graph representation scheme for mechanical assemblies is reviewed and extended to truss structures. The assembly, disassembly and repair sequence planning problem is then formulated as a graph search problem using assembly's AND/OR graph and appropriate cost functions. The general search problem, which is known to be exponential, is simplified by taking advantage of the symmetries that exist in truss structures. General cost functions for truss assembly are discussed. Author

A92-23715
HUGE OBJECT MANIPULATION IN SPACE BY VEHICLES
HIROSHI KIMURA, ZHIDONG WANG, and EIJI NAKANO (Tohoku University, Sendai, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

The studies about space robots have assumed a relatively small object as a manipulated target, but in space a target object can be relatively huge. For example the spacecraft, the space station, the solar power satellite. In these cases, manipulation by several vehicles which have a thrust engine is superior than that

by arms mounted on the spacecraft. In the manipulation by vehicles, the fuel consumption in a thrust engine is related to the size of force activated by a vehicle and the size of force depends on the positions of contacting points. Therefore, contacting points of the vehicles are important in view of the fuel consumption. This paper discusses how to find the optimal contacting points. The optimal contacting points are defined as the points which minimize the norm of force needed for the specified acceleration of a target object and maximize the dynamic manipulability margin. The results of the simulation are indicated. Author

A92-23721 National Aeronautics and Space Administration, Washington, DC.
ASSESSMENT OF THE A&R TECHNOLOGY ASSOCIATED WITH THE USE OF SUPERVISED AUTONOMY FOR ON-ORBIT SATELLITE SERVICING
GEORGE M. LEVIN (NASA, Office of Space Flight, Washington, DC), NEVILLE MARZWELL (JPL, Pasadena, CA), JAMES S. MOORE, and WILLIAM J. HUNGERFORD (NASA, Johnson Space Center, Houston, TX) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

The Satellite Servicer Flight Demonstration Program is NASA's first definitive attempt at addressing the problems associated with the supervised autonomous servicing of satellites in orbit. NASA has completed a study of its on-orbit requirements for the next decade. Utilizing the results of this study, the necessary key servicing functions, which require on-orbit demonstration before a program would commit to servicing capability, were determined. These capabilities are: (1) autonomous rendezvous and docking; (2) supervised autonomous orbital replacement unit exchange; and (3) supervised autonomous fluid transfer. A satellite servicer system plan to conduct a series of on-orbit flight demonstrations of these capabilities utilizing the Orbital Maneuvering Vehicle, elements of the Flight Telerobotic Servicer and other applicable hardware has been developed. This paper surveys the A&R technologies that must be matured from the laboratory to flight status prior to conducting these on-orbit flight demonstrations. Author

A92-23723* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
ROBOTIC SERVICING OF EOS INSTRUMENTS
ANDREA I. RAZZAGHI and MARIS JUBERTS (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p

This paper addresses robotic servicing of the Earth Observing Satellite (EOS) instruments. The goals of implementing a robotic servicing system on EOS would be to maintain the instruments throughout the required mission life and minimize life-cycle costs. To address robot servicing, an initial design concept has been developed which will be applied to a representative EOS instrument. This instrument will be used as a model for determining the most practical level of servicing of its parts, and how to design these parts for robot servicing. Using this representative EOS instrument as a model, a generic design scheme will be developed that can be applied to all EOS instruments. The first task is to determine how to identify which parts must be designed for robot servicing. Next, the requirements imposed on the instruments and the servicing robot when designing for robot serviceability must be examined. Author

A92-23724
ON ORBIT SERVICING AND ITS IMPLICATIONS ON FUTURE GEOSTATIONARY ACTIVITY GROWTH
TETSUO YASAKA, YOSHITSUGU YASUI, and SHUN-ICHI ODA (NTT, Radio Communication Systems Laboratories, Yokosuka, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

The on-orbit servicing of geostationary satellites is considered in terms of cost efficiency, the minimization of environmental change, and the utilization of material resources. The concept of the Geostationary Service Vehicle is presented with attention given to its inapplicability to spent satellites and parts left in GEO. In order to determine the requirements for reusing satellites and related materials left in GEO a brief study is performed of GEO servicing potential needs. The roles of the proposed type of service vehicle include automated refueling, unit replacement, orbit-resource conservation, and material-resource utilization. Although the economic benefits of the Geostationary Service Vehicle are initially outweighed by the cost associated with robotics development, this type of service vehicle can eventually make satellite resources more efficient. C.C.S.

A92-23725
ON-ORBIT SERVICING FOR U.S. AIR FORCE SPACE MISSIONS - A PHASED DEVELOPMENT APPROACH
WILLIAM I. SHANNEY (Aerospace Corp., Sunnyvale, CA) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

The cost and schedule risks associated with the development of on-orbit satellite servicing are examined in the light of spacecraft removal and servicing requirements. The extensive supporting infrastructure needed for an Orbital Maneuvering Vehicle is considered with respect to the benefits provided by applying incremental improvements to a space vehicle series. A program is described which addresses the need for an orbiter that functions operationally as a servicer and evolves into a servicing program. The on-orbit service program initially responds to the hazards of the uncontrolled reentry of LEO test spacecraft and is called the Space Test Range. The operational system is expected to provide suitable characteristics that can facilitate the evolution from spacecraft-removal technology to spacecraft-servicing technology. C.C.S.

A92-24364*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
INSTRUMENTATION AND CALIBRATION ISSUES FOR SPACE STATION FREEDOM AND FUTURE SPACE PROJECTS
DAVID M. BUSHMAN and ROBERT V. BURDINE (NASA, Marshall Space Flight Center, Huntsville, AL) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 7 p
(AIAA PAPER 91-4110) Copyright

Space-based instrumentation calibration for long duration and remote space missions is discussed. The traditional approach, in which instrumentation was an afterthought in the space program design process and calibration was not even addressed until after design was completed, are discussed. Current issues and approaches to calibration are discussed, and guidelines are developed to instrumentation calibration for the Space Station Freedom and beyond. C.D.

A92-24377#
DEVELOPMENT TESTING, NON-DESTRUCTIVE EVALUATION AND CHECK-OUT IN SPACE CONSTRUCTION AND ITS IMPACT ON SPACE LOGISTICS SUPPORT
GEORGE W. MORGENTHALER and ROSARIO NICI (Colorado, University, Boulder) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 9 p refs
(AIAA PAPER 91-4129) Copyright

The needs and requirements of the development testing, NDE, and checkout in SEI mission space construction are identified and discussed. A sweeping SEI test and evaluation philosophy is proposed which includes the need to develop space-qualified NDE equipment which can reliably determine the suitability of each SEI system to ensure mission accomplishment. Specific NDE applications and procedure for astronauts and robots are addressed, including checkout equipment and procedure needs for the SEI program. C.D.

A92-24379#
ASSEMBLY INTERRUPTABILITY ROBUSTNESS MODEL APPLIED TO SPACE STATION FREEDOM
JAMES W. WADE (Colorado, University, Boulder) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 8 p refs
(AIAA PAPER 91-4132) Copyright

The Interruptability Robustness Model presented in this paper provides a method which shows the overall interruptability robustness of construction of a project design and its assembly sequence to be quantified. In addition, it identifies the susceptibility to interruptions for the assembly sequence at all points within the assembly sequence. Such interruptions may jeopardize: the survival of the structure being assembled, the survival of the support equipment, and/or the safety of the members of the construction crew, depending upon the stage in the assembly sequence when the interruption occurs. The interruption may be due to a number of factors such as: the machinery breakdowns, environmental damage, or worker emergency illness or injury. The model was applied to the present problem of quantifying and improving interruptability robustness during the construction of the United States Space Station Freedom. The model may also be utilized to assist in the analysis of interruptability robustness for other space-related construction projects. Author

A92-24383#
A COST TRADE-OFF MODEL FOR ON-ORBIT ASSEMBLY LOGISTICS
GEORGE W. MORGENTHALER (Colorado, University, Boulder) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 22 p refs
(AIAA PAPER 91-4148) Copyright

An expected cost model to rationalize the main elements of the Space Station Freedom orbital assembly logistic support problem is presented. The model attempts to encapsulate the major variables based on historical data and the engineering factors that will size the Heavy Lift Launch Vehicle planned as the logistic vehicle for SEI missions. A calculative example using typical inputs is given. C.D.

A92-24386#
NANOTECHNOLOGY AND THE BIRTH OF SELF-HEALING SYSTEMS
RICHARD G. CLINE (Rockwell International Corp., Space Systems Div., Downey, CA) AIAA and Society of Logistics Engineers, Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991. 8 p. Nov. 1991 8 p refs
(AIAA PAPER 91-4062) Copyright

Nanotechnology and its potential to embed self-healing characteristics into equipment is examined. Self-healing equipment requirements and capabilities are described along with potential applications of nanotechnology involving self-healing to the SEI. Some current nanotechnology efforts are surveyed. C.D.

A92-28409#
DEVELOPMENT OF A MODULAR TOOL CONCEPT FOR SPACE ASSEMBLY AND MAINTENANCE OPERATIONS
PHILLIP L. FUSON and STEVEN M. CHUCKER (McDonnell Douglas Space Systems Co., Huntington Beach, CA) AIAA and Society of Logistics Engineers, Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991. 6 p. Nov. 1991 6 p
(AIAA PAPER 91-4085)

The development of a modular tool designed to accommodate both the telerobotic and manned capabilities for performing a variety of operational tasks is described. The various missions from which the modular power tool has evolved are discussed along with a description of the proof-of-concept tool and task hardware developed. Attention is given to some of the lessons learned resulting from the 1-g and neutral buoyancy evaluations performed. Through the development of concepts such as the modular power tool, standardization and commonality of space maintenance operations and procedures can be realized. R.E.P.

A92-31301
SPACE STATION AND ADVANCED EVA; PROCEEDINGS OF THE 21ST INTERNATIONAL CONFERENCE ON ENVIRONMENTAL SYSTEMS, SAN FRANCISCO, CA, JULY 15-18, 1991
Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-872), 1991, 237 p. For individual items see A92-31302 to A92-31322. 1991 237 p
(ISBN 1-56091-152-2; SAE SP-872) Copyright

The present volume discusses such Space Station Freedom-related and EVA-related as a neutral-buoyancy portable life-support system (LSS), transient thermal modeling for a neutrally-buoyant cryofluid delivery system, extravehicular mobility units (EMUs) for future missions, human factors in spacesuit-glove design, a power-assisted EVA glove, casting technologies applicable to space suits, Space Shuttle EMU thermal vacuum test results, information requirements for Space Station Freedom EVA, and EVA capability enhancement via telerobotics. Also discussed are an ESA spacesuit design concept's verification, sublimator technology for the ESA spacesuit, a design process for an interplanetary mission EVA system, and candidates for fusible heat-sink materials. O.C.

A92-31302* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
COMPARISON OF METAL OXIDE ABSORBENTS FOR REGENERATIVE CARBON DIOXIDE AND WATER VAPOR REMOVAL FOR ADVANCED PORTABLE LIFE SUPPORT SYSTEMS
GREG T. STONESIFER (Lockheed Engineering and Sciences Co., Houston, TX), CRAIG H. CHANG (Allied-Signal Aerospace Co., Torrance, CA), ROBERT J. CUSICK (NASA, Johnson Space Center, Houston, TX), and JOAN M. HART (Allied-Signal Aerospace Co., AiResearch Los Angeles Div., CA) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 10 p refs
(Contract NAS9-17900)
(SAE PAPER 911344) Copyright

Metal-oxide absorbents (MOAs) have a demonstrated capability for removal of both metabolic CO2 and H2O from breathing atmospheres, simplifying portable life support system (PLSS) design and affording reversible operation for regeneration. Attention is presently given to the comparative performance levels obtained by silver-oxide-based and silver/zinc-oxide-based systems, which also proved to be longer-lasting than the silver oxide-absorber system. The silver/zinc system is found to substantially simplify the ventilation loop of a prospective Space Station Freedom PLSS. O.C.

A92-31303* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
NEUTRAL BUOYANCY PORTABLE LIFE SUPPORT SYSTEM PERFORMANCE STUDY
CHI-MIN CHANG (NASA, Johnson Space Center, Houston, TX), BRUCE C. CONGER, and JOHN V. IOVINE (Lockheed Engineering and Sciences Co., Houston, TX) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 15 p refs
(SAE PAPER 911346) Copyright

The Neutral Buoyancy Portable Life Support System (NBPSS) has been designed to support astronaut underwater training activities associated with EVA operations. The performance of competing NBPSS configurations has been analyzed on the basis of a modified 'Metabolic Man' program. NBPSS success is dependent on the development of novel cryogen supply tank and liquid-cooling garment vaporizer. Attention is given to mass and thermal balances and the evaluation results for the vent-loop ejector and heat-exchanger designs. O.C.

A92-31305* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
EMU PROCESSING - A MYTH DISPELLED
PAUL R. PEACOCK (Hamilton Standard, Houston, TX), RICHARD C. WILDE (Hamilton Standard, Windsor Locks, CT), GLENN C. LUTZ (NASA, Johnson Space Center, Houston, TX), and MICHAEL A. MELGARES (Boeing Aerospace Operations, Houston, TX) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 9 p
(SAE PAPER 911348) Copyright

The refurbishment-and-checkout 'processing' activities entailed by the Space Shuttle Extravehicular Mobility Units (EMUs) are currently significantly more modest, at 1050 man-hours, than when Space Shuttle services began (involving about 4000 man-hours). This great improvement in hardware efficiency is due to the design or modification of test rigs for simplification of procedures, as well as those procedures' standardization, in conjunction with an increase in hardware confidence which has allowed the extension of inspection, service, and testing intervals. Recent simplification of the hardware-processing sequence could reduce EMU processing requirements to 600 man-hours in the near future. O.C.

A92-31306
EVOLUTION OF THE EXTRAVEHICULAR MOBILITY UNIT FOR FUTURE MISSIONS
BRADFORD R. PROUTY, RICHARD C. WILDE, and MICHAEL GAN (Hamilton Standard, Windsor Locks, CT) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 12 p refs
(SAE PAPER 911349) Copyright

The various configurations being considered for Space Station Freedom have resulted in a moving target for tomorrow's demand for EVA and the requirements that will be imposed on the Extravehicular Mobility Unit (EMU). The Shuttle EMU is baselined to perform the assembly and operational activities of station and is currently undergoing the necessary incremental re-certification. This paper presents the evolution of an EMU from two perspectives. First, evolution is discussed within the context of continuously improving the life support system and the space suit assembly from the Mercury Program to NASA's current flight EMU. This includes a status of the ongoing enhancements and a discussion on the merits of additional improvements. The second perspective describes evolution for future programs involving significant differences in mission requirements and environments. Author

A92-31307* National Aeronautics and Space Administration, Washington, DC.
MR IMAGING OF HAND MICROCIRCULATION AS A POTENTIAL TOOL FOR SPACE GLOVE TESTING AND DESIGN
STEVEN W. PETERSON, ALVIN M. STRAUSS, TRISTA A. NIEMANN, and CHRISTINE H. LORENZ (Vanderbilt University, Nashville, TN) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 5 p refs
(SAE PAPER 911382) Copyright

The task of evaluating and designing space gloves requires accurate biomechanical characterization of the hand. The availability of magnetic resonance (MR) imaging has created new opportunities for in vivo analysis of physiological phenomena such as the relationship between circulation and fatigue. An MR imaging technique originally proposed to quantitatively evaluate cerebral perfusion has been modified to evaluate the capillary microcirculation in hand muscles. An experimental protocol was developed to acquire perfusion-weighted images in the hand before and after various levels of exercise. Preliminary results on the feasibility of applying the MR imaging technique to the study of microcirculation and fatigue in the hand are presented. The potential of this method for space glove testing and design is also discussed. Author

A92-31308
SPACESUIT GLOVE THERMAL MICROMETEOROID GARMENT PROTECTION VERSUS HUMAN FACTORS DESIGN PARAMETERS
JEFF CHODACK and PHIL SPAMPINATO (ILC Dover, Frederica, DE) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 17 p refs
(SAE PAPER 911383) Copyright

The thermal micrometeoroid garment (TMG) is a multilayered fabric assembly covering and protecting the Space Shuttle EVA suit's pressurized gloves. The TMG must both protect against space hazards that may abrade, puncture, or heat the glove, while meeting critical human-factors requirements to maximize tactility and grip while minimizing fatigue. Attention is presently given to pegboard-based glove dexterity test procedures and results which illustrate the importance of the TMG to glove performance. Lessons learned regarding the use of velcro fasteners and knurled surfaces are discussed. O.C.

A92-31309* National Aeronautics and Space Administration, Washington, DC.
A PROTOTYPE POWER ASSIST EVA GLOVE
JOHN A. MAIN, STEVEN W. PETERSON, and ALVIN M. STRAUSS (Vanderbilt University, Nashville, TN) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 9 p refs
(SAE PAPER 911384) Copyright

The most recent generation of space suit EVA gloves has addressed the problem of loose fit and stiffness in the fingers, but it remains difficult to build a glove assembly with low metacarpophalangeal joint stiffness. Fatigue due to constantly displacing the glove from a neutral position has been reported as the limiting factor in some EVA activities. This paper outlines an actuation system that uses gas filled bladders attached to the back of the EVA glove to provide the necessary force to bend the glove at the metacarpal joint, thus providing greater endurance during finger grasping tasks. A simple on-off controller senses hand movement through small pressure sensors between the finger and the glove restraint. The controller then fills or exhausts the bladders on the back of the glove to effectively move the neutral position of the glove as the hand inside moves. Author

A92-31310
ANALYSIS OF SPACE SUIT MOBILITY BEARINGS USING THE FINITE ELEMENT METHOD
JOSEPH V. WELCH (ILC Dover, Frederica, DE) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 18 p refs
(SAE PAPER 911385) Copyright

During the redesign of the Shuttle Space Suit Waist Bearing, ILC Dover investigated using the Finite Element Method as a means to evaluate a bearings' deflection characteristics. The minimization of bearing torque to reduce crew member fatigue is one of the design goals for the bearings' use in the space suit. A structural analysis method was developed that predicts relative radial deflections, ball loads, and contact angle, some of the determinants of bearing torque. This technique offers deflection and ball load information to the design engineer that have previously not been available until after prototype construction and testing. Having the Finite Element Analysis capability for space suit bearings played an important role in the design of a zero prebreathe suit development bearing. Author

A92-31311
CASTING TECHNOLOGY AS APPLIED TO ADVANCED SPACE SUIT CONCEPTS
RALPH A. TOSCANO, JR. (Air-Lock, Inc., Milford, CT) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July

15-18, 1991 1991 11 p refs
(SAE PAPER 911386) Copyright

Such advanced technologies and methods as CAD/CAM, FEM, soft tooling and computerized numerical control have been employed to render feasible the investment casting of hard EVA space suit elements from Al alloys, with minimal subsequent machining. Such castings have been found to be reliable, dimensionally accurate and economical, relative to components machined from solid billets. Attention is given to cast components for the AX-5 hard space suit design; graphs are presented for wall thickness vs span and tolerancing design considerations, together with a tabulation of casting Al alloy properties in various tempers. O.C.

A92-31312
DEVELOPMENT OF A PORTABLE CONTAMINATION DETECTOR FOR USE DURING EVA
PETER E. GLASER, GARY C. KOGER, DALE N. LASON, JAMES R. VALENTINE (Arthur D. Little, Inc., Cambridge, MA), JOSEPH H. BROOKS, ALBERT C. COPELAND, and ROBERT L. FROST (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 10 p refs
(SAE PAPER 911387) Copyright

Initial efforts in the development of an EVA portable contamination detector (EVA PCD) for use by the EVA crew have resulted in the selection and preliminary testing of a concept based upon time-of-flight (TOF) mass spectrometry. The EVA PCD will be a compact, man-portable device intended for use in the ambient vacuum outside the Space Station. It will be used to monitor the surfaces of the EVA suits and mobility units for the presence of potentially toxic contaminants, such as hydrazine propellants and oxidizers, which might otherwise be inadvertently carried into the interior of the Station. The EVA PCD will also be used to locate small leaks of heat exchange fluids in the outer surface of the Station. This paper describes some key performance needs for the EVA PCD system, approaches taken to interpreting those needs, and some of the results of tradeoff analyses which led to the selection of the TOF concept. Some results from initial experimental tests of a TOF unit are presented. Author

A92-31313 National Aeronautics and Space Administration. John C. Stennis Space Center, Bay Saint Louis, MS.
RESULTS OF SHUTTLE EMU THERMAL VACUUM TESTS INCORPORATING AN INFRARED IMAGING CAMERA DATA ACQUISITION SYSTEM
JAMES E. ANDERSON (NASA, Stennis Space Center, Bay Saint Louis, MS), EDWARD H. TEPPER (Hamilton Standard, Windsor Locks, CT), and LOUIS A. TREVINO (NASA, Johnson Space Center, Houston, TX) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 17 p refs
(SAE PAPER 911388) Copyright

Manned tests in Chamber B at NASA JSC were conducted in May and June of 1990 to better quantify the Space Shuttle Extravehicular Mobility Unit's (EMU) thermal performance in the cold environmental extremes of space. Use of an infrared imaging camera with real-time video monitoring of the output significantly added to the scope, quality and interpretation of the test conduct and data acquisition. Results of this test program have been effective in the thermal certification of a new insulation configuration and the '5000 Series' glove. In addition, the acceptable thermal performance of flight garments with visually deteriorated insulation was successfully demonstrated, thereby saving significant inspection and garment replacement cost. This test program also established a new method for collecting data vital to improving crew thermal comfort in a cold environment. Author

A92-31314
INFORMATION REQUIREMENTS FOR SPACE STATION FREEDOM EVA
GAIL GOODMAN (Grumman Corp., Bethpage, NY) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 5 p refs
(SAE PAPER 911526) Copyright

An analysis is conducted of the software-supported information requirements of advanced EVA operations. Pre-EVA information encompasses crew familiarization with tasks to be performed, task prioritization, and requisitions from inventory for maintenance-related replacement. In-progress EVA information includes detailed instructions regarding processes, tool selection, and component removal/replacement. Post-EVA information involves logging of maintenance and inventory data, damage/wear-trend analyses, etc. Attention is given to the helmet-mounted displays and inventory-management techniques critical to this category of information processing. O.C.

A92-31315
DESIGN AND TESTING OF AN ELECTRONIC EXTRAVEHICULAR MOBILITY UNIT (EMU) CUFF CHECKLIST
CHARLES H. SIMONDS and CHEN-HSIANG CHEN (Lockheed Engineering and Sciences Co., Houston, TX) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 9 p refs
(SAE PAPER 911529) Copyright

Design considerations and test results are presented for a breadboard version of an EMU electronic cuff checklist (ECC) encompassing an electroluminescent flat-panel display, control and data-storage electronics, a serial data port, and a battery. Display test results indicate that the display can be read in a wide range of illumination conditions, including full insolation. Water-tank weightless environment test results of a volumetric mockup of the ECC show that a cuff checklist which will not compromise astronaut reach and mobility can be designed. O.C.

A92-31316
INCREASING EVA CAPABILITY THROUGH TELEROBOTICS AND FREE FLYERS
DAVID E. ANDERSON, LISA M. ROCKOFF, and LISA K. EVELSIZER (McDonnell Douglas Space Systems Co., Space Station Div., Huntington Beach, CA) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 11 p refs
(SAE PAPER 911530) Copyright

The advancement of EVA performance toward large space structure assembly capabilities entailed by the projected Space Station Freedom, through such technologies as free-flyers and telerobotics, is presently illustrated in light of results from aerobrake and propellant tank farm neutral buoyancy testing. Attention is given to 8-psi EVA suits, EVA end-effectors, latch interfaces, EVA restraint methods, the Standard Quick-Release Universal Interface Device, 'zip' nuts, and orbital-replacement unit handoffs. Telerobotics for EVA require effective communications, an astronaut-positioning system, and high tooling commonality; free-flyers entail attention to monitoring camera views, hardware transportation, and crew and equipment retrieval. O.C.

A92-31317
EUROPEAN SPACE SUIT DESIGN CONCEPT VERIFICATION
A. I. SKOOG (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) and Y. OLLIVIER (Dassault Aviation, Saint-Cloud, France) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 14 p refs
(SAE PAPER 911575) Copyright

Test results are presented for the technology-breadboard of the ESA EVA Space Suit, whose hardware components encompassed gloves, shoulder joints, seals and bearings, a heat-removal sublimator, high pressure oxygen regulators, an integrated fan-pump separator, biomedical sensors, and a voice processor. Attention is given to the design details of these suit

components. A large performance data base has been compiled in the course of breadboard testing. The suit reference concept fulfils the given EVA system performance requirements in all regards except overall mass, lying 10 percent above the design target. O.C.

A92-31318
TECHNOLOGY FOR AN EVA FAN-PUMP-SEPARATOR
S. KLINGELE, H. FUNKE (Dornier GmbH, Friedrichshafen, Federal Republic of Germany), JOHANNES WITT (ESTEC, Noordwijk, Netherlands), B. MERCHIE, and V. BOITEL (Technofan, Blagnac, France) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 6 p
(SAE PAPER 911576) Copyright

A breadboard-level, integrated 'fan-pump-separator' unit has been developed and tested for the European EVA Space Suit system. Conceptual tradeoff and design-definition studies confirmed the power-, mass-, and volume-related advantages of a three-device integration; the resulting unit accomplishes oxygen circulation, coolant-water circulation, and water separation on the basis of a single brushless dc motor. Concept benefits have been demonstrated during breadboard operation in air at both ambient pressure and 500 hPs. O.C.

A92-31319
DEVELOPMENT OF SUBLIMATOR TECHNOLOGY FOR THE EUROPEAN EVA SPACE SUIT
CHRISTINE PLANERT, PETER KREMER (Nord-micro Elektronik Feinmechanik AG, Frankfurt am Main, Federal Republic of Germany), and JOHANNES WITT (ESTEC, Noordwijk, Netherlands) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 7 p
(SAE PAPER 911577) Copyright

Heat generated during EVA operations by the European Space Suit will be dissipated via water sublimation from ice to vapor at pressures below 6 hPa. The sublimator consists of a porous plate with feedwater distribution underneath and a liquid/gas heat-exchanger component. A breadboard model of this device has been constructed from stainless steel and tested to demonstrate concept feasibility and performance capabilities. Attention is given to the detailed design features of the porous plate. O.C.

A92-31320
DEVELOPMENT OF A PP CO2 SENSOR FOR THE EUROPEAN SPACE SUIT
KLAUS AMMANN (Draegerwerk AG, Luebeck, Federal Republic of Germany) and JOHANNES WITT (ESTEC, Noordwijk, Netherlands) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 10 p refs
(SAE PAPER 911578) Copyright

A summary of a technology research program is given aiming at the development of a CO2 partial pressure sensor suitable for monitoring the PP CO2 inside the oxygen ventilation loop of the EVA life support module. At first, a trade-off of candidate sensor concepts is presented. As a result, the infrared optical sensor concept has been selected. In the frame of a discussion on basic facts of IR absorption the rationale for the selected configuration of the IR sensor is given. A breadboard model of the PP CO2 sensor together with a test set-up has been established. The sensor was subjected to a test program consisting of two separate test periods. The main results are given. Finally, the findings are discussed in the light of the development of future flight hardware. Author

A92-31321
A DESIGN PROCESS FOR AN INTERPLANETARY EXTRAVEHICULAR ACTIVITY SYSTEM
PETER J. WELLS (Grumman Corp., Space Station Program Support Div., Reston, VA) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 6 p refs
(SAE PAPER 911580) Copyright

This paper describes a design process for an extravehicular system suitable for accomplishing a set of specific missions in an interplanetary environment. This process is based upon project management, system engineering, and strategic management concepts. The process is a sequential set of incremental actions which build upon prior activities in order to reach a design solution. Each process step considers a specific goal, environmental influences, as well as the general mission. The paper first addresses the overal mission in order to produce a set of functional requirements for each of the major mission components. The extravehicular system is then developed via a similar process to satisfy those functional requirements. The end result of this process is an extravehicular system specifically tailored to accomplish the mission. Author

A92-31322* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FUSIBLE HEAT SINK MATERIALS - AN IDENTIFICATION OF ALTERNATE CANDIDATES
GUNA SELVADURAY (San Jose State University, CA) and CURTIS LOMAX (NASA, Ames Research Center, Moffett Field, CA) IN: Space Station and advanced EVA; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 7 p refs
(Contract NCC2-260)
(SAE PAPER 911345) Copyright

Fusible heat sinks are a possible source for thermal regulation of space suited astronauts. An extensive database search was undertaken to identify candidate materials with liquid solid transformations over the temperature range of -18 C to 5 C; and 1215 candidates were identified. Based on available data, 59 candidate materials with thermal storage capability, DeltaH values higher than that of water were identified. This paper presents the methodology utilized in the study, including the decision process used for materials selection. Author

N92-11215*# Massachusetts Inst. of Tech., Cambridge.
SPACE ENGINEERING Final Report, 1 Nov. 1979 - 31 Mar. 1991
HAROLD L. ALEXANDER 29 Oct. 1991 22 p
(Contract NAGW-21)
(NASA-CR-187820; NAS 1.26:187820) Avail: CASI HC A03/MF A01

Human productivity was studied for extravehicular tasks performed in microgravity, particularly including in-space assembly of truss structures and other large objects. Human factors research probed the anthropometric constraints imposed on microgravity task performance and the associated workstation design requirements. Anthropometric experiments included reach envelope tests conducted using the 3-D Acoustic Positioning System (3DAPS), which permitted measuring the range of reach possible for persons using foot restraints in neutral buoyancy, both with and without space suits. Much neutral buoyancy research was conducted using the support of water to simulate the weightlessness environment of space. It became clear over time that the anticipated EVA requirement associated with the Space Station and with in-space construction of interplanetary probes would heavily burden astronauts, and remotely operated robots (teleoperators) were increasingly considered to absorb the workload. Experience in human EVA productivity led naturally to teleoperation research into the remote performance of tasks through human controlled robots. Author

N92-13260# Aerospatiale, Cannes (France).
THE AMADEUS EXPERIMENT: IN-FLIGHT TEST RESULTS EVALUATION
DELAMBRE BASTARD (Aerospatiale, Cannes (France).) and MERCIER CONDE (Centre National d'Etudes Spatiales, Toulouse, France) *In* ESA, European Space Power Conference. Volume

2: Photovoltaic Generators p 713-723 Aug. 1991
Copyright Avail: CASI HC A03/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

The AMADEUS experiment performed on board the Soviet station MIR offered the advantage of deployment undisturbed by the gravity compensation device; thusly, it was a good way to validate the JAMES software. The experiment consisted of deploying a mock up built of four deployment arms and AMEDE (French acronym for improvement of deployment mechanisms) mechanisms in two and three space directions. Evaluation of the test results provides a good correlation between tests and simulations; 5 percent on the mockup arms' trajectories and 3.5 percent on the global deployment time, giving a good confidence in the actual full scale solar array deployment kinematics (SPOT4/HELIOS, Spacebus solar arrays for example). A description of the inflight experiment is given. Main inputs and outputs of the deployment simulation are considered and tests results are evaluated. Its applicability to solar array deployments is looked into. ESA

N92-15113*# National Aeronautics and Space Administration, Washington, DC.
SPACE STATION FREEDOM. A FOOTHOLD ON THE FUTURE
LEONARD DAVID 1988 47 p LIMITED REPRODUCIBILITY: More than 20% of this document may be affected by color photographs
(NASA-NP-107/10-88; NAS 1.83:107/10-88)

A general account of the Space Station Freedom, accompanied by many color photographs and drawings, is given. Topics covered include conducting science in space, living in space, the use of the Space Station in space exploration missions, orbital mechanics, Space Station configuration evolution, and future space scenarios. Author

N92-15116*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SPACE STATION FREEDOM CONTINGENCY REBOOST AND RESUPPLY STRATEGIES
PATRICK A. TROUTMAN, JONATHAN N. CRUZ, MICHAEL L. HECK, DANIEL D. MAZANEK, and RENJITH R. KUMAR (Analytical Mechanics Associates, Inc., Hampton, VA.) Oct. 1991 79 p
(Contract RTOP 476-14-15-01)
(NASA-TM-104169; NAS 1.15:104169) Avail: CASI HC A05/MF A01

The objective of this study was to determine the requirements necessary to ensure a viable Space Station Freedom (SSF) in the event of a delay in the date of the first element launch, and/or in the event that the nominal assembly sequence is interrupted, perhaps due to a delay in the Space Shuttle Launch Schedule. Orbit lifetimes, reboost fuel requirements, and controllability requirements were calculated for each stage of the SSF assuming anywhere from a 6 to 24 month delay/interruption in the baseline SSF assembly sequence. These results were assessed in order to formulate strategies to assure SSF viability in the presence of assembly sequence delays and interruptions. Author

N92-17354*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
EMU EVOLUTION
M. ROUEN *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 2: Space Station Freedom, Part 2 p 1201-1235 Sep. 1991
Avail: CASI HC A03/MF A04

Evolution of Extravehicular Mobility Unit (EMU) technology is necessary to support the Extravehicular Activity (EVA) requirements of the Space Station Freedom Program and those of the Space Exploration Initiative (SEI). Key qualities supporting long-duration missions include technologies that are highly reliable, durable, minimize logistics requirements, and are in-flight maintainable and serviceable. While these qualities are common to SSF and SEI EVA, development paths will differ where specific mission requirements impose different constraints. Development of reusable, regenerative technologies is necessary to minimize the logistics penalties. Increased battery discharge/recharge cycle life and usable wet life, compact high current density fuel cells, reusable CO2 absorbing media, and thermal radiation coupled with venting heat rejection technologies are just some methods of reducing consumables. Development must strive for durable, reliable systems that are in-flight serviceable and maintainable, which are vital for missions where logistics capabilities are extremely constrained. Key areas include suit components (e.g., gloves, boots, and cooling garments), and life support hardware such as fans, pumps, instrumentation, and emergency O2 systems. Higher pressure suits will reduce EVA prebreathe requirements and pre-EVA operations overall. Many challenges of higher pressure suits have been addressed by on-going development. Emphasis on glove development is necessary to provide low fatigue, dexterous glove mobility at higher suit pressures. Minimum impact hooks and scars which support an advanced SSF EMU have been identified. These accommodations permit upgrades that support servicing of low volume, high pressure oxygen systems, and hydrogen technologies such as fuel cell, and venting hydrogen heat rejection systems. Author

N92-17361*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
COLLISION AVOIDANCE SENSOR SKIN
In NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 2: Space Station Freedom, Part 2 p 1405-1432 Sep. 1991
Avail: CASI HC A03/MF A04

The objective was to totally eliminate the possibility of a robot (or any mechanism for that matter) inducing a collision in space operations. We were particularly concerned that human beings were safe under all circumstances. This was apparently accomplished, and it is shown that GSFC has a system that is ready for space qualification and flight. However, it soon became apparent that much more could be accomplished with this technology. Payloads could be made invulnerable to collision avoidance and the blind spots behind them eliminated. This could be accomplished by a simple, non-imaging set of 'Capaciflector' sensors on each payload. It also is evident that this system could be used to align and dock the system with a wide margin of safety. Throughout, lighting problems could be ignored, and unexpected events and modeling errors taken in stride. At the same time, computational requirements would be reduced. This can be done in a simple, rugged, reliable manner that will not disturb the form factor of space systems. It will be practical for space applications. The lab experiments indicate we are well on the way to accomplishing this. Still, the research trail goes deeper. It now appears that the sensors can be extended to end effectors to provide precontact information and make robot docking (or any docking connection) very smooth, with minimal loads impacted back into the mating structures. This type of ability would be a major step forward in basic control techniques in space. There are, however, baseline and restructuring issues to be tackled. The payloads must get power and signals to them from the robot or from the astronaut servicing tool. This requires a standard electromechanical interface. Any of several could be used. The GSFC prototype shown in this presentation is a good one. Sensors with their attendant electronics must be added to the payloads, end effectors, and robot arms and integrated into the system. Author

N92-19493*# Arizona Univ., Tucson. Dept. of Aerospace and Mechanical Engineering.
AUTONOMOUS SPACE PROCESSOR FOR ORBITAL DEBRIS Summary Report, 1990 - 1991
KUMAR RAMOHALLI, MICKY MARINE, JAMES COLVIN, RICHARD CROCKETT, LEE SWORD, JENNIFER PUTZ, and SHERI WOELFLE 1991 66 p Presented at the 7th Annual Summer Conference, Coccoa Beach, FL, 17-21 Jun. 1991 Original contains color illustrations
(Contract NASW-4435)
(NASA-CR-189986; NAS 1.26:189986)

The development of an Autonomous Space Processor for Orbital Debris (ASPOD) was the goal. The nature of this craft, which will process, in situ, orbital debris using resources available in low Earth orbit (LEO) is explained. The serious problem of orbital debris is briefly described and the nature of the large debris population is outlined. The focus was on the development of a versatile robotic manipulator to augment an existing robotic arm, the incorporation of remote operation of the robotic arms, and the formulation of optimal (time and energy) trajectory planning algorithms for coordinated robotic arms. The mechanical design of the new arm is described in detail. The work envelope is explained showing the flexibility of the new design. Several telemetry communication systems are described which will enable the remote operation of the robotic arms. The trajectory planning algorithms are fully developed for both the time optimal and energy optimal problems. The time optimal problem is solved using phase plane techniques while the energy optimal problem is solved using dynamic programming. Author

N92-19772*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
A METHOD OF EVALUATING EFFICIENCY DURING SPACE-SUITED WORK IN A NEUTRAL BUOYANCY ENVIRONMENT
MICHAEL C. GREENISEN (Krug International, Houston, TX.), PHILLIP WEST, FREDERICK K. NEWTON, JOHN H. GILBERT, and WILLIAM G. SQUIRES (Texas Lutheran Coll., Seguin.) Oct. 1991 11 p
(NASA-TP-3153; S-648; NAS 1.60:3153) Avail: CASI HC A03/MF A01

The purpose was to investigate efficiency as related to the work transmission and the metabolic cost of various extravehicular activity (EVA) tasks during simulated microgravity (whole body water immersion) using three space suits. Two new prototype space station suits, AX-5 and MKIII, are pressurized at 57.2 kPa and were tested concurrently with the operationally used 29.6 kPa shuttle suit. Four male astronauts were asked to perform a fatigue trial on four upper extremity exercises during which metabolic rate and work output were measured and efficiency was calculated in each suit. The activities were selected to simulate actual EVA tasks. The test article was an underwater dynamometry system to which the astronauts were secured by foot restraints. All metabolic data was acquired, calculated, and stored using a computerized indirect calorimetry system connected to the suit ventilation/gas supply control console. During the efficiency testing, steady state metabolic rate could be evaluated as well as work transmitted to the dynamometer. Mechanical efficiency could then be calculated for each astronaut in each suit performing each movement. Author

09

ROBOTICS & REMOTE OPERATIONS

Simulations, models, analytical techniques, and requirements for remote, automated or robotic mechanical systems. Includes remote control of experiments.

A92-11149* Lockheed Engineering and Sciences Co., Houston, TX.
HAND CONTROLLER COMMONALITY EVALUATION PROCESS
MARK A. STUART, JOHN M. BIERSCHWALE, ROBERT P. WILMINGTON, SUSAN C. ADAM, MANUEL F. DIAZ (Lockheed Engineering and Sciences Co., Houston, TX), and DEAN G. JENSEN (NASA, Johnson Space Center, Houston, TX) IN: Human Factors Society, Annual Meeting, 34th, Orlando, FL, Oct. 8-12, 1990, Proceedings. Vol. 1 1990 5 p refs
(Contract NAS9-17900)
Copyright

A hand controller evaluation process has been developed to determine the appropriate hand controller configurations for supporting remotely controlled devices. These devices include remote manipulator systems (RMS), dexterous robots, and remotely-piloted free flyers. Standard interfaces were developed to evaluate six different hand controllers in three test facilities including dynamic computer simulations, kinematic computer simulations, and physical simulations. The hand controllers under consideration were six degree-of-freedom (DOF) position and rate minimaster and joystick controllers, and three-DOF rate controllers. Task performance data, subjective comments, and anthropometric data obtained during tests were used for controller configuration recommendations to the SSF Program. O.G.

A92-11321
CONTROL OF SPACE FREE-FLYING ROBOT
KAZUYA YOSHIDA and YOJI UMETANI (Tokyo Institute of Technology, Japan) IN: IEEE Conference on Decision and Control, 29th, Honolulu, HI, Dec. 5-7, 1990, Proceedings. Vol. 1 1990 6 p refs
Copyright

Both theoretical and experimental studies on the control of a free-flying robot manipulator for space application are presented. The goal of the studies is to develop a new control method for target capturing in a space micro-gravity environment, considering the dynamical interaction between the manipulator operation and the base vehicle motion. In the theoretical study, a generalized Jacobian matrix (GJM) concept of motion control and a guaranteed workspace (GWS) for path planning are investigated. In the experimental study, a laboratory model of a robot satellite supported on air bearings is developed; the model comprises a base satellite and a two-link manipulator arm. An on-line control scheme with vision feedback is developed for experimenting with capture operations, on the basis of the GJM and GWS. The manipulator can properly chase and capture both a standing target and a moving target in spite of the complex satellite/manipulator dynamical interaction. I.E.

A92-11322
CONTROL OF SPACE MANIPULATOR FOR CAPTURING A TUMBLING OBJECT
ZHENG H. LUO and YOSHIYUKI SAKAWA (Osaka University, Toyonaka, Japan) IN: IEEE Conference on Decision and Control, 29th, Honolulu, HI, Dec. 5-7, 1990, Proceedings. Vol. 1 1990 6 p refs
Copyright

A space robot is considered which consists of a satellite base and a manipulator mounted on the base. The mission of the robot is to capture a tumbling object in space, the motion of which is governed by Euler's equation, by controlling the manipulator joint angles. First, the equations of motion of the space robot are derived by using the conservation law of linear and angular moments. Then, a sensory feedback control law is proposed which guarantees that both the position and the orientation of the manipulator hand coincide asymptotically with those of the tumbling object. Some results of a computer simulation are also shown. I.E.

A92-11568
KINEMATICS AND CONTROL OF A SPACE MANIPULATOR USING THE MACRO-MICRO MANIPULATOR CONCEPT
OLAV EGELAND and JAN R. SAGLI (Norwegian Institute of Technology, Trondheim, Norway) IN: IEEE Conference on Decision and Control, 29th, Honolulu, HI, Dec. 5-7, 1990, Proceedings. Vol. 6 1990 6 p refs
Copyright

A control scheme for the coordination of motion in a spacecraft/manipulator system is presented. The augmented task-space approach is used for feedback linearization and decoupling of the system, and it is shown how end-effector motion can be decoupled from satellite motion, satellite rotation, or total system momentum by selecting suitable coordinates to represent the motion of the satellite. The schemes are based on recursive calculation of kinematics and dynamics, and 12 degrees-of-freedom

can be controlled without excessive computational effort. Feedback linearization and decoupling of end-effector motion and total system momentum are discussed in detail. The satellite controller can then be developed independently of the manipulator controller, and reaction jets and momentum wheels are used only to reposition the satellite. The spacecraft-manipulator system is regarded as a redundant manipulator of the macro-micro type, and a redundancy resolution scheme is used to generate the position reference for the spacecraft. The proposed controller was simulated with a 12-degrees-of-freedom model which was generated with a recursive formulation of Jacobians and the dynamics, and the results are presented. I.E.

A92-12448
SUPERVISED SPACE ROBOTIC SYSTEM - OPERATOR INTERFACE DESIGN
PIOTR WOJCIK, PATRICK FEIGHAN, and KEITH CHRYSTALL (Alberta Research Council, Advanced Computing and Engineering Dept., Calgary, Canada) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 10 p. Oct. 1991 10 p refs
(IAF PAPER 91-027) Copyright

The conceptual design of an operator interface for a teleoperated robotic system is presented. This concept addresses the problems of information and command transmission time delays by using predictive simulations of robot activities. It is shown that the predictive simulation enables a human operator to preview performance of robots before a work plan is executed by the robotic system in orbit. R.E.P.

A92-12469
CONTROL SYSTEM ARCHITECTURE OF THE MOBILE SERVICING SYSTEM
MICHAEL E. STIEBER, DANTE A. LAURENZIO (Canadian Space Agency, Ottawa, Canada), and PATRICK T. K. FUNG (Spar Aerospace, Ltd., Toronto, Canada) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 8 p. Oct. 1991 8 p refs
(IAF PAPER 91-055) Copyright

The design of the Canadian Mobile Servicing System (MSS) for the Space Station Freedom is described. Special attention is given to the Space Station Remote Manipulator System, a larger of the two robotic systems designed for massive payloads; the Special Purpose Manipulator, a robot for tasks that require dexterous manipulation of small objects such as Orbital Replaceable Units; and the functions and control architecture of the MSS control system. A diagram of the MSS is presented. I.S.

A92-12470
DEVELOPMENT OF FLYING TELEROBOT MODEL FOR GROUND EXPERIMENTS
YOSHITSUGU TODA, TOSHIAKI IWATA, KAZUO MACHIDA (Electrotechnical Laboratory, Tsukuba, Japan), AKIKO OTSUKA, HIDETOSHI TORIU, and YASUO SHINOMIYA (Toshiba Corp., Komukai Works, Kawasaki, Japan) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p refs
(IAF PAPER 91-056) Copyright

A space telerobot model for ground experiments is presently operable for free flying and manipulating on a 2D flat test bed with an air bearing system. A method is proposed for cooperative control between the robot body's attitude control and the manipulator position control that indicates adequate performance. The manipulator force control methods, e.g., impedance control and the active limp, are very effective while capturing and handling a floating object in a microgravity field. R.E.P.

A92-12475
ROBOTIC VISION TECHNOLOGY FOR SPACE STATION AND SATELLITE APPLICATIONS
A. K. C. WONG, D. N. C. TSE, G. R. HEPPLER (Waterloo, University, Canada), and K. RUEB (Virtek Corp., Waterloo, Canada) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 15 p. Oct. 1991 15 p refs
(IAF PAPER 91-061) Copyright

Robotic vision technologies newly developed for satellites and Space Station applications are presented. The utilization of stereo CCD camera for sensing the deformed shape of a third generation satellite is described. Attention is given to the notion of shape interpolation and error reduction. R.E.P.

A92-12483
ON THE DESIGN AND DEVELOPMENT OF THE SPACE STATION REMOTE MANIPULATOR SYSTEM (SSRMS)
R. G. DANIELL (Spar Aerospace, Ltd., Weston, Canada) and J. R. BECK (Canadian Space Agency, Ottawa, Canada) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. Oct. 1991 12 p
(IAF PAPER 91-074) Copyright

The significant design features of the SSRMS and details of the several new mechanical designs being developed for the SSRMS are presented. Design requirements must permit remotely controlled relocation of the SSRMS to various operating points on the Station and provide the capability using robotics and/or EVA, to maintain and repair the SSRMS while on-orbit. Attention is given to the latching end effector, the collet latch, the power and data grapple fixture, the force moment sensor, and the joint motor modules. R.E.P.

A92-12484
THE SPACE STATION REMOTE MANIPULATOR SYSTEM, HUMAN COMPUTER INTERFACE CONSIDERATIONS
GILLES PELLETIER (CAE Electronics, Ltd., Saint-Laurent, Canada) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Research supported by Canadian Space Agency. Oct. 1991 9 p
(IAF PAPER 91-075) Copyright

NASA's Space Station Freedom (SSF) will incorporate the Space Station Remote Manipulator System (SSRMS). The interface between the SSRMS and its human operator must compensate for the preclusion of direct vision by distances and obstacles. Operator reaction time is presently identified as a major factor in the design of this human-computer interface; operator-reaction delays will be minimized through the use of real-time animated graphics that are overlaid on the SSRMS's video images. Accounts are presently given of the SSRMS's display of measured and computed parameters, command modes, input techniques, and interactions between user and computer. O.C.

A92-12499
SPDM ROBOT/ASTRONAUT COMPARISONS WITH RESPECT TO SPACE STATION FREEDOM OPERATIONS
D. L. BROWN and L. R. STEVENS (Spar Aerospace, Ltd., Toronto, Canada) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. Oct. 1991 12 p refs
(IAF PAPER 91-093) Copyright

Assembly and maintenance operations for NASA's Space Station Freedom (SSF) will be performed either by EVA or by teleoperated extravehicular robotics. The Mobile Servicing System (MSS) supplied by Canada for the SSF employs two robotic manipulators: the Space Station Remote Manipulator System and the Special Purpose Dextrous Manipulator (SPDM). A comparative study is presently conducted for the EVA and SPDM approaches of the MSS during SSF assembly and maintenance. Attention is given to the illustrative case of a Design Reference Mission for the self-maintainability of the MSS. O.C.

A92-14737
ON THE CONTROL OF A CLASS OF FLEXIBLE MANIPULATORS USING FEEDBACK LINEARIZATION APPROACH
V. J. MODI, F. KARRAY, and J. K. CHAN (British Columbia, University, Vancouver, Canada) IAF, International Astronautical

Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 11 p. Research supported by Centers of Excellence Program. Oct. 1991 11 p refs
(Contract NSERC-A-2181)
(IAF PAPER 91-324) Copyright

The paper studies nonlinear dynamics and control of the Space Station based mobile, flexible, two-linked manipulators accounting for elastic character of the joints. The governing highly nonlinear, nonautonomous and coupled equations of motion are described first followed by the modal discretization procedure. A parametric response study suggests situations with unacceptable levels of deflections and accelerations for certain proposed missions, as well as station libration and payload positioning errors. An inverse control technique is suggested to achieve high tracking accuracy of the MSS in presence of maneuver induced as well as other external and internal disturbances. The control strategy is so designed as to regulate the libration of the Space Station and to insure joints tracking of prescribed trajectories, while limiting the effect of the structural vibration during large slewing maneuvers of the MSS. Two different control schemes, both based on the feedback linearization technique, are developed and their relative merit assessed. Author

A92-15260* Howard Univ., Washington, DC.
CENTRALIZED, DECENTRALIZED, AND INDEPENDENT CONTROL OF A FLEXIBLE MANIPULATOR ON A FLEXIBLE BASE
FEIYUE LI, PETER M. BAINUM, and JIANKE XU (Howard University, Washington, DC) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. Oct. 1991 12 p refs
(Contract NSG-1414)
(IAF PAPER 91-357) Copyright

The dynamics and control of a flexible manipulator arm with payload mass on a flexible base in space are considered. The controllers are provided by one torquer at the center of the base and one torquer at the connection joint of the robot and the base. The nonlinear dynamics of the system is modeled by applying the finite element method and Lagrangian formula. Three control strategies are considered and compared, i.e., centralized control, decentralized control, and independent control. All these control designs are based on the linear quadratic regulator theory. A mathematical decomposition is used in the decentralization process so that the coupling between the subsystems is weak, while a physical decomposition is used in the independent control design process. For both the decentralized and the independent controls, the stability of the overall linear system is checked before a numerical simulations is initiated. Two numerical examples show that the response of the independent control system are close to those of the centralized control system, while the responses of the decentralized control system are not. Author

A92-15391
EFFICIENT SIMULATION OF IN-ORBIT TRANSPORTATION AND CONTROL OF FLEXIBLE BEAMS BY A FREE-FLYING ROBOTIC DEVICE
J. MARCZYK and A. BELLAZZI (Ripto International, Turin, Italy) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 23 p refs
Copyright

Modeling/simulation issues of a free-flying robotic vehicle dedicated to in-orbit transportation of flexible payloads are addressed. Emphasis is placed on the robot-payload docking mechanism simulated in various ways and its impact on simulation duration. The performance of ESA-MIDAS has been compared with the simulation codes which are currently under development, particularly Kane's minimum order approach. It is concluded that Kane's approach performs far better than the classical Lagrange multiplier-based method. The ratio of effective running speeds is found to be highly topology-dependent, but typical ratios range from two to ten. O.G.

A92-15392
THE USE OF KANE'S EQUATION TO WRITE A CONTINUOUS MODEL OF A FLEXIBLE ROBOT AS A STEP TOWARD A DISCRETE MODEL
J. C. PIEDBOEUF (Royal Military College of Canada, Kingston) and R. HURTEAU (Ecole Polytechnique, Montreal, Canada) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 15 p refs
Copyright

Kane's equations are used to write the nonlinear continuous model of a two-degrees-of-freedom robot with a flexible forearm. The generalized coordinates are defined as discrete, as distributed or as local. A first phase results in a set of nonlinear ODEs representing the rigid motion and a set of nonlinear PDEs corresponding to the flexible motion. In a second phase, the discrete model is written by using the assumed-mode method to substitute the distributed generalized coordinates for a set of coordinates which depend only on the time. At this point it is demonstrated that the equations for the flexible motion of the discrete model can be written as a linear combination of the PDEs and of their associated boundary conditions. Author

A92-17878
COOPERATIVE DYNAMIC CONTROL FOR DUAL-ARM FLYING ROBOT IN PROXIMITY MANEUVER
TOSHIAKI IWATA, YOSHITSUGU TODA, and KAZUO MACHIDA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 39, no. 453, 1991, p. 513-521. In Japanese. 1991 9 p In JAPANESE refs

This paper presents cooperative dynamic control methods for a dual-armed free-flying robot in proximity maneuvering. A 2D space robot model equipped with thrusters and dual three-degree-of-freedom arms is considered. First, the equation of motion is derived by Kane's method. Secondly, the method is adapted to point-to-point resolved motion acceleration control. Two cases are considered: control with thrusters, and without thrusters; these are then compared. Third, it is inappropriate to use thrusters for controlling the attitude because of the amount of propellant required. If a single arm is enough for a task, the other arm is available to control the attitude. When the robot avoids an obstacle or chases a moving target, point-to-point control is insufficient. The control law is extended to follow an arbitrary trajectory. Aligning with a target axis and chasing a moving target are demonstrated. Author

A92-18560
AUTOMATION AND TELEOPERATION IN MANNED SPACEFLIGHT
E. SCHAFHAUSER, J. R. KASS, and E. GIBSON (OHB System GmbH, Bremen, Federal Republic of Germany) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 7 p. Oct. 1991 7 p
(Contract ESA-8548/89/NL/IW)
(IAF PAPER 91-567) Copyright

In this paper, a qualitative analysis is made of the various impacts of automation and teleoperations on manned-spacecraft-crew efficiency, facility and experiment development, cost lead-time, and scientific return, with some examples quantitatively analyzed. Teleoperations and ground control of a manned space laboratory carries with it a host of new problems and areas of concern not previously encountered, such as the domain of command and control execution. Conflicts of control and priority, manual override, and procedural guidelines and language, are areas that must be considered from a crew point of view as well as that of the ground operators and experimenters. An attempt is made, in this paper, to view the question of automation and teleoperations not only in the context of technical feasibility, but also with respect to all other relevant impacted factors. Author

A92-19089* Lockheed Engineering and Sciences Co., Houston, TX.
SYNTHETIC LASER RANGE IMAGERY USING Z-BUFFERING
ROBERT NORSWORTHY (Lockheed Engineering and Sciences Co., Intelligent Systems Dept., Houston, TX) IN: 1990 Annual Summer Computer Simulation Conference, 22nd, Calgary, Canada, July 16-18, 1990, Proceedings 1990 6 p refs
(Contract NAS9-15800; NAS9-17900)
Copyright
A technique for simulating laser range imagers using Z-buffering and readily available 3D graphics hardware is described. This approach utilizes the graphics hardware features available for hidden surface removal to achieve faster than real-time speed. How Z-buffering works in graphics workstations, how it can be adapted to provide a simulation of laser range images, and the performance characteristics of this simulation on a computer are shown. C.D.

A92-19455
MODELLING AND CONTROL OF FLEXIBLE ROBOTS
P. CHEDMAIL, Y. AOUSTIN, and CH. CHEVALLEREAU (Ecole Nationale Superieure de Mecanique, Nantes, France) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 32, Dec. 1991, p. 1595-1619. Dec. 1991 25 p refs
Copyright
The object of this paper is to present a study on the modeling and control of flexible robots by using a knowledge-based control design approach. An appropriate model of such a mechanical system in the case of open loop robot structures is developed. A total Lagrangian formulation is used. After discretization, the degrees of freedom are the joint variables and the elastic degrees of freedom of each link. The elastic motions are referred to the rigid configuration of the considered link. The control law is obtained by using a nonlinear decoupling technique which is applied to the joint variables. A second control loop performs an active damping of the elastic motions: it is based on the linearized model and uses the LQR method. This approach has been experimented with a two-flexible-links robot. The results demonstrate its feasibility. Further developments mainly concern theoretical aspects on the robustness of these control laws, the identification of the model parameters and the choice of other appropriate modeling techniques. Author

A92-19461 Colorado Univ., Boulder.
A MODULAR MULTIBODY ANALYSIS CAPABILITY FOR HIGH-PRECISION, ACTIVE CONTROL AND REAL-TIME APPLICATIONS
K. C. PARK, J. D. DOWNER, J. C. CHIOU, and C. FARHAT (Colorado, University, Boulder) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 32, Dec. 1991, p. 1767-1798. Dec. 1991 32 p refs
(Contract NAG1-756; NGT-50254; F49620-87-C-0074)
Copyright
A computationally oriented formulation and its solution procedures for the analysis of rigid-flexible multibody dynamics systems are presented. The present formulation adopts a set of dual coordinate systems, an inertially fixed one for the measure of translational motions and a body-based one for rotational motions. The origins of these coordinate systems are located at the centers of rigid bodies and at the nodal points of flexible bodies for implementation ease. The flexibility is modeled by an intrinsic spatial beam theory which is approximated by transverse-shear deformable linear beam elements. The solution of the resulting equations of motion including system constraints is obtained by a partitioned procedure, which solves first for the constraint force vector, then the generalized coordinates for the rigid and flexible components, and finally interaction quantities such as active control forces, maneuvering space ranges and corrections due to state measurements, with each solution stage being processed by the corresponding separate module. A central feature of the present capability is its high accuracy of the analysis results by demanding the energy conservation throughout the various stages of response analyses. Several examples are included to demonstrate the capabilities of the present analysis software both on sequential and parallel machines. Author

A92-20455
AUTOMATION AND ROBOTICS - A FLEXIBLE TECHNOLOGY FOR IN-ORBIT PAYLOAD OPERATIONS
W. DE PEUTER, A. ELFVING (ESTEC, Noordwijk, Netherlands), and M. TOUSSAINT (ESA, Directorate for Space Station and Microgravity, Paris, France) ESA Bulletin (ISSN 0376-4265), no. 68, Nov. 1991, p. 77-82. Nov. 1991 6 p
Copyright
Several concepts for the automation of system and payload operations in space are examined. Special attention is given to the Automation and Robotics (A&R) technology and to the being developed by the ESA Columbus Programme and the ground-based Columbus Automation and Robotics Testbed (CAT) being developed by the ESA Columbus Programme as a tool for evaluating the benefits of A&R for microgravity experimenter and for familiarizing potential users, payload engineers, and operators with A&R concepts and applications. The CAT will be integrated with the Telescience Testbed, the Crew-Workstation Testbed, and the Data Management System Testbed, allowing very realistic end-to-end simulations of space experimentation scenarios. I.S.

A92-21151
SMART END EFFECTOR FOR DEXTEROUS MANIPULATION IN SPACE
KAZUO MACHIDA, YOSHITSUGU TODA, TOSHIAKI IWATA (MITI, Electrotechnical Laboratory, Tsukuba, Japan), and TADASHI KOMATSU (Toshiba Corp., Kawasaki, Japan) Feb. 1992 7 p refs
Copyright

A92-23653* National Aeronautics and Space Administration, Washington, DC.
I-SAIRAS '90; PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM ON ARTIFICIAL INTELLIGENCE, ROBOTICS AND AUTOMATION IN SPACE, KOBE, JAPAN, NOV. 18-20, 1990
Symposium sponsored by AIAA, American Association of Artificial Intelligence, NASA, et al. Tokyo, REN Associates, Inc., 1990, 352 p. For individual items see A92-23654 to A92-23729. 1990 352 p
The present conference on artificial intelligence (AI), robotics, and automation in space encompasses robot systems, lunar and planetary robots, advanced processing, expert systems, knowledge bases, issues of operation and management, manipulator control, and on-orbit service. Specific issues addressed include fundamental research in AI at NASA, the FTS dexterous telerobot, a target-capture experiment by a free-flying robot, the NASA Planetary Rover Program, the Katydid system for compiling KEE applications to Ada, and speech recognition for robots. Also addressed are a knowledge base for real-time diagnosis, a pilot-in-the-loop simulation of an orbital docking maneuver, intelligent perturbation algorithms for space scheduling optimization, a fuzzy control method for a space manipulator system, hyperredundant manipulator applications, robotic servicing of EOS instruments, and a summary of astronaut inputs on automation and robotics for the Space Station Freedom. C.C.S.

A92-23654* National Aeronautics and Space Administration, Washington, DC.
AUTOMATION AND ROBOTICS FOR SPACE OPERATION AND PLANETARY EXPLORATION
MELVIN D. MONTEMERLO (NASA, Office of Aeronautics and Exploration Technology, Washington, DC) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p
This paper presents a perspective of Automation and Robotics (A&R) research and developments at NASA in terms of its history, its current status, and its future. It covers artificial intelligence,

telerobotics and planetary rovers, and it encompasses ground operations, operations in earth orbit, and planetary exploration. Author

A92-23655
RESEARCH AND DEVELOPMENT PROGRAM IN AUTOMATION AND ROBOTICS IN SUPPORT OF CANADA'S MOBILE SERVICING SYSTEM FOR THE SPACE STATION FREEDOM
FRED A. CHRISTIE (Canadian Space Agency, Space Station Project Office, Ottawa, Canada) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p

The Strategic Technologies in Automation and Robotics (STEAR) program for developing a robotics system for the Space Station Freedom is outlined in terms of objectives, scope, and status. The technologies that the STEAR program addresses include teleoperation, robotics, automated operations, electronics, structural materials, and verification equipment. Competitive R&D studies are supported that address the technologies, and emphasizes projects which directly address the Mobile Servicing System for the Space Station. Existing and developing activities are mentioned in which STEAR companies establish joint projects with the industrial team to develop technologies for STEAR activities. The STEAR program is intended to stimulate industry-wide technological development and to enhance the development of terrestrial automation and robotics. C.C.S.

A92-23656
MODELLING AND REAL-TIME SIMULATION OF THE HERMES ROBOT ARM HERA
P. DIELEMAN, M. J. H. COUWENBERG (National Aerospace Laboratory, Emmeloord, Netherlands), and F. VAN DER LAAN (Fokker Space and Systems, Amsterdam, Netherlands) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

The HErmes Robot Arm (HERA) is a sophisticated and highly automated Space Manipulator System developed to be launched with and operated from the European Spaceplane Hermes. During operational use HERA will be located at the Columbus Free-Flying Laboratory which is part of the European In-Orbit Infrastructure. The HERA Simulation Facility Pilot (HSF-P) is the first dedicated simulation facility built for research and development needed for HERA. Main objectives of the HSF-P are evaluation of tele-operator station requirements, evaluation of operator-in-the-loop support software, experimentation on manipulator operations feasibility and visualization of manipulator operations both in real-time and in non-real-time. Simulation models of flight elements used for HSF-P are described in the paper, with main attention to the models used for simulation of HERA. The paper concludes with a description of the HSF-P architecture and its realization. Author

A92-23657
DESIGN AND DEVELOPMENT STATUS OF THE JEMRMS
K. KURAOKA (NASDA, Tokyo, Japan), K. GOMA, T. SUMI, and R. OKAMURA (Toshiba Corp., Space Programs Div., Kawasaki, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

The JEM Remote Manipulator System (RMS) under development for the Space Station Freedom is described in terms of the status and salient characteristics of the design. Two manipulators are delineated which include a 10-m primary arm and a 2-m small fine arm intended for, respectively, transfer operations and dexterous tasks. The automatic control mode of the larger main arm is discussed although, manual input is also possible with a six-DOF hand controller. The small arm is manually operated, and the system is described in terms of the bilateral and master-slave modes that are available. Feedback force for both arms can be detected by a force-moment sensor, and several tests are described to examine the specific components. A 2D functional model is illustrated that has verified some of the primary precepts of the JEMRMS project designs. C.C.S.

A92-23659
ASI'S SPACE PROGRAMS
SIMONETTA DI PIPPO (ASI, Rome, Italy) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p

The Italian Space Agency (ASI) is described in terms of current projects related to automation and robotics with attention given to specific applications of the technologies. Two main programs are reviewed: the Space Inspections Device for Extravehicular Repairs (SPIDER) and the Space Automation and Robotics Technology Development Program (SARTD). The SPIDER program envisages an autonomous integrated space robot to perform visual inspections and repairs of a space-station environment. The SPIDER program comprises three phases, and the small low-mass unit is intended to permit technological evolution and modularity. The SARTD program is a parallel ASI program intended to support the technological aspects of the SPIDER, and plans for a test-bed facility to support both the SPIDER and the SARTD developments. C.C.S.

A92-23660* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
FTS - NASA'S FIRST DEXTEROUS TELEROBOT
HARRY G. MCCAIN (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p

NASA development and use of the Space Station Flight Telerobotic Servicer (SSFTS) is described. The SSFTS is a robotic device that combines the capability to be teleoperated (operates under the constant command of a human operator) and to be autonomous (performs mostly by itself but under the supervision of a human operator). Plans call for the SSFTS to assist the astronauts in the assembly, maintenance, servicing, and inspection of Space Station Freedom. The project forms the basis for combining teleoperational and robotics technologies and for rapidly applying the evolving technologies to government and commercial ventures in space and on earth. Author

A92-23661
AUTOMATION OF MOBILE SERVICING SYSTEM OPERATIONS
DAVID G. HUNTER (Canadian Space Agency, Ottawa, Canada) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

The Mobile Servicing System (MSS) is described in terms of robotic features being developed to play key functional roles in the servicing of the Space Station Freedom. The MSS comprises two major features: the large Space Station Remote Manipulator System (SSRMS) and the small Special Purpose Dexterous Manipulator (SPDM). The SSRMS is a part of the Mobile Servicing Center - a base for robotic and human EVA - and is made up of a latching-end effector for use in several locations and measures 17 m. The SPDM comprises three smaller segments, replaceable units, a tool-changeout mechanism, and a video camera. The versatile system is expected to be an integral component of Space Station maintenance and other activities including: attached payload servicing, Space Station assembly, transportation, deployment and retrieval functions, and EVA support. C.C.S.

A92-23662* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HIGHLIGHTS OF NASA RESEARCH IN TELEROBOTICS
C. R. WEISBIN and J. F. STOCKY (JPL, Pasadena, CA) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

This paper provides a brief overview of the NASA program of research in telerobotics. It describes ongoing effort in a number

of participating laboratories investigating topics in human-machine interaction, intelligent task planning and execution, dual-arm control of manipulators with redundant degrees-of-freedom, sensing and perception. A brief list of illustrative references is provided.
Author

A92-23665* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ANTHROPOMORPHIC DUAL-ARM SPACE TELEMANIPULATION SYSTEM
BRUNO M. JAU (JPL, Pasadena, CA) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

Dexterous dual-arm manipulations are feasible with the system described and illustrated in the paper. The structure is based on an extensible host arm that carries the dual-arm robot which comprises two 7-DOF arms each of which includes a hand with a thumb and three fingers with 4 DOF each. Joint compliance can be stiffened to any level, and the operator uses arm harnesses and gloves to utilize the robotics in an anthropomorphic fashion. The configuration eliminates coordinate-transformation computations, and the system is found to achieve a control-frequency rate of 1000 Hz for its direct man/machine interfaces based on fiber-optic cables. The electronics control for the system utilizes a sensory system consisting of force, position, and compliance sensors. The robotics system is expected to be a user-friendly device that permits assembly, repair, tethering, and other complex mechanical operations. C.C.S.

A92-23666
DEVELOPMENT OF DUAL ARM TELEOPERATED SYSTEM FOR SEMIAUTONOMOUS ORBITAL OPERATIONS
HIROSHI KOYAMA, HIROYUKI TAMURA, KYOUSUKE KAWABATA, and NORIMASA YOSHIDA (Mitsubishi Electric Corp., Kamakura Works, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

This paper deals with several concepts to facilitate the development of a practical teleoperated system for semiautonomous dual-arm space robots. The concept of local arm-control functions and problems related to the handling object's design and object-handling sequences are presented and discussed. A dual-arm teleoperated system is described to confirm the present approach to the problem. Truss-structure assembly experiments are performed for this purpose. Author

A92-23667* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
EVOLUTION OF THE FLIGHT TELEROBOTIC SERVICER
RONALD LUMIA (NIST, Gaithersburg, MD) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs
(Contract NASA ORDER S-28187-D)

The Flight Telerobotic Servicer (FTS) is a two-armed manipulator which will be used to build and maintain Space Station Freedom. One of the goals of the project is to be able to upgrade the capabilities of the FTS by incorporating new technology. To achieve this goal, the FTS is using the NASA/NIST Standard Reference Model for Telerobot Control System Architecture (NASREM) for its functional architecture. While using NASREM helps integrate new technology into the system, the decisions concerning the precise technology needing development must be addressed. In this paper, an approach to the technological evolution of the FTS will be explored. The approach begins with detailed scripts of representative FTS activities. These scripts are analyzed to determine the generic or common actions performed by the FTS. Then, technological alternatives are described in terms of a decision tree format. Author

A92-23668
RESEARCH AND EXPERIMENT OF ACTIVE COMPLIANCE END EFFECTOR (ACE)
YOSHITUGU TODA, TOSHIAKI IWATA, KAZUO MACHIDA (Electrotechnical Laboratory, Tsukuba, Japan), TADASHI KOMATSU, CHIAKI HONDA, and KAZUHITO KASUGA (Toshiba Corp., Kawasaki, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p

The development of a smart end effector is expected to perform precise on-orbit activity by space robots instead of EVA by astronauts. The Active Compliance End effector (ACE) is developed as a step of the research of the future space robotics technologies. The ACE mainly consists of an effector mechanism, controller, gripper, proximity sensor and force/torque sensor. The experimental demonstrations of on-orbit high functional tasks using ACE, such as 'pin insertion', 'flying-target capture' and others are performed on the 2D air-bearing table at ETL. The experimental tests regarding position/velocity feedback control, velocity feedforward compensation, and force/torque feedback control are performed and confirm the feasibility and applicability of space robot system in the future. Author

A92-23669
AUTONOMOUS CAPTURE EXPERIMENT OF FREE-FLYING TARGET ON THE ZERO GRAVITY SIMULATOR
HARUHIKO SHIMOJI, MASAO INOUE, KAZUO TSUCHIYA (Mitsubishi Electric Corp., Amagasaki, Japan), KEIKEN NINOMIYA, ICHIRO NAKATANI, and JUN'ICHIRO KAWAGUCHI (Institute of Space and Astronautical Science, Sagamihara, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

This paper presents a developed experimental robot system that can recognize target position and control a manipulator accordingly. The algorithm for recognizing the position and the orientation of the target from visual information using extended Kalman filter is proposed. The algorithm to control the manipulator according to these information is proposed. Finally, automatic capture experiments of the free-flying target on the 6-DOF zero-gravity simulator where the relative motion between the robot and the target exists are presented. The validity of the proposed algorithms is confirmed in the experiments. Author

A92-23671
TARGET CAPTURE EXPERIMENT BY A SPACE FREE-FLYING ROBOT
KAZUYA YOSHIDA and YOJI UMETANI (Tokyo Institute of Technology, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

This paper presents experimental study of the control of a free-flying robot manipulator for space application. The goal is to develop a control method for target capturing in space microgravity environment, considering the dynamical interaction between the manipulator arm and the base vehicle. The Generalizd Jacobian Matrix (GJM) concept for motion control and the Guaranteed Workspace (GWS) for path planning, are discussed. A laboratory model of robot satellite supported on air bearings is developed, which comprises a base satellite and a two-link manipulator arm. An on-line control scheme with vision feedback is developed for experimenting capture operations, utilizing the GJM and GWS. The manipulator can properly chase and capture both a standing target and a moving target in spite of complex satellite/manipulator dynamical interaction. Author

A92-23672
DEVELOPMENT OF SELF-MOBILE SPACE MANIPULATOR SYSTEM
TETSUJI YOSHIDA and HIROSHI UENO (Shimizu Corp., Tokyo,

Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

The development of a self-mobile manipulator system is described. The system includes a five-degree-of-freedom walking robot, a gravity-compensation system to provide a zero-gravity environment for experiments, and corresponding control software for both robot and gravity compensation system. A general description of the development of the system is given, i.e., robot hardware design, flexible robot control, sensing utilization, human/machine interface, and gravity compensation system. The objectives of the mechanical design are sufficient strength with minimum weight, and compact joints with minimum friction and backlash. The walking motion is partitioned into four phases, and different controllers are used for the corresponding motions. Visual and force feedback to operators for teleoperation are described as are command input via master/slave control and a six-degree-of-freedom stylus. A gravity compensation system is developed with a passive counterweight to balance gravitational effects, while an active x-y planar positioner keeps the support point above the robot. Author

A92-23673
IHI'S R&D ACTIVITIES ON THE 2ND GENERATION SPACE ROBOTS - IHI TESTBED FOR SPACE TELEROBOTICS

YUKI YOSHIE, FUMIAKI SANO, SHIGEKI MURAYAMA, MASAHIKO UTSUMI (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan), and TOSHIHIRO MIYASAKO (Ishikawajima System Technology Co., Ltd., Tokyo, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

The testbed for space telerobotics is described in terms of its components, structure, and planned experiments with specific attention given to the operator-robot interface. The interface is composed of a dataglove, a head-mounted display (HMD), and voice-recognition and composition systems. The testbed is designed to test the teleoperation capabilities of second-generation space robots by: (1) developing an interface with the sensation of presence; (2) using a predictive display that simulates a suitable time delay; and (3) simultaneously increasing autonomous control and decreasing the operator load. The testbed is made up of a master manipulator, a stereo view system, a command input/output system, a slave robot, and a dummy orbital replacement unit. Several improvements are to be included in the testbed design including an overlay function to compare the predicted and real images. C.C.S.

A92-23674
CONTROL RESEARCH AT FORD AEROSPACE FOR SPACE TELEROBOTIC APPLICATIONS

SCOTT W. TILLEY and MICHAEL G. HOLLARS (Ford Aerospace Corp., Space Systems Div., Palo Alto, CA) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

Current R&D activities are discussed related to the analysis of space manipulators and their operational control in laboratory environments which emphasize the development of impedance controls. General robotics activities are reviewed to develop the context for the teleoperator control which is based on impedance control. This type of control permits the simultaneous control of manipulator position and force interaction, and a demonstration of the integrated approach is given for the case of a kinematically redundant manipulator. A peg-in-hole insertion demonstration is reported to prove the capability of the impedance-based system and shows that no undesirable force overshoots or bounce phenomena occur. Telerobotic applications and methodologies are expected to demonstrate force-guided assembly tasks under supervisory control and with large time delays. C.C.S.

A92-23675
SELF-ORGANIZATION IN CELLULAR ROBOTIC SYSTEM (CEBOT) FOR SPACE APPLICATION WITH KNOWLEDGE ALLOCATION METHOD

TOSHIO FUKUDA, TSUYOSHI UEYAMA (Nagoya University, Japan), and YOSHIO KAWAUCHI (Tokyo, Science University, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

A hardware is developed for a cellular robotic system (CEBOT) which is designed for the application to a space robot, and automatic docking between cells is realized by using air thrusters. As an analysis of CEBOT software, matrices are proposed; a knowledge-based structure matrix and task matrix are shown which can describe various states of the cell connection and knowledge allocation. By using these proposed matrices, the automatic knowledge allocation is performed effectively and the simulation results are also dealt with. Author

A92-23676
INVESTIGATING ROBOT SAFETY AND ROBUSTNESS IN AN AUTONOMOUS SYSTEMS LABORATORY

R. P. BONASSO, V. S. HWANG, J. C. SANBORN, and W. E. STONEY (Mitre Corp., McLean, VA) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

The development of systems methods is intended to permit the integration of robot sensing and planning for semiautonomous and autonomous robotic operations. The approach involves the development of situated reasoning software to integrate planning and plan monitoring in real time. The planning system therefore selectively employs available sensors that the robot can use to track changes in the environment. An integrated system is described that incorporates 2D vision, task-level programming, and goal-directed reasoning in performing the repair and replacement of electrical components. A vision algorithm is mentioned that permits the detection of visual characteristics on some spacecraft components, and some code generators can provide code for moving and turning motions. The developments are of significant interest to the continued growth of useful robotics technologies. C.C.S.

A92-23677
ADVANCED SPACE TELEROBOTICS - CONCEPT AND APPLICATIONS

MASATOSHI ONO, KAZUO MACHIDA (Electrotechnical Laboratory, Tsukuba, Japan), and HIROYUKI NAGAYAMA (Mitsubishi Research Institute, Inc., Tokyo, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

The concept of an advanced telerobot, which is an extra-vehicular flying telerobot for maintaining space facilities, is considered. The main technological targets for the robot are high autonomy, flexible operation and space fly/walk capabilities. For the application of this robot, the concept of space maintenance facility which maintains geostationary satellites periodically is proposed. R&D plans utilizing ground testbeds and test flights using the Japanese Experiment Module of Space Station Freedom are also discussed. Author

A92-23678
AUTONOMOUS SATELLITE ROBOT TESTBED

TADASHI KOMATSU, MICHIHIRO UENOHARA, SHOICHI IIKURA (Toshiba Corp., Research and Development Center, Kawasaki, Japan), HIROFUMI MIURA, and ISAO SHIMOYAMA (Tokyo, University, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p

A 2D operation testbed is developed for an autonomous free-flying space robot such as an orbital maneuvering vehicle.

This system basically consists of a satellite robot, a target, a host computer and a planar base. This is an intelligent machine represented by its functions which include: a vision sensing system, tactical path planning, and real-time operation. The features provided initially by the space robot testbed are described both at the subsystem level and at the fully-integrated system level.
Author

A92-23686
MODULAR NEURAL NETWORKS FOR MOTION CONTROL OF THE TRUSS-TYPE REDUNDANT ROBOT ARM
KAZUYUKI HANAHARA, MASAO TANAKA, and YASUYUKI SEGUCHI (Osaka University, Toyonaka, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

In order to utilize kinematical redundancy effectively, this study proposes a neural-network approach for the criteria-oriented motion control of the truss-type redundant robot arm. A multilayered network and back propagation are the basic elements. The modular constitution is employed to build the resultant network for motion control, and it reduces the necessary transactions during the preparation stage of the network and the motion-control stage. This also enables flexible construction of the motion-control network in accordance with the various configurations of the arm system. A simulation study is carried out with the transputer-based multiprocessor system which demonstrates the feasibility of the proposed approach. Author

A92-23687
SPEECH RECOGNITION FOR ROBOTS - A PROBABILISTIC APPROACH
RENATO DE MORI and ROLAND KUHN (McGill University, Montreal, Canada) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

This paper argues that speech will be a vital capability for robots that operate in space. Subsequently, it describes a probabilistic model for spoken dialogue between an operator and a robot. The model incorporates knowledge about dialogue in order to improve speech recognition by the robot and aid in the design of the robot's language generation component. Author

A92-23700* National Aeronautics and Space Administration, Washington, DC.
EXPERIMENTS IN TELEOPERATOR AND AUTONOMOUS CONTROL OF SPACE ROBOTIC VEHICLES
HAROLD L. ALEXANDER (MIT, Cambridge, MA) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs
(Contract NAGW-21)

A research program and strategy are described which include fundamental teleoperation issues and autonomous-control issues of sensing and navigation for satellite robots. The program consists of developing interfaces for visual operation and studying the consequences of interface designs as well as developing navigation and control technologies based on visual interaction. A space-robot-vehicle simulator is under development for use in virtual-environment teleoperation experiments and neutral-buoyancy investigations. These technologies can be utilized in a study of visual interfaces to address tradeoffs between head-tracking and manual remote cameras, panel-mounted and helmet-mounted displays, and stereoscopic and monoscopic display systems. The present program can provide significant data for the development of control experiments for autonomously controlled satellite robots. C.C.S.

A92-23701
INFORMATION-CONTROL ARCHITECTURE FOR SPACE AUTOMATION AND ROBOTICS SYSTEM
KOHJI KAMEJIMA, TOMOYUKI HAMADA, IKUO TAKEUCHI (Hitachi, Ltd., Mechanical Engineering Research Laboratory, Ibaraki, Japan), KENJIRO KUMAMOTO, and SHIN'ICHI TAKARADA (Hitachi, Ltd., Space Systems Div., Yokohama, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

An information-control architecture is presented for interactive operation of autonomous space robotics systems. Knowledge representation of environment and manufacturing step is introduced as a basis for monitoring and command in ground facilities. A perception-control mechanism is designed for onboard adaptation of instructions transmitted from the ground facilities. The architecture is verified with experiments using a prototype.
Author

A92-23702
A THEORETICAL FRAMEWORK FOR SUPERVISORY CONTROL OF TELEROBOTIC SYSTEMS
THURSTON L. BROOKS (ST Systems Corp., Lanham, MD) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

This paper devlops a framework that describes the relationship between man and machine under a supervisory role. This framework focuses on the supervisor-subordinate relationship and the process by which commands flow down to the robot system under both shared and traded control modes. Author

A92-23709* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MINIMIZING ATTITUDE CONTROL FUEL IN SPACE MANIPULATOR SYSTEMS
STEVEN DUBOWSKY and MIGUEL A. TORRES (MIT, Cambridge, MA) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs
(Contract NAG1-801)

Techniques are presented for finding space manipulator motions which result in reduced spacecraft dynamic disturbances. Although a spacecraft's attitude control reaction jets can compensate for these disturbances, reaction jet fuel is a limited resource and excessive disturbances would limit the life of a space manipulator. A graphical tool called the Enhanced Disturbance Map (EDM) is presented and is demonstrated as an aid in developing planning and control algorithms to solve this complex problem. Author

A92-23710
SIMULATION SYSTEM FOR TELE-OPERATABILITY EXPERIMENTS OF FREE-FLYING SPACE ROBOTS
YASUHIRO MASUTANI and FUMIO MIYAZAKI (Osaka University, Toyonaka, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

To examine the teleoperatability of free-flying space robots, a computer simulation system is developed. This system, consisting of human interface devices, a dynamics model, a graphics model, and a subcontroller can simulate the teleoperated mission on the orbit in real-time. An operator gives commands to the robot with a joystick as he observes camera images simulated in the graphic display. The dynamics model is used to take into consideration dynamic coupling between the manipulator and its base body (spacecraft). The graphics model is employed to present a three-dimensional work area to an operator with stereo vision. As an example of teleoperatability experiments, the effectiveness of some types of subcontrollers through a positioning task is compared. These controllers use the conventional or generalized Jacobian matrices to transform the operator's velocity command in the task-oriented coordinates into that in terms of the manipulator joint space. Author

A92-23711
SPACE ROBOT DYNAMICS AND ITS EFFICIENT COMPUTATION
RANJAN MUKHERJEE and YOSHIHIKO NAKAMURA (California, University, Santa Barbara) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

A free-flying space robot is expected to perform various tasks for construction and maintenance of space structures. Such a robotic system has kinematic and dynamic features different from those fixed on the earth. This paper presents the solution to the inverse dynamics problem of a space robotic system, in the presence of external generalized forces. While solving inverse dynamics, the computations for inverse kinematics is considered simultaneously, and both computations are developed on the basis of momentum constraints. An efficient computational scheme for the inverse dynamics problem is then established. Author

A92-23712
FUZZY CONTROL METHOD FOR A SPACE MANIPULATOR SYSTEM
NAOKI IMASAKI, MASAAKI SONE, YASUO SHINOMIYA, and SHIN'ICHIRO NISHIDA (Toshiba Corp., Kawasaki, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

For a long manipulator, such as in a Space Station, precise positioning performance is required. A flexible and robust control method is required, otherwise a backlash in the arm joint mechanism might cause positioning errors. The fuzzy temporal control method can be applied to the controller for such a manipulator. This paper reports results obtained from examination of fuzzy control rules containing ambiguous temporal information, and shows computer simulation results for a simple manipulator model. Author

A92-23713
POSITIONING CONTROL OF SPACE ROBOT WITH FLEXIBLE MANIPULATOR
YOSHISADA MUROTSU, SHOZO TSUJIO, KEI SENDA, and MASATO HAYASHI (Osaka Prefecture, University, Sakai, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

This paper is concerned with a formulation for a dynamical model of space robots with flexible manipulators and a control scheme to regulate the robot systems. Advanced space robots consist of a satellite base to fly freely and manipulators with structural flexibility caused by requirement of a light weight system. To control the complicated systems, a mathematical model of a space robot with structurally flexible manipulators is developed. An extended local PD-control scheme to control the flexible manipulators on a satellite base is proposed. The presented scheme is very simple and the stability of the closed loop system is proved by Liapunov's direct method. The effectiveness of the control scheme is also verified by numerical simulation. Author

A92-23714
DYNAMIC ANALYSIS AND EVALUATION OF SPACE SHUTTLE REMOTE MANIPULATOR SYSTEM
THOMAS E. ALBERTS, HOUCHUN XIA, and YUNG CHEN (Old Dominion University, Norfolk, VA) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

To facilitate the evaluation of effective end-point control strategies for large flexible space manipulators, an investigation of the dynamic behavior of the Space Shuttle Remote Manipulator System (RMS) is conducted. Modal potential energy analysis is used to examine the vibrational properties of each structural member and each mode of the complex flexible chained system. Impulse responses and frequency spectra, as well as natural frequencies and mode shapes are examined based on an improved finite element model. The results indicate that the most dominant contributors to end-point oscillations fall into two categories. These include very low frequency modes due to joint flexibility and higher frequency modes due to bending in the booms. Significant end-point motions result from each category, but the most significant motions are associated with joint flexibility. The results presented suggest that active control of the joint modes combined with passive control of the boom modes may be a practical approach for the control of space manipulator end-point oscillations. Author

A92-23716
ON THE MANIPULATION CONTROL OF SPACE ROBOT
NOBUYUKI KUBOTA, KIYOSHI IOI, TAKASHI KATSURAGAWA, OSAMU NORO, NOBUYOSHI MUROI, KENJI OGIMOTO, and OSAMU MIKI (Kawasaki Heavy Industries, Ltd., Kakamigahara, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p

Experimental investigations are described in which 'hybrid impedance control' is employed to design the control criteria for manipulating a space robot. The performance of impedance control is examined in terms of the dynamic simulation analyses conducted for several maneuvers and operations. The response characteristics and actuator-torque requirements are defined for hybrid impedance control, and the simulation techniques are outlined. The sufficient conditions are given for catching a flying object, and illustrations are given of the incorporation of impedance control in and orbital replacement unit (ORU) insertion. ORU change-out is discussed as a candidate task for impedance control in the context of a task analysis that defines the components of the robot actions. The utility of computer simulations is noted for the development of the robotic requirements and supplementary sensors. C.C.S.

A92-23717
APPLICATIONS OF HYPER-REDUNDANT MANIPULATORS FOR SPACE ROBOTICS AND AUTOMATION
GREGORY S. CHIRIKJIAN and JOEL W. BURDICK (California Institute of Technology, Pasadena) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

The development of hyperredundant (snakelike) manipulators is examined and considered in terms of applying these complex kinematics to space-based robotics. Attention is given to the need for suitable actuator technologies for the hyperredundant approach, and developments are described in such areas as obstacle avoidance, locomotion, grasping, and end-effector placement. The hyperredundant manipulator are considered good potential tools for obstacle avoidance because of their high number of degrees of freedom. Locomotion and grasping are illustrated to demonstrate the use of the manipulators' potential for wavelike motion. Methods are presented for addressing the complex kinematics required for the manipulators, and it is concluded that the practical application of this class of robotics is presently feasible. C.C.S.

A92-23719* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
REACTION-COMPENSATION TECHNOLOGY FOR MICROGRAVITY LABORATORY ROBOTS
DOUGLAS A. ROHN, CHARLES LAWRENCE (NASA, Lewis Research Center, Cleveland, OH), and JEFFREY H. MILLER (Sverdrup Technology, Inc., Brookpark, OH) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

Robots operating in the microgravity environment of an orbiting laboratory should be capable of manipulating payloads such that the motion of the robot does not disturb adjacent experiments. The current results of a NASA Lewis Research Center technology program to develop smooth, reaction-compensated manipulation based on both mechanism technology and trajectory planning strategies are present. Experimental validation of methods to

reduce robot base reactions through the use of redundant degrees of freedom is discussed. Merits of smooth operation roller-driven robot joints for microgravity manipulators are also reviewed.
Author

A92-23720
EFFICIENT COMPUTATIONAL ALGORITHMS FOR TRAJECTORY CONTROL OF MULTI-ARM SPACE MANIPULATORS
T. YOSHIKAWA, Y. YOKOKOHJI, and T. TOYOSHIMA (Kyoto University, Uji, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

The generalized Jacobian matrix is employed as an effective algorithm for the case of multiple-arm space manipulators by two composite-link subsystems. The generalized Jacobian matrix is derived analytically for manipulators with n arms, and the two composite links are treated as a one-DOF system with only one reference joint. Based on this treatment an algorithm is developed for resolved acceleration control of multiple-arm space manipulators, and it is found that the computational amount is of the order O(n) as it is in the single-arm space manipulators. The resolved-acceleration control algorithm is derived by incorporating the Newton-Euler method to determine the joint driving force. The result is an extension of the work by Yamada (1989) and presents a case for the development of multiple-arm space manipulators.
C.C.S.

A92-23727* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
SUMMARY OF ASTRONAUT INPUTS ON AUTOMATION AND ROBOTICS FOR SPACE STATION FREEDOM
DAVID J. WEEKS (NASA, Marshall Space Flight Center, Huntsville, AL) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

Astronauts and payload specialists present specific recommendations in the form of an overview that relate to the use of automation and robotics on the Space Station Freedom. The inputs are based on on-orbit operations experience, time requirements for crews, and similar crew-specific knowledge that address the impacts of automation and robotics on productivity. Interview techniques and specific questionnaire results are listed, and the majority of the responses indicate that incorporating automation and robotics to some extent and with human backup can improve productivity. Specific support is found for the use of advanced automation and EVA robotics on the Space Station Freedom and for the use of advanced automation on ground-based stations. Ground-based control of in-flight robotics is required, and Space Station activities and crew tasks should be analyzed to assess the systems engineering approach for incorporating automation and robotics.
C.C.S.

A92-23728
CONCEPT AND EXEMPLARY REALIZATION OF INTELLIGENT ROBOT CONTROL IN SPACE
E. FREUND and CH. BUEHLER (Dortmund, Universitaet, Federal Republic of Germany) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

The integration of autonomous multiple robot systems in a space environment is a challenging problem concerning the design of the entire system and the related control structure. Components of different levels of intelligence and activity have to cooperate in the overall system, where the direct intervention of human operators should be possible in case of contingency. Since the development and implementation of the full capabilities of such a complex, intelligent system cannot be realized all at once, the automation concept has to be modular and open for new extensions in the future. In this context the development of control structures for space robots is of special interest. Here components for planning, knowledge based diagnosis, coordinated motion control based on multiple sensors, collision avoidance and man-machine communication are of high importance to provide autonomous and flexible responses of the system in a changing environment. Such kind of hierarchical control architecture for intelligent robot control in space is presented. The benefit of the proposed control structure for space robotic systems is studied on the exemplary realization of a fully automated space laboratory.
Author

A92-23729
AN EXPERIMENTAL SIMULATOR FOR FREE-FLYING SPACE ROBOTS
HIRONORI FUJII, KENJI UCHIYAMA, MASAKI TAKINAMI (Tokyo Metropolitan Institute of Technology, Hino, Japan), TAKASHI UCHIYAMA (Fujitsu Laboratories, Ltd., Kawasaki, Japan), and TATSUO MIKAMI (Fujitsu, Ltd., Kawasaki, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

A system to simulate controlled behavior of a free-flying space robot experimentally on the ground environment is introduced. The simulator is a hybrid of a software simulator to analyze motion of the free-flying robot in space environment and a hardware simulator to realize the analyzed motion on ground environment through suspension of a model of the free-flying robot by many tethers. Philosophy and special features of the simulator are discussed.
Author

A92-24090* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ON THE NATURE OF CONTROL ALGORITHMS FOR FREE-FLOATING SPACE MANIPULATORS
EVANGELOS PAPADOPOULOS (McGill University, Montreal, Canada) and STEVEN DUBOWSKY (MIT, Cambridge, MA) IEEE Transactions on Robotics and Automation (ISSN 1042-296X), vol. 7, Dec. 1991, p. 750-758. Dec. 1991 9 p refs
(Contract NAG1-801)
Copyright

It is suggested that nearly any control algorithm that can be used for fixed-based manipulators also can be employed in the control of free-floating space manipulator systems, with the additional conditions of estimating or measuring a spacecraft's orientation and of avoiding dynamic singularities. This result is based on the structural similarities between the kinematic and dynamic equations for the same manipulator but with a fixed base. Barycenters are used to formulate the kinematic and dynamic equations of free-floating space manipulators. A control algorithm for a space manipulator system is designed to demonstrate the value of the analysis.
I.E.

A92-24091* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TASK DECOMPOSITION FOR A MULTILIMBED ROBOT TO WORK IN REACHABLE BUT UNORIENTABLE SPACE
CHAU SU (MCI Telecommunications Corp., Clarksburg, MD) and YUAN F. ZHENG (Ohio State University, Columbus) IEEE Transactions on Robotics and Automation (ISSN 1042-296X), vol. 7, Dec. 1991, p. 759-770. Dec. 1991 12 p refs
(Contract NSF DDM-89-96237; NSF DDM-89-96238; JPL-958150)
Copyright

Robot manipulators installed on legged mobile platforms are suggested for enlarging robot workspace. To plan the motion of such a system, the arm-platform motion coordination problem is raised, and a task decomposition is proposed to solve the problem. A given task described by the destination position and orientation of the end effector is decomposed into subtasks for arm manipulation and for platform configuration, respectively. The former is defined as the end-effector position and orientation with respect to the platform, and the latter as the platform position and orientation in the base coordinates. Three approaches are proposed for the task decomposition. The approaches are also evaluated in terms of the displacements, from which an optimal approach can be selected.
I.E.

A92-24097* National Aeronautics and Space Administration, Washington, DC.
ADAPTIVE CONTROL OF SPACE-BASED ROBOT MANIPULATORS
MICHAEL W. WALKER and LIANG-BOON WEE (Michigan, University, Ann Arbor) IEEE Transactions on Robotics and Automation (ISSN 1042-296X), vol. 7, Dec. 1991, p. 828-835. Research supported by NASA. Dec. 1991 8 p refs
Copyright

A control method is presented that achieves globally stable trajectory tracking in the presence of uncertainties in the inertial parameters of the system. The 15-DOF system dynamics are divided into two components: a 9-DOF invertible portion and 6-DOF noninvertible portion. A controller is then designed to achieve trajectory tracking of the invertible portion of the system, which consists of the manipulator-joint positions and the orientation of the base. The motion of the noninvertible portion is bounded but otherwise unspecified. This portion of the system consists of the position of the robot's base and the position of the reaction wheels. A simulation is presented to demonstrate the effectiveness of the controller. A quadratic polynomial is used to generate the desired trajectory to illustrate the trajectory-tracking capability of the controller. I.E.

A92-26660* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SUPERVISORY TELEROBOTICS TESTBED FOR UNSTRUCTURED ENVIRONMENTS
S. HAYATI and J. BALARAM (JPL, Pasadena, CA) Journal of Robotic Systems (ISSN 0741-2223), vol. 9, March 1992, p. 261-280. Mar. 1992 20 p refs

A telerobotics testbed for performing tasks such as assembly and repair of spacecraft in unstructured environments is described. This fully operational multiarm system can operate in teleoperated or supervisory control modes, as well as mixed shared-control modes, thus enabling operations in totally to partially unstructured environments. Various sources of uncertainty are identified and approaches to minimize their effects are presented. In the teleoperated mode, the system uses two force-reflecting hand controllers to operate two manipulator arms. A third arm is utilized to position four cameras to view the scene. In the supervisory mode, the system can be operated from three different levels: task, process, and servo levels, providing different levels of autonomy and performance. Various tools are provided so that an operator can perform tasks even when objects are partially occluded or their positions are not known a priori. P.D.

A92-27373
ARM OF THE FUTURE
IAN PARKER Space (ISSN 0267-954X), vol. 8, Feb.-Mar. 1992, p. 38, 39, 41. Mar. 1992 3 p
Copyright

The use of robotics to service the Space Station Freedom is described in terms of the Hermes Robot Arm (HRA) presently being developed which can reduce total costs. The HRA project is based on the parallel development of the manipulator arm, the control system, and simulation and test facilities to investigate indirect vision, relocatability, and in-orbit maintenance of the HRA. A high degree of redundancy is designed into the HRA to protect against failures, and the HRA incorporates an optical sensor and a proximity sensor to aid service operations. C.C.S.

A92-27393
POSITIONING CONTROL FOR A SPACE MANIPULATOR SYSTEM USING FUZZY CONTROL METHOD
NAOKI IMASAKI and SHIN'ICHIRO NISHIDA (Toshiba Corp., Kawasaki, Japan) (International Fuzzy Systems Association, World Congress, 4th, Brussels, Belgium, July 7-12, 1991) Toshiba's Selected Papers on Science and Technology (ISSN 0916-1465), vol. 4, no. 1, 1992, p. 13-16. 1992 4 p refs
Copyright

For a space manipulator system with long links, it is difficult to achieve the precise positioning, because small amounts of backlash in the arm joint mechanisms might cause large positioning errors at the end effector. A flexible and robust controller is required to overcome the effects of backlash. A control method using fuzzy reasoning units can be applied to such a long-linkage manipulator system. Fuzzy temporal reasoning is also useful for smoothing changes in actuator force. This paper proposes a fuzzy control system which consists of fuzzy reasoning units, and presents a computer simulation with results for a simple manipulator model. Author

A92-28139
DESIGN, MANUFACTURE, AND APPLICATION TO SPACE ROBOTICS OF DISTRIBUTED PIEZOELECTRIC FILM SENSORS
S. A. COLLINS, C. E. PADILLA, R. J. NOTESTINE, A. H. VON FLOTOW (MIT, Cambridge, MA), E. SCHMITZ, and M. RAMEY (Martin Marietta Space Systems Co., Denver, CO) Apr. 1992 8 p refs
(Contract AF-AFOSR-88-00291)
(AIAA PAPER 90-0949) Copyright

This paper describes the development and manufacture of distributed piezoelectric film strain sensors. The sensors are spatially shaped such that, when bonded to a vibrating structure, their output is selectively proportional to a particular deformation pattern of the flexible structure. In this paper, the selectivity is based on the spatial orthogonality of the structure's natural modes of vibration, but orthogonality of arbitrary basis functions might also be exploited. The generalized amplitudes of these basis functions are states in a multiple-flexible-body dynamic simulation; the new sensors permit direct measurement of states otherwise available only from a dynamic estimation procedure. An experimental two-link planar manipulator is employed in this study to quantify the performance of these sensors in a dynamic environment. Sensor outputs are compared with the state estimates generated by open-loop simulation and by several Kalman filters. Surprisingly close agreement is found, even for a crude linear estimator. This process can also be viewed as using the piezoelectric film sensors to evaluate state estimation procedures applicable to multiple-flexible-body systems. Author

A92-29073* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
IMPEDANCE CONTROL OF ROBOTS WITH HARMONIC DRIVE SYSTEMS
NEVILLE HOGAN (MIT, Cambridge, MA), B. A. RASOLEE (McDonnell Douglas Space Systems Co., Seabrook, MD), and JAMES ANDARY (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 1 1991 5 p refs
Copyright

The design of an impedance controller based on actuator-level feedback is considered. It is shown that actuator effort (e.g. torque) feedback alone is insufficient to achieve satisfactory contact performance. Instead, combined feedback of actuator effort and motion is sufficient to achieve feedback contact performance. I.E.

A92-29204
ON TRANSFER FUNCTIONS AND CONTROL OF A FLEXIBLE SLEWING LINK
ENRIQUE BARBIERI (Tulane University, New Orleans, LA) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 2 1991 2 p refs
Copyright

An unconstrained mode expansion for the solution to the linear equations of motion of a flexible slewing link is used to obtain single-input/single-output transfer functions for tip-position control purposes. Attention is given to the zero locations of the tip-position to hub-torque transfer function in terms of the flexible-to-rigid inertia ratio. A local tip-position to hub-torque transfer function is defined, and it is found that it is minimum-phase and not passive. A sequential root locus design approach is then used to determine suitable stabilizing hub angle, hub rate and local tip position

feedback gains. Simulations indicate that for certain gain values, a constrained-mode expansion leads to erroneous conclusions regarding system performance and even stability. I.E.

A92-29212* National Aeronautics and Space Administration, Washington, DC.
EXPERIMENTS IN TELEOPERATOR AND AUTONOMOUS CONTROL OF SPACE ROBOTIC VEHICLES
HAROLD L. ALEXANDER (MIT, Cambridge, MA) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 2 1991 4 p refs
(Contract NAGW-21)
Copyright

A program of research embracing teleoperator and automatic navigational control of freely flying satellite robots is presented. Current research goals include: (1) developing visual operator interfaces for improved vehicle teleoperation; (2) determining the effects of different visual interface system designs on operator performance; and (3) achieving autonomous vision-based vehicle navigation and control. This research program combines virtual-environment teleoperation studies and neutral-buoyancy experiments using a space-robot simulator vehicle currently under development. Visual-interface design options under investigation include monoscopic versus stereoscopic displays and cameras, helmet-mounted versus panel-mounted display monitors, head-tracking versus fixed or manually steerable remote cameras, and the provision of vehicle-fixed visual cues, or markers, in the remote scene for improved sensing of vehicle position, orientation, and motion. I.E.

A92-29213* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EXPERIMENTS WITH SIMPLIFIED COMPUTED-TORQUE CONTROLLERS FOR FREE-FLYING ROBOTS
R. KONINGSTEIN (CriSys, Ltd., Newmarket, Canada) and R. H. CANNON, JR. (Stanford University, CA) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 2 1991 7 p refs
(Contract NCC2-333)
Copyright

The effect of neglecting base accelerations in an inertial space endpoint computed-torque (CT) controller is examined. Numerical simulations predict a rather wide set of conditions under which CT controllers can neglect base accelerations in their dynamic model with insignificant performance degradation. Two predictions are experimentally verified with a laboratory robot. These two experiments show that negligible additional endpoint controller error results with a simplified CT controller for the given robot mass parameters and manipulator articulation. I.E.

A92-29214* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FAILURE RECOVERY CONTROL FOR SPACE ROBOTIC SYSTEMS
EVANGELOS PAPADOPOULOS and STEVEN DUBOWSKY (MIT, Cambridge, MA) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 2 1991 6 p refs
(Contract NAG1-801)
Copyright

The problem of controlling a failed joint of a space manipulator is addressed. It is shown that failure-recovery control is possible when dynamic coupling exists between the link whose joint has failed and some other link whose joint is working and when the system inertia matrix is invariant with respect to the failed joint angle. A failure-recovery control technique is developed and applied to two simple examples. I.E.

A92-29215
NONHOLONOMIC REDUNDANCY OF SPACE ROBOTS AND ITS UTILIZATION VIA HIERARCHICAL LIAPUNOV FUNCTIONS
RANJAN MUKHERJEE and YOSHIHIKO NAKAMURA (California, University, Santa Barbara) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 2 1991 6 p refs
Copyright

A discussion is presented of the presence of nonholonomic redundancy - as opposed to ordinary kinematic redundancy - in space robots. Nonholonomic redundancy can be utilized to make maximum use of the workspace of space robots. A path-planning scheme is presented using Liapunov functions in a hierarchy for the utilization of nonholonomic redundancy. I.E.

A92-29216
REDUNDANT ACTUATOR COORDINATION FOR A FREE-FLYING TELEROBOT
JOHN R. SPOFFORD (Martin Marietta Astronautics Group, Denver, CO) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 2 1991 6 p refs
Copyright

A supervisory control strategy is presented that operates with real-time input and provides task-relative control to reduce the operator's workload. This algorithm coordinates a redundant manipulator and vehicle actuators to achieve end-effector command tracking. The controller minimizes vehicle thruster use while maintaining a desirable system kinematic configuration. Two recent extensions are the use of a reaction wheel for vehicle attitude control and incorporation of a redundant manipulator. A brief description of a planar air-bearing testbed is presented which simulates the zero-gravity dynamics of flight vehicle/manipulator systems. I.E.

A92-29217* National Aeronautics and Space Administration, Washington, DC.
ADAPTIVE CARTESIAN COORDINATE CONTROL OF SPACE BASED ROBOT MANIPULATORS
MICHAEL W. WALKER and LIANG-BOON WEE (Michigan, University, Ann Arbor) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 2 1991 6 p refs
Copyright

A Cartesian coordinate robot controller is presented for use when the mass properties of a load are unknown. The mass, center of mass, and moments of inertia of the end-effector are assumed unknown. All other inertial properties of the robot are assumed known. This knowledge of the parameters allows the control of the end-effector in a way similar to the use of reaction wheels to control the orientation of a satellite. This is the primary result of the controller. The basic method of the controller is similar to that used for terrestrial-based robot manipulators. The controller is demonstrated using a new simulation algorithm which is based on Hamilton's form of the equations of motion. I.E.

A92-29258
NONLINEAR MODELING AND DYNAMIC FEEDBACK CONTROL OF THE FLEXIBLE REMOTE MANIPULATOR SYSTEM
F. KARRAY, V. J. MODI, and J. K. CHAN (British Columbia, University, Vancouver, Canada) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 2 1991 4 p refs
Copyright

Nonlinear dynamics and control of a class of space-station-based mobile flexible two-link manipulators, normally referred to as the mobile serving system (MSS), are studied. The governing nonlinear, nonautonomous and coupled equations of motion are described, followed by the modal discretization procedure. A parametric response study suggests situations with unacceptable levels of deflections and accelerations for certain proposed missions, as well as station libration and payload positioning errors. An inverse control technique is proposed to achieve high tracking accuracy of the MSS in presence of maneuver induced disturbances. Two different control schemes, both based on the feedback linearization technique, are developed and their relative merits assessed. I.E.

A92-29286* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
REAL-TIME CONTROL OF THE MIT VEHICLE EMULATION SYSTEM
WILLIAM K. DURFEE, HUSNI R. IDRIS, and STEVEN DUBOWSKY (MIT, Cambridge, MA) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 2 1991 2 p refs
(Contract NAG1-801)
Copyright

The MIT vehicle emulation system (VES) is an experimental facility designed to facilitate the study of controlling robots fixed to nonstationary bases. This includes assembly and repair manipulators attached to space vehicles, or to the space shuttle arm, as well as manipulators fixed to the bed of moving ground vehicles. Controlling manipulators under these conditions for endpoint force and positioning tasks requires both the development of new theory, and the development of a testbed for verifying theoretical results through experimentation. A description is presented of the technical details of the real-time controller for the second generation VES system. I.E.

A92-29704
ANALYSIS OF A REDUNDANT FREE-FLYING SPACECRAFT/MANIPULATOR SYSTEM
DRAGOMIR NENCHEV (Sofia, Technical University, Bulgaria), YOJI UMETANI, and KAZUYA YOSHIDA (Tokyo Institute of Technology, Japan) IEEE Transactions on Robotics and Automation (ISSN 1042-296X), vol. 8, Feb. 1992, p. 1-6. Feb. 1992 6 p refs
Copyright

An analysis of the momentum conservation equations of a redundant free-flying spacecraft/manipulator system acting in a zero-gravity environment is presented. In order to follow a predefined end-effector path, the inverse kinematics at velocity level is considered. The redundancy is solved alternatively in terms of pseudoinverses and null-space components of the manipulator inertia matrix, the manipulator Jacobian matrix, and the generalized Jacobian matrix. A general manipulation task is defined as end-effector continuous path tracking with simultaneous attitude control of the spacecraft. Three subtasks of the general task are considered. The case of manipulator motions that yield no spacecraft attitude disturbance is analyzed in more detail and a special Åfixed-attitude-restricted' (FAR) Jacobian is defined. Through singular-value decomposition of this Jacobian, corresponding FAR dexterity measures (FAR manipulability and FAR condition number) are derived. I.E.

A92-31649
COOPERATION WITHOUT COMMUNICATION - MULTIAGENT SCHEMA-BASED ROBOT NAVIGATION
RONALD C. ARKIN (Georgia Institute of Technology, Atlanta) Journal of Robotic Systems (ISSN 0741-2223), vol. 9, April 1992, p. 351-364. Apr. 1992 14 p
Copyright

A study to demonstrate the efficiency of multiagent schema-based navigation for object retrieval is presented. Primitive motor behaviors are specified for each of the individual robotic agents, which produce safe task-achieving action in an unstructured environment. When implemented over a number of identical units, retrieval is assisted in the absence of interagent communication as evidenced by spontaneous recruitment of several agents to conclude a task. Simulation results are given to show these effects. R.E.P.

A92-32463
AUTOMATION AND ROBOTICS FOR COLUMBUS UTILIZATION
SIMONETTA DI PIPPO (ASI, Rome, Italy) (Columbus VII - Symposium on Space Station Utilization, 7th, Anacapri, Italy, July 1-6, 1991, Proceedings. A92-32451 12-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, p. 203-207. Apr. 1992 5 p
Copyright

The paper concerns mainly the automation and robotics concepts for Columbus utilization. Starting with the present Columbus baseline configuration, the need of A&R on-board Columbus laboratories is addressed. Also presented are some details on the strategy adopted by the Italian Space Agency (ASI) in the field of A&R for the maintenance and servicing of the in-orbit infrastructure and in particular, the ASI standpoint on the possibility to implement A&R concepts for Columbus laboratories. Author

N92-10033*# Research Inst. for Advanced Computer Science, Moffett Field, CA.
TELESCIENCE TESTBED PILOT PROGRAM, VOLUME 2: PROGRAM RESULTS Final Report
BARRY M. LEINER Feb. 1989 115 p
(Contract NASW-4234)
(NASA-CR-188835; NAS 1.26:188835; RIACS-TR-89-8) Avail: CASI HC A06/MF A02

Space Station Freedom and its associated labs, coupled with the availability of new computing and communications technologies, have the potential for significantly enhancing scientific research. A Telescience Testbed Pilot Program (TTPP), aimed at developing the experience base to deal with issues in the design of the future information system of the Space Station era. The testbeds represented four scientific disciplines (astronomy and astrophysics, earth sciences, life sciences, and microgravity sciences) and studied issues in payload design, operation, and data analysis. This volume, of a 3 volume set, which all contain the results of the TTPP, contains the integrated results. Background is provided of the program and highlights of the program results. The various testbed experiments and the programmatic approach is summarized. The results are summarized on a discipline by discipline basis, highlighting the lessons learned for each discipline. Then the results are integrated across each discipline, summarizing the lessons learned overall. Author

N92-10282*# Research Inst. for Advanced Computer Science, Moffett Field, CA.
HUMAN PERFORMANCE MEASUREMENT: VALIDATION PROCEDURES APPLICABLE TO ADVANCED MANNED TELESCIENCE SYSTEMS
RICHARD F. HAINES 12 Feb. 1990 35 p Sponsored in part by USRA
(Contract NCC2-387)
(NASA-CR-185447; NAS 1.26:185447; RIACS-TR-90-10) Avail: CASI HC A03/MF A01

As telescience systems become more and more complex, autonomous, and opaque to their operators it becomes increasingly difficult to determine whether the total system is performing as it should. Some of the complex and interrelated human performance measurement issues are addressed as they relate to total system validation. The assumption is made that human interaction with the automated system will be required well into the Space Station Freedom era. Candidate human performance measurement-validation techniques are discussed for selected ground-to-space-to-ground and space-to-space situations. Most of these measures may be used in conjunction with an information throughput model presented elsewhere (Haines, 1990). Teleoperations, teleanalysis, teleplanning, teledesign, and teledocumentation are considered, as are selected illustrative examples of space related telescience activities. Author

N92-11223*# Research Inst. for Advanced Computer Science, Moffett Field, CA.
TELEVISION IMAGE COMPRESSION AND SMALL ANIMAL REMOTE MONITORING
RICHARD F. HAINES and ROBERT W. JACKSON Apr. 1990 20 p
(Contract NCC2-387)
(NASA-CR-186614; NAS 1.26:186614; RIACS-TR-90-19) Avail: CASI HC A03/MF A01

It was shown that a subject can reliably discriminate a difference in video image quality (using a specific commercial product) for

image compression levels ranging from 384 kbits per second to 1536 kbits per second. However, their discriminations are significantly influenced by whether or not the TV camera is stable or moving and whether or not the animals are quiescent or active, which is correlated with illumination level (daylight versus night illumination, respectively). The highest video rate used here was 1.54 megabits per second, which is about 18 percent of the so-called normal TV resolution of 8.4MHz. Since this video rate was judged to be acceptable by 27 of the 34 subjects (79 percent), for monitoring the general health and status of small animals within their illuminated (lights on) cages (regardless of whether the camera was stable or moved), it suggests that an immediate Space Station Freedom to ground bandwidth reduction of about 80 percent can be tolerated without a significant loss in general monitoring capability. Another general conclusion is that the present methodology appears to be effective in quantifying visual judgments of video image quality. Author

N92-11637*# *Vanderbilt Univ., Nashville, TN. Dept. of Electrical* Engineering.
ROBOT GRAPHIC SIMULATION TESTBED Final Report
GEORGE E. COOK, JANOS SZTIPANOVITS, CSABA BIEGL, GABOR KARSAI, and JAMES F. SPRINGFIELD Aug. 1991 119 p Original contains color illustrations
(Contract NAG8-690)
(NASA-CR-188998; NAS 1.26:188998)

The objective of this research was twofold. First, the basic capabilities of ROBOSIM (graphical simulation system) were improved and extended by taking advantage of advanced graphic workstation technology and artificial intelligence programming techniques. Second, the scope of the graphic simulation testbed was extended to include general problems of Space Station automation. Hardware support for 3-D graphics and high processing performance make high resolution solid modeling, collision detection, and simulation of structural dynamics computationally feasible. The Space Station is a complex system with many interacting subsystems. Design and testing of automation concepts demand modeling of the affected processes, their interactions, and that of the proposed control systems. The automation testbed was designed to facilitate studies in Space Station automation concepts. Author

N92-12033*# Research Inst. for Advanced Computer Science, Moffett Field, CA.
AMES LIFE SCIENCE TELESCIENCE TESTBED EVALUATION
RICHARD F. HAINES, VICKI JOHNSON, KRISTOFER H. VOGELSONG, and WALT FROLOFF (Lockheed Engineering and Sciences Co., Moffett Field, CA.) *Jul. 1989* 36 p
(Contract NASW-4234)
(NASA-CR-188856; NAS 1.26:188856; RIACS-TR-89-31) Avail: CASI HC A03/MF A01

Eight surrogate spaceflight mission specialists participated in a real-time evaluation of remote coaching using the Ames Life Science Telescience Testbed facility. This facility consisted of three remotely located nodes: (1) a prototype Space Station glovebox; (2) a ground control station; and (3) a principal investigator's (PI) work area. The major objective of this project was to evaluate the effectiveness of telescience techniques and hardware to support three realistic remote coaching science procedures: plant seed germinator charging, plant sample acquisition and preservation, and remote plant observation with ground coaching. Each scenario was performed by a subject acting as flight mission specialist, interacting with a payload operations manager and a principal investigator expert. All three groups were physically isolated from each other yet linked by duplex audio and color video communication channels and networked computer workstations. Workload ratings were made by the flight and ground crewpersons immediately after completing their assigned tasks. Time to complete each scientific procedural step was recorded automatically. Two expert observers also made performance ratings and various error assessments. The results are presented and discussed. Author

N92-14671*# Martin Marietta Space Systems, Inc., Denver, CO. Astronautics Group.
INTELLIGENT ROBOTIC SYSTEMS STUDY (IRSS), PHASE 3 Final Report
Sep. 1991 36 p
(Contract NAS8-36431)
(NASA-CR-184261; NAS 1.26:184261; MCR-91-1340) Avail: CASI HC A03/MF A01

This phase of the Intelligent Robotic Systems Study (IRSS) examines some basic dynamics and control issues for a space manipulator attached to its worksite through a compliant base. One example of this scenario is depicted, which is a simplified, planar representation of the Flight Telerobotic Servicer (FTS) Development Test Flight 2 (DTF-2) experiment. The system consists of 4 major components: (1) dual FTS arms to perform dextrous tasks; (2) the main body to house power and electronics; (3) an Attachment Stabilization and Positioning Subsystem (ASPS) to provide coarse positioning and stabilization of the arms, and (4) the Worksite Attachment Mechanism (WAM) which anchors the system to its worksite, such as a Space Station truss node or Shuttle bay platform. The analysis is limited to the DTF-2 scenario. The goal is to understand the basic interaction dynamics between the arm, the positioner and/or stabilizer, and the worksite. The dynamics and controls simulation model are described. Analysis and simulation results are presented. Author

N92-14672*# Martin Marietta Space Systems, Inc., Denver, CO. Astronautics Group.
INTELLIGENT ROBOTIC SYSTEMS STUDY (IRSS), PHASE 4 Final Report
Oct. 1991 52 p
(Contract NAS8-36431)
(NASA-CR-184262; NAS 1.26:184262; MCR-91-1341) Avail: CASI HC A04/MF A01

Under the Intelligent Robotics Systems Study (IRSS), a generalized robotic control architecture was developed for use with the ProtoFlight Manipulator Arm (PFMA). Based upon the NASREM system design concept, the controller built for the PFMA provides localized position based force control, teleoperation, and advanced path recording and playback capabilities. The PFMA has six computer controllable degrees of freedom (DOF) plus a 7th manually indexable DOF, making the manipulator a pseudo 7 DOF mechanism. Joints on the PFMA are driven via 7 pulse width modulated amplifiers. Digital control of the PFMA is implemented using a variety of single board computers. There were two major activities under the IRSS phase 4 study: (1) enhancement of the PFMA control system software functionality; and (2) evaluation of operating modes via a teleoperation performance study. These activities are described and results are given. Author

N92-15854*# Jackson State Univ., MS. Dept. of Technology.
END-EFFECTOR FOR ROBOTIC ASSEMBLY OF WELDED TRUSS STRUCTURES IN SPACE
WILLIAM V. BREWER *In* Alabama Univ., Research Reports: 1991 NASA/ASEE Summer Faculty Fellowship Program 5 p Oct. 1991
(Contract NGT-01-008-021)
Avail: CASI HC A01/MF A03

In June 1987, work was initiated at LaRC on end-effectors and preloaded joints for robotic truss assembly. This is part of an on-going research effort centered on a test facility that assembles 1 inch x 2 m identical struts into an 8 m diameter x 1.5 m deep platform truss. A detailed description of the test facility was published. The end-effector being used for the LaRC assembly demonstration is quite suitable for the Precision Segmented Reflector or other precision applications. These require high stiffness provided by mechanical joint preloads. Stiffness obtained in this manner is only required and provided over a load range far less than the ultimate strength of the strut tubes. Beyond this useful range, truss behavior is somewhat unpredictable. Mechanically preloaded joints of this type are less suitable for applications such as the Aero Brake where predictable strength and stiffness are required over a greater fraction of the load bearing

capacity of component parts. Preliminary studies of the Aerobrake support truss indicate that struts of at least 3 different diameters and various lengths would improve performance. The double-ended end-effector currently in service is designed for only one diameter and length. Anticipated single-ended versions can accommodate varying lengths but not multiple diameters. Tradeoff considerations for welded joints relative to their mechanically preloaded counterparts are presented. Conclusions from this research are as follows: (1) repair by cut and re-weld on the original weld site should be research; (2) welded joints, though repairable, should not be used where high repair frequencies are anticipated; and (3) welded joints should be considered for an Aero Brake truss. Author

N92-17358*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
JPL SPACE STATION TELEROBOTIC ENGINEERING PROTOTYPE DEVELOPMENT: ADVANCED TELEROBOTICS SYSTEM TECHNOLOGY
PAUL G. BACKES *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 2: Space Station Freedom, Part 2 p 1353-1374 Sep. 1991
Avail: CASI HC A03/MF A04

The objective of the Advanced Telerobotics System Technology Task is to develop/prototype advanced telerobotics supervisory and shared control to enhance Intra-Vehicular Activity (IVA) teleoperation in the Space Station. The technology provides enhanced telerobotics capabilities while operating within the expected constraints of computation limitations, time delay, and bus bandwidth. A local site operator interface has also been developed for specifying teleoperation and shared control modes as well as supervised autonomous macros for execution at the remote site. The primary objective of the task is to transfer the advanced technology to appropriate flight centers to enhance the baseline Station capabilities. Author

N92-19618 Rice Univ., Houston, TX.
DEVELOPMENT OF A LARGE SPACE ROBOT: A MULTI-SEGMENT APPROACH Ph.D. Thesis
REGINALD BRUCE BERKA 1991 190 p
Avail: Univ. Microfilms Order No. DA9135998

A multi-segment robot is developed as a concept for use in space-based construction operations. The multi-segment robot is envisioned as a member of a class of large space robots, or space cranes, used in the space assembly of advanced spacecraft. The problems that arise when the requisite robot size becomes large are explored. The unique capabilities of the multi-segment robot are discussed. The multi-segment robot involves a collection of common bodies, or segments, that are pinned together to form a snake-like configuration. A degree of freedom representing rotation is retained at each pinned connection. Reaction flywheels are suspended within each segment and provide the control to position each segment. Algorithms are developed to position this serpentine robot to a prescribed location and orientation. The first algorithm is used to compute a general shape, based on a constrained polynomial function, that locates the robot tip at the proper position. Next, an algorithm is developed that is used to position the discrete bodies along the shape function and determines their relative positions. An n-body simulation program is developed based on Newton-Euler equations of motion for the robot. The simulation is used to develop the robot control strategy, to verify its performance, and to size prototype hardware. Two cases are analyzed to study the dexterity of the proposed configuration. Dissert. Abstr.

10

MECHANICAL SYSTEMS

Design and operation of mechanical equipment, including gyroscopes and pointing mechanisms. Includes lubrication and lubricants.

A92-12428
IN-ORBIT DEMONSTRATION OF NOVEL SOLID STATE MICRO-ACCELEROMETERS
GERHARD KULZER (Compagnie Industrielle Radioelectrique, Gals, Switzerland), YVES DE COULON (Centre Suisse d'Electronique et de Microtechnique, Neuchatel, Switzerland), PHILIPPE ROUSSEL, and MANFRED TRISCHBERGER (ESA, Noordwijk, Netherlands) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 5 p. Oct. 1991 5 p refs
(IAF PAPER 91-003) Copyright

A selfcontained sensor package comprising 12 Solid State Micro-Accelerometers with its support system flown in a Get-Away-Special canister onboard the Columbia orbiter during the STS 40 mission. The aim of this experiment is to characterize these novel accelerometers in space in microgravity environment and to prove the technology's potential in space applications. The successful flight on 6th June 1991 returned excellent calibration data of the accelerometer and gave insight into the real microgravity level of the Space Shuttle. While the demonstrated sensitivity is in the order of 50 x 10 exp -9 g, the residual gravitational disturbances of the Shuttle are at least a factor of 10 above. Current and future space projects will benefit from the ultrasensitive small size, low weight/low power sensors. Author

A92-29126
ACTIVE GRAVITY GRADIENT TORQUE CONTROL FOR EARTH-ORBITING ASTRONOMICAL TELESCOPES
A. G. EMSLIE (Alabama, University, Huntsville) and J. ZHU (Louisiana State University, Baton Rouge) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 1 1991 6 p refs
Copyright

The controlled pointing of an earth-orbiting astronomical telescope in the presence of time-dependent gravity-gradient torques is studied using techniques for the analysis and synthesis of time-varying linear scalar dynamical systems. Results are presented which show that effective adaptive control of unstable motions due to gravity gradient torques can be accomplished, resulting in high pointing accuracy and stability for astronomical telescopes in both circular and elliptical orbits. I.E.

A92-30125
DESIGNING EXERCISE GEAR FOR ZERO GRAVITY
HENRY WHITMORE and STEVE TURPIN (Whitmore Enterprises, Inc., San Antonio, TX) Mechanical Engineering (ISSN 0025-6501), vol. 114, March 1992, p. 70, 71. Mar. 1992 2 p
Copyright

An account is given of the design of a rowing machine and a treadmill for use aboard the Space Shuttle. The treadmill is the only exercise machine that demonstrably prevents loss of bone density during space travel, through the effect of foot impact on the treadmill; these shocks, however, are structurally distributed throughout the spacecraft and can interfere with delicate zero-gravity experiments. Attention is given to the CAD/CAM process employed for design of these exercise machines. O.C.

A92-30407
A THREE-DEGREE-OF-FREEDOM ELECTROMECHANICAL TRANSDUCER IN THE SPACECRAFT ANGULAR STABILIZATION SYSTEM [TREKHSTEPENNOI ELEKTROMEKHANICHESKII PREOBRAZOVATEL' V SISTEME UGLOVOI STABILIZATSII KOSMICHESKOGO APPARATA]
E. V. DVOINYKH (Kievskii Politekhnicheskii Institut, Kiev, Ukraine) Tekhnicheskaia Elektrodinamika (ISSN 0204-3599), May-June

1991, p. 46-52. In Russian. Jun. 1991 7 p In RUSSIAN refs
Copyright

The possibility of using hydraulic drives based on a 3-DOF electromechanical transducer in the distributed angular stabilization system of spacecraft is investigated. The principle of stabilizing moment synthesis is described for different distributions of the elementary kinetic moment carriers of the angular stabilization system over the spacecraft volume. Some practical recommendations concerning the use of a 3-DOF electromechanical transducer in spacecraft stabilization applications are given. V.L.

N92-13148# Aerospace Corp., El Segundo, CA. Technology Operations.
ASSESSMENT OF THE TRIBIOLOGICAL REQUIREMENTS OF ADVANCED SPACECRAFT MECHANISMS Technical Operating Report
PAUL D. FLEISCHAUER and MICHAEL R. HILTON 30 Sep. 1991 34 p Previously announced in IAA as A90-14018
(Contract F04701-88-C-0089)
(AD-A241674; TOR-0090(5064)-1) Avail: CASI HC A03/MF A01

A survey was conducted of existing technologies for moving mechanical assemblies used in spacecraft applications. The purpose was to identify areas where future requirements for lifetimes in excess of ten years with anticipated speeds, loads, and temperatures might not be satisfied. Some specific mechanisms, such as momentum/reaction wheels, high speed turbines, pointing and tracking mechanisms, despin mechanisms, and gimbal mechanisms, were identified as areas for potential application of existing but unused technologies. Two major problem areas identified involve boundary regime lubrication and lubricant supply (active or passive) for long life. Areas where substantial, near term improvements appear practical include the use of hybrid bearings, new synthetic fluid lubricants, new bearing retainer materials, and properly designed solid film lubricants. GRA

N92-15191*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TRIBOLOGY NEEDS FOR FUTURE SPACE AND AERONAUTICAL SYSTEMS
ROBERT L. FUSARO Dec. 1991 40 p
(Contract RTOP 505-63-5B)
(NASA-TM-104525; E-6399; NAS 1.15:104525) Avail: CASI HC A03/MF A01

Future aeronautical and space missions will push tribology technology beyond its current capability. The objective is to discuss the current state of the art of tribology as it is applied to advanced aircraft and spacecraft. Areas of discussion include materials lubrication mechanisms, factors affecting lubrication, current and future tribological problem areas, potential new lubrication techniques, and perceived technology requirements that need to be met in order to solve these tribology problems. Author

N92-18634# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany). Design Assurance Dept.
A MANAGERIAL APPROACH FOR RELIABILITY VERIFICATION OF MECHANICAL EQUIPMENT
GERHARD ALBRECHT *In* ESA, Space Product Assurance for Europe in the 1990s: An ESA Symposium p 165-167 Aug. 1991
(MBB-UK-0140-PUB; OTN-033148) Copyright Avail: CASI HC A01/MF A03

The verification of the required reliability of mechanical equipment is a difficult task in space programs since adequate statistical failure data covering the specific properties of mechanical equipment is usually not available. However, since straightforward demonstration of the reliability (reliability testing) for the individual equipment is not feasible in most cases for cost and time reasons, effective Reliability, Availability, Maintainability, and Safety (RAMS) management is needed to verify the reliability using test data and other available data. ESA

N92-21579*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LUBRICATION OF SPACE SYSTEMS: CHALLENGES AND POTENTIAL SOLUTIONS
ROBERT L. FUSARO 1992 23 p Presented at the International Conference on Metallurgical Coatings and Thin Films, San Diego, CA, 6-10 Apr. 1991; sponsored by the American Vacuum Society
(Contract RTOP 506-43-41)
(NASA-TM-105560; E-6864; NAS 1.15:105560) Avail: CASI HC A03/MF A01

Future space missions will all require advanced mechanical moving components which will require wear protection and lubrication. The tribology practices used today are primarily based upon a technology base that is more than 20 years old. This paper will discuss NASA's future space missions and some of the mechanism tribology challenges that will be encountered. Potential solutions to these challenges using coatings technology will be assessed. Author

N92-22032*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
SPACE STATION FREEDOM DELTA PRESSURE LEAKAGE RATE COMPARISON TEST DATA ANALYSIS REPORT
E. B. SORENSEN Feb. 1992 26 p
(NASA-TM-103576; NAS 1.15:103576) Avail: CASI HC A03/MF A01

Results are provided of a series of tests performed to identify the relationship between gas leakage rates across a seal at various internal to external pressure ratios. The results complement and provide insight into the analysis technique used to obtain the results presented in MSFC SSF/DEV/EL91-008, 'Space Station Freedom (S.S. Freedom) Seal Flaw Study with Delta Pressure Leak Rate Comparison Test Report.' 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.

A92-13369
LOW HEAT LEAK CURRENT LEADS FOR SPACE BORNE MAGNETS
M. A. HILAL (Wisconsin, University, Madison) IN: Advances in cryogenic engineering. Vol. 35A - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 8 p refs
Copyright

Space borne magnets may be required to operate in a standby mode for long durations and the use of optimized high current leads will result in unacceptable refrigeration power which affects both system efficiency and system weight since large compressors will be required. An innovative concept of low heat leak current leads is presented. The leads consist of a single layer superconductive helical winding section connected in series to a high purity aluminum or copper section. The windings turns are thermally insulated from each other and are internally cooled by the existing helium vapor. During magnet charge the turns are actively cooled below the critical temperature to keep them superconducting. During standby operation, no winding cooling is provided causing the lead temperature at the transition point (where copper or aluminum lead is used) to rise close to room temperature. The superconducting windings have a small diameter wire and a long length causing the heat leak to be small. A closing switch is used to divert the current from the lead during standby mode. The refrigeration power using such a scheme can be reduced by two orders of magnitude. Author

A92-13370
OPTIMAL DESIGN OF CRYOGENIC BUCKLING CYLINDER FOR SPACE BORNE TOROIDAL MAGNETS
H. H. ABDELMOHSEN and M. K. ABDELSALAM (Wisconsin, University, Madison) IN: Advances in cryogenic engineering. Vol. 35A - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 7 p refs
Copyright
Optimal design of the buckling cylinder for spaceborne toroidal magnets is presented. The mechanical properties of boron-epoxy and graphite-epoxy composites have been related to the geometrical dimension of the buckling cylinder. A minimum weight design for a toroidal magnet buckling cylinder based on truss-core sandwich geometry is developed. O.G.

A92-13372
COOLING OF VERY LARGE FOCAL PLANE ARRAYS
W. W. BURT (TRW Space and Technology Group, Redondo Beach, CA) IN: Advances in cryogenic engineering. Vol. 35A - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 15 p refs
Copyright
The generic focal plane is considered from the overall thermal viewpoint with an examination of the origin of the cryogenic thermal requirement. Attention is given to the thermal loads from various sources and some of the practical thermal issues. It is seen that practical implementation of cooling at the focal plane and avoidance of parasitic effects necessitates engineering tradeoffs in concert with the system design. R.E.P.

A92-13374
OPTIMIZATION OF CRYOGENIC AND HEAT REMOVAL SYSTEM OF SPACE BORNE MAGNETS
Z. MUSICKI, M. A. HILAL, and G. E. MCINTOSH (Wisconsin, University, Madison) IN: Advances in cryogenic engineering. Vol. 35B - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 8 p refs
Copyright
Space-based superconducting magnets require a refrigerator system to maintain operating temperature at the design value. The magnets use helium gas cooled shields and multilayer insulation. Refrigerator power is determined based on the heat leak to the shields and to the magnet winding, as well as current leads and charging losses. Electric power is supplied by a power source such as an SP-100-type reactor or solar panels. Cryogenic and heat removal system masses included in the optimization are: the insulation and shields, the refrigerator, the power supply and the heat removal panel. The system is optimized to determine the optimum radiator temperature, superinsulation thickness, helium mass flow rate and helium inlet temperature to the shields.
Author

A92-13375* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DEVELOPMENT OF A COMPACT DILUTION REFRIGERATOR FOR ZERO GRAVITY OPERATION
PAT R. ROACH and BEN HELVENSTEIJN (NASA, Ames Research Center, Moffett Field, CA) IN: Advances in cryogenic engineering. Vol. 35B - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 9 p refs
Copyright
A compact dilution refrigerator design based on internal charcoal adsorption is being tested for operation in zero gravity. This refrigerator is self-contained with no external pumps or gas handling system and provides reliable operation since it has no moving parts. All operations are performed with heaters and are completely computer controlled. The refrigerator is capable of providing many hours of operation at very low temperature before the charcoal pumps must be recycled. O.G.

A92-13376* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
JPL RESEARCH TO DEVELOP A HE-3/HE-4 DILUTION REFRIGERATOR FOR SPACE APPLICATIONS
D. PETRAC, U. E. ISRAELSSON, H. W. JACKSON, and D. M. STRAYER (JPL, Pasadena, CA) IN: Advances in cryogenic engineering. Vol. 35B - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 11 p refs
Copyright
A research program to develop a He-3/He-4 solution refrigerator for space applications is underway. The results of the effort to use an electric field as a substitute for gravity to control the He-3/He-4 mixture interface that separates phases in terrestrial units are described. Further, experimental results obtained from an engineering model of a single-cycle dilution refrigerator with a mixing chamber capable of operating in a zero-gravity environment are described. Future research and development plans are outlined, in particular the need to test the operation of a single-cycle as well as a continuously operating dilution refrigerator in space.
Author

A92-13379* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CONCEPTUAL DESIGN OF A 0.1 W MAGNETIC REFRIGERATOR FOR OPERATION BETWEEN 10 K AND 2 K
BEN P. M. HELVENSTEIJN and ALI KASHANI (NASA, Ames Research Center; Sterling Federal Systems, Inc., Moffett Field, CA) IN: Advances in cryogenic engineering. Vol. 35B - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 9 p refs
Copyright
The design of a magnetic refrigerator for space applications is discussed. The refrigerator is to operate in the temperature range of 10 K-2 K, at a 2 K cooling power of 0.10 W. As in other magnetic refrigerators operating in this temperature range GGG has been selected as the refrigerant. Crucial to the design of the magnetic refrigerator are the heat switches at both the hot and cold ends of the GGG pill. The 2 K heat switch utilizes a narrow He II filled gap. The 10 K heat switch is based on a narrow helium gas gap. For each switch, the helium in the gap is cycled by means of activated carbon pumps. The design concentrates on reducing the switching times of the pumps and the switches as a whole. A single stage system (one magnet; one refrigerant pill) is being developed. Continuous cooling requires the fully stationary system to have at least two stages running parallel/out of phase with each other. In order to conserve energy, it is intended to recycle the magnetic energy between the magnets. To this purpose, converter networks designed for superconducting magnetic energy storage are being studied. Author

A92-13384
PULSE TUBE REFRIGERATOR PERFORMANCE
E. TWARD, C. K. CHAN, and W. W. BURT (TRW Space and Technology Group, Redondo Beach, CA) IN: Advances in cryogenic engineering. Vol. 35B - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 6 p refs
Copyright
The performance of pulse tube coolers is being studied in order to determine their suitability for development into long-life space coolers. Coolers based on the pulse tube phenomenon appear to be attractive for long-life space application because of their inherent simplicity. Single-stage and two-stage pulse tube test coolers have been designed and tested. In these early tests a single stage cooler has achieved a low temperature of 53 K while rejecting heat above 300 K. An unoptimized two-stage cooler has reached 26 K while rejecting heat above 300 K. Performance measurements for the coolers is presented. Author

A92-13398 Alabama Cryogenic Engineering, Inc., Huntsville.
THE MINIMUM TEMPERATURE OF THE 'VORTEX' CRYOCOOLER

JOHN B. HENDRICKS (Alabama Cryogenic Engineering, Inc., Huntsville) IN: Advances in cryogenic engineering. Vol. 35B - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 7 p refs
(Contract NAS8-35254; NAS5-29418)
Copyright

The 'vortex' cryocooler originally developed by Staas and Severijns, uses flowing He II to produce a cooling effect. The device is an attractive candidate for zero-gravity applications as there are no liquid/vapor interfaces that create fluid control problems. Experimentally, the minimum temperature produced by the device is approximately 0.7 K. It is shown that this temperature limit is due to the Joule-Thomson effect in the flowing He II. It is thus an intrinsic limit. The minimum temperature is weakly dependent on the system pressure and on exit capillary diameter. Author

A92-13400* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
REGENERATIVE SORPTION COMPRESSORS FOR CRYOGENIC REFRIGERATION
STEVEN BARD and JACK A. JONES (JPL, Pasadena, CA) IN: Advances in cryogenic engineering. Vol. 35B - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 9 p refs
Copyright

Dramatic efficiency improvements for sorption coolers appear possible with use of compressor heat regeneration techniques. The general theory of sorption compressor heat regeneration is discussed in this paper, and several design concepts are presented. These designs result in long-life, low-vibration cryocoolers that potentially have efficiencies comparable to Stirling refrigerators for 65 to 90 K spacecraft instrument cooling applications. Author

A92-13409* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
ADIABATIC DEMAGNETIZATION REFRIGERATOR FOR SPACE USE
A. T. SERLEMITSOS, B. A. WARNER, S. CASTLES, S. R. BREON (NASA, Goddard Space Flight Center, Greenbelt, MD), M. SAN SEBASTIAN, and T. HAIT (STX Corp., Greenbelt, MD) IN: Advances in cryogenic engineering. Vol. 35B - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 7 p refs
Copyright

An Adiabatic Demagnetization Refrigerator (ADR) for space use is under development at NASA's Goddard Space Flight Center (GSFC). The breadboard ADR operated at 100 mK for 400 minutes. Some significant changes to that ADR, designed to eliminate shortcomings revealed during tests, are reported. To increase thermal contact, the ferric ammonium sulfate crystals were grown directly on gold-plated copper wires which serve as the thermal bus. The thermal link to the X-ray sensors was also markedly improved. To speed up the testing required to determine the best design parameters for the gas gap heat switch, the new heat switch has a modular design and is easy to disassemble. Author

A92-13410* Sterling Software, Palo Alto, CA.
SALT MATERIALS TESTING FOR A SPACECRAFT ADIABATIC DEMAGNETIZATION REFRIGERATOR
M. L. SAVAGE (Sterling Software, Inc., Palo Alto, CA), P. KITTEL, and T. ROELLIG (NASA, Ames Research Center, Moffett Field, CA) IN: Advances in cryogenic engineering. Vol. 35B - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 8 p refs
Copyright

As part of a technology development effort to qualify adiabatic demagnetization refrigerators for use in a NASA spacecraft, such as the Space Infrared Telescope Facility, a study of low temperature characteristics, heat capacity and resistance to dehydration was conducted for different salt materials. This report includes results of testing with cerrous metaphosphate, several synthetic rubies, and chromic potassium alum (CPA). Preliminary results show that CPA may be suitable for long-term spacecraft use, provided that the salt is property encapsulated. Methods of salt pill construction and testing for all materials are discussed, as well as reliability tests. Also, the temperature regulation scheme and the test cryostat design are briefly discussed. Author

A92-13411* California Univ., Berkeley.
A ROCKET-BORNE HE-3 REFRIGERATOR
L. DUBAND, D. ALSOP, A. LANGE (California, University, Berkeley), and P. KITTEL (NASA, Ames Research Center, Moffett Field, CA) IN: Advances in cryogenic engineering. Vol. 35B - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 10 p refs
Copyright

A self-contained, recyclable He-3 refrigerator suitable for use in space has been developed. The refrigerator is compact, has no moving parts, and requires only electrical connections and thermal contact in order to operate from a 2 K cold stage. A charcoal adsorption pump is used to efficiently condense and cool the He-3. Sintered copper confines the He-3 to the evaporator in zero-gravity and, in fact, allows the refrigerator to operate upside-down in the laboratory. Mounted on a 2 K cold stage, the refrigerator provides 100 microwatts of cooling power at 346 mK, with a 7 hour hold time. On a 1.5 K cold stage, the lowest temperature achieved is 277 mK. The refrigerator has been vibration tested at 7.5 G amplitude from 30 to 400 Hz and 15 G amplitude from 400 to 2000 Hz. Author

A92-17877
THERMAL DESIGN EVALUATION OF ON-BOARD LARGE DEPLOYABLE ANTENNA
HIROAKI TSUNODA, KATSUHIKO NAKAJIMA, and AKIHIRO MIYASAKA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 39, no. 453, 1991, p. 504-512. In Japanese. 1991 9 p In JAPANESE refs

A future multibeam communication satellite requires a large deployable antenna which has a total length of about 9 m, including two large main reflectors and a tower. Thermal balance test for such a large-sized antenna system are limited by the volume of a space simulation chamber. The deployment mechanisms cannot support the reflectors without damage under gravitational conditions. In order to overcome these problems, a two-step thermal design verification method is devised. First, the antenna component thermal analytical model was verified by each component test in critical test cases. Next, the antenna system thermal analytical model was verified by a system test. The antenna system test is performed by using supporting structures which support the hardpoints of each main-reflector in order to minimize the gravity force to the antenna deployment mechanisms. Author

A92-19149
THE DELTA STAR THERMAL VACUUM TEST - A UNIQUE APPROACH TO SPACE THERMAL SIMULATION
DICK Q. DURANT and CHRISTOPHER J. FULD (McDonnell Douglas Space Systems Co., Huntington Beach, CA) Dec. 1991 11 p
Copyright

Several techniques were developed to perform the thermal vacuum test of the Delta Star Spacecraft. Test design and fabrication was completed in only four months, producing a 21-zone, computer-modeled reflectorless lamp array system. Array zone control was based on discreet absorbed flux measurements provided by adiabatic coupons that were conceived to eliminate the need for conventional radiometers. Test requirements, methodology, anomalies, test data correlation, and flight data correlation are presented. Author

A92-20309
THERMAL PERFORMANCE OF THERMAL PAD CONTACT HEAT EXCHANGERS
G. P. PETERSON, L. S. FLETCHER (Texas A & M University,

College Station), and DAVID BLACKLER (Rockwell International Corp., Canoga Park, CA) Mar. 1992 8 p refs
Copyright

A92-20320
TRANSIENT THERMAL ANALYSIS OF THREE FAST-CHARGING LATENT HEAT STORAGE CONFIGURATIONS
THERESE K. STOVALL (Oak Ridge National Laboratory, TN) and RAO V. ARIMILLI (Tennessee, University, Knoxville) Journal of Thermophysics and Heat Transfer (ISSN 0887-8722), vol. 6, Jan.-Mar. 1992, p. 152-157. Previously announced in STAR as N88-28960. Mar. 1992 6 p refs
(Contract DE-AC05-84OR-21400)

A space-based thermal storage application must accept large quantities of heat in a short period of time at an elevated temperature. A model of a lithium hydride phase change energy storage system was used to estimate reasonable physical dimensions for this application which included the use of a liquid metal heat transfer fluid. A finite difference computer code was developed and used to evaluate three methods of enhancing heat transfer in the PCM energy storage system. None of these three methods, inserting thin fins, reticulated nickel, or liquid lithium, significantly improved the system performance. The use of a 95 percent void fraction reticulated nickel insert was found to increase the storage capacity (total energy stored) of the system slightly with only a small decrease in the system energy density (energy storage/system mass). The addition of 10 percent liquid lithium was found to cause minor increases in both storage density and storage capacity with the added benefit of reducing the hydrogen pressure of the lithium hydride. Author

A92-20367
HEAT TRANSFER PREDICTIONS FOR A NEW HEAT-PIPE LATENT-HEAT-STORAGE RECEIVER ELEMENT FOR SOLAR DYNAMIC SPACE POWER SYSTEMS
S. KRAUSE (DLR, Institut fuer Technische Thermodynamik, Stuttgart, Federal Republic of Germany) and S. ORTNER Space Power - Resources, Manufacturing and Development (ISSN 0883-6272), vol. 10, no. 2, 1991, p. 239-256. 1991 18 p refs
Copyright

An array of cylindrical heat pipes with annular latent heat-storage units is generally recognized as the most promising heat-transfer/thermal-storage alternative for spacecraft solar-dynamic power systems (SDPS) receivers. A storage unit was developed containing LiF in graphite containers with internal capillary notches to handle the LiF volume change upon melting. Successful terrestrial tests are reported. Theoretical predictions are presented of the relevant heat flows and temperatures in heat-pipe/storage elements (HPSE) employing such storage units. The HPSE were sized for a receiver combined with a fictitious 25 kWe Stirling engine in an SDPS. The capillary notches were optimized for maximum heat transfer. The results show that the required heat flows are essentially feasible, and what deviations are to be expected and must be handled by the spacecraft-energy management during a typical orbit. The knowledge of the receiver and internal heat pipe temperatures is important for design purposes. Author

A92-21828
A FEED-BACK THERMAL REGULATION SYSTEM FOR THE COLUMBUS FREE FLYER BATTERY SECTION
ALAIN LANTERI, C. W. B. POTTS (Aerospatiale, Cannes, France), PETER MOELLER, J. HELD, and H. KREEB (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 14 p. Jul. 1991 14 p
(SAE PAPER 911409) Copyright

The process of design selection and verification is discussed for the BSTCA (Battery-Section Thermal-Control Assembly), a module of the Columbus Man-Tended Free Flyer. Electrical power required during eclipse periods is made available from six nickel-hydrogen batteries. A sophisticated multiradiator configuration with a hybrid heat-pipe network is employed. Autonomous control of the assembly heat-rejection capability is achieved by an integrated network of liquid-trap heat pipes and constant-conductance heat pipes under the control of a conventional heater control unit. Author

A92-21829
FUNDAMENTAL STUDY ON TWO PHASE FLUID LOOP FOR THERMAL CONTROL SYSTEM IN FUTURE SPACE PLATFORMS
KOICHI CHIBA, SHINYA SUGURI, HIDEAKI TOKUTOMI, and SHINTAROU ENYA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 10 p. Jul. 1991 10 p refs
(SAE PAPER 911410) Copyright

Since 1987, the liquid-gas two-phase fluid loop and several kinds of cold plates in order to provide large platforms in the future have been studied. This report describes the following in connection with the two-phase fluid loop: (1) an outline of the recent trial manufacture of the two-phase fluid loop provided with a bellows-type flow control system, which can be used in space; (2) new type cold plates featuring porous fin; and (3) tests results confirming that the loop and heat exchangers have adequate operational characteristics. Author

A92-21842
THERMAL CONTROL DESIGN ASPECTS OF COLUMBUS PRESSURISED MODULES
SILVIO DOLCE, MASSIMO ANTONACCI, and MICHELE TRICHILO (Alenia Spazio S.p.A., Turin, Italy) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 13 p. Jul. 1991 13 p refs
(SAE PAPER 911446) Copyright

Columbus Pressurised Modules (the Attached Pressurised Module (APM)) permanently attached to Space Station Freedom and the Man Tended Flyer (MTFF) module will support the scientific experiments and commercial space exploitation requiring manned interaction and intervention (APM) or infrequent servicing/resupply by flight crew (MTFF) in a low gravity environment. This paper is based on the activities performed during the early stages of Columbus Phase C/D and presents: (1) the Active Thermal Control design solutions including the architecture of the fluid loops, the fluid loops monitoring and control philosophy, and the fluid loops components and design features; and (2) the Passive Thermal Control design solutions including multilayer insulating, anticondensation, heaters concept, and thermooptical properties selection. Author

A92-21843
CONCEPTUAL DESIGN OF THE COLUMBUS FREE FLYING LABORATORY RESOURCE MODULE THERMAL CONTROL SUBSYSTEM
JOST MUNDER, MANFRED BADER, and PETER MOELLER (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 11 p. Jul. 1991 11 p
(SAE PAPER 911447) Copyright

The thermal control subsystem of the Columbus Resource Module RM has to cope with an unusual variety of orbit attitudes, mission modes, and configurations. A short overview over the past RM thermal concepts is given, and the present thermal design is described in detail. A passive concept with extensive use of heatpipes configured as network is baselined. The low available heater power in conjunction with the significant dissipation variations of the NiH2 batteries, require a very effective heat-rejection-control concept. A new regulation concept has been selected which allows to switch off up to 75 percent of the battery radiator area by use of liquid trap heatpipes. The verification concept which does not use system level testing is briefly described. Author

A92-21844
THE THERMAL CONTROL OF THE EUROPEAN RETRIEVABLE CARRIER, AN EXAMPLE OF FLEXIBLE THERMAL CONTROL SYSTEM
GIUSEPPE D. RACCA (ESTEC, Noordwijk, Netherlands) and WOLFGANG HAHN (MBB-ERNO, Bremen, Federal Republic of Germany) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 14 p. Jul. 1991 14 p refs
(SAE PAPER 911448) Copyright

The development and verification of the design and operational aspects of the thermal control system of the European Retrievable Carrier (ERC) are addressed. Examples are used to show how model development, implementation of the different requirements, and design solutions are obtained for problems not solvable by the affected subsystems alone. These problems include: missing power interface for a payload in some mission cases, electronic design problem of the 20 N thruster chamber temperature monitoring, high temperature of the battery due to specification problems, and power shortage during operational phase. C.D.

A92-21846
COLUMBUS WATER PUMP PACKAGE OVERVIEW
R. ORLANDO, P. OSELLA, and M. FERRERA (Microtecnica S.p.A., Turin, Italy) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 11 p. Jul. 1991 11 p
(SAE PAPER 911450) Copyright

This paper provides a comprehensive description of the present status of the Water Pump Subassembly (WPSA) that will be part of the Active Thermal Control System of the Pressurized Modules of Columbus, the Attached Laboratory (PM4), and the PM2 of the Man Tended Free Flyer. Description of major conponents of the WPSA are presented along with the results of trade-offs performed and rationals for concept selection. Author

A92-21860
THERMAL TEST OF AN AMMONIA TWO-PHASE LOOP - RESULTS OF CONDENSER STUDY
V. BERTHON, S. ANDRE (Aerospatiale, Cannes, France), T. LAFON (CNES, Toulouse, France), and M. LALLEMAND (Lyon, Institut National des Sciences Appliquees, Villeurbanne, France) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 11 p. Jul. 1991 11 p refs
(SAE PAPER 911522) Copyright

This paper describes the operating principles of a 600 W mechanically pumped two-phase elementary loop using ammonia as the working fluid, designed for the thermal control system of a large spacecraft and presents experimental results of the condenser's thermal performance. The tests have demonstrated good operating conditions, with no starting difficulties, control problems, or flow instabilities. A previously developed condensation model gave the theoretical two-phase flow patterns corresponding to the test cases, and the predicted thermal performances for stratified and annular flows. I.S.

A92-21861
A SPACE PUMP PROTOTYPE DESIGNED FOR OPERATION IN THERMAL LOOPS
H. G. WULZ (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) and E. WUNDERLICH SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 13 p. Jul. 1991 13 p refs
(SAE PAPER 911523) Copyright

A pump concept was elaborated based on the Columbus requirements. Mainly the requirements for long-life and low-noise operation were taken into consideration in this design. According to the pump concept a model pump for operation in a thermal loop was built and tested with existing industrial facilities. Tests revealed that this very compact and light pump fulfills already the hydraulic requirements completely and is near to the low-noise requirement. After a running time of 1000 hrs with the fluids water and liquid ammonia the ceramic bearings show no water at all. Author

A92-21869
FHTS - ACTIVE THERMAL CONTROL ANALYSER, *VERIFICATION, VALIDATION AND UPGRADE*
C. J. KIRTLEY (GEC Alsthom, Engineering Research Centre, Whetstone, England), Y. BOILLOT, and A. LEBRU (ESA, Noordwijk, Netherlands) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 14 p. Jul. 1991 14 p refs
(SAE PAPER 911545) Copyright

The paper describes the FHTS, a major extension to the existing ESATAN, the standard thermal analyzer used throughout the European space industry. Special attention is given to the capabilities of FHTS and the stringent quality assurance standards which were used during its development. The first step in validating FHTS was carried out by ESA in 1990 for the single phase package by comparing experimental data against simulated results, using the hybrid radiator that was then being developed for Columbus. At present, FHTS is being used in the framework of space application for both the Columbus and the Hermes projects. I.S.

A92-21870
MODELLING APPROACH FOR THE THERMAL/ENVIRONMENTAL SYSTEM OF THE COLUMBUS ATTACHED PRESSURISED MODULE
RUGGERO VENERI, VINCENZO PUGLIESE, EUGENIO GARGIOLI, and CESARE LOBASCIO (Alenia Spazio S.p.A., Turin, Italy) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 15 p. Jul. 1991 15 p
(SAE PAPER 911546) Copyright

The modeling approach selected for the Thermal/Environmental Control System of the Columbus Attached Pressurized Module is described. The approach uses an integrated overall thermal mathematical model (TMM) together with a set of additional TMMs for detailed tasks. The overall TMM, (up to 900 nodes, written in ESATAN) allows the element thermal balance verification and the provision of the sink and interface temperatures for the equipment thermal design. Other TMMs include the simplified active TMM (up to 150 nodes, written in ESACAP) and the local thermohydraulic models (up to 250 nodes each, written in ESATAN-FHTS). It is shown that the use of a set of several models for an extensive analysis task on a complex station is preferable to the use of one very large model. I.S.

A92-21887* Lockheed Missiles and Space Co., Sunnyvale, CA.
THERMAL SYNTHESIZER SYSTEM - AN INTEGRATED APPROACH TO SPACECRAFT THERMAL ANALYSIS
TIM PANCZAK, LARRY FRIED (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA), STEVEN RICKMAN (NASA, Johnson Space Center, Houston, TX), and MARK WELCH (Lockheed Engineering and Sciences Co., Houston, TX) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 19 p. Jul. 1991 19 p refs
(SAE PAPER 911582) Copyright

The Thermal Synthesizer System (TSS), which is being developed to meet the thermal analysis needs of Space Station Freedom and of the proposed Space Exploration Initiative missions, is examined. The key requirements and design goals to be met by TSS are summarized, and the software engineering and user interface design philosophy are reviewed. The basic architecture for all applications within TSS is described. An overview is given of the main features of each of the applications of TSS. C.D.

A92-21888
IMPLEMENTATION OF AUTOMATIC CONTROL FEATURES IN ESATAN MODELS
WERNER HOFACKER, JOACHIM LUCAS, and JUERGEN SCHILKE (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) SAE, International Conference on Environmental

Systems, 21st, San Francisco, CA, July 15-18, 1991. 11 p. Jul. 1991 11 p refs
(SAE PAPER 911583) Copyright

An addition to ESA's thermal analyzer ESATAN which concerns the implementation of automatic control features is addressed. A method is described which allows automatic control of the status of a variable based on a feedback control loop. The automatic control of temperatures in the pressurized volumes of the Hermes spaceplane is considered as an example. C.D.

A92-21889
THERMAL ANALYSIS OF SPACECRAFT BY COMBINING DIFFERENT ANALYSIS TOOLS
WERNER HOFACKER, JOACHIM LUCAS, and F. ZILLY (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 10 p. Jul. 1991 10 p refs
(SAE PAPER 911584) Copyright

Methods for analyzing complex thermal effects occurring on spacecraft and satellites are described. It is shown that the various thermal effects can only be assessed by combining different analysis tools. An approach is examined which ensures that all major thermal aspects are correctly taken into account. The analysis carried out for the Hermes spaceplane is shown as an example. C.D.

A92-21892
TWO-PHASE THERMAL CONTROL SYSTEM MODELING USING SINDA'85/FLUINT
ROSEMARY A. SCHMIDT (Swales and Associates, Inc., Beltsville, MD) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 10 p. Jul. 1991 10 p refs
(SAE PAPER 911590) Copyright

Simultaneous thermal and hydraulic analysis is completed using SINDA'85/FLUINT for a two-phase ammonia thermal-control system proposed for Space Station Freedom Attached Payload Accommodation Equipment (APAE). This analysis provided information on system performance, transient behavior during heat-load changes, and control-system response. Control-system logic and nonequilibrium effects were included in the model. The hardware used in this thermal control system is described as are the modeling techniques used to represent it. A brief comparison of the predicted system performance with test results from ground testing of similar systems at NASA Johnson Space Center is also provided. Author

A92-21894* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
INSTRUMENT THERMAL TEST BED - A UNIQUE TWO PHASE TEST FACILITY
THEODORE SWANSON and JEFFREY DIDION (NASA, Goddard Space Flight Center, Greenbelt, MD) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 9 p. Jul. 1991 9 p
(SAE PAPER 911592) Copyright

The Instrument Thermal Test Bed (ITTB) is a modular, large-scale test facility which provides a medium for ground testing and flight qualification of spacecraft thermal control components and system configurations. The initial 'shade-down' operations are discussed herein. Operational parameters and performance characteristics were determined and quantified on a preliminary basis. The ITTB was successfully operated at evaporator power loads ranging from 600 W to 9600 W as well as in both capillary pumped and series hybrid pumped modes. Author

A92-23691 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A THERMAL EXPERT SYSTEM (TEXSYS) DEVELOPMENT OVERVIEW - AI-BASED CONTROL OF A SPACE STATION PROTOTYPE THERMAL BUS
B. J. GLASS (NASA, Ames Research Center, Moffett Field, CA) and E. C. HACK (Lockheed Engineering and Sciences Co., Houston, TX) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs
(Contract NAS9-15800; NAS9-17900)

A knowledge-based control system for real-time control and fault detection, isolation and recovery (FDIR) of a prototype two-phase Space Station Freedom external thermal control system (TCS) is discussed in this paper. The Thermal Expert System (TEXSYS) has been demonstrated in recent tests to be capable of both fault anticipation and detection and real-time control of the thermal bus. Performance requirements were achieved by using a symbolic control approach, layering model-based expert system software on a conventional numerical data acquisition and control system. The model-based capabilities of TEXSYS were shown to be advantageous during software development and testing. One representative example is given from on-line TCS tests of TEXSYS. The integration and testing of TEXSYS with a live TCS testbed provides some insight on the use of formal software design, development and documentation methodologies to qualify knowledge-based systems for on-line or flight applications. Author

A92-23841
A HIGH CAPACITY RE-ENTRANT GROOVE HEAT PIPE FOR CRYOGENIC AND ROOM TEMPERATURE SPACE APPLICATIONS
F. EDELSTEIN and R. KOSSON (Grumman Corp., Bethpage, NY) (Space Cryogenics Workshop, 10th, Cleveland, OH, June 18-20, 1991, Proceedings. A92-23826 08-31) Cryogenics (ISSN 0011-2275), vol. 32, no. 2, 1992, p. 167-172. 1992 6 p refs
Copyright

Attention is given to a high-capacity heat pipe developed for use in both the cryogenic and room-temperature range. The configuration consists of 24 reentrant axial grooves extruded in a 1-in.-diameter aluminum pipe. Using methane, the pipe demonstrated transport capacities as high as 6500 W in a level orientation at 115 K, which is an order of magnitude higher than state-of-the-art cryogenic heat pipe technology. Being a derivative of conventional rectangular axial groove heat pipes that have had extensive flight experience, the reentrant design offers the same high reliability and ease of fabrication. Other benefits include low fluid charge resulting in reduced internal pressure at ambient temperature, tolerance to the presence of noncondensible gas, and the capability to be bent to fit within tight spacecraft envelopes. The design lends itself to optimization for specific loads and temperatures, within the constraints of the extrusion process. P.D.

A92-24065
ELECTROSTATIC DISCHARGE INDUCED THERMO-OPTICAL DEGRADATION OF OPTICAL SOLAR REFLECTORS (OSRS)
A. BOGORAD, C. BOWMAN (General Electric Co., Astro-Space Div., Princeton, NJ), T. LLOYD, J. LOMAN, and J. ARMENTI (General Electric Co., Astro-Space Div., Philadelphia, PA) (1991 IEEE Annual Conference on Nuclear and Space Radiation Effects, 28th, San Diego, CA, July 15-19, 1991, Proceedings. A92-24025 08-33) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 38, pt. 1, Dec. 1991, p. 1608-1613. Research supported by General Electric Co. Dec. 1991 6 p refs
Copyright

In a combined space environment (20-keV electrons and protons; UV), non-ITO-coated OSRs exhibited a 50 percent increase in alpha (thermal absorptivity) compared with a negligible increase for ITO-coated OSRs. The increase is attributed to ESD-induced degradation. The results of this study will allow thermal designers to more accurately predict the spacecraft on-orbit temperatures by taking into account ESD-induced degradation of the thermal-optical properties of OSRs. I.E.

A92-24660* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PREDICTION OF RADIANT ENERGY FORCES ON THE TOPEX/POSEIDON SPACECRAFT

PETER G. ANTREASIAN and GEORGE W. ROSBOROUGH (Colorado, University, Boulder) Feb. 1992 10 p refs
(Contract JPL-957388)
Copyright

A92-24662
LONG DURATION EXPOSURE FACILITY SURFACE TEMPERATURES
P. C. HUGHES and R. C. TENNYSON (Toronto, University, Downsview, Canada) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 29, Jan.-Feb. 1992, p. 96-101. Research supported by NSERC. Feb. 1992 6 p refs
Copyright

Temperatures on the surface of the Long Duration Exposure Facility (LDEF) depend on a number of factors. The LDEF is sometimes in sunlight, sometimes in eclipse; even when the LDEF is in sunlight, a particular surface area (e.g., a test patch) may not be able to see the sun; and, finally, even if it can see the sun, the angle of incidence of the sun's radiation on the test patch is important. The heat input to the test patch from the rest of the LDEF vehicle depends on the average vehicle temperature, which in turn depends on its eclipse history. This paper examines all of these factors and uses a multiple-time-scale description (corresponding to orbital, precessional, and annual time scales) to build an understanding of the chief features observed in the flight data. Geometrical, orbital, and thermal models are developed. Numerical calculations based on these models are shown to be in general agreement with the characteristics of flight data. Thus, all of the salient features of the in-orbit temperature data can be explained in terms of the physical phenomena described. Author

A92-28232*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
EFFECTS OF SPACE EXPOSURE ON THERMAL CONTROL COATINGS
ROGER C. LINTON (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 11 p. Jan. 1992 11 p refs
(AIAA PAPER 92-0795) Copyright

Optical degradation of selected thermal control coatings exposed on LDEF Experiment A0034, 'Atomic Oxygen Stimulated Outgassing', attributable to effects of solar radiation, was significantly changed for specimens whose exposure included orbital atomic oxygen impingement. This LDEF experiment consisted of two passive modules, one exposed to the total space environment on the Leading Edge (RAM) and another exposed to the relative wake of the Trailing Edge. Evidence of atomic oxygen stimulated outgassing and the interrelated effects of the natural environment based on evaluation of the flight specimens will be discussed. Author

A92-29587*# National Aeronautics and Space Administration, Washington, DC.
SPACE STATION FREEDOM MAIN TRUSS THERMAL ANALYSIS
ANDREW H. WARREN (Grumman Space Systems, Bethpage, NY) and JOSEPH E. ARELT (Grumman Corp., Grumman Space Station Program Support Div. Reston, VA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 13 p. Jan. 1992 13 p refs
(Contract NASW-4300)
(AIAA PAPER 92-0813) Copyright

The main truss structure of the Permanently Manned Capability configuration of the Space Station Freedom is analyzed in order to evaluate orbital heating loads and determine the temperature distributions and temperature gradients in the structure. The results are to be utilized in a thermal/structure analysis in the determination of thermal stresses and deflections in the truss members caused by solar heating loads and by shadowing of the truss members by other segments of the Space Station as it moves around the orbit. A SINDA thermal finite different model and a TRASYS radiation interchange model of the truss were generated automatically from a NASTRAN finite element structural model. The analysis yielded transient temperature distribution in the truss structure around the orbit, indicating large temperature gradients in the structure. P.D.

A92-29588#
IN-FLIGHT TEMPERATURE CORRELATION AND THERMAL PERFORMANCE EVALUATION FOR THE SUPERBIRD COMMUNICATIONS SPACECRAFT
HENRY V. CHANG, WILLIAM K. BRYZA, DEAN LAMBERTSON, and CHRIS GOODMAN (Space Systems/Loral Spacecraft Engineering Laboratory, Palo Alto, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 11 p. Jan. 1992 11 p
(AIAA PAPER 92-0814) Copyright

The paper discusses the in-flight thermal performance evaluation for a three-axis stabilized spacecraft. It is found that spacecraft heat pipes simplify analytical thermal modeling and that temperature correlations can be obtained to within 1 C to 2 C. Due to the high performance of the heat pipes and passive use of multi-layer insulation blankets, it is found that all spacecraft components are within acceptance temperature limits from beginning of spacecraft life to spacecraft end of life (using correlated model for end of life predictions). The correlated thermal model is used to determine the optical solar reflector degradation. Author

A92-29627# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SOLAR PROBE THERMAL SHIELD DESIGN AND TESTING
JERRY M. MILLARD, ROBERT N. MIYAKE, and RICHARD A. RAINEN (JPL, Pasadena, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 15 p. Research supported by NASA. Jan. 1992 15 p refs
(AIAA PAPER 92-0862) Copyright

This paper discusses the major thermal shield subsystem development activities in support of the Solar Probe study being conducted at JPL. The Solar Probe spacecraft will travel to within 4 solar radii of the sun's center to perform fundamental experiments in space physics. Exposure to 2900 earth suns at perihelion requires the spacecraft to be protected within the shadow envelope of a protective shield. In addition, the mass loss rate off of the shield at elevated temperature must comply with plasma instrument requirements and has become the driver of the shield design. This paper will focus on the analytical design work to size the shield and control the shield mass loss rate for the various spacecraft options under study, the application of carbon-carbon materials for shield components, development and preparation of carbon-carbon samples for materials testing, and a materials testing program for carbon-carbon and tungsten alloys to investigate thermal/optical properties, mass loss (carbon-carbon only), material integrity, and high velocity impact behavior. Author

A92-31291*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ANODIZED ALUMINUM COATINGS FOR THERMAL CONTROL. I - COATING PROCESS AND STRESSES
R. S. ALWITT (Boundary Technologies, Inc., Buffalo Grove, IL), R. C. MCCLUNG (Southwest Research Institute, San Antonio, TX), and S. JACOBS (NASA, Johnson Space Center, Houston, TX) IN: AIAA Materials Specialist Conference - Coating Technology for Aerospace Systems, Dallas, TX, Apr. 16, 17, 1992, Technical Papers 1992 7 p refs
(Contract NAS9-18087; NAS9-18350)
(AIAA PAPER 92-2158) Copyright

Anodized aluminum is a candidate material for use as a thermal radiator surface on Space Station Freedom. Here, results of measurements of coating stress at room temperature are presented. The effects of coating process conditions and also subsequent exposure to different humidities, from above ambient to vacuum, are reported. The most important observation with regard to space applications is that the coating stress is very dependent on humidity, changing from compressive at ambient

humidity to strongly tensile in 10 exp -6 torr vacuum. The increase in stress is accompanied by loss of water from the coating, and the process is reversible. Author

A92-31292*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ANODIZED ALUMINUM COATINGS FOR THERMAL CONTROL. II - ENVIRONMENTAL EFFECTS AND CRACKING
R. C. MCCLUNG (Southwest Research Institute, San Antonio, TX), R. S. ALWITT (Boundary Technologies, Inc., Buffalo Grove, IL), and S. JACOBS (NASA, Johnson Space Center, Houston, TX) IN: AIAA Materials Specialist Conference - Coating Technology for Aerospace Systems, Dallas, TX, Apr. 16, 17, 1992, Technical Papers 1992 10 p refs
(Contract NAS9-18087; NAS9-18350)
(AIAA PAPER 92-2159) Copyright

The environmental effects of thermal cycling and humidity on coating cracking are examined. Experimental measurements of thermal deflection were used to calculate values for the thermal expansion coefficient and the in situ elastic modulus of an anodized aluminum. The thermal expansion coefficient is found to be approximately the same as for alumina in bulk form. The modulus in atmospheres with less than 100 ppm water is about 12,500 ksi. Two sets of experiments are used to study cracking directly during thermal excursions: one determines the minimum temperature (Tc) at which cracks first appear during a single heating cycle and the other involves rapid thermal cycling (RTC) between fixed T max and T min values. Fatigue models for describing initiation of the first crack and the development of multiple cracking are presented, which can be used as the basis for prediction of LEO cracking. O.G.

A92-31293#
BLACK ANODIZE AS A THERMAL CONTROL COATING FOR SPACE STATION FREEDOM
RAY LEVESQUE, MARGUERITE HO, BRIAN W. VICKERS, HANK BABEL (McDonnell Douglas Space Systems Co., Huntington Beach, CA), and ALBERT PARD (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) IN: AIAA Materials Specialist Conference - Coating Technology for Aerospace Systems, Dallas, TX, Apr. 16, 17, 1992, Technical Papers 1992 10 p refs
(AIAA PAPER 92-2160) Copyright

Candidate black thermal control coatings for aluminum hardware in Work Packages 2 and 4 of the SSF program are discussed. Anodic coatings under consideration include cobalt sulfide dyed sulfuric acid anodize coating and three commercial electrolytic processes, a one-step process, and two two-step electrolytic dye processes. It is concluded that three commercial processes appear quite promising for 6061 and 7075 aluminum hardware. O.G.

A92-31294*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
USE OF COBALT SULFIDE (BLACK DYE) ANODIZE FOR THERMAL CONTROL OF THE SPACE STATION FREEDOM AIRLOCK
JOHN SAIZ (NASA, Johnson Space Center, Houston, TX) and MARK BERGER (McDonnell Douglas Space Systems Co., Space Station Div., Huntington Beach, CA) IN: AIAA Materials Specialist Conference - Coating Technology for Aerospace Systems, Dallas, TX, Apr. 16, 17, 1992, Technical Papers 1992 9 p
(AIAA PAPER 92-2161) Copyright

This paper presents six thermal design options of the Space Station Freedom (SSF) airlock and shows the important role that exterior coatings had in minimizing heater power. Options included using anodized coatings separately or in combination, employing fans to circulate interior air, and using a solar shade that eliminates the adverse effect of degrading optical properties. The design that is most efficient, in terms of cost and minimum heater power, and that meets all temperature requirements, has a black anodized exterior finish and uses a maximum of 410 watts of heater power. Author

A92-31296#
MOLECULAR ENGINEERING OF PIGMENTS FOR DEGRADATION-RESISTANT THERMAL CONTROL COATINGS
J. F. CORDARO and C. STEIN (USAF, Phillips Laboratory, Kirtland AFB, NM) IN: AIAA Materials Specialist Conference - Coating Technology for Aerospace Systems, Dallas, TX, Apr. 16, 17, 1992, Technical Papers 1992 3 p refs
(AIAA PAPER 92-2167)

Zinc oxide pigment for white thermal control coatings can be radiation hardened by the incorporation of minor dopants which form shallow donorlike states within the band gap of ZnO. Dopants which form donorlike states include, but are not limited to, aluminum, gallium, and indium. The physical origins of the radiation hardening effects and their implications for thermal control coatings are discussed. Author

A92-31297*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ESTIMATION OF THE END-OF-LIFE OPTICAL PROPERTIES OF Z-93 THERMAL CONTROL COATING FOR THE SPACE STATION FREEDOM
MARK M. HASEGAWA and HANK W. BABEL (McDonnell Douglas Space Systems Co., Huntington Beach, CA) IN: AIAA Materials Specialist Conference - Coating Technology for Aerospace Systems, Dallas, TX, Apr. 16, 17, 1992, Technical Papers 1992 10 p refs
(Contract NAS9-18200)
(AIAA PAPER 92-2168) Copyright

This paper describes an approach to estimating the 30-year end-of-life optical properties of Z-93 white, thermal control coating on the Space Station Freedom. Estimations of the 30-year end-of-life properties of thermal control coatings are necessary for sizing the thermal radiators. The available flight and ground data and computer generated contamination models are used to predict the effects of ground handling, exposure to UV radiation, and on-orbit contamination on the optical properties of Z-93. The solar absorptance for portions of the thermal control system radiator surfaces is predicted to change from 0.15 to 0.36 after 30 years of low earth orbit environmental exposure. The infrared emittance is predicted to change from 0.92 to 0.90. Author

A92-31298#
THERMAL CONTROL COATING SELECTION AND VERIFICATION FOR THE SPACE STATION FREEDOM
R. E. BOOTH and J. E. STOYACK (LTV Aerospace and Defense Co., Missiles Div., Grand Prairie, TX) IN: AIAA Materials Specialist Conference - Coating Technology for Aerospace Systems, Dallas, TX, Apr. 16, 17, 1992, Technical Papers 1992 11 p refs
(AIAA PAPER 92-2169) Copyright

This paper presents a review of six thermal control coatings candidates for the radiators on Space Station Freedom. Based on a trade study which considered weight, cost, optical properties and maturity, Z-93 white paint was the final selection. Included is an extensive technical review of the seven candidate coatings. Author

A92-31299*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE EFFECTS OF RF PLASMA ASHING ON ZINC ORTHOTITANATE/POTASSIUM SILICATE THERMAL CONTROL COATINGS
JOYCE A. DEVER (NASA, Lewis Research Center, Cleveland, OH) and ERIC J. BRUCKNER (Cleveland State University, OH) IN: AIAA Materials Specialist Conference - Coating Technology for Aerospace Systems, Dallas, TX, Apr. 16, 17, 1992, Technical Papers 1992 10 p refs
(AIAA PAPER 92-2171) Copyright

Samples of YB-71, a white thermal control coating composed of zinc orthotitanate pigment in a potassium silicate binder, were exposed in air plasma and in oxygen plasma to determine optical property and surface chemistry changes. Results show that YB-71 undergoes a significant reflectance decrease upon exposure to the simulated LEO atomic oxygen environment provided by an air

plasma asher. YB-71 samples exposed to the same effective fluence in oxygen plasma, or in a UV screening Faraday cage in air or oxygen, do not undergo as severe reflectance decreases as the samples exposed in the air plasma asher environment. The UV and VUV radiation present in the plasma ashers affects the YB-71 degradation. It is noted that, when using plasma ashers to determine LEO degradation, it is necessary to take into account the sensitivity of the material to the synergistic effects of atomic oxygen and accelerated UV radiation. O.G.

A92-31351
SPACE STATION ECLSS AND THERMAL CONTROL; PROCEEDINGS OF THE 21ST INTERNATIONAL CONFERENCE ON ENVIRONMENTAL SYSTEMS, SAN FRANCISCO, CA, JULY 15-18, 1991
Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-875), 1991, 366 p. For individual items see A92-31352 to A92-31377. 1991 366 p
(ISBN 1-56091-155-7; SAE SP-875) Copyright

Topics presented include an integrated energy balance analysis for SSF, high conductance thermal interface concept for space applications, heat pump evaluation for Space Station radiator orientation profile, heat pump evaluation for Space Station ATCS evolution, and SSF for environmental database system for MSFC testing. Also presented are an assessment of the readiness of vapor compression distillation for spacecraft wastewater processing, shower water recovery by UF/RO, SPE water electrolyzers for closed environment life support, and developing real-time control software for SSF CO2 removal. R.E.P.

A92-31353
SPACE STATION FREEDOM MODULE TO TRUSS SYSTEM THERMAL/STRUCTURAL ANALYSIS
ANDREW H. WARREN (Grumann Corp., Space Systems Div., Bethpage, NY) and JOSEPH E. ARELT (Grumman Corp., Space Station Program Support Div., Reston, VA) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 10 p refs
(SAE PAPER 911339) Copyright

A thermal/structural analysis of the Module to Truss System of SSF is conducted. The objective of the analysis is to determine the temperature gradients and distributions in the structure to evaluate thermal stresses and deflections in the truss members caused by solar loads and by shadowing of the truss members by other segments of SSF, as it moves around the orbit. The process of model development, analysis, and thermal/structural data transfer is automated, reducing analysis time and the possibility of errors. R.E.P.

A92-31354* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
HIGH CONDUCTANCE THERMAL INTERFACE CONCEPT FOR SPACE APPLICATIONS
ELIZABETH C. POULIN (Foster-Miller, Inc., Waltham, MA) and D. C. HORAN (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 9 p refs
(SAE PAPER 911340) Copyright

An interface concept has been developed which produces high conductance at a thermal/mechanical joint without resorting to high clamping forces or potentially contaminating fillers such as thermal grease. This paper discusses the characteristics of several variations of the high conductance interface concept and compares them to those of existing interface concepts proposed for several Space Station applications. The application of the high conductance concept to thermal joints such as internal coldplate interfaces and external equipment module to heat acquisition plate interfaces would reduce the weight and complexity and increase the efficiency of the Space Station Thermal Management System. Author

A92-31356* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
HEAT PUMP EVALUATION FOR SPACE STATION ATCS EVOLUTION
BRIAN E. AMES (Lockheed Engineering and Sciences Co., Houston, TX) and PATRICIA A. PETETE (NASA, Johnson Space Center, Houston, TX) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 10 p refs
(SAE PAPER 911342) Copyright

A preliminary feasibility assessment of the application of a vapor compression heat pump to the Active Thermal Control System (ATCS) of SSF is presented. This paper focuses on the methodology of raising the surface temperature of the radiators for improved heat rejection. Some of the effects of the vapor compression cycle on SSF examined include heat pump integration into ATCS, constraints on the heat pump operating parameters, and heat pump performance enhancements. R.E.P.

A92-31357
RECOMMENDED SPACE STATION RADIATOR ORIENTATION PROFILE
JAMES J. KANTARA (Lockheed Engineering and Sciences Co., Crew and Thermal Systems Dept., Houston, TX) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 7 p refs
(SAE PAPER 911343) Copyright

An investigation is conducted of a SSF central thermal bus radiator array orientation profile that will meet the 82.5 kW heat rejection requirement while maintaining radiator angular velocities under 45 deg/minute. The environments studied are the minimum environment, the alternate minimum environment, the maximum environment, and a -80 F sink temperature environment. The collective data are then used to recommend a radiator orientation profile that, under transient conditions, will meet the heat rejection requirements and prevent the ammonia in the panels from freezing. R.E.P.

A92-32193
THERMAL DESIGN VERIFICATION OF A LARGE DEPLOYABLE ANTENNA FOR A COMMUNICATIONS SATELLITE
H. TSUNODA, K. NAKAJIMA, and A. MIYASAKA (NTT, Radio Communication Systems Laboratories, Yokosuka, Japan) Apr. 1992 8 p refs
Copyright

N92-13142# Toronto Univ. (Ontario). Inst. for Aerospace Studies.
LDEF TEMPERATURE HISTORIES: A SIMPLE THEORY
P. C. HUGHES Oct. 1990 75 p
(ISSN 0082-5255)
(UTIAS-340; CTN-91-60238; AD-B151978L) Avail: CASI HC A04/MF A01

The temperature of a particular area (an experimental test patch) on the surface of the Long Duration Exposure Facility (LDEF) varies with time in a manner that depends on a large number of factors. The direct input from the sun depends on whether LDEF is in sunlight; if in sunlight, on whether the test patch can actually see sun; and if it can see sun, on the angle of incidence of the sun's radiation. The heat input to the test patch from the rest of the LDEF vehicle also depends on the average temperature of the LDEF vehicle, which in turn depends on its eclipse history. This report examines all these factors and uses a multiple time scale description (corresponding physically to orbital, precessional and annual time scales) to build an understanding of the chief features observed in the flight data. Geometrical, orbital, and thermal models are developed. Numerical calculations based on these models are shown to be be in qualitative agreement (and usually even in semi quantitative agreement) with flight data. Thus

all the salient features of the in-orbit temperature data can be explained in terms of the physical phenomena described.
Author (CISTI)

N92-13143*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PARAMETRIC STUDIES OF PHASE CHANGE THERMAL ENERGY STORAGE CANISTERS FOR SPACE STATION FREEDOM
THOMAS W. KERSLAKE 1991 9 p Presented at the International Solar Energy Conference, Maui, HI, 4-8 Apr. 1991; sponsored by the American Society of Mechanical Engineers
(Contract RTOP 474-52-10)
(NASA-TM-105350; E-6724; NAS 1.15:105350) Avail: CASI HC A02/MF A01

Phase Change Materials (PCM) canister parametric studies are discussed wherein the thermal-structural effects of changing various canister dimensions and contained PCM mass values are examined. With the aim of improving performance, 11 modified canister designs are analyzed and judged relative to a baseline design using five quantitative performance indicators. Consideration is also given to qualitative factors such as fabrication/inspection, canister mass production, and PCM containment redundancy. Canister thermal analyses are performed using the finite-difference based computer program NUCAM-2DV. Thermal-stresses are calculated using closed-form solutions and simplifying assumptions. Canister wall thickness, outer radius, length, and contained PCM mass are the parameters considered for this study. Results show that singular canister design modifications can offer improvements on one or two performance indicators. Yet, improvement in one indicator is often realized at the expense of another. This confirms that the baseline canister is well designed. However, two alternative canister designs, which incorporate multiple modifications, are presented that offer modest improvements in mass or thermal performance, respectively. Author

N92-14174# Pacific Northwest Lab., Richland, WA.
TESTING OF ADVANCED CERAMIC FABRIC HEAT PIPE FOR A STIRLING ENGINE
Z. I. ANTONIAK, B. J. WEBB, and J. M. BATES Sep. 1991 4 p Presented at the AIAA/NASA/OAI Conference on Advanced SEI Technologies, Cleveland, OH, 3-4 Sep. 1991 Previously announced in IAA as A91-52421
(Contract DE-AC06-76RL-01830)
(DE92-000142; PNL-SA-19728; CONF-9109226-16) Avail: CASI HC A01/MF A01

The development and application of Stirling engines for space power production requires concomitant development of an advanced heat rejection system. We are currently involved in the design, development, and testing of advanced ceramic fabric (ACF) water heat pipes for optimal heat rejection from the Stirling cycle without the use of hazardous working fluids such as mercury. Our testing to-date has been with a 200 micron thick titanium heat pipe utilizing Nextel (trademark) fabric as both the outer structural component and as a wick. This heat pipe has been successfully started up from a frozen condition against a negative 4 degree tilt (i.e., fluid return to evaporator was against gravity), with 75 W heat input, in ambient air. In a horizontal orientation, up to 100 W heat input was tolerated without experiencing dryout. DOE

N92-16034*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EVALUATION OF SELECTED THERMAL CONTROL COATINGS FOR LONG-LIFE SPACE STRUCTURES
LOUIS A. TEICHMAN, WAYNE S. SLEMP, and WILLIAM G. WITTE, JR. Jan. 1992 17 p
(Contract RTOP 506-43-21)
(NASA-TM-4319; L-16930; NAS 1.15:4319) Avail: CASI HC A03/MF A01

Graphite-reinforced resin matrix composites are being considered for spacecraft structural applications because of their light weight, high stiffness, and lower thermal expansion. Thin protective coatings with stable optical properties and the proper ratio of solar absorption (alpha sub s) to thermal emittance (epsilon) minimize orbital thermal extremes and protect these materials against space environment degradation. Sputtered coatings applied directly to graphite/epoxy composite surfaces and anodized coatings applied to thin aluminum foil were studied for use both as an atomic oxygen barrier and as thermal control coatings. Additional effort was made to develop nickel-based coatings which could be applied directly to composites. These coating systems were selected because their inherent tenacity made them potentially more reliable than commercial white paints for long-life space missions. Results indicate that anodized aluminum foil coatings are suitable for tubular and flat composite structures on large platforms in low Earth orbit. Anodized foil provides protection against some elements of the natural space environment (atomic oxygen, ultraviolet, and particulate radiation) and offers a broad range of tailored alpha sub s/epsilon. The foil is readily available and can be produced in large quantities, while the anodizing process is a routine commercial technique. Author

N92-17775*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ACTIVE THERMAL CONTROL SYSTEM EVOLUTION
PATRICIA A. PETETE and BRIAN E. AMES *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 2: Space Station Freedom, Part 1 p 921-969 Sep. 1991
Avail: CASI HC A03/MF A03

The 'restructured' baseline of the Space Station Freedom (SSF) has eliminated many of the growth options for the Active Thermal Control System (ATCS). Modular addition of baseline technology to increase heat rejection will be extremely difficult. The system design and the available real estate no longer accommodate this type of growth. As the station matures during its thirty years of operation, a demand of up to 165 kW of heat rejection can be expected. The baseline configuration will be able to provide 82.5 kW at Eight Manned Crew Capability (EMCC). The growth paths necessary to reach 165 kW have been identified. Doubling the heat rejection capability of SSF will require either the modification of existing radiator wings or the attachment of growth structure to the baseline truss for growth radiator wing placement. Radiator performance can be improved by enlarging the surface area or by boosting the operating temperature with a heat pump. The optimal solution will require both modifications. The addition of growth structure would permit the addition of a parallel ATCS using baseline technology. This growth system would simplify integration. The feasibility of incorporating these growth options to improve the heat rejection capacity of SSF is under evaluation. Author

N92-18201*# Hughes Aircraft Co., Torrance, CA. Electron Dynamics Div.
INVESTIGATION OF MICRO-GRAVITY EFFECTS ON HEAT PIPE THERMAL PERFORMANCE AND WORKING FLUID BEHAVIOR, PHASE B Final Technical Report
K. D. GIER and M. O. SMITH Jan. 1990 105 p
(Contract NAS5-30359)
(NASA-CR-189254; NAS 1.26:189254) Avail: CASI HC A06/MF A02

The purpose of this experiment is to develop an in-depth understanding of the behavior of heat pipes in space. Both fixed conductance heat pipes (FCHPs) with axial grooves and variable conductance heat pipes (VCHPs) with porous wicks will be investigated. This understanding will be applied to the development of improved performance heat pipes subjected to various accelerations in space, including those encountered on a lunar base or Mars mission. More efficient, reliable, and lighter weight spacecraft thermal control systems should result from these investigations. Author

N92-19670*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LONG DURATION EXPOSURE FACILITY POST-FLIGHT THERMAL ANALYSIS, PART 1

WILLIAM M. BERRIOS and THOMAS R. SAMPAIR (Lockheed Engineering and Sciences Co., Hampton, VA.) Jan. 1992 534 p
(Contract RTOP 506-43-21-14)
(NASA-TM-104208-PT-1; NAS 1.15:104208-PT-1) Avail: CASI HC A23/MF A04

Results of the post-flight thermal analysis of the Long Duration Exposure Facility (LDEF) mission are presented. The LDEF mission thermal analysis was verified by comparing the thermal model results to flight data from the LDEF Thermal Measurements System (THERM). Post-flight calculated temperature uncertainties have been reduced to under +/- 18 F from the pre-flight uncertainties of +/- 40 F. The THERM consisted of eight temperature sensors, a shared tape recorder, a standard LDEF flight battery, and an electronics control box. The temperatures were measured at selected locations on the LDEF structure interior during the first 390 days of flight and recorded for post-flight analysis. After the LDEF retrieval from Space on 12 Jan. 1990, the tape recorder was recovered from the spacecraft and the data reduced for comparison to the LDEF predicted temperatures. The LDEF mission temperatures were calculated prior to the LDEF deployment on 7 Apr. 1980, and updated after the LDEF retrieval with the following actual flight parameter data: including thermal fluxes, spacecraft attitudes, thermal coatings degradation, and contamination effects. All updated data used for the calculation of post-flight temperatures is also presented in this document. Author

N92-19671*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LONG DURATION EXPOSURE FACILITY POST-FLIGHT THERMAL ANALYSIS, PART 2
WILLIAM M. BERRIOS and THOMAS R. SAMPAIR (Lockheed Engineering and Sciences Co., Hampton, VA.) Jan. 1992 455 p
(Contract RTOP 506-43-21-14)
(NASA-TM-104208-PT-2; NAS 1.15:104208-PT-2) Avail: CASI HC A20/MF A04

Results of the post-flight thermal analysis for the Long Duration Exposure Facility (LDEF) mission are presented. The LDEF mission thermal analysis was verified by comparing the thermal model results to flight data from the LDEF Thermal Measurements System (THERM). Post-flight calculated temperature uncertainties have been reduced to under +/- 18 F from the pre-flight uncertainties of +/- 40 F. The THERM consisted of eight temperature sensors, a shared tape recorder, a standard LDEF flight battery, and an electronics control box. The temperatures were measured at selected locations on the LDEF structure interior during the first 390 days of flight and recorded for post-flight analysis. After the LDEF retrieval from Space on 12 Jan. 1990, the tape recorder was recovered from the spacecraft and the data reduced for comparison to the LDEF predicted temperatures. The LDEF mission temperatures were calculated prior to the LDEF deployment on 7 Apr. 1980, and updated after the LDEF retrieval with the following actual flight parameter data: thermal fluxes, spacecraft attitudes, thermal coatings degradation, and contamination effects. All updated data used for calculation of post-flight temperatures is also presented in this document. Author

N92-20034*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
THERMAL CONDUCTANCE OF TWO INTERFACE MATERIALS AND THEIR APPLICATIONS IN SPACE SYSTEMS
J. J. SCIALDONE, C. H. CLATTERBUCK, and J. L. WALL Mar. 1992 11 p
(NASA-TM-104554; REPT-92B00012; NAS 1.15:104554) Avail: CASI HC A03/MF A01

The temperature control of spacecraft and instrument systems and subsystems requires heat transfer interface materials that possess good thermal and structural characteristics, among other properties, to respond to the vacuum environment of space. These materials must be easy to apply to, and remove from, the surfaces where they are applied, and must be able to withstand power dissipation extremes, and be used for different clamping configurations and pressures. Silicone based greases, used in the past, tend to migrate and to contaminate nearby surfaces. Bare metal to metal contact offers low thermal conductance and difficulties in estimating the actual heat transfer. Several polymeric materials containing different thermal conductive compounds and structural reinforcements were prepared to overcome grease and metal problems. Two polymeric materials were evaluated: Cho-Therm 1671 elastomer; and the CV-2946, a conductive RTV silicone. Tests were done to learn more about these products. Results indicate that the tightly bolted, torqued fixtures did not buckle or distort, and provided optimum thermal conductance. Fixtures simulating actual spacecraft configuration suffered bowing and separating. Author

N92-21275*# Texas Univ., San Antonio. Div. of Engineering.
A LOCAL CONDENSATION ANALYSIS REPRESENTING TWO-PHASE ANNULAR FLOW IN CONDENSER/RADIATOR CAPILLARY TUBES Final Report
AMIR KARIMI *In* Texas A and M Univ., NASA/ASEE Summer Faculty Fellowship Program, 1991, Volume 1 15 p Dec. 1991 Avail: CASI HC A03/MF A03

NASA's effort for the thermal environmental control of the Space Station Freedom is directed towards the design, analysis, and development of an Active Thermal Control System (ATCS). A two phase, flow through condenser/radiator concept was baselined, as a part of the ATCS, for the radiation of space station thermal load into space. The proposed condenser rejects heat through direct condensation of ATCS working fluid (ammonia) in the small diameter radiator tubes. Analysis of the condensation process and design of condenser tubes are based on the available two phase flow models for the prediction of flow regimes, heat transfer, and pressure drops. The prediction formulas use the existing empirical relationships of friction factor at gas-liquid interface. An attempt is made to study the stability of interfacial waves in two phase annular flow. The formulation is presented of a stability problem in cylindrical coordinates. The contribution of fluid viscosity, surface tension, and transverse radius of curvature to the interfacial surface is included. A solution is obtained for Kelvin-Helmholtz instability problem which can be used to determine the critical and most dangerous wavelengths for interfacial waves. Author

N92-29869# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Thermal Control and Life Support Div.
ESATAN USER MANUAL
Nov. 1991 444 p
(ISSN 0379-4059)
(ESA-PSS-03-105-ISSUE-2; ETN-92-91386) Copyright Avail: CASI HC A19/MF A04

The ESATAN user manual provides a full description of the use and operation of the ESA thermal analyzer, ESATAN. It describes in detail the preprocessor, editor, SINDA to ESATAN translator, and the syntax checker. A complete list of the ESATAN library routines and their usage is given. ESA

12

POWER SYSTEMS

Analyses, systems and trade studies of electric power generation, storage, conditioning and distribution.

A92-10467* Alabama Univ., Huntsville.
CURRENT COLLECTION BY A LONG CONDUCTING CYLINDER IN A FLOWING MAGNETIZED PLASMA
NAGENDRA SINGH (Alabama, University, Huntsville) and BHARAT I. VASHI Oct. 1991 7 p refs
(Contract NAGW-1562)
Copyright

A92-12490
JEM ELECTRICAL POWER SYSTEM ARCHITECTURE
TAKEHIKO KATO (NASDA, Tokyo, Japan) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p
(IAF PAPER 91-083) Copyright

The architecture of the Japanese Experiment Module Electrical Power System (JEM EPS) designed for the Space Station Freedom is described and its requirements are documented. The relationship between the physical and functional aspects of the EPS are explained using a specially designed matrix representation. Special attention is given to the relationship between the EPS architecture to other subsystems of the Space Station Manned Base. I.S.

A92-12491
INTEGRATING THE SPACE STATION REMOTE MANIPULATOR SYSTEM INTO THE SPACE STATION ASSEMBLY PROCESS - THE CHALLENGES AND TECHNIQUES
T. DARLINGTON, K. KRUKEWICH, and D. LAURENZIO (Canadian Space Agency, Ottawa, Canada) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 10 p. Oct. 1991 10 p
(IAF PAPER 91-084) Copyright

The Space Station Remote Manipulator System (SSMRS) design and operational considerations associated with SSMRS manifesting, on-orbit maintenance and operations, on-orbit checkout and deployment, and interfaces to Station and Shuttle systems are described. The constraints and special provisions required due to limited on-orbit resources available during early assembly pertaining to power, video, data, mass and volume, and control station capability are discussed. The role of the SSRMS in Space Station maintenance and assembly operations is presented. R.E.P.

A92-12578
SOLAR-DYNAMIC POWER SUPPLY FOR SPACECRAFT BY A CONVECTION TURBINE
WILFRIED LEY (Aachen, Fachhochschule, Federal Republic of Germany) and DIETMAR NEUHAUS IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 4 p. Oct. 1991 4 p refs
(IAF PAPER 91-221) Copyright

The design of a closed-loop gas turbine is presented which can be employed for efficiently supplying power to and storing power in spacecraft. The convection-turbine concept is based on a solar-dynamic power supply and resembles a rotating disk. The compact turbine can also be utilized as a flywheel to store kinetic energy, and the design is shown to be highly efficient as compared to photovoltaic systems. C.C.S.

A92-12581
ORBIT DEMONSTRATION OF TWO-DIMENSIONAL DEPLOYABLE ARRAY INCLUDING HIGH VOLTAGE PHOTOVOLTAIC POWER GENERATION
HITOSHI KUNINAKA, MICHIHIRO NATORI (Institute of Space and Astronautical Science, Sagamihara, Japan), YOSHIHARU KAWAI (Toshiba Corp., Kawasaki, Japan), and SHINGO IKEGAMI (Nippon Electric Co., Ltd., Yokohama, Japan) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 10 p. Oct. 1991 10 p refs
(IAF PAPER 91-224) Copyright

The development of a 2D deployable high voltage (2D/HV) solar array experiment to demonstrate repetitive deployment/retraction of a plane structure and high voltage photovoltaic power generation in space is presented. Flight objective of 2D/HV is to demonstrate fundamental technologies on a high power solar array in LEO. The 2D experiment will advance the space membrane structure from line to plane and the HV experiment will conduct high voltage power generation utilizing solar cells in a space environment. R.E.P.

A92-12582
A CASE-BASED PLANNING SYSTEM FOR SPACECRAFT ELECTRICAL POWER SYSTEM CONTROL
PETER ADAMOVITS (Canadian Space Agency, Ottawa, Canada) and SELIM ULUG (Software Kinetics, Ltd., Stittsville, Canada) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 10 p. Oct. 1991 10 p refs
(IAF PAPER 91-226) Copyright

A case-based planning system (CBPS) is considered which encompasses both space-based and ground-based electrical power system (EPS) planning and scheduling. EPS control functions include load scheduling, battery charge maintenance, and battery reconditioning. The CBPS performs plan library maintenance, plan selection, plan modification, replanning, and plan success evaluation. Being controlled by an operator the CBPS is also coupled to other monitoring and control software systems including an independent diagnostic system. O.G.

A92-13164
MULTI-USER POWER MODULES - A COMMERCIAL EVALUATION
K. SHOCKEY (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA), A. D. PATTON, and A. PARLOS (Texas A & M University, College Station) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 11 p. Oct. 1991 11 p
(IAF PAPER 91-220) Copyright

Approximately 30 percent of the weight and 25 to 50 percent of the cost of the average spacecraft is in the electrical power system. Thus, it is logical for significant attention to be directed at common or multiple user power modules to supply power, either by mechanical attachment, tether, or microwave transmission to satellite users. The first phase of this study was a state-of-the art survey to develop building blocks data for the later power module configuration study. In parallel with this effort, analysis was made of currently planned and projected missions which might be a candidate for an attached or detached power module, either as a primary power source, or an add-on power augmentation. Design concepts were evaluated, baselined designs created, configuration and weight analysis conducted and cost analysis models created to be employed in future commercial feasibility studies. Limiting and pacing technology needs were identified and critical operational constraints were evaluated. Author

A92-17023* Stanford Univ., CA.
ESTIMATING RADIATED POWER FROM A CONDUCTING TETHERED SATELLITE SYSTEM
D. J. DONOHUE, T. NEUBERT, and P. M. BANKS (Stanford University, CA) Journal of Geophysical Research (ISSN 0148-0227), vol. 96, Dec. 1, 1991, p. 21,245-21,253. 1 Dec. 1991 9 p refs
(Contract NGT-50151; NAGW-2076)
Copyright

In anticipation of the upcoming TSS-1 experiment, theoretical calculations are made of radiated power from a conducting tethered satellite system. The radiation results from the steady motion of the system through the ionospheric plasma and it is stimulated by collection and emission of charge by the noninsulated surfaces of the tethered end connectors. A model of the current system is developed which incorporates the tether wire, satellite surfaces, and sheath currents. The radiation impedance of the current model is calculated using the previously developed theory of Barnett and Olbert (1986). The results confirm the low-frequency Alfven wave description with a predicted radiation impedance of a few tenths of an ohm in the Alven wave limit. Calculations are also made in the lower hybrid and whistler wave band. A larger impedance of about 13 ohm is found for the frequency range 5-50 kHz. By estimating the passive ion current drawn by the system a prediction of the total radiated power is also made. The result of 0.38 mW raises the question of whether or not wave emissions from a passive current collecting system may be detectable by either ground- or space-based platforms. Author

A92-17753
THE ENVIRONMENTAL IMPACT OF SPS - A SOCIAL VIEW
G. E. CANOUGH and L. P. LEHMAN (ExtraTerrestrial Materials, Inc., Endicott, NY) IN: Space manufacturing 8 - Energy and materials from space; Proceedings of the 10th Princeton/AIAA/SSI Conference, Princeton, NJ, May 15-18, 1991 1991 6 p refs
Copyright

Prospective solar power satellite (SPS) systems entail extensive evaluation of real and perceived environmental impact, in virtue of their extremely high publicity profile. Attention is presently given to current understanding of SPS microwave power beaming system operations' effects on terrestrial communications and biological systems, as well as the associated consequences of a lengthy, heavy-payload launch program on space debris scenarios and stratospheric pollution by the launch vehicles' propellant combustion products. Education of the public in these issues is stressed. O.C.

A92-17755
ADVANCED SOLAR HEAT RECEIVERS FOR SPACE POWER
CHARLES A. LURIO (Aerodyne Research, Inc., Billerica, MA) IN: Space manufacturing 8 - Energy and materials from space; Proceedings of the 10th Princeton/AIAA/SSI Conference, Princeton, NJ, May 15-18, 1991 1991 7 p refs
Copyright

NASA-sponsored research into solar flux receivers for space-based solar thermal powerplants suitable for electrical power generation on an industrial scale has achieved design innovations capable of reducing system mass and volume while improving system thermal efficiency. The critical technology experiments presently discussed involved a Stirling engine receiver employing a fluoride phase-change material for energy storage during eclipse periods in LEO. A 'cavity heat pipe' is defined for transporting the energy of liquid Na. O.C.

A92-18401* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SPACE POWER BY GROUND-BASED LASER ILLUMINATION
GEOFFREY A. LANDIS (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 6, Nov. 1991, p. 3-7. Nov. 1991 5 p refs
Copyright

Reducing energy storage requirements of space power systems by illuminating the photovoltaic arrays with a remotely located laser system is addressed. It is proposed that large lasers be located on cloud-free sites at one or more ground locations and that large lenses or mirrors with adaptive optical correction be used to reduce the beam spread due to diffraction or atmospheric turbulence. During the eclipse periods or lunar night, the lasers illuminate the solar arrays to a level sufficient to provide operating power. Two applications are discussed: illumination of geosynchronous orbit satellites and illumination of a moonbase power system. Issues for photovoltaic receivers for such a system are discussed. I.E.

A92-18402
FUTURE TRENDS IN SPACE POWER TECHNOLOGY
LOWELL D. MASSIE (USAF, Wright Laboratory, Wright-Patterson AFB, OH) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 6, Nov. 1991, p. 8-13. Research supported by SDIO. Nov. 1991 6 p refs
Copyright

The status of the US Air Force Space Power Research and Development Program is summarized. Current generic issues and requirements affecting the strategic planning of space power advances for the 1990s and beyond are described. The major thrusts of the Air Force part of the Strategic Defense Initiative Office Space Power Program are highlighted, with emphasis on the ongoing advanced component technology development program. The status of these component technologies in the areas of power sources, energy storage, power management and distribution, and thermal management is described. Technology projections for the full range of envisioned technology options for the foregoing are used as the basis for a series of point designs for deriving the subsystem- and system-level benefits of the technologies. The primary focus is on baseload (CW) power systems operating in the range from 100 W for small satellites to 50 kW for potential large surveillance satellites. The secondary focus is on large, multimegawatt pulsed power systems and related components for potential applications such as directed energy. Potential Åtrump card' technologies related to energy conversion, storage, power electronics, and thermal management are identified. I.E.

A92-18936* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SPACE ELECTROCHEMICAL RESEARCH AND TECHNOLOGY CONFERENCE, 3RD, NASA LEWIS RESEARCH CENTER, CLEVELAND, OH, APR. 9, 10, 1991, PROCEEDINGS
MARVIN WARSHAY, ED. (NASA, Lewis Research Center, Cleveland, OH) Conference supported by NASA. Journal of Power Sources (ISSN 0378-7753), vol. 36, Dec. 1, 1991, 202 p. Previously announced in STAR as N91-32549; No individual items are abstracted in this volume. 1 Dec. 1991 202 p
Copyright

The proceedings of NASA's third Space Electrochemical Research and Technology (SERT) conference are presented. The objective of the conference was to assess the present status and general thrust of research and development in those areas of electrochemical technology required to enable NASA missions in the next century. The conference provided a forum for the exchange of ideas and opinions of those actively involved in the field, in order to define new opportunities for the application of electrochemical processes in future NASA missions. Papers were presented in three technical areas: the electrochemical interface, the next generation in aerospace batteries and fuel cells, and electrochemistry for nonenergy storage applications. Author

A92-20388
DIELECTRIC CHARGING PROCESSES AND ARCING RATES OF HIGH VOLTAGE SOLAR ARRAYS
MENGU CHO and DANIEL E. HASTINGS (MIT, Cambridge, MA) Dec. 1991 9 p refs
(Contract AF-AFOSR-87-0340)
Copyright

A92-20390
SOLAR PROTON EVENTS OF 1989 - EFFECTS ON SPACECRAFT SOLAR ARRAYS
D. C. MARVIN and D. J. GORNEY (Aerospace Corp., Los Angeles, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Nov.-Dec. 1991, p. 713-719. Dec. 1991 7 p refs
(Contract F04701-88-C-0089)
Copyright

Three energetic solar proton events occurred in the August-October 1989 time period. The energetic (1-10 MeV) proton fluence from these events was among the highest fluence levels observed during the space age. The solar proton events were of sufficient magnitude to produce easily observable (several percent), irreversible losses in solar array output on geosynchronous and polar low-earth-orbiting satellites. The degradation of solar array output was measured on the GOES-5, GOES-6, and GOES-7 satellites and on two other U.S. Government satellites in geosynchronous orbit. The observed solar array degradation was compared with that computed based on knowledge of the solar cell type, coverglass thickness, the operational mode of the array, the observed proton spectrum, and the length of time on orbit for each satellite. In each case, good agreement was obtained between the observed and the computed results. Author

A92-21675
NUCLEAR POWER ENGINEERING IN SPACE - A NEW TREND IN THE POWER INDUSTRY OF THE FUTURE [KOSMICHESKOE ATOMNOE ENERGOMASHINOSTROENIE - NOVOE NAPRAVLENIE V ENERGETIKE BUDUSHCHEGO]

G. M. GRIAZNOV Akademiia Nauk SSSR, Izvestiia, Energetika i Transport (ISSN 0002-3310), Nov.-Dec. 1991, p. 24-33. In Russian. Dec. 1991 10 p In RUSSIAN
Copyright

Current developments and trends in space nuclear power engineering are reviewed. In particular, attention is given to the development of a space nuclear power plant, Topaz, with a thermionic converter of thermal nuclear energy to electric power. Some engineering challenges and problems that have to be solved when designing, constructing, and operating first space-based nuclear power plants are identified, and prospects for the future are discussed. V.L.

A92-24906
MIR SOLAR BATTERIES - MORE THAN MEETS THE EYE
V. S. SYROMIATNIKOV (NPO Energiia, Kaliningrad, Russia) Aerospace America (ISSN 0740-722X), vol. 30, Feb. 1992, p. 10-12. Feb. 1992 3 p
Copyright

The Krystal module that docked with the Mir space station in June of 1990 contains materials-manufacturing equipment encompassing semiconductor melt-processing. This entails the use of module solar arrays of radically novel design concept as well as exceptional size. Each of this array's 36 panels contains a 1 sq m photovoltaic element, the array as a whole can be repeatedly stowed and redeployed. Orbital operation to date has confirmed the validity of this concept, which is applicable to various other spacecraft types. O.C.

A92-26983*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE ARCING RATE FOR A HIGH VOLTAGE SOLAR ARRAY - THEORY, EXPERIMENT AND PREDICTIONS
DANIEL E. HASTINGS, MENGU CHO (MIT, Cambridge, MA), and HITOSHI KUNINAKA (Institute of Space and Astronautical Science, Sagamihara, Japan) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 28 p. Research supported by NASA, NSF, USAF, et al. Jan. 1992 28 p refs
(AIAA PAPER 92-0576) Copyright

All solar arrays have biased surfaces which can be exposed to the space environment. It has been observed that when the array bias is less than a few hundred volts negative then the exposed conductive surfaces may undergo arcing in the space plasma. A theory for arcing is developed on these high voltage solar arrays which ascribes the arcing to electric field runaway at the interface of the plasma, conductor and solar cell dielectric. Experiments were conducted in the laboratory for the High Voltage Solar Array (HVSA) experiment which will fly on the Japanese Space Flyer Unit (SFU) in 1994. The theory was compared in detail to the experiment and shown to give a reasonable explanation for the data. The combined theory and ground experiments were then used to develop predictions for the SFU flight. Author

A92-26985*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ARCING OF NEGATIVELY BIASED SOLAR CELLS IN LOW EARTH ORBIT
B. L. UPSCHULTE, G. M. WEYL, W. J. MARINELLI (Physical Sciences, Inc., Andover, MA), E. AIFER (Boston University, MA), and D. HASTINGS (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 8 p. Research supported by NASA. Jan. 1992 8 p refs
(AIAA PAPER 92-0578) Copyright

A set of experiments is described in which the arcing of negatively biased solar cells is examined and characterized in terms of the primary factors that cause such behavior. The experiments are conducted in an ultrahigh vacuum chamber, and an image-intensified CCD camera is employed to monitor UV emission from arc events at the interfacial edge between the cover slip and the solar cell. A bead of encapsulant along the interfacial edge is noted which can be removed to reduce arc frequency, and water contamination is found to further enhance arcing. Frequency of arcing is found to vary indirectly with temperature and directly with exposure to H2O, but no other significant correlations are noted. The sensitivity to H2O vapor is eliminated by simply removing the adhesive/encapsulant, and the corresponding arc-rate performance is low. C.C.S.

A92-27143
ENVIRONMENTAL INTERACTIONS OF SOLAR GENERATORS IN LOW EARTH ORBIT
K. BOGUS (ESTEC, Noordwijk, Netherlands) and H. THIEMANN (Thiemann & Noack, Freiburg im Breisgau, Federal Republic of Germany) IN: Space environment: Prevention of risks related to spacecraft charging; International Course on Space Technology, Toulouse, France, Nov. 26-30, 1990, Proceedings 1992 19 p refs
Copyright

The state of the art in solar array interactions with the environment in LEO is reviewed. Emphasis is given to the design, development, and testing of arrays with regard to their interaction with plasma, micrometeorites, high-energy charged particles, and electrostatic charging. The effect of atomic oxygen, UV radiation, and solar thermal cycles, and solar eclipses on the survivability of solar generators in LEO are also considered. C.D.

A92-27650
INTERNATIONAL PHOTOVOLTAIC SCIENCE AND ENGINEERING CONFERENCE, 5TH, KYOTO, JAPAN, NOV. 26-30, 1990, TECHNICAL DIGEST
Conference sponsored by Japan Society of Applied Physics, Institute of Electrical Engineers of Japan, Agency of Industrial Science and Technology, et al. Kyoto, Japan, International PVSEC-5, 1990, 1072 p. No individual items are abstracted in this volume. 1990 1072 p

The present conference on photovoltaic science and engineering encompasses amorphous silicon materials, compound solar cells, a national photovoltaic project, solar cells fabricated from polycrystalline silicon and amorphous silicon, the use of solar cells in space systems, photovoltaic systems components, and experience from field use of the systems. Specific issues addressed include the status of the U.S. National Photovoltaic Program, a novel p-type window material for amorphous silicon solar cells, low dislocation-density GaAs on Si for solar cells, the spin-cast process for Si solar cells, advances in a-Si:H alloy multijunction devices, and n-ZnO/p-MoSe2 heterojunction solar cells. Also addressed are polycrystalline photovoltaic silicon-ingot production, cells with large areas and high efficiency, a vacuum-evaporated CdS/CdTe solar cell, proton-irradiation damage in thin-film GaAs solar cells fabricated on Si substrates, and advanced power systems for the Space Station Freedom. C.C.S.

A92-28768
SPACE NUCLEAR POWER AND THE UN - A GROWING FIASCO
STEVEN AFTERGOOD (Federation of American Scientists, Washington, DC) Space Policy (ISSN 0265-9646), vol. 8, Feb. 1992, p. 9-12. Feb. 1992 4 p refs
Copyright

The structure and aims are examined of the United Nation's Committee on Peaceful Uses of Outer Space policy regarding the safe use of nuclear power in space. Since 1986, 8 of the 12 draft principles concerning space nuclear power have been adopted by the member countries, but the potential for accidents is illustrated by the reentry of the Cosmos nuclear-powered satellite in 1978. It is concluded that the UN committee is of limited value in insuring the safe use of nuclear power in space and that individual governments have to act responsibly. C.C.S.

A92-29167
EXPERIMENTS ILLUSTRATING THE IMPORTANCE OF AUTOMATED REASONING IN SPACECRAFT REACTOR CONTROL
JOHN A. BERNARD (MIT, Cambridge, MA) and FRANCIS J. WYANT (Sandia National Laboratories, Albuquerque, NM) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28,

1991, Proceedings. Vol. 2 1991 6 p refs
(Contract DE-FG07-90ER-12390)
Copyright

The importance of automated reasoning to the control of spacecraft nuclear reactors is discussed. Presented are results from experiments that demonstrate the role of planning, prediction, and assessment in the realization of autonomous control. These experiments were performed under closed-loop conditions on the Annular Core Research Reactor. Automated diagnostics is identified as an area that requires much research. I.E.

A92-29614*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
APPLICABILITY OF LONG DURATION EXPOSURE FACILITY ENVIRONMENTAL EFFECTS DATA TO THE DESIGN OF SPACE STATION FREEDOM ELECTRICAL POWER SYSTEM
ROBERT J. CHRISTIE, CHENG-YI LU, and IRENE ARONOFF (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 14 p. Jan. 1992 14 p refs
(Contract NAS3-25082)
(AIAA PAPER 92-0848) Copyright

Data defining space environmental effects on the Long Duration Exposure Facility (LDEF) are examined in terms of the design of the electrical power system (EPS) of the Space Station Freedom (SSF). The significant effects of long-term exposure to space are identified with respect to the performance of the LDEF's materials, components, and systems. A total of 57 experiments were conducted on the LDEF yielding information regarding coatings, thermal systems, electronics, optics, and power systems. The resulting database is analyzed in terms of the specifications of the SSF EPS materials and subsystems and is found to be valuable in the design of control and protection features. Specific applications are listed for findings regarding the thermal environment, atomic oxygen, UV and ionizing radiation, debris, and contamination. The LDEF data are shown to have a considerable number of applications to the design and planning of the SSF and its EPS. C.C.S.

A92-29629*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SOLAR PROBE POWER SYSTEMS CONCEPTS
BILL J. NESMITH (JPL, Pasadena, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 9 p. Jan. 1992 9 p refs
(AIAA PAPER 92-0864) Copyright

Some of the design options under consideration for providing on-board electric power for the Solar Probe Mission are discussed. Five spacecraft configurations were evaluated with slightly different power demands and volumetric constraints on the power system. This resulted in three different baseline power system designs to satisfy the five spacecraft configurations. These three current baseline power system designs use modified general-purpose heat source (GPHS) radioisotope thermoelectric generators (RTGs) similar to those launched on the Galileo and Ulysses spacecraft. The modular RTG currently under development and testing is a potential advanced alternative to the current baseline GPHS-RTG technology design. P.D.

N92-10032*# Research Inst. for Advanced Computer Science, Moffett Field, CA.
TELESCIENCE TESTBED PILOT PROGRAM, VOLUME 3: EXPERIMENT SUMMARIES Final Report
BARRY M. LEINER Feb. 1989 142 p
(Contract NASW-4234)
(NASA-CR-188834; NAS 1.26:188834; RIACS-TR-89-9) Avail: CASI HC A07/MF A02

Space Station Freedom and its associated labs, coupled with the availability of new computing and communications technologies, have the potential for significantly enhancing scientific research. A Telescience Testbed Pilot Program (TTPP), aimed at developing the experience base to deal with issues in the design of the future information system of the Space Station era. The testbeds represented four scientific disciplines (astronomy and astrophysics, earth science, life sciences, and microgravity sciences) and studied issues in payload design, operation, and data analysis. This volume, of a 3 volume set, which all contain the results of the TTPP, presents summaries of the experiments. This experiment involves the evaluation of the current Internet for the use of file and image transfer between SIRTF instrument teams. The main issue addressed was current network response times. Author

N92-10055*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DESCRIPTION OF THE PMAD DC TEST BED ARCHITECTURE AND INTEGRATION SEQUENCE
R. F. BEACH, L. TRASH, D. FONG, and B. BOLERJACK (Rockwell International Corp., Canoga Park, CA.) 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-105284; E-6614; NAS 1.15:105284) Avail: CASI HC A02/MF A01

NASA-Lewis is responsible for the development, fabrication, and assembly of the electric power system (EPS) for the Space Station Freedom (SSF). The SSF power system is radically different from previous spacecraft power systems in both the size and complexity of the system. Unlike past spacecraft power system the SSF EPS will grow and be maintained on orbit and must be flexible to meet changing user power needs. The SSF power system is also unique in comparison with terrestrial power systems because it is dominated by power electronic converters which regulate and control the power. Although spacecraft historically have used power converters for regulation they typically involved only a single series regulating element. The SSF EPS involves multiple regulating elements, two or more in series, prior to the load. These unique system features required the construction of a testbed which would allow the development of spacecraft power system technology. A description is provided of the Power Management and Distribution (PMAD) DC Testbed which was assembled to support the design and early evaluation of the SSF EPS. A description of the integration process used in the assembly sequence is also given along with a description of the support facility. Author

N92-10058# Oak Ridge National Lab., TN.
MATERIALS IN SPACE NUCLEAR POWER SYSTEMS
R. H. COOPER and J. P. MOORE 1991 3 p Presented at the Winter Meeting of the American Nuclear Society (ANS), San Francisco, CA, 10-15 Nov. 1991
(Contract DE-AC05-84OR-21400)
(DE91-017688; CONF-911107-28-EXTD-ABST) Avail: CASI HC A01/MF A01

Man's presence in space has been limited by the availability of reliable lightweight sources of power. Over the course of the last 30 years, a variety of space nuclear power systems have been designed and, in some cases, built and flown. Although a number of technology issues effect the overall performance of these systems, technical issues associated with the materials of construction have most often been a major limitation in obtaining the desired system performance goals. This paper will review selected materials limitations associated with the three major nuclear power systems being considered at this time: radioisotope power, nuclear power, and nuclear propulsion systems. DOE

N92-10059# Oak Ridge National Lab., TN.
STATUS OF RANKINE-CYCLE TECHNOLOGY FOR SPACE NUCLEAR POWER APPLICATIONS
R. S. HOLCOMB 1991 4 p Presented at the AIAA/NASA/OAI Conference on Advanced SEI Technologies, Cleveland, OH, 3-4 Sep. 1991 Previously announced in IAA as A91-52474
(Contract DE-AC05-84OR-21400)
(DE91-017859; CONF-9109226-11) Avail: CASI HC A01/MF A01

A substantial effort on the development of the liquid metal Rankine cycle space nuclear power system was carried out in

programs jointly sponsored by the National Aeronautics and Space Administration (NASA) and the Atomic Energy Commission (AEC) during the period of 1960 to 1972. Component tests were conducted which have established a considerable technology base for the concept. The development effort and technology status of each component are presented. The key technology issues remaining for development of the system are refractory metal parts fabrication, turbine blade endurance, turbine bearings and seals, and generator winding seal. DOE

N92-10221*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TRADE STUDIES FOR NUCLEAR SPACE POWER SYSTEMS
JOHN M. SMITH, DAVID J. BENTS, and HARVEY S. BLOOMFIELD 1991 12 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 A91-52413
(Contract RTOP 590-13-00)
(NASA-TM-105231; E-6554; NAS 1.15:105231; AIAA PAPER 91-3518) Avail: CASI HC A03/MF A01

As human visions of space applications expand and as we probe further out into the universe, our needs for power will also expand, and missions will evolve which are enabled by nuclear power. A broad spectrum of missions which are enhanced or enabled by nuclear power sources have been defined. These include Earth orbital platforms, deep space platforms, planetary exploration, and terrestrial resource exploration. The recently proposed Space Exploration Initiative (SEI) to the Moon and Mars has more clearly defined these missions and their power requirements. Presented here are results of recent studies of radioisotope and nuclear reactor energy sources, combined with various energy conversion devices for Earth orbital applications, SEI lunar/Mars rovers, surface power, and planetary exploration. Author

N92-11086*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DEVELOPMENT OF A NINETY STRING SOLAR ARRAY SIMULATOR
THOMAS E. VASEK and ARTHUR G. BIRCHENOUGH Oct. 1991 11 p
(Contract RTOP 474-74-10)
(NASA-TM-105278; E-6601; NAS 1.15:105278) Avail: CASI HC A03/MF A01

A power source was developed to support testing for the Space Station Freedom Power Management and Distribution (PMAD) DC Testbed. The intent was to simulate as closely as possible the steady-state and transient responses of a solar array. Several breadboards and one thermal prototype were built and tested. Responses were successfully verified and improved upon during successive breadboards. The completed 90-string simulator consists of four power MOSFETs, four 25 watt source resistors, and four 250 watt drain source bypass resistors per string, in addition to the control circuitry. Author

N92-11106*# Layton (J. Preston), Princeton Junction, NJ.
COMMENTS ON DUAL-MODE NUCLEAR SPACE POWER AND PROPULSION SYSTEM CONCEPTS
J. PRESTON LAYTON and JERRY GREY *In* NASA. Lewis Research Center, Nuclear Thermal Propulsion: A Joint NASA/DOE/DOD Workshop p 323-329 1991
Avail: CASI HC A02/MF A04

Some form of Dual-Mode Nuclear Space Power & Propulsion System (D-MNSP&PS) will be essential to spacefaring throughout teh solar system and that such systems must evolve as mankind moves into outer space. The initial D-MNPSP&PS Reference System should be based on (1) present (1990), and (2) advanced (1995) technology for use on comparable mission in the 2000 and 2005 time period respectively. D-MNSP&PS can be broken down into a number of subsystems: Nuclear subsystems including the energy source and controls for the release of thermal power at elevated temperatures; power conversion subsystems; waste heat rejection subsystems; and control and safety subsystems. These systems are briefly detailed. Author

N92-11114*# Edgerton, Germeshausen and Grier, Inc., Idaho Falls, ID.
NUCLEAR SAFETY
D. BUDEN *In* NASA. Lewis Research Center, Nuclear Thermal Propulsion: A Joint NASA/DOE/DOD Workshop p 423-439 1991
Avail: CASI HC A03/MF A04

Topics dealing with nuclear safety are addressed which include the following: general safety requirements; safety design requirements; terrestrial safety; SP-100 Flight System key safety requirements; potential mission accidents and hazards; key safety features; ground operations; launch operations; flight operations; disposal; safety concerns; licensing; the nuclear engine for rocket vehicle application (NERVA) design philosophy; the NERVA flight safety program; and the NERVA safety plan. Author

N92-11116*# Science Applications International Corp., La Jolla, CA.
DISPOSAL METHODS
ALAN FRIEDLANDER *In* NASA. Lewis Research Center, Nuclear Thermal Propulsion: A Joint NASA/DOE/DOD Workshop p 445-456 1991
Avail: CASI HC A03/MF A04

A number of disposal options for space nuclear reactors and the associated risks, mostly in the long term, based on probabilities of Earth reentry are discussed. The results are based on a five year study that was conducted between 1978 and 1983 on the space disposal of high level nuclear waste. The study provided assessment of disposal options, stability of disposal or storage orbits, and assessment of the long term risks of Earth reentry of the nuclear waste. Author

N92-11131*# National Aeronautics and Space Administration, Washington, DC.
ENABLING THE SPACE EXPLORATION INITIATIVE: NASA'S EXPLORATION TECHNOLOGY PROGRAM IN SPACE POWER
GARY L. BENNETT and RONALD C. CULL Oct. 1991 27 p Previously announced in IAA as A91-52372
(NASA-TM-4325; NAS 1.15:4325) Avail: CASI HC A03/MF A01

Space power requirements for Space Exploration Initiative (SEI) are reviewed, including the results of a NASA 90-day study and reports by the National Research Council, the American Institute of Aeronautics and Astronautics (AIAA), NASA, the Advisory Committee on the Future of the U.S. Space Program, and the Synthesis Group. The space power requirements for the SEI robotic missions, lunar spacecraft, Mars spacecraft, and human missions are summarized. Planning for exploration technology is addressed, including photovoltaic, chemical and thermal energy conversion; high-capacity power; power and thermal management for the surface, Earth-orbiting platform and spacecraft; laser power beaming; and mobile surface systems. Author

N92-12052*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
AUTOMATING A SPACECRAFT ELECTRICAL POWER SYSTEM USING EXPERT SYSTEMS
L. F. LOLLAR Washington Oct. 1991 22 p
(NASA-TP-3161; M-670; NAS 1.60:3161) Avail: CASI HC A03/MF A01

Since Skylab, Marshall Space Flight Center (MSFC) has recognized the need for large electrical power systems (EPS's) in upcoming Spacecraft. The operation of the spacecraft depends on the EPS. Therefore, it must be efficient, safe, and reliable. In 1978, as a consequence of having to supply a large number of EPS personnel to monitor and control Skylab, the Electrical power Branch of MSFC began the autonomously managed power system (AMPS) project. This project resulted in the assembly of a 25-kW high-voltage dc test facility and provided the means of getting man out of the loop as much as possible. AMPS includes several

embedded controllers which allow a significant level of autonomous operation. More recently, the Electrical Division at MSFC has developed the space station module power management and distribution (SSM/PMAD) breadboard to investigate managing and distributing power in the Space Station Freedom habitation and laboratory modules. Again, the requirement for a high level of autonomy for the efficient operation over the lifetime of the station and for the benefits of enhanced safety has been demonstrated. This paper describes the two breadboards and the hierarchical approach to automation which was developed through these projects. Author

N92-13153# European Space Agency, Paris (France).
EUROPEAN SPACE POWER CONFERENCE. VOLUME 1: POWER SYSTEMS, POWER ELECTRONICS, BATTERIES AND FUEL CELLS
JAMES J. HUNT, ed. Aug. 1991 456 p Conference held in Florence, Italy, 2-6 Sep. 1991
(ISSN 0379-6566)
(ESA-SP-320-VOL-1; ISBN-92-9092-122-6; ETN-91-90065)
Copyright Avail: CASI HC A20/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

Papers on power systems, power electronics, batteries, and fuel cells are presented. The following topics are covered: circuit modeling and analysis; pulse width modulated regulators and resonant converters; power systems for Earth satellites; power system/equipment definition; resonant power conversion; future power/energy system concepts; manned mission power systems; NIH2 battery technology; NiCd battery technology; high voltage technology; deep space power systems; power system simulation; advanced battery systems; new battery technology studies; and fuel cell technology. ESA

N92-13154# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
IN-ORBIT PERFORMANCE OVERVIEW OF THE HST SOLAR GENERATOR
B. W. HENSON, B. JACKSON, and LOTHAR GERLACH *In its* European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 3-8 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

The Hubble Space Telescope (HST) was launched into a 614 km low Earth orbit on 24 Apr. 1990. The HST is a joint NASA/ESA project which has a very ambitious astrometry program with very stringent stability requiremenets to achieve a pointing accuracy of 0.007 arc seconds. ESA provided two major elements towards the project one being the Solar Arrays (SA). The SA's comprise two double roll out wings each with two blankets. Each blanket has five flexible solar panel assemblies which provide more than 5 kW at the beginning of life. Deployment of the arrays and the in-orbit performance both for power and dynamics are addressed. The design and verification program of the second SA are being revised to incorporate changes to improve the integrity and performance. A servicing mission to replace the SA's and other key instruments on the HST is planned for the end of 1993. ESA

N92-13155# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
POWER SYSTEM PERFORMANCE PREDICTION FOR THE HIPPARCOS SPACECRAFT
R. L. CRABB, J. E. HAINES, E. J. DALY, DERMOT M. OSULLIVAN, G. DUDLEY, A. K. SEPERS, and H. K. FIEBRICH *In its* European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 9-18 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

Following the August 1989 launch of the Hipparcos Spacecraft, a failure in the Apogee Boost Motor (ABM) system resulted in the mission being permanently constrained to the very damaging radiation environment of the geosynchronous transfer orbit. The electrical power implications that faced the Hipparcos Spacecraft at that time are described and the analyses conducted and the performance predictions made are presented. How a mission survival assessment was made for both the critical February/March 1990 eclipse period and for the overall lifetime of the spacecraft, with the aid of a spreadsheet program, is described. Predictions made against the actual results obtained during the February/March 1990 eclipses are compared and from this correlation conclusions for the remaining period are drawn. ESA

N92-13156# Telefunken System Technik G.m.b.H., Wedel (Germany).
ADVANCED CONCEPTS FOR DESIGN AND MANAGEMENT OF THE COLUMBUS NICKEL-HYDROGEN-BATTERIES
VOLKER LEISTEN and UWE NEMSMANN *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 19-24 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

The objectives of and the very stringent requirements imposed on the nickel hydrogen batteries of the Man Tended Free Flyer (MTFF) of Columbus are dealt with. The envisaged technical solutions are presented whereby great importance is attached to mechanical and thermal aspects of the battery design, e.g., the proposed concept of a light weight construction using integrated heat pipes. The battery management tools necessary to achieve the required life time of 5 years under low earth orbit (LEO) conditions are addressed. For the first time, a combination of hardware and, to a large extent, software will be implemented into the onboard battery control. ESA

N92-13157*# National Aeronautics and Space Administration, Washington, DC.
THE NASA RESEARCH AND TECHNOLOGY PROGRAM ON SPACE POWER: A KEY ELEMENT OF THE SPACE EXPLORATION INITIATIVE
GARY L. BENNETT, HENRY W. BRANDHORST, JR., and KENNETH L. ATKINS (Jet Propulsion Lab., California Inst. of Tech., Pasadena.) *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 25-29 Aug. 1991
Copyright Avail: CASI HC A01/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

In July 1989, President Bush announced his space exploration initiative of going back to the Moon to stay and then going to Mars. Building upon its ongoing research and technology base, NASA has established an exploration technology program to develop the technologies needed for piloted missions to the Moon and Mars. A key element for the flights and for the planned bases is power. The NASA research and technology program on space power encompasses power sources, energy storage, and power management. ESA

N92-13159# Gdansk Technical Univ. (Poland). Inst. of Electronic Technology.
DUALITY CONCEPT LEADS TO A NOVEL SWITCHING CONTROL METHOD
MAREK S. MAKOWSKI *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 39-45 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

The concept of a new switching control method of DC-DC current converters is presented. The so-called open circuit switch voltage programming method is dual to the well established current programming one. The basic principle and the resulting advantages of the method are discussed and the general Z type model of the converter is derived. Switch voltage programming control can be easily implemented and in the case of a single cut set current converter tends to make the power stage output behave as a voltage source. ESA

N92-13167# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
A NEW NON-DISSIPATIVE SWITCH
ALAN H. WEINBERG and INIGO SEGURA *In its* European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 89-94 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

In recent years, there has been a trend towards an ever increasing frequency for switching power regulators to obtain lower volume, mass, and wider regulation bandwidth. The introduction of regulated quasi-resonant (QR) techniques to achieve this aim has not fulfilled its initial promise. There is also some doubt about the suitability of this technique for power levels above several hundred watts. In addition, it is a difficult task to satisfy the requirements regarding the stability of operation of any regulators in a satellite power systems using QR techniques. On the other hand, the well established Pulse Width Modulated (PWM) technique cannot be operated at high frequency without the penalty of high switching loss. A technique to overcome the switching losses of a PWM power stage and which therefore enables it to operate at high frequency is described. ESA

N92-13168# LABEN Ferranti International, Vimodrone (Italy).
TOPOLOGY AND CONTROL OPTIMIZATION OF ON-BOARD POWER SUPPLIES BY COMPUTER-AIDED MODELING
E. BANFI (LABEN Ferranti International, Vimodrone (Italy).), P. MARANESI (Politecnico di Milano, Italy), and G. F. VOLPI *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 95-98 Aug. 1991
Copyright Avail: CASI HC A01/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

A variable topology multi-output switching cell for onboard satellite applications is analyzed with the aid of the program FREDOMSIM. The cell is connected to an LC input filter and realizes a fourth order DC/DC converter, which is modeled as a unique system. Dynamic characterizations, provided by the automatic modeling tool, allow the comparison of the performances of the different topologies and of the possible conduction modes and control modes on the basis of frequency response plots and of loci of poles and of zeros. Some steps of the design optimization drawn by computer aided modeling are illustrated. ESA

N92-13171# Alcatel Espace, Toulouse (France).
POWER DISTRIBUTION SYSTEM FOR A SYNTHETIC APERTURE RADAR
A. CAPEL and A. BATLE *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 115-129 Aug. 1991
Copyright Avail: CASI HC A03/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

A spread sheet software was applied for the selection of the electrical architecture of a spaceborne synthetic aperture radar power supply using an active array antenna. Mathematical models for the evaluation of the power losses and mass of the power supply modules were developed and a tradeoff analysis is detailed for two typical architecture concepts based on decentralized DC/DC and hybrid DC/AC electrical distributions. ESA

N92-13174# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
ESA POWER STANDARD
H. SPRUIJT, P. PEROL, and A. HOGSHOLM (Danish Space Research Inst., Lyngby.) *In its* European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 145-150 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

The ESA Power standard, its objectives and its capability are introduced. The standard contains two parts: (1) general requirements containing only general statements and formulas; and (2) the template of the specification format, which shall be updated during the development phases of a satellite application. This standard is supported by a rationale explaining the parameters specified in the standard together with example cases. ESA

N92-13176# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
PROTECTION CONCEPTS USED IN SPACECRAFT POWER SYSTEMS
DERMOT LEVINS *In its* European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 157-162 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

Some of the protections used in spacecraft power system designs or which have been forgotten or rejected on the assumption that they were unnecessary are addressed. Protection is one of the more critical features of any reliable design, unfortunately its omission is often only recognized in hindsight and in spacecraft applications this can be catastrophic. ESA

N92-13178# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
ZERO VOLTAGE SWITCHING CONVERTER TECHNIQUES
DERMOT M. OSULLIVAN and INIGO SEGURA *In its* European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 173-178 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

A common problem associated with the majority of isolating DC/DC converters and DC/AC inverters (normally with power stages designed to drive a power transformer) is the undesired behavior of the parasitic parameters of the transformer and in particular the loading effect of the interwinding and switch capacitances. The consequence of driving a converter with a significant parasitic capacitance is that the inverter must provide high peak currents to reverse the voltage across these capacitors and hence, results in high switching losses in the inverter power stage. The effect is of major importance for high frequency and high voltage ratio applications. A Zero Voltage Switching (ZVS) method for the soft switching of classical converters is described and the basic idea is extended to the general concept of ZVS for any converter or regulator power stage employing inductive elements. ESA

N92-13181# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
PARALLEL POWER REGULATION OF A CONSTANT FREQUENCY, ZV-ZC SWITCHING RESONANT PUSH-PULL
L. GHISLANZONI *In its* European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 191-198 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

A resonant push-pull stage topology which merges the Zero-Voltage Zero Current (ZV-ZC) switching principle with a fixed frequency Pulse Width Modulted technique, acting just on part of the transferred power, in order to achieve regulation and first order behavior, is proposed. As a steady state regulation is carried out just on part of the transferred power, this topology is best suited for utilization with a regulated bus, i.e., if regulation can be achieved handling just 10 percent of the transferred power some 90 percent efficiency, then the effective efficiency of the preregulator function is 99 percent. ESA

N92-13184# Technische Univ., Munich (Germany). Inst. C for Thermodynamics.
POWER CONVERSION UNITS FOR SOLAR-DYNAMIC SPACE POWER GENERATION

W. ZOERNER and J. BLUMENBERG *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 213-218 Aug. 1991

The future low Earth orbit infrastructure (manned and unmanned) will demand considerably higher electric power supplies as compared to past applications. The power conversion unit is of major influence within the overall power system. The power conversion unit's qualities decide on the mass and the size/efficiency of the power system. After an introduction to the power conversion units and a preoptimization, a tradeoff was carried out, identifying a free piston Stirling engine based power system as the best future choice and an Organic Rankine Cycle based power system as a good near term experiment alternative. ESA

N92-13186# Texas A&M Univ., College Station. Power Electronics Lab.
POWER ELECTRONIC TECHNIQUES FOR HIGH-POWER DYNAMIC SPACE SYSTEMS
M. EHSANI and J. HANSEN *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 225-230 Aug. 1991

Increasing demand for high power long duration space power systems has led to a renewed investigation of using nuclear reactor sourced power systems employing dynamic power conversion. Dynamic power converters, in turn, can employ several types of electrical generator/regulation systems. The synchronous wound field (WF) rotary generator and the synchronous permanent magnet (PM) rotary generator are identified as the best machines to use for dynamic generation. Advanced AC-DC converters will maintain unity power factor at the WF generator terminals and for the PM generator, unity power factor at the air gap is maintained. Results of simulations using a computer model are reviewed. Discussions of the implementation of generator rectifier architectures are given. ESA

N92-13187# National Space Development Agency, Ibaraki (Japan).
DESIGN OF THE JAPANESE EXPERIMENT MODULE ELECTRICAL POWER SYSTEM
M. KOMATSU (National Space Development Agency, Tokyo (Japan).), T. GOHNAI (Mitsubishi Electric Corp., Tokyo (Japan).), and S. KITAKATA (Mitsubishi Electric Corp., Tokyo, Japan) *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 233-238 Aug. 1991

The design of the Japanese Experiment Module's (JEM) electric power system is discussed including the key design goals of electrical performance, power distribution system, power management, and control. Tradeoff studies were conducted for many of the more important JEM electric power system design decisions. The results of the tradeoff studies should be reflected in the first development model of the Power Distribution Unit (PDU). ESA

N92-13188# Telefunken System Technik G.m.b.H., Wedel (Germany).
COMPUTER SIMULATION OF COLUMBUS 4-DOMAIN 120 VDC MAINBUS REGULATION
ADDI SCHREGER *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 239-244 Aug. 1991

A realistic computer simulation of the extent and complexity Electrical Power Systems (EPS) of the Columbus Man Tended Free Flyer (MTFF) is demonstrated. Special interest is given to the calculation of the mainbus impedance when operating in 4 different domains of the nonlinear sequential switching shunt regulator, the linear external power regulator, battery charge regulator and battery discharge regulator. The determination of the stability of the EPS control loops is of great importance. The impacts of failure modes and dead bands are shown. The results of these investigations support hardware design and test. ESA

N92-13189# Alenia Spazio S.p.A., Naples (Italy).
SIMULATION OF LARGE POWER DISTRIBUTION SYSTEM BEHAVIOR UNDER LOAD SWITCHING CONDITIONS: THE COLUMBUS ATTACHED LABORATORY EPDS CASE
GIORGIO MINIOTTI, GIUSEPPE GERVASIO, and LEONARDO SCHIAVONE *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 245-255 Aug. 1991

The prediction of phenomena of transients is of particular concern when a large amount of power is managed. The identification, during the design phase, of potential out of limits behavior is mandatory and, considering the complexity of the Electrical Power Distribution System (EPDS) of the Columbus Attached Laboratory, the need for computer simulations is evident. The EPDS architecture consists of a star distribution configuration to supply the payloads and a mixed one (bus plus star) for subsystem power (1990 proposal configuration). The lines are simulated by lump parameter models while the on/off switching function, which is implemented by Solid State Power Controllers'(SSPCs), is simulated with a nonlinear voltage generator driven by the current source. Within the constraints imposed by the modeling of lump parameters, the analysis of EPDS transient voltages and currents was performed. The following cases are considered: short ciruit; on/off switching of different loads in each analysis; maximum voltage transient; transient time duration; and maximum voltage swing. ESA

N92-13191# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
SAFT SECOND GENERATION NI-H2 CELL IN THE 40AH-100AH RANGE FOR GEOSTATIONARY APPLICATION
J. VERNIOLLE (Centre National d'Etudes Spatiales, Toulouse (France).), T. JAMIN, and D. PAUGAM (Societe des Accumulateurs Fixes et de Traction, Romainville, France) *In its* European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 267-272 Aug. 1991

The status of the development of SAFT improved nickel hydrogen (Ni-H2) technology in the range 40 Ah to 100 Ah is presented. Initiated after the successful qualification of the SAFT 50 Ah to 50 Wh/kg technology, this development was aimed at a cell of extended capacity range with improved mass and cost performances. To meet the stringent safety requirements imposed by ESA, specific considerations were given to the design of the pressure vessel, its fracture mechanics analysis and its characterization versus the hydrogen embrittlement effect. While retaining the major design features that guarantee the cycle life of SAFT Ni-H2 technology, a dual stack configuration in a standard 3.5 inch diameter, hydroformed vessel was defined, analyzed and validated. An energy density of 59 Wh/Kg was achieved for an actual capacity of 100 Ah. ESA

N92-13192# Societe des Accumulateurs Fixes et de Traction, Romainville (France). Space Dept.
FRENCH TECHNOLOGY IN NIH2 CELL AND BATTERY IN GEO SATELLITE FOR THE PRESENT DECADE
B. LACOUT and D. PAUGAM *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 273-277 Aug. 1991

Work carried out on cell general design, performance and

qualification level in the new approach for battery development, is described. For Geosynchronous Earth Orbit (GEO) and low Earth orbit satellite programs the NiH2 cells offer an optimized solution to power demands for the present decade. This NiH2 battery developed with a multiplatform approach allows the project requirements to be fulfilled with low cost and reduced delivery time. The definition has already been successfully validated on a structural and thermal model battery. The qualification will be achieved on the two extremes of the battery range: 27 VHS90CM (27 cells of 90 Ah) and 12VHS50CM (12 cells of 50 Ah). This work will be completed by early 1992. ESA

N92-13193# Eagle-Picher Industries, Inc., Joplin, MO.
EUTELSAT 2 NICKEL-HYDROGEN STORAGE BATTERY SYSTEM DESIGN AND PERFORMANCE SUMMARY
PHILLIP DUFF *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 279-284 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

The Eutelsat 2 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 nickel hydrogen battery system was selected to support this mission primarily due to long life, high energy density characteristics and sucessful spaceflight heritage. Details of the cell and battery design and battery electrical performance are outlined and results of qualification/acceptance testing are summarized. ESA

N92-13194# Aerospace Corp., El Segundo, CA. Electronics Technology Center.
MODELING PERFORMANCE DEGRADATION IN NICKEL HYDROGEN CELLS
LAWRENCE H. THALLER and THOMAS P. BARRERA *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 285-290 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

With the increasing use of nickel hydrogen cells and batteries, degradation models and cycle life predictions can be valuable if they are valid. Previous studies of the expansion characteristics of nickel electrodes, as well as early efforts to predict cycle life as a function of depth of discharge are reviewed. The results of these earlier studies are used to suggest a more accurate degradation model for nickel electrodes. Preliminary experimental studies were focused on electrodes of the type used in typical flight hardware. The objective is to explore the stiffness of electrodes as they are cycled to different depths of discharge and different concentrations of KOH. Electrodes of different plaque strengths, loading levels of active material, and amount of cobalt additives will eventually be investigated. The ultimate goal is to more accurately predict life cycle of a cell as affected by design parameters. ESA

N92-13195# Centre National d'Etudes Spatiales, Toulouse (France).
RECENT PROGRESS IN THE FIELD OF NICKEL AND CADMIUM ELECTRODES AIMED AT MAKING HIGH SPECIFIC ENERGY NI-CD AND NI-H2 BATTERIES
G. BRONOEL (Sorapec, Fontenay sous Bois (France).), N. TASSIN (Sorapec, Fontenay sous Bois (France).), T. POTIER (Sorapec, Fontenay sous Bois (France).), S. BESSE, and R. ROUGET (Sorapec, Fontenay sous Bois, France) *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 293-295 Aug. 1991
Copyright Avail: CASI HC A01/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

Recent progress in the manufacture of new collectors for nickel and cadmium electrodes is reviewed. High specific energy NiCd and NiH2 batteries can be realized with such collectors (nickel foam or felts). Cadmium electrodes prepared with a high porosity nickel foam, have a good ability for oxygen recombination and an appropriate doping treatment leads to high yields (90 percent). Nickel electrodes are prepared with a fibrous nickel collector electrochemically impregnated and also have high yields (90 percent). ESA

N92-13196# Furukawa Electric Co. Ltd., Tokyo (Japan). Space and Aeronautical Div.
LIFE CHARACTERISTICS OF NI-CD BATTERY CELLS FOR SCIENTIFIC SATELLITES
Y. ISHIKAWA (Furukawa Electric Co. Ltd., Tokyo (Japan).), K. FUJITA (Furukawa Electric Co. Ltd., Tokyo (Japan).), M. HIROSE (Furukawa Electric Co. Ltd., Tokyo (Japan).), M. KOUBATA (Nippon Electric Co. Ltd. (Japan).), M. KUDOH (Nippon Electric Co. Ltd. (Japan).), K. MATSUI (Furukawa Electric Co. Ltd., Tokyo (Japan).), K. MURATA, K. SAITOH, M. TAJIMA, K. TAKAHASHI (Tokyo Univ., Japan) et al. *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 297-302 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

Nickel cadmium battery cells have been used as a secondary power source for scientific satellites in Japan. Battery cells which have a capacity of 2 to 19 Ah were mounted and worked well in orbit during the mission life of each satellite. The ground life test and flight data of the Prototype Model (PM) battery cells and onboard cells with 19 Ah capacity for the 11th scientific satellite GINGA are described. It is confirmed that the NiCd PM battery cells for GINGA have life characteristics of more than 25,000 charge/discharge cycles at 25 percent of depth of discharge. Therefore, it can be presumed that the PM cells have characteristics providing more than 45 years of life in low Earth orbit. ESA

N92-13197# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Electrical Systems Dept.
UPDATE ON LOW-EARTH ORBIT NICKEL CADMIUM BATTERY LIFETIME TESTING
B. HENDEL, G. DUDLEY, and G. GAVE (Centre National d'Etudes Spatiales, Toulouse, France) *In its* European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 303-308 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

Within the joint CNES-ESA ELAN program, which has been running for six years, nickel cadmium batteries are cycling under various Low Earth Orbit (LEO) conditions. No sudden cell failures have occurred, but all cells in the battery subjected to the most severe conditions (25 C, 40 pct. depth of discharge) have reached the end of life criterion for end of discharge voltage. Capacity retention was poor and teardown analysis revealed a loss of negative plate capacity and extensive cadmium migration into the separator. The remaining 20 batteries continue cycling. Initial lifetime expectations have been considerably surpassed. The so called memory effect is very evident and long term as well as short term beneficial effects of both shallow and deep reconditioning are evident. In the absence of reconditioning, memory effects are likely to determine the useful lifetime of a battery on board a spacecraft. In the case of a battery subjected to a simulated ERS-1 spacecraft load profile, reconditiong after two years has allowed a second two year period of life to be sustained. This has important implications for the management of batteries for future LEO missions such as the Columbus Polar Platform. ESA

N92-13199# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
EXPERIMENTAL PARTIAL DISCHARGE DETECTION EQUIPMENT FOR DC AND DC RAMP HIGH VOLTAGE TESTING
J. C. J. EEMAN *In its* European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel

Cells p 317-322 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

The facility for detection and recording of partial discharges which occur in DC and DC ramp and ramp plateau high voltage testing is described. Discussed topics are the general layout of the facility, the required shielding, the selection criteria for critical system components, a newly developed partial discharge detector with a wide logarithmic scale, an input circuit adaptable to various specimen capacitances and an output voltage waveform optimized for recording on instrumentation like a pulse height analyzer and/or a strip chart recorder. ESA

N92-13200# Nippon Telegraph and Telephone Public Corp., Tokyo (Japan). Applied Electronics Lab.
A HIGH-EFFICIENCY AND LIGHT-WEIGHT TWT POWER SUPPLY FOR A COMMUNICATIONS SATELLITE
TAKASHI YAMASHITA, SATOSHI OHTSU, KATSUHIKO YAMAMOTO, and TOSHIYUKI SUGIURA *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 323-328 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

The weight of Traveling Wave Tube (TWT) power supply can be reduced by increasing the switching frequency. It is however difficult to raise the switching frequency since there is much switching loss caused by current charging and discharging to/from the stray capacitance of a high voltage transformer. A new method for designing high voltage transformers and choke coils to reduce power loss caused by tranformer stray capacitance is described. With the method, the switching frequency of a TWT power supply can be raised to 200 kHz from 20 kHz without increasing power loss. Furthermore, a heater inverter is simplified and surface mount technology is applied to a control circuit and the heater inverter. As a result, a newly developed TWT power supply weighs about 30 percent of the conventional power supply. ESA

N92-13201# Aston Univ., Birmingham (England). Dept. of Electrical Engineering and Applied Physics.
THE THREAT OF PARASITIC ELECTRON EMISSION IN HIGH-VOLTAGE POWER AND COMMUNICATION SYSTEMS OPERATING UNDER SPACE CONDITIONS
R. V. LATHAM (Aston Univ., Birmingham (England).), N. S. XU (Aston Univ., Birmingham (England).), A. E. D. HEYLEN (Leeds Univ. (England).), and V. POSTOYALKO (Leeds Univ., England) *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 329-334 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

Experimental studies have established that at fields exceeding approximately 20 MV/m, the insulation of high voltages in both a vacuum and gas environment is ultimately limited by the surface state of electrodes. Of particular significance are such factors as their preparation procedure, cleanliness, and level of oxidation. ESA

N92-13202# Eidgenoessische Technische Hochschule, Zurich (Switzerland). High Voltage Lab.
PARTIAL DISCHARGE MEASUREMENTS TO DETERMINE LONG-TERM CHARACTERISTICS OF THIN EPOXY PLATES UNDER CYCLIC STRESS
HANS-JUERG WEBER (Bern Univ. (Switzerland).), KURT LEHMANN, PETER BOCHSLER, and JOSEF FISCHER (Bern Univ., Switzerland) *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 335-341 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

For the investigation of suprathermal solar particles a High Voltage (HV) electrostatic analyzer was developed for use onboard the Solar and Heliospheric Observatory (SOHO) spacecraft. The high and variable electric field strengths at the insulating parts of the analyzer demand an extensive HV test program to ensure reliable operation during the projected lifetime of the spacecraft of two years. To perform such tests a custom made partial discharge measuring system was constructed. A newly developed software package was utilized for automatic detection, protocoling and graphics presentation of small partial discharges. A special feature of the system is its flexibility. Thus the system can be useful for numerous nonstandard applications in space projects. ESA

N92-13203# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
CONDUCTANCE CONTROL WITH A BOOST REGULATOR FOR A HIGH VOLTAGE POWER CONDITIONER FOR A TWTA
I. ARENS and F. TONICELLO (Fabrica Italiana Apparecchiature Radioelettriche S.p.A., Padua.) *In its* European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 343-350 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

The current controlled boost pulse width modulated regulator for the Traveling Wave Tube Amplifier (TWTA) is analyzed in terms of current and voltage loops, input and output impedance, and input voltage susceptibility. The analysis is performed in small signal approximation using the time averaging method. The duty ratio generator is based on a comparison of the inductor current with a double sided sawtooth without a storage device. A computer evaluation of the full transfer functions is given and simpler expressions are derived by further approximations, displayed by inspection of poles and zeroes and proposed for converter synthesis. ESA

N92-13207*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ISSUES AND STATUS OF POWER DISTRIBUTION OPTIONS FOR SPACE EXPLORATION
ROBERT W. BERCAW, RONALD C. CULL, and BARBARA H. KENNY *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 375-380 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

The Space Exploration Initiative (SEI) will need a wide variety of manned systems with requirements significantly different than those for existing systems. The concept of a space power utility is discussed and the impact of this concept on the engineering of space power systems is examined. Almost all existing space power systems use low voltage direct current. Although they have been very succesful, increasing power system requirements in recent years have exposed their inherent limitations and led to the proposal of a number of alternatives including high voltage DC and AC at various frequencies. Drawing on the experience gained from Space Station Freedom and SEI systems studies, factors that may affect the choice of frequency standards on which to build such a space power utility are discussed. ESA

N92-13208# British Aerospace Public Ltd. Co., Stevenage (England).
SIMPA: A POWER SYSTEM EQUIPMENT SIZING TOOL FOR GEOSTATIONARY SATELLITES
STEPHEN TERENCE KING (British Aerospace Aircraft Group, Hertfordshire (England).) and BARRY LYNCH (Generics, Software Ltd., Dublin, Ireland) *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 383-393 Aug. 1991
(Contract ESTEC-7986/88/NL/RE(SC))
Copyright Avail: CASI HC A03/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

SIMPA is a computer software simulation tool to aid in the sizing of power systems for geostationary satellites. SIMPA runs on any IBM personal computer or compatible. The program structure and error trapping, user screens, algorithms and

assumptions used are described. Examples are presented showing the flexibility of SIMPA. These cover battery and battery discharge regulator sizing using buck and boost discharge regulators, the effect of solar array latchup on the sunlight regulated power bus and the effect of increased converter operating frequency on equipment sizing. ESA

N92-13209# Dornier System G.m.b.H., Friedrichshafen (Germany).
PSCAP: A MODULAR TOOL FOR POWER SYSTEMS DESIGN AND ANALYSIS
H.-D. JUNGINGER *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 395-401 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

In order to enable a safer and more economical handling of system design and performance analysis in the area of power system engineering for space systems, the Power System Configuration and Analysis Program (PSCAP) was developed. PSCAP was designed as a modular structured software tool, which will be able to simulate alternative power subsystem configurations, taking into account mission and operational requirements. For the handling of the required input data and the produced output data, the data base management system RSYST was selected. This opens further possibilities such as data base management, generation of plots, and the use of special RSYST command procedures. ESA

N92-13210# Alcatel Espace, Toulouse (France).
GEPOS: GLOBAL EVALUATION AND OPTIMISATION OF FUTURE POWER SYSTEMS CONCEPTS
J. VANDUIVENBODE (Alcatel Espace, Toulouse (France).), B. LACORE (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).), C. RYM (Etudes Techniques et Constructions Aerospatiales, Charleroi (Belgium).), and R. SALAMONE (Etudes Techniques et Constructions Aerospatiales, Charleroi, Belgium) *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 403-408 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

Work concerning the development of a software tool that evaluates and optimizes future power system concepts is presented. A general presentation of the software is followed by a discussion of the underlying models and algorithm. It is shown how artificial intelligence techniques can be applied to engineering problems. An example case shows possible applications. ESA

N92-13211# MATRA Espace, Toulouse (France).
PSS SIZING TOOLS: EBLOS, A NEW IMPROVED MODEL
ALAIN LEHMAN, DIDIER LOUP, and DIDIER ALARY *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 409-414 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

Sizing of low Earth orbit power systems is presently achieved by the use of software simulators. The Energy Budget Low order Satellite (EBLOS) program is a software tool used to precisely size new missions using the Power Supply Systems (PSS) based on the paralleling of the solar array and the batteries. EBLOS was developed to simulate these satellites. In spite of some approximations in the program, mainly related to the thermal environment and the battery parameters, the accuracy of the simulation was demonstrated to be sufficient for its present applications. However, future missions require much more various conditions and cannot be simulated precisely. Therefore, the EBLOS program was improved in order to simulate any type of orbit (circular or elliptic, of any inclination and altitude), any type of solar cell and any satellite orbital configuration. In addition, work was performed to reach a more reliable simulation of the battery electrical behavior. The electrical effect of each physical process was identified, and the new model is now able to work with any kind of satellite use. This improved EBLOS software was revalidated, and its accuracy demonstrated over a large range of operating conditions. ESA

N92-13212# Societe des Accumulateurs Fixes et de Traction, Romainville (France). Aerospace Dept.
THE 250 AH LITHIUM/THIONYL-CHLORIDE CELL EVALUATION TEST RESULTS
J. P. SEMERIE and J. L. FIRMIN (Societe des Accumulateurs Fixes et de Traction, Poitiers, France) *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 417-421 Aug. 1991
Copyright Avail: CASI HC A01/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

Test results obtained during evaluation of a primary lithium/thionyl chloride cell developed for use in a booster battery are presented. Cell weight is 2.8 Kg and returned capacity is over 250 Ah in the range 10 to 80 C with currents 0 to 60 A plus pulse capability of 75 A. Average voltage is 3.3 V at 60 A and 45 C. Behavior under some classical abuse testing is described. Discussion of thermal interfaces is done to highlight the conditions to obtain the advantages of the demonstrated energy density of 350 Wh/Kg at C/4 rate. ESA

N92-13214# Electrotechnical Lab., Ibaraki (Japan).
EXPERIMENTAL AND DESIGN STUDY ON ALKALI METAL THERMOELECTRIC CONVERTER FOR AEROSPACE POWER
T. MASUDA, A. NEGISHI, K. TANAKA, T. HONDA, and T. FUJII *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 431-435 Aug. 1991
Copyright Avail: CASI HC A01/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

The experimental results of the series connected Alkali Metal Thermoelectric Convertor (AMTEC) cells and the theoretical considerations about internal resistances are reported. For the series cells, the open voltage of 2.73 V, the short circuit current of 20 A and the maximum power of 9.24 W at 1077 K were obtained. This power was about 60 percent of the sum power of each single cell. This power decrease was due to the large resistance of the current collecting bus bar. In a design study, numerical data which seemed to be achievable in near future were assumed. The calculated output power, total cell number, reactor thermal output, radiator output, efficiency and total mass were 300 kW, 3415 cells, 1032 kWt, 732 kWt, 29 percent, and 8059 kg, respectively. ESA

N92-13218# Dornier System G.m.b.H., Friedrichshafen (Germany).
EUROPEAN REGENERATIVE FUEL CELL SYSTEMS FOR SPACE STATIONS AND LARGE PLATFORMS
UWE BENZ (Dornier Luftfahrt G.m.b.H., Friedrichshafen (Germany, F.R.).), WERNER TILLMETZ (Dornier Luftfahrt G.m.b.H., Friedrichshafen (Germany, F.R.).), and KARIM BOURIDAH (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 459-465 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

The basic concepts of a Regenerative Fuel Cell System (RFCS) as an energy storage device for space stations are presented. The focal points of the work are discussed. The development activities concerning the Fixed Alkaline Electrolyte (FAE) electrolyzer technology showed good progress: stable operation for several hundred hours in continuous and intermittent mode, operation up to 25 bar and demonstration of a high cell performance. An energy storage system optimization with respect to a minimum overall mass was performed and the main design data are given. Various system engineering aspects (e.g.,

preliminary redundancy concept) are discussed. A brief comparison to competing energy storage systems (NiCd and NiH2 batteries) shows that even if only considered from systems mass point of view, the RFCS has an advantage over batteries. Furthermore, a possible integration of the RFCS with the Environmental Control and Life Support System (ECLSS) and propulsion system could even increase this advantage. ESA

N92-13219*# Los Alamos National Lab., NM. Advanced Engineering Technology Group.
ELECTROCHEMICAL ENERGY STORAGE USING PEM SYSTEMS
N. E. VANDERBORGH, J. C. HEDSTROM, and J. R. HUFF *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 467-471 Aug. 1991 Previously announced as N91-31711 Sponsored by NASA. Lewis Research Center
Copyright Avail: CASI HC A01/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

Results of an engineering assessment for future, long lived space power systems for extraterrestrial applications are given. Solar based, regenerative fuel cell power plants formed from either alkaline or Polymer Exchange Membrane (PEM) components are the focus. Test results on advanced PEM fuel cell stack components are presented. ESA

N92-13222# European Space Agency, Paris (France).
EUROPEAN SPACE POWER CONFERENCE. VOLUME 2: PHOTOVOLTAIC GENERATORS
JAMES J. HUNT, ed. Aug. 1991 314 p Conference held in Florence, Italy, 2-6 Sep. 1991
(ISSN 0379-6566)
(ESA-SP-320-VOL-2; ISBN-92-9092-122-6; ETN-91-90066)
Copyright Avail: CASI HC A14/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Photovoltaic generators are considered. Specific subjects investigated include: solar cell technology; solar cell assembly technology; solar cell/array tests; measurements and modeling; solar array technology; solar array environmental effects and flight data.

ESA

N92-13223# Messerschmitt-Boelkow G.m.b.H., Ottobrunn (Germany). Space Communications and Propulsion Systems.
ASSESSMENT OF THIRD GENERATION SOLAR CELLS
G. J. LAROCHE, W. SCHULTZE, I. RIZOS, and K. BOGUS (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 487-493 Aug. 1991
Copyright Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Third generation solar cells for use on solar generators selected for typical future space missions were investigated. Detailed information on the cell status and the development potential was provided. On the basis of these data specially selected missions in low Earth orbit, geostationary orbit, and interplanetary space were defined and the corresponding spacecraft equipped with solar generators utilizing each of the cell candidates for power generation. Characteristic solar generator parameters were determined for each candidate and mission. The evaluation of these data together with the assessment of the actual development status resulted in parameters enabling a quantitative and qualitative assessment of each candidate for application in future missions. Since silicon solar cells presently have the highest development status and still enough potential for further improvements, silicon was found to be the leading solar cell candidate for the near future. But some other candidates have been identified which would be superior to silicon as soon as a comparably high development status are achieved. Higher costs of those candidates can be compensated by savings on subsystem and system level. ESA

N92-13224# Centro Informazioni Studi Esperienze, Milan (Italy).
THIN GAAS/GE SOLAR CELL DEVELOPMENT
B. BOLLANI (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).), R. CAMPESATO, R. L. CRABB (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands), C. FLORES, F. PALETTA, D. PASSONI, G. TIMO, and A. TOSONI *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 495-500 Aug. 1991
Copyright Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Thin GaAs/Ge Metalorganic Chemical Vapor Deposition (MOCVD) solar cells were developed in order to overcome the high cost and fragility of conventional GaAs/GaAs cells. Cells with passive rather than active tandem structures were developed in order to maintain the intrinsic advantages of GaAs/GaAs cells, namely high radiation and temperature resistance. Test results are presented for 100 to 200 micron thick solar cells with conversion efficiencies up to 19 percent air mass zero (AM0) 25 C. ESA

N92-13226# English Electric Valve Co. Ltd., Chelmsford (England).
GAAS SPACE SOLAR CELLS: A EUROPEAN PILOT PRODUCTION FACILITY
T. A. CROSS, C. M. HARDINGHAM, and S. P. WOOD *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 507-511 Aug. 1991
Copyright Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Until recently, the volume commercial production of GaAs solar cells has been limited to the U.S. and Japan. The commissioning of a European 1 kW pilot line which is now producing GaAs solar cells with production efficiencies of over 18 percent (air mass zero, 1 sun) is reported. The development of a cost effective gold plated molybdenum interconnector compatible with ultrasonic welding is investigated. On orbit demonstration of this solar cell technology is scheduled for mid 1991 with the launch of a power panel on the forthcoming UoSAT-F microsatellite. ESA

N92-13227# English Electric Valve Co. Ltd., Chelmsford (England).
DIFFUSED JUNCTION, SURFACE TEXTURE ENGINEERED GAAS HETEROFACE SOLAR CELL
C. M. HARDINGHAM and T. A. CROSS *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 513-516 Aug. 1991
Copyright Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Surface texture engineered (i.e., V-grooved front surface and recessed contact metallization) GaAs heteroface space solar cells are considered. Surface texture engineering of Infinite Melt Liquid Phase Epitaxy (IMLPE) cells is discussed. Compatibility with current pilot production manufacturing process, in particular with the front contact metallization system, is demonstrated. Cell I-V results showing no deleterious effects from recessing front contacts are presented. ESA

N92-13228*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THIN-FILM PHOTOVOLTAICS: STATUS AND APPLICATIONS TO SPACE POWER
GEOFFREY A. LANDIS (Sverdrup Technology, Inc., Brook Park, OH.) and ALOYSIUS F. HEPP *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 517-522 Aug. 1991
Copyright Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

The potential applications of thin film polycrystalline and amorphous cells for space are discussed. There have been great advances in thin film solar cells for terrestrial applications; transfer of this technology to space applications could result in ultra low weight solar arrays with potentially large gains in specific power. Recent advances in thin film solar cells are reviewed, including

polycrystalline copper iridium selenide and related I-III-VI2 compounds, polycrystalline cadmium telluride and related II-VI compounds, and amorphous silicon alloys. The possibility of thin film multi bandgap cascade solar cells is discussed. ESA

N92-13229# Tsukuba Space Center (Japan).
INVESTIGATION OF SILICON SOLAR CELL AND MODULE REVERSE CHARACTERISTICS
M. UESUGI (National Space Development Agency, Ibaraki (Japan).), T. NOGUCHI (National Space Development Agency, Ibaraki (Japan).), Y. TONOMURA (Tsukuba Space Center, Ibaragi (Japan).), T. HISAMATSU (Tsukuba Space Center, Ibaragi (Japan).), T. SAGA (Tsukuba Space Center, Ibaragi (Japan).), T. MATSUTANI (Sharp Corp., Nara (Japan).), and A. SUZUKI (Sharp Corp., Nara, Japan) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 523-528 Aug. 1991
Copyright Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Investigations into the reverse characteristics of ultrathin silicon solar cells and modules for space application are reported. Based on the acquired data, a computer simulation program for evaluation of reverse characteristics of the shadowed cell and module was proposed. The results of experiments suggested the possibility that breakdown occurred at relative low reverse bias voltage (about 20 V) due to raising of the cell temperature on the partially shadowed module in the space environment. ESA

N92-13230*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THIN FILM, CONCENTRATOR, AND MULTIJUNCTION SPACE SOLAR CELLS: STATUS AND POTENTIAL
DENNIS J. FLOOD *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 531-536 Aug. 1991 Previously announced as N91-31218
Copyright Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Recent, rapid advances in a variety of solar cell technologies offer the potential for significantly enhancing, or enabling entirely new, mission capabilities. Thin film solar cells are of particular interest. A review is provided of the status of those thin film cell technologies of interest for space applications, and the issues to be resolved before mission planners can consider them. A short summary of recent developments in concentrator and multijunction space solar cell and array technology is given. ESA

N92-13231# Telefunken System Technik G.m.b.H., Wedel (Germany).
PILOT-LINE PRODUCTION OF ALUMINIUM INTERCONNECTED SOLAR MODULES
U. HOFFMANN (Telefunken Electronic G.m.b.H., Heilbronn (Germany, F.R.).) and J. C. LARUE (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 537-542 Aug. 1991
Copyright Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

An interconnection technology for photovoltaic space solar cells was developed using aluminum alloy interconnectors. The interconnectors are joined to the solar cells by means of an ultrasonic welding process. The Al alloy interconnector technique provides intrinsic protection against atomic oxygen corrosion and a cabling weight reduction potential. The developmental investigations for the selection of the candidate interconnector alloys as well as the solar cells, structure, and weld equipment are described. Verification of the design and final interconnector alloy selection is to be executed on five inlet line modules after a thermal cycling test. The test simulates a five year mission in low Earth orbit. ESA

N92-13232# English Electric Valve Co. Ltd., Chelmsford (England).
INTERCONNECTING AND CONTACTING TO INP BASED SOLAR CELLS
C. M. HARDINGHAM (Newcastle Polytechnic, Newcastle-upon-Tyne (England).), J. BURRAGE (Newcastle Polytechnic, Newcastle-upon-Tyne (England).), S. MCLEOD, T. A. CROSS, N. M. PEARSALL, I. FORBES, and J. WINCKLER (Newcastle-upon-Tyne Univ., England) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 543-546 Aug. 1991 Sponsored in part by Dept. of Trade and Industry and Science Research Council LINK
Copyright Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Indium phosphide (InP) based solar cells show promise for space applications due to their excellent radiation resistance. However, due to the early stage of development, it has not been possible to assess the suitability of these cells for array integration. The ultrasonic bonding of flight standard interconnects, based on either silver or gold, onto the epitaxially grown InP homojunction and the indium tin oxide/InP cell is studied. It is shown that bonds of reasonable pull strength can be effected without degradation of cell properties. ESA

N92-13233# Pilkington Bros. Ltd., Ormskirk (England).
CMG: COVERGLASS FOR GALLIUM ARSENIDE CELLS
P. A. WHITE *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 547-550 Aug. 1991 Sponsored in part by RAE
Copyright Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

A specific coverglass (CMG) for GaAs solar cells was developed to optimize the performance of these cells. The development and properties of CMG are presented. By using CMG coverglasses on GaAs cells it is felt that a more advanced and lighter solar cell assembly can be produced. Because the glass is expansion matched it significantly reduces any stresses within the cell assembly caused by thermal cycling. It allows advanced bonding techniques such as electrostatic bonding to be implemented or alternatively the use of Teflon or a rigid adhesive layer. For GaAs cells the elimination of the coverglass adhesive would be very significant since it would be the first step towards the realization of ultrathin GaAs cells relying on the coverglass for strength. ESA

N92-13234# Pilkington Bros. Ltd., Ormskirk (England).
TEFLON BONDING OF SILICON SOLAR CELLS
P. A. WHITE *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 551-554 Aug. 1991
Copyright Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

The silicon adhesive used to bond the coverglass onto the solar cell can be replaced by a thin layer of fluoroethylkene polymer teflon. The advantage of using Teflon as the adhesive is that it is supplied as a thin sheet in thicknesses of 25 or 50 microns and can be cut to size prior to use. Because the Teflon does not extrude from the join in the same manner as conventional adhesives, the clean up after Teflon bonding is virtually nonexistent. It is considered that the use of a coverglass which is thermally matched to silicon will prevent the build up of thermal stresses which could cause delamination. Work done to data on the Teflon bonding process including the results of some critical end of life tests is reviewed. ESA

N92-13235# Telefunken System Technik G.m.b.H., Wedel (Germany).
PREQUALIFICATION OF VERY THIN SILICON SOLAR CELLS ON MODULE LEVEL FOR GEO APPLICATIONS
GERD NEUHAEUSSER and JUERGEN W. KOCH *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 555-559 Aug. 1991 Sponsored in part by ESTEC

 Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Solar cells with reduced thicknesses lead to improved power to mass ratios on panel level with advantages for the spacecraft and its mission. Several hundreds of 2 by 4 sq cm solar cells of 70 micron thickness were subjected to all solar array producing loads, followed by a thermal cycling test representing Geosynchronous Earth Orbit (GEO) mission conditions. Two types of solar cells rear side contact configurations were investigated. Major steps of scrap were the welding and coverbonding. Additionally it was found that an intensive incoming inspection will reduce subsequent scrap drastically. All tests were passed without defects and degradations. The applicability of very thin solar cells was successfully demonstrated. ESA

N92-13236# Dornier System G.m.b.H., Friedrichshafen (Germany).

HOLOGRAPHIC DISPERSIVE CONCENTRATORS FOR PHOTOVOLTAIC POWER GENERATORS

G. REICH (*European Space Agency. European Space Research* and Technology Center, ESTEC, Noordwijk (Netherlands).), W. DENNER (Technische Hochschule, Aachen (Germany, F.R.).), K. BOGUS, C. G. STOJANOFF, and H. W. SCHOCK (Stuttgart Univ., Germany, F.R.) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 561-566 Aug. 1991

 Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Photovoltaic (PV) generators based on different semiconductor materials with optimized band gaps can achieve higher efficiency values than those obtained with single junction solar cells. With *simultaneous concentration of the incident solar radiation a further* improvement of the efficiency is realized. Based on PV space solar generator technology and terrestrial holographic concentrator technology a system analysis is performed that investigates the feasibility of a Holographic Dispersive Solar Generator (HDSG) for space application. The holographic solar concentrator allows simultaneous splitting and concentration of the incident sunlight. The upper limits of concentrator efficiency, spectral bandwidth and concentration ratio of holographic dispersive concentrators are evaluated with respect to the space environmental conditions. Two concepts of photovoltaic power generators with holographic *dispersive concentrators for space application are described.* ESA

N92-13237# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).

GAAS SOLAR PANEL TECHNOLOGY ASSESSMENT

R. L. CRABB (Centro Informazioni Studi Esperienze, Milan (Italy).), C. FLORES (Centro Informazioni Studi Esperienze, Milan (Italy).), F. PALETTA (Fabrica Italiana Apparecchiature Radioelettriche S.p.A., Milan.), A. CAON (Fabrica Italiana Apparecchiature Radioelettriche S.p.A., Milan.), R. CONTINI (Fabrica Italiana Apparecchiature Radioelettriche S.p.A., Milan.), E. ROSSI, and C. SIGNORINI (*Fabrica Italiana Apparecchiature Radioelettriche* S.p.A., Milan.) *In its* European Space Power Conference. Volume 2: Photovoltaic Generators p 567-573 Aug. 1991

 Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

The current status of a GaAs solar panel flight demonstration experiment that will culminate with the placement of the 28 W solar panel (one of four) on the small cubic United Kingdom microsatellite STRV-1A is presented. This spacecraft will be launched in mid 1993 into the very damaging radiation environment of a geosynchronous transfer orbit. Results of extensive precursory ground testing aimed at GaAs solar cell module design, assessment, and optimization in terms of in-orbit life expectancy are presented. This test program encompassed electron/proton irradiations, thermal cycling, prolonged UV and high temperature exposure, the determination of thermo-optical alpha/epsilon properties, and the measurement of simulated air mass zero electrical performance V-I characteristics. ESA

N92-13238# Pilkington Bros. Ltd., Ormskirk (England).

ELECTROSTATIC BONDING OF SILICON SOLAR CELLS

P. A. WHITE *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 575-580 Aug. 1991 Sponsored by ESTEC

 Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

An alternative method of attaching the coverglass to the solar cell, other than the conventional silicone adhesive, is electrostatic bonding where a direct bond is formed between the glass and the cell, i.e., the adhesive is eliminated. An electrostatic bonding process that is virtually equivalent to the conventional adhesive process in most cases and superior in other instances was developed. The process improvements achieved and the end of life testing performed on the electrostatically bonded Solar Cell Assemblies (SCA) are reported. ESA

N92-13239# Royal Aerospace Establishment, Farnborough (England). Space Dept.

THE CALIBRATION OF SOLAR CELLS IN TERRESTRIAL SUNLIGHT

M. A. H. DAVIES and C. GOODBODY *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 583-587 Aug. 1991

 Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

A method of calibrating solar cells in sunlight is described. This method has been used for at least 15 years, and produces a value of the solar cell's short circuit current for any predetermined space of terrestrial condition. The main advantage of this method is that a large number of cells can be calibrated reasonably quickly at a relatively low cost per cell. Choosing from this large number of standards minimizes spectral mismatch errors when measuring an unknown cell on a laboratory solar simulator. The effect of using standards with good and poor spectral match with the test cells is discussed. ESA

N92-13240# Thiemann und Noack, Freiburg (Germany).

ARC DISCHARGES AT NEGATIVELY BIASED SOLAR ARRAYS

H. THIEMANN (Thiemann und Noack, Freiburg (Germany, F.R.).) and R. W. SCHUNK (Utah State Univ., Logan.) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 589-595 Aug. 1991

 Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Arcing effects on solar array test modules were experimentally observed around the gap region between adjacent solar cells and at the solar cell edge substrate interface. Arcing effects around the negatively biased interconnects were not observed. Computer experiments on the interaction of the interconnects with low Earth plasma are reviewed. The situation in the gap and edge regions is assessed according to the quasi neutral potential conditions at these locations and their influence on the plasma particle dynamics. A possible mechanism for arc discharges at the critical locations *involves specific potential structures. This mechanism allows* charged particle flow between different locations on the surface through the outer space. ESA

N92-13242# Artegie (France).

WATTS PER KILO (WPK): SOLAR ARRAY DIMENSIONING TOOL VERSION 2 ENHANCEMENTS

P. BOBO *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 603-607 Aug. 1991

 Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

The main features of the solar array dimensioning tool Watts Per Kilo (WPK) are presented. Emphasis is put on version 2 enhanced modes which accept basic data input to derive intermediate results needed to achieve a solar array design or evaluation. WPK is described from a user's point of view. The common functions such as power output computation or sensitivity curves are reviewed with example of standard output. ESA

N92-13243# National Space Development Agency, Ibaraki (Japan).
PRODUCTION AND IMPROVEMENT OF 50 MICRON AND 100 MICRON THIN SILICON SOLAR CELLS FOR SPACE USE
S. MATSUDA (National Space Development Agency, Ibaraki (Japan).), T. NOGUCHI (National Space Development Agency, Ibaraki (Japan).), M. UESUGI (National Space Development Agency, Ibaraki (Japan).), T. SAGA (Sharp Corp., Nara (Japan).), Y. TONOMURA (Sharp Corp., Nara (Japan).), K. KAMIMURA (Sharp Corp., Nara (Japan).), H. YOSHIOKA (Sharp Corp., Nara (Japan).), T. MATSUTANI (Sharp Corp., Nara (Japan).), and A. SUZUKI (Sharp Corp., Nara, Japan) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 609-613 Aug. 1991
Copyright Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Fifty micron and 100 micron silicon solar cells (phase 1 cells) were produced for eight Japanese satellite programs. The production of thin solar cells showed high mechanical yields and tight distributions of power output. The photolithographic mask and lift off technique to form fine gridlines was introduced to realize high short circuit current. The improved 50 micron and 100 micron cells (phase 2 cells) showed 14.3 percent and 14.8 percent efficiencies respectively. More efficient thin silicon solar cells are under study. The target efficiencies of 50 micron and 100 micron Back Surface Field Reflecting (BSFR) cells are 16 percent and 17 percent respectively. Efficiencies up to 16 percent on 100 micron cells were obtained. ESA

N92-13244# Aix-Marseilles Univ. (France). Lab. de Photoelectricite.
DYNAMICAL ANALYSIS BY INFRARED THERMOGRAPHY OF BREAKDOWN PHENOMENA IN BSFR TYPE REVERSE BIASED SOLAR CELLS MOUNTED ON A GSR3 COUPON IN SIMULATED SPATIAL CONDITIONS
J. P. DAVID (Laboratoire de Sondages Electromagnetiques de l'Environment Terrestre, Toulon (France).), J. DUVEAU (Centre National d'Etudes Spatiales, Toulouse (France).), J. GUERIN, A. MICHEL, and ETIENNE RAPP (Centre National d'Etudes Spatiales, Toulouse, France) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 615-620 Aug. 1991
Copyright Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

A dynamical analysis of breakdown phenomena in Back Surface Field Reflecting (BSFR) cells mounted on a GSR3 (French acronym for rigid solar array 3rd generation) coupon is made in simulated spatial conditions. BSFR cells are reverse biased in hot spot conditions until breakdown is reached. Observations by IR thermography give a mapping of cell temperature and hot spots localized in failing zones. A post mortem analysis of destroyed cells is made, paying close attention to the failed zones. In conclusion, a quality control approach is achieved, leading to safety zones for cell performances. ESA

N92-13245# *Centre d'Etudes et de Recherches, Toulouse* (France). Dept. d'Etudes et Recherches en Technologie Spatiale.
INVESTIGATIONS OF TRANSIENTS ON THE SOLAR ARRAY BUS CAUSED BY ELECTROSTATIC DISCHARGES
L. LEVY, R. REULET, D. SARRAIL, J.-M. SIGUIER, and A. P. ROBBEN (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 621-625 Aug. 1991
Copyright Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Electrostatic discharges are studied as a possible source of hardware damage on solar arrays. During the discharges performed at the laboratory, voltage transients of several hundreds volts were measured on the cells with respect to the array local ground. An electric stress results across the insulating substrate, brief, but much higher than the one from the nominal solar array voltage at steady state. These transients could be triggering events which might initiate breakdowns in the insulating substrate and failures of the solar array. ESA

N92-13247# Indian Space Research Organization, Bangalore. Satellite Centre.
A NEAR OPTIMUM DESIGN OF SOLAR ARRAY FOR STRETCHED ROHINI SATELLITE SERIES-C (SROSS-C)
K. VIJAYAKUMAR, M. SUDHAKAR, N. SRINIVASAMURTHY, and B. L. AGRAWAL *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 635-640 Aug. 1991
Copyright Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

The Stretched Rohini Satellite Series (SROSS-C) is a part of the program of the Indian Space Research Organization. The SROSS-C is aimed at providing space platforms for various scientific and application purposes and space qualification of indigenous technologies. To meet all the power requirement conditions of the mission with the available generator area, a new approach to the design philosophy was adopted. The new approach deviates from the customary practice of basing the solar array design on worst case temperature. The near optimum design of the solar array for SROSS-C is described. ESA

N92-13248*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ENHANCED EOS PHOTOVOLTAIC POWER SYSTEM CAPABILITY WITH INP SOLAR CELLS
SHEILA G. BAILEY, IRVING WEINBERG, and DENNIS J. FLOOD *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 641-645 Aug. 1991
Copyright Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

The Earth Observing System (EOS), which is part of the International Mission to Planet Earth, is NASA's main contribution to the Global Change Research Program which opens a new era in international cooperation to study the Earth's environment. Five large platforms are to be launched into polar orbit, two by NASA, two by ESA, and one by the Japanese. In such an orbit the radiation resistance of indium phosphide solar cells combined with the potential of utilizing five micron cell structures yields an increase of 10 percent in the payload capability. If further combined with the advanced photovoltaic solar array the payload savings approaches 12 percent. ESA

N92-13249# Aerospatiale, Cannes (France).
LOCSTAR SOLAR ARRAY
G. A. MARTIN (Aerospatiale, Cannes (France).), PHILIPPE SAMSON (Aerospatiale, Cannes (France).), and K. DETTLAFF BEHRENS (Telefunken System Technik G.m.b.H., Wedel, Germany, F.R.) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 647-651 Aug. 1991
Copyright Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

The structural, mechanical and electrical performances of the LOCSTAR solar array, which was designed using the GSR3 (French acronym for rigid solar array 3rd generation) technology, are described. The two wings of this solar generator are equipped with TST (trademark) back side reflector (BSR) solar cells. The particularity of the solar generator is to include three types of flaps which are used for satellite thermal control, thruster protection, and attitude/orbit control. ESA

N92-13250# Aerospatiale, Cannes (France).
SPOT 4 SOLAR ARRAY
P. BENARROCHE (Aerospatiale, Cannes (France).), R. LAGET (Aerospatiale, Cannes (France).), E. CONDE (Centre National d'Etudes Spatiales, Toulouse (France).), and H.-D. WEGMANN (Telefunken System Technik G.m.b.H., Wedel, Germany, F.R.) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 653-657 Aug. 1991
Copyright Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

The solar array that will equip the next SPOT spacecraft, SPOT 4, is described. The Aerospatiale GSR3 (French acronym for rigid solar array 3rd generation) AMEDE (French acronym for improvement of deployment mechanisms) concept was adapted

to the Space Shuttle Orbiter (SSO) mission. The 2.8 kW SPOT 4 solar array is a single U shaped wing. The SPOT 4 solar array is the first of a new generation of solar generators characterized by their deployment concept. ESA

N92-13251# Fokker Space and Systems, Amsterdam (Netherlands). Solar Array Group.
THE SAX SOLAR ARRAY DESIGN AND VERIFICATION
J. T. KONINK *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 659-664 Aug. 1991
Copyright Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

The design and verification approach for the solar array on low earth orbit (LEO) Satellite for Astronomy in the X-rays (SAX) scientific satellite is addressed. The solar array is a derivative of the Advanced Rigid Array (ARA) specifically adjusted for the LEO mission. A suitable material choice was made, such as a Kapton indium tin oxide (ITO) layer on the panel rearside to protect the carbon fiber skins against the hostile atomic oxygen environment during its 26 month presence in LEO. The array consists of 2 deployable non suntracking wings each with 3 rigid sandwich panels. Large Back Surface Field Reflecting (BSFR) silicon solar cells will be produced and bonded by TST (trademark). The solar cell stringing is optimized to guarantee a minimum power during the mission for a large range of Solar Aspect Angles (SAA's). The verification approach of the design is based on an extensive analysis effort and a qualification by similarity with previous ARA programs. The test effort on the structural and flight wings is limited. A Design Verification Test (DVT) sample is required to qualify the solar cell and substrate combination for 12,000 cycles in LEO orbit conditions. ESA

N92-13252# Fokker Space and Systems, Amsterdam (Netherlands). Solar Array Mechanism Group.
THE COLUMBUS SOLAR ARRAY
R. ZWANENBURG and B. BUSZ *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 665-670 Aug. 1991
Copyright Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

For the Columbus program a rigid panel fold out solar array was selected, based on the so called flat pack array concept. A single wing array is proposed for the Polar Platform (PPF). The Man Tended Free Flyer solar array is comprised of two similar wings. The large degree of commonality between the two design layouts is essential to the minimization of the overall program cost. The PPF power requirement of 7.7 kW for a single wing puts this design in an entirely new category for Europe. A major challenge is the design of the holddown system for the large and relatively heavy wing package. A unique flexible holddown concept is under development to meet this challenge. ESA

N92-13253# Centre National d'Etudes Spatiales, Toulouse (France).
SPOT 1 SOLAR ARRAY: NOW 5 YEARS IN ORBIT
ETIENNE RAPP and PHILIPPE SAMSON (Aerospatiale, Cannes, France) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 671-674 Aug. 1991
Copyright Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

The first French Earth observation satellite was retired after 5 years of operation. Its flexible solar array was designed to provide more than 4 kW after 3 years in orbit. Its actual performance was, unexpectedly, much higher. In orbit information is analyzed in order to improve future predictions. ESA

N92-13254*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DEMONSTRATION OF THE ADVANCED PHOTOVOLTAIC SOLAR ARRAY
R. M. KURLAND (TRW Space Technology Labs., Redondo Beach, CA.) and P. M. STELLA *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 675-680 Aug. 1991
Copyright Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

The Advanced Photovoltaic Solar Array (APSA) design is reviewed. The testing results and performance estimates are summarized. The APSA design represents a critical intermediate milestone for the NASA Office of Aeronautics, Exploration, and Technology (OAET) goal of 300 W/kg at Beginning Of Life (BOL), with specific performance characteristics of 130 W/kg (BOL) and 100 W/kg at End Of Life (EOL) for a 10 year geosynchronous (GEO) 10 kW (BOL) space power system. The APSA wing design is scalable over a power range of 1 to 15 kW and is suitable for a full range of missions including Low Earth Orbit (LEO), orbital transfer from LEO to GEO and interplanetary out to 5 AU. ESA

N92-13255*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ENVIRONMENTAL INTERACTIONS OF THE SPACE STATION FREEDOM ELECTRIC POWER SYSTEM
HENRY K. NAHRA and C. Y. LU (Rockwell International Corp., Canoga Park, CA.) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 683-688 Aug. 1991
Copyright Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

The Space Station Freedom will be operating in the Low Earth Orbit (LEO) environment. LEO environment operation results in different potential interactions with the Space Station systems including the Electric Power Systems (EPS). These potential interactions result in environmental effects which include neutral species effects such as atomic oxygen erosion, effects of micrometeroid and orbital debris impacts, plasma effects, ionizing radiation effects, and induced contamination degradation effects. The EPS design and its interactions with the LEO environment are described. The results of analyses and testing programs planned and performed thus far to resolve the environmental concerns related to the EPS and its function in the LEO environment are discussed. ESA

N92-13256# Newcastle-upon-Tyne Univ. (England). Photovoltaics Applications Centre.
FLIGHT AND IRRADIATION STUDIES OF ITO/INP SOLAR CELLS
N. M. PEARSALL, N. ROBSON, and I. FORBES *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 689-693 Aug. 1991 Sponsored in part by Ministry of Defence; Dept. of Trade and Industry; and Science Research Council
Copyright Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Indium phosphide based cells show promise for space applications due to superior radiation resistance when compared to silicon and gallium arsenide cells. Data on flight and irradiation experiments for the Indium Tin Oxide/Indium Phosphide (ITO/InP) cell design are presented. Data from the longest running InP solar cell flight experiment (LIPS3) are reported, covering over three years in orbit. Measured short circuit currents remain close to launch values. Annealing data for cells irradiated with 1 MeV protons, with devices showing an increase in all cell parameters are also presented. ESA

N92-13257# Indian Space Research Organization, Bangalore. Dept. of Space.
SOLAR ARRAY FOR THE FIRST INDIAN REMOTE SENSING SATELLITE (IRS-1A): DESIGN AND PERFORMANCE
B. L. AGRAWAL, N. SRINIVASAMURTHY, K. VIJAYAKUMAR, M. SUDHAKAR, S. K. SHARMA, and SURESH PUTHANVEETTIL *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 695-699 Aug. 1991
Copyright Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

The first Indian Remote Sensing Satellite (IRS-1A) built by the Indian Space Research Organization was launched on 17 Mar. 1988 into a polar Sun synchronous orbit of 904 km and 99 deg inclination. Power is supplied to the three axis stabilized spacecraft

by a rigid array of six panels designed to give a power of 700 W at normal incidence at end of life of three years. The design and fabrication of the array and analyses of its performance for two years in orbit are discussed. ESA

N92-13261# Aerospatiale, Cannes (France).
EFFECT OF AN IN-FLIGHT POLLUTION BY THRUSTERS ON A SOLAR ARRAY
L. PELENC (Aerospatiale, Cannes (France).), J. C. DEDUIT (Aerospatiale, Cannes (France).), ETIENNE RAPP (Centre National d'Etudes Spatiales, Toulouse (France).), and A. RUTSCHLE (Centre National d'Etudes Spatiales, Toulouse, France) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 719-723 Aug. 1991
Copyright Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Evaluation of the TDF1 satellite inflight results showed abnormal behavior in one thermal sensor of the solar array after a few days in orbit (high temperature and overshoot after eclipse recovery). The phenomenon was computer simulated with fair accuracy with regard to the number of parameters involved and the accuracy of inflight measurements. This phenomenon is due to the contamination of a part of the solar array surface by an attitude control thruster during the apogee boost. A clear correlation can be established between the thrusting time and abnormal temperature given by the thermistor. Analysis of eventual effects on power at end of life showed very low degradation risk. Nevertheless, any configuration allowing this pollution should be avoided on future satellites. ESA

N92-13262# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
HST SOLAR GENERATOR ELECTRICAL PERFORMANCE DURING THE FIRST YEAR IN ORBIT
LOTHAR GERLACH *In its* European Space Power Conference. Volume 2: Photovoltaic Generators p 725-731 Aug. 1991
Copyright Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

The Space Telescope Solar Array (STSA), which is supplying the power for the joint NASA/ESA Hubble Space Telescope (HST) is the largest flexible solar array built to date, carrying 48760 BSFR silicon cells. The double roll out solar array was successfully deployed in orbit on 25 April 1990, one day after launch, and has been designed to survive at least 5 years in low Earth orbit (30,000 thermal cycles). STSA will supply at least 4450 W at 34 V after four years in space. During the first year in orbit the telemetry data received at the ground stations was evaluated in detail and compared with the predictions. The results are presented. ESA

N92-13265# Sverdrup Technology, Inc., Brook Park, OH.
STRUCTURAL SCALING APPROXIMATIONS FOR SOLAR ARRAYS
GEOFFREY A. LANDIS *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 747-751 Aug. 1991
Copyright Avail: CASI HC A01/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

General scaling rules for a photovoltaic array structure are required in order to compare the effectiveness of different cell technologies. Important evaluation criteria for an array are moment of inertia, resonant frequency of vibrational modes, stiffness against acceleration, and resistance losses in the wiring. Approximate scaling relationships for these parameters for a generic solar array structure are presented. ESA

N92-13268# Messerschmitt-Boelkow G.m.b.H., Ottobrunn (Germany). Space Communications and Propulsion Systems.
DARK FORWARD CURRENT MEASUREMENTS OF SOLAR ARRAYS
H. PREITNACHER (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).), A. P. ROBBEN, and LOTHAR GERLACH (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 765-770 Aug. 1991
Copyright Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

The dark current measurement system introduced is a comprehensive solution to automatic generator measurements. Once set up, the complete cycle for measuring a reference cell, 3 temperature sensors, and 10 different strings or sections of a solar generator will be performed in such a short time interval that the ambient temperature conditions will remain equal throughout the measurement. This is especially useful during temperature cycling tests where the temperatures vary quickly. Fine graded measurement ranges (8 for voltage and 4 for current) in conjunction with the high resolution of the programmed output voltage (25 mV for the 100 V system and 60 mV for the 250 V system) enable the system to cover the whole selection of measurements on different arrays from single cell to solar panels up to 250 V/10A. ESA

N92-13270# Centre National d'Etudes Spatiales, Toulouse (France).
EXPERIMENTAL INVESTIGATIONS OF SOLAR CELL AT LOW TEMPERATURE
DENIS SCHWANDER *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 775-780 Aug. 1991
Copyright Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

Safe electric coupling between solar array and switching regulators depends upon the knowledge of static and transient parameters of the solar array. These parameters are necessary to size the snubber circuit for worst cases. The differences between interface conditions for series regulators and shunt regulators are presented. Theoretical and experimental investigations in modeling of solar cells are also presented. ESA

N92-13271# Italian Space Agency, Rome.
DEVELOPMENT AND APPLICATION OF A COMPUTER TOOL FOR GAAS SOLAR ARRAY ELECTRICAL DESIGN AND IN ORBIT PERFORMANCE PREDICTION
F. SVELTO, A. CAON, R. CONTINI, G. DACCOLTI, and C. SIGNORINI (Fabrica Italiana Apparecchiature Radioelettriche S.p.A., Milan.) *In* ESA, European Space Power Conference. Volume 2: Photovoltaic Generators p 781-786 Aug. 1991
Copyright Avail: CASI HC A02/MF A03; ESA, EPD, Noordwijk, Netherlands, HC 150 Dutch guilders (2 vols)

A computer tool for the electrical design and space performance prediction for GaAs photovoltaic generator subsystems is presented; Electrical Characteristics Simulation (ECS) and Solar Array Electrical Degradation Simulation (SAEDS) softwares were developed. Electrical performance simulations of gallium arsenide liquid phase epitaxy solar cells, obtained by Single Exponential Model (SEM) and Double Exponential Model (DEM) are computed by ECS and then compared. The degradation factors of solar cells due to integration and environmental conditions as well as the thermal behavior of the solar panel are evaluated and implemented by SAEDS; a particular emphasis was devoted to the protection philosophy from the hot spot phenomena. A design demonstration for an Italian satellite to be injected into a LEO orbit is also given. ESA

N92-13275*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DEVELOPMENT OF A SINGLE-PHASE HARMONIC POWER FLOW PROGRAM TO STUDY THE 20 KHZ AC POWER SYSTEM FOR LARGE SPACECRAFT
L. ALAN KRAFT (Valparaiso Univ., IN.) and M. DAVID KANKAM Nov. 1991 37 p
(Contract RTOP 506-41-41)
(NASA-TM-105326; E-6687; NAS 1.15:105326) Avail: CASI HC A03/MF A01

The development of software is described to aid in design and analysis of AC power systems for large spacecraft. The algorithm is an important version of harmonic power flow program, HARMFLO, used for the study of AC power quality. The new program is applicable to three-phase systems typified by terrestrial power systems, and single-phase systems characteristic of space power systems. The modified HARMFLO accommodates system operating frequencies ranging from terrestrial 60 Hz to and beyond aerospace 20 kHz, and can handle both source and load-end harmonic distortions. Comparison of simulation and test results of a representative spacecraft power system shows a satisfactory correlation. Recommendations are made for the direction of future improvements to the software, to enhance its usefulness to power system designer and analysts. Author

N92-13484*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
IMPEDANCES OF LI/SO2 CELLS RETRIEVED FROM THE LONG DURATION EXPOSURE FACILITY (LDEF SATELLITE) AND COMPARISON WITH CELLS STORED TERRESTRIALLY
MARGARET A. REID Nov. 1991 9 p
(Contract RTOP 506-41-21)
(NASA-TM-104526; E-6400; NAS 1.15:104526) Avail: CASI HC A02/MF A01

Impedances were measured on several Li/SO2 cells retrieved from the Long Duration Exposure Facility (LDEF) satellite. These cells were used to power instruments and recorders and had all been partially or fully discharged. Impedances were also measured on several cells that were stored in cold storage since manufacture. Unfortunately, none of the cells stored terrestrially had undergone any discharge, whereas all of the cells on the satellite were at least partially discharged early in the mission and then remained on orbit for about 5 years further. It has been observed by others that storage of an Li/SO2 cell after partial discharge, increases the resistance and thickness of the passive film on the Li electrode, as indicated by an increase in the time for recovery of voltage when a load is applied (voltage lag), or in some cases by an inability of a cell to sustain a normal current after such storage. Since the cells stored terrestrially were not discharged in the same manner as the LDEF cells, a direct comparison cannot be made. Thus, the effects of the space environment cannot be separated from the effects of storage after partial discharge. It is believed that the increases in impedance in the LDEF cells are largely due to the storage upon partial discharge rather than the effects of the space environment. Author

N92-15120*# Valparaiso Univ., IN. Dept. of Electrical and Computer Engineering.
DEVELOPMENT OF SOFTWARE TO IMPROVE AC POWER QUALITY ON LARGE SPACECRAFT
L. ALAN KRAFT 31 Dec. 1991 30 p
(Contract NAG3-1254)
(NASA-CR-189511; NAS 1.26:189511) Avail: CASI HC A03/MF A01

To insure the reliability of a 20 kHz, AC power system on spacecraft, it is essential to analyze its behavior under many adverse operating conditions. Some of these conditions include overloads, short circuits, switching surges, and harmonic distortions. Harmonic distortions can cause malfunctions in equipment that the power system is supplying, and during extreme distortions such as voltage resonance, it can cause equipment and insulation failures due to the extreme peak voltages. HARMFLO, a power flow computer program, which was capable of analyzing harmonic conditions on three phase, balanced, 60 Hz, AC power systems, was modified to analyze single phase, 20 kHz, AC power systems. Since almost all of the equipment used on spacecraft power systems is electrically different from equipment used on terrestrial power systems, it was also necessary to develop mathematical models for the equipment to be used on the spacecraft. The results are that (1) the harmonic power now has a model of a single phase, voltage controlled, full wave rectifier; and (2) HARMFLO was ported to the SUN workstation platform. Author

N92-16018*# Sverdrup Technology, Inc., Brook Park, OH.
PHOTOVOLTAIC RECEIVERS FOR LASER BEAMED POWER IN SPACE Final Report
GEOFFREY A. LANDIS Dec. 1991 19 p Presented at the 22nd Photovoltaic Specialists Conference, Las Vega, NV, 8-11 Oct. 1991; sponsored in part by Inst. of Electrical and Electronics Engineers (IEEE)
(Contract NAS3-25266; RTOP 506-41-11)
(NASA-CR-189075; E-6699; NAS 1.26:189075) Avail: CASI HC A03/MF A01

There has recently been a resurgence of interest in the use of beamed power to support space exploration activities. One of the most promising beamed power concepts uses a laser beam to transmit power to a remote photovoltaic array. Large lasers can be located on cloud-free sites at one or more ground locations and illuminate solar arrays to a level sufficient to provide operating power. Issues involved in providing photovoltaic receivers for such applications are discussed. Author

N92-16291# Sandia National Labs., Albuquerque, NM.
FALCON REACTOR-PUMPED LASER TECHNOLOGY FOR SPACE POWER APPLICATIONS
D. A. MCARTHUR, G. N. HAYS, and P. S. PICKARD 1991 7 p Presented at the 6th International Conference on Emerging Nuclear Energy Systems, Albuquerque, NM, 12-16 Jan. 1992
(Contract DE-AC04-76DP-00789)
(DE91-018795; SAND-91-1774C; CONF-920133-1) Avail: CASI HC A02/MF A01

The FALCON reactor-pumped laser program is investigating concepts for high power laser systems pumped directly by fission energy from a nuclear reactor. The direct pumping of laser media with fission energy offers the potential system advantages of scaling to very high laser powers with long run times, extremely compact and low-mass energy storage, and relatively simple gain generator design. Reactor pumping has been studied in the ACRR and SPR research reactor facilities at Sandia National Laboratories. Based on these experiments and extensive system analysis, large reactor-pumped laser systems have been evaluated for extraction efficiency, beam quality, and practically (considering auxiliary power needs, radiation damage to optical components, rejection of waste heat, and expected imperfections in excitation structures). It appears that high-power reactor-pumped lasers can be developed in the near term to provide important capabilities for the exploration and utilization of space. DOE

N92-16481*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE NASA CSTI HIGH CAPACITY POWER PROGRAM
JERRY M. WINTER Sep. 1991 18 p Presented at the Conference on Advanced Space Exploration Initiative Technologies, Cleveland, OH, 4-6 Sep. 1991; sponsored by AIAA, and OAI Previously announced in IAA as A91-52493
(Contract RTOP 590-13-11)
(NASA-TM-105240; E-6567; NAS 1.15:105240; AIAA PAPER 91-3629) Avail: CASI HC A03/MF A01

The SP-100 program was established in 1983 by DOD, DOE, and NASA as a joint program to develop the technology necessary for space nuclear power systems for military and civil applications. During 1986 and 1987, the NASA Advanced Technology Program was responsible for maintaining the momentum of promising technology advancement efforts started during Phase 1 of SP-100 and to strengthen, in key areas, the chances for successful development and growth capability of space nuclear reactor power systems for future space applications. In 1988, the NASA Advanced Technology Program was incorporated into NASA's new Civil Space Technology Initiative (CSTI). The CSTI program was established to provide the foundation for technology development in automation and robotics, information, propulsion, and power. The CSTI High Capacity Power Program builds on the technology efforts of the SP-100 program, incorporates the previous NASA advanced technology project, and provides a bridge to the NASA exploration technology programs. The elements of CSTI high capacity power development include conversion systems: Stirling and

thermoelectric, thermal management, power management, system diagnostics, and environmental interactions. Technology advancement in all areas, including materials, is required to provide the growth capability, high reliability, and 7 to 10 year lifetime demanded for future space nuclear power systems. The overall program will develop and demonstrate the technology base required to provide a wide range of modular power systems while minimizing the impact of day/night operations as well as attitudes and distance from the Sun. Significant accomplishments in all of the program elements will be discussed, along with revised goals and project timelines recently developed. Author

N92-17769*# Boeing Aerospace Co., Huntsville, AL. Defense and Space Group.
TANDEM CONCENTRATOR PHOTOVOLTAIC ARRAY APPLIED TO SPACE STATION FREEDOM EVOLUTIONARY POWER REQUIREMENTS
EDWARD M. FISHER, JR. *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 2: Space Station Freedom, Part 1 p 729-764 Sep. 1991
Avail: CASI HC A03/MF A03

Additional power is required to support Space Station Freedom (SSF) evolution. Boeing Defense and Space Group, LeRC, and Entech Corporation have participated in the development of efficiency gallium arsenide and gallium antimonide solar cells make up the solar array tandem cell stacks. Entech's Mini-Dome Fresnel Lens Concentrators focus solar energy onto the active area of the solar cells at 50 times one solar energy flux. Development testing for a flight array, to be launched in Nov. 1992 is under way with support from LeRC. The tandem cells, interconnect wiring, concentrator lenses, and structure were integrated into arrays subjected to environmental testing. A tandem concentrator array can provide high mass and area specific power and can provide equal power with significantly less array area and weight than the baseline array design. Alternatively, for SSF growth, an array of twice the baseline power can be designed which still has a smaller drag area than the baseline. Author

N92-17771*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SPACE STATION FREEDOM ELECTRIC POWER SYSTEM EVOLUTION ANALYSIS STATUS
MICHAEL J. ZERNIC *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 2: Space Station Freedom, Part 1 p 813-833 Sep. 1991
Avail: CASI HC A03/MF A03

The ability is examined of the SSF baselined EPS to transition to operate at a greater system capacity beyond the SSF Permanent Manned Capability PMC) milestone. Specifically, a status of a current analysis is discussed concerning additions, modifications, changeout, or combination thereof of baseline EPS hardware and/or software needed to accomplish the power generation, distribution, operation, and use needed to meet evolving SSF mission objectives. This discussion results in several EPS architectural options that facilitate the addition or substitution of new technologies. Author

N92-17773*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AUTOMATED POWER MANAGEMENT AND CONTROL
JAMES L. DOLCE *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 2: Space Station Freedom, Part 1 p 853-883 Sep. 1991
Avail: CASI HC A03/MF A03

A comprehensive automation design is being developed for Space Station Freedom's electric power system. A joint effort between NASA's Office of Aeronautics and Exploration Technology and NASA's Office of Space Station Freedom, it strives to increase station productivity by applying expert systems and conventional algorithms to automate power system operation. The initial station operation will use ground-based dispatches to perform the necessary command and control tasks. These tasks constitute planning and decision-making activities that strive to eliminate unplanned outages. We perceive an opportunity to help these dispatchers make fast and consistent on-line decisions by automating three key tasks: failure detection and diagnosis, resource scheduling, and security analysis. Expert systems will be used for the diagnostics and for the security analysis; conventional algorithms will be used for the resource scheduling. Author

N92-17774*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
THE SSM/PMAD AUTOMATED TEST BED PROJECT
LOUIS F. LOLLAR *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 2: Space Station Freedom, Part 1 p 885-919 Sep. 1991
Avail: CASI HC A03/MF A03

The Space Station Module/Power Management and Distribution (SSM/PMAD) autonomous subsystem project was initiated in 1984. The project's goal has been to design and develop an autonomous, user-supportive PMAD test bed simulating the SSF Hab/Lab module(s). An eighteen kilowatt SSM/PMAD test bed model with a high degree of automated operation has been developed. This advanced automation test bed contains three expert/knowledge based systems that interact with one another and with other more conventional software residing in up to eight distributed 386-based microcomputers to perform the necessary tasks of real-time and near real-time load scheduling, dynamic load prioritizing, and fault detection, isolation, and recovery (FDIR). Author

N92-18926*# California Univ., Santa Barbara. Dept. of Mechanical and Environmental Engineering.
LONG TERM INTEGRITY FOR SPACE STATION POWER SYSTEMS
F. A. LECKIE and D. L. MARRIOTT (Illinois Univ., Urbana-Champaign.) Jan. 1991 69 p
(Contract NAG3-1218)
(NASA-CR-189910; NAS 1.26:189910) Avail: CASI HC A04/MF A01

A study was made of the High Temperature Design Codes ASME N47, British R5, and the French RCC-MR Rules. It is concluded that all these codes provide a good basis of design for space application. The new British R5 is the most complete since it deals with the problem of defects. The ASME N47 was subjected longer to practical application and scrutiny. A draft code is introduced, and a proposed draft for high temperature design in which attempts were made to identify gaps and improvements is suggested. The design is limited by creep characteristics. In these circumstances, life is strongly affected by the selected value of the factor of safety. The factor of safety of primary loads adopted in the codes is 1.5. Maybe a lower value of 1.25 is permissible for use in space. Long term creep rupture data for HAYNES 188 is deficient and it is suggested that extrapolation methods be investigated. Author

N92-20924# Tokyo Univ., Sagamihara (Japan).
BRAYTON-RANKINE TOTAL ENERGY SPACE DYNAMIC POWER SYSTEM ANALYSIS
ZHI-GUANG LING and KOICHI OSHIMA *In its* Proceedings of the Symposium on Mechanics for Space Flight 1990 p 69-80 Mar. 1991
Avail: CASI HC A03/MF A02

A study was made on combined Brayton-Rankine total energy space dynamic power system. Thermodynamic analysis and comparative calculation were performed for the system and the regenerative Brayton system. Results show that under space conditions even with water as the working fluid of the Rankine part, the thermal efficiency could be raised by 5 to 10 pct. at working point, in comparison with a regenerative Brayton system and with the existing technology for the Rankine system alone. An increase in steam turbine and pumps in comparison with regenerative Brayton system brought no significant reduction in system weight. Through radiator area analysis, the suggested total energy system shows no significant increase in radiation area. The spray radiator is more suitable for this purpose. Further

conceptional projective study is needed to proceed in the optimization of parameters and appropriate working substance together with the spray radiator condenser design considerations. Author

N92-21216*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EXPERIMENTS WITH PHASE CHANGE THERMAL ENERGY STORAGE CANISTERS FOR SPACE STATION FREEDOM
THOMAS W. KERSLAKE 1991 17 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 474-52-10)
(NASA-TM-104427; E-6102; NAS 1.15:104427) Avail: CASI HC A03/MF A01

The solar dynamic power module proposed for the Space Station Freedom (SSF) uses the heat of fusion of a phase change material (PCM) to efficiently store thermal energy for use during eclipse periods. The PCM, a LiF-20CaF2 salt, is contained in annular, metal canisters located in a heat receiver at the focus of a solar concentrator. PCM canister ground-based experiments and analytical heat transfer studies are discussed. The hardware, test procedures, and test results from these experiments are discussed. After more than 900 simulated SSF orbital cycles, no canister cracks or leaks were observed and all data were successfully collected. The effect of 1-g test orientation on canister wall temperatures was generally small while void position was strongly dependent on test orientation and canister cooling. In one test orientation, alternating wall temperature data were measured that supports an earlier theory of oscillating vortex flow in the PCM melt. Analytical canister wall temperatures compared very favorably with experimental temperature data. This illustrates that ground-based canister thermal performance can be predicted well by analyses that employ straight-forward, engineering models of void behavior and liquid PCM free convection. Because of the accuracy of analytical models and the relative insensitivity of 1-g performance to test orientation, canister performance in micro-g should be predictable with a high degree of confidence by removing gravity effects from the analytical modeling. Author

N92-21278*# Florida Inst. of Tech., Melbourne. Dept. of Computer Science.
PLANNING AND RESOURCE MANAGEMENT IN AN INTELLIGENT AUTOMATED POWER MANAGEMENT SYSTEM Final Report
ROBERT A. MORRIS *In* Texas A and M Univ., NASA/ASEE Summer Faculty Fellowship Program, 1991, Volume 1 16 p Dec. 1991
Avail: CASI HC A03/MF A03

Power system management is a process of guiding a power system towards the objective of continuous supply of electrical power to a set of loads. Spacecraft power system management requires planning and scheduling, since electrical power is a scarce resource in space. The automation of power system management for future spacecraft has been recognized as an important R&D goal. Several automation technologies have emerged including the use of expert systems for automating human problem solving capabilities such as rule based expert system for fault diagnosis and load scheduling. It is questionable whether current generation expert system technology is applicable for power system management in space. The objective of the ADEPTS (ADvanced Electrical Power management Techniques for Space systems) is to study new techniques for power management automation. These techniques involve integrating current expert system technology with that of parallel and distributed computing, as well as a distributed, object-oriented approach to software design. The focus of the current study is the integration of new procedures for automatically planning and scheduling loads with procedures for performing fault diagnosis and control. The objective is the concurrent execution of both sets of tasks on separate transputer processors, thus adding parallelism to the overall management process. Author

N92-21550# Midwest Research Inst., Golden, CO. National Renewable Energy Lab.
MEMBRANE DISH ANALYSIS: A SUMMARY OF STRUCTURAL AND OPTICAL ANALYSIS CAPABILITIES
C. R. STEELE, C. D. BALCH, G. J. JORGENSEN, T. WENDELIN, and A. LEWANDOWSKI Nov. 1991 196 p
(Contract DE-AC02-83CH-10093)
(DE91-002162; NREL/TP-253-3432) Avail: CASI HC A09/MF A03

Research at SERI within the Department of Energy's Solar Thermal Technology Program has focused on the development of membrane dish concentrators for space and terrestrial power applications. As potentially lightweight, inexpensive, high performance structures, they are excellent candidates for space-deployable energy sources as well as cost effective terrestrial energy concepts. A thorough engineering research treatment of these types of structures consists primarily of two parts: (1) structural mechanics of the membrane and ring support, and (2) analysis and characterization of the concentrator optical performance. It is important to understand the effects of the membrane's structure and support system on the optical performance of the concentrator. This requires an interface between appropriate structural and optical models. Until recently, such models and the required interface have not existed. This report documents research that has been conducted at SERI in this area. It is a compilation of several papers describing structural models of membrane dish structures and optical models used to predict dish concentrator optical and thermal performance. The structural models were developed under SERI subcontract by Dr. Steele and Dr. Balch of Stanford University. The optical model was developed in-house by SERI staff. In addition, the interface between the models is described. It allows easy and thorough characterization of membrane dish systems from the mechanics to the resulting optical performance. The models described herein have been and continue to be extremely useful to SERI, industry, and universities involved with the modeling and analysis of lightweight membrane concentrators for solar thermal applications. DOE

N92-21977*# Solar Kinetics, Inc., Dallas, TX.
DEVELOPMENT OF AN IMPROVED MIRROR FACET FOR SPACE APPLICATIONS Final Report
PAUL SCHERTZ, SHABBAR SAIFEE, and LUKE LAMMERT Oct. 1991 98 p
(Contract NAS3-25632; SBIR-10.01-2376)
(NASA-CR-189109; NAS 1.26:189109) Avail: CASI HC A05/MF A02

A fabrication technique was successfully developed for a metallic aluminum honeycomb, high-accuracy, lightweight, and long-life solar concentrator (mirror) for Advanced Solar Dynamic Space Power Systems. The program scope was limited to the development, fabrication, evaluation, and delivery of a solar concentrator facet (petal) that was sized for a 2-meter deployable solar concentrator. A surface accuracy of 1.0 mrad was achieved. The development incorporated tooling design, material selection, facet forming, adhesive selection, testing, and analysis. Techniques for applying levelizing, reflective, and protective optical coatings were also developed. Author

13

ELECTRONIC SYSTEMS & EQUIPMENT

Design and operation of electrical equipment such as motors, switch gear, connectors and other fixtures.

A92-10313
RADIATION REQUIREMENTS FOR ELECTRONIC COMPONENTS IN NUCLEAR AND SPACE ENVIRONMENTS
P. S. WINOKUR (Sandia National Laboratories, Albuquerque, NM)

IN: Electronic materials - Our future; Proceedings of the 4th International SAMPE Electronic Materials and Processes Conference, Albuquerque, NM, June 12-14, 1990 1990 6 p refs
Copyright

The operation of integrated circuits in severe radiation environments is reviewed with specific requirements for silicon-based circuits and attention to the effects of 'total-dose' ionizing radiation on MOS structures. Four types of radiation effects are discussed for MOS and bipolar circuits in which electron holes in SiO2 components are produced by ionizing radiation. Electron-hole generation and recovery and single-event upsets are described, and system responses corresponding to the circuit defects are listed. C.C.S.

A92-10320
DEVELOPMENT OF A THERMAL TRANSFER ADHESIVE FOR SPACE ELECTRONICS
RALPH D. HERMANSEN, ROBERT B. MITSUHASHI, JAMES C. CAMMARATA, and MATTHEW T. MIKA (Hughes Aircraft Co., El Segundo, CA) IN: Electronic materials - Our future; Proceedings of the 4th International SAMPE Electronic Materials and Processes Conference, Albuquerque, NM, June 12-14, 1990 1990 9 p
Copyright

Because commercially available adhesives do not meet the requirements for application to space electronics, a film adhesive is developed for use under flatpacks to conduct heat from the printed wiring board. Requirements for the adhesive include NASA outgassing criteria, thermal conductivity, flexibility, and the abilities to resist solvents and insulate from electricity. Tests are reported for 40 epoxy formulations to find those with fast cures at 93 C and low cohesive strength. The resulting film adhesive on glass cloth is tested, and the characteristics are presented including thermal, mechanical, and electrical properties and outgassing performance. Total mass loss is less than the 1 percent allowed by NASA, and the collected volatile condensible material meets the maximum requirement. The film adhesive is found to be an effective material for applications in the electronics components of spacecraft. C.C.S.

A92-12051
THEORY AND OBSERVATION OF TRIPLE-ROOT JUMP IN SPACECRAFT CHARGING
SHU T. LAI (USAF, Phillips Laboratory, Hanscom AFB, MA) Journal of Geophysical Research (ISSN 0148-0227), vol. 96, Nov. 1, 1991, p. 19,269-19,281. 1 Nov. 1991 13 p refs

Sudden onsets of high-voltage differential charging on spacecraft in an ambient environment may affect operations and the survival of on-board electronics. Triple-root jumps may be very sudden. The paper discusses two aspects, one theoretical and one observational. By using current balance, the theoretical parametric domain in which triple-root jumps may occur for a surface material in a double Maxwellian electron environment has been calculated. The relation between the domain and the 'critical' or 'threshold' temperature for a material is revealed. An example of the prediction of the occurrence of a triple-root spacecraft potential jump in a time-varying space environments is presented. Author

A92-14682* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CORRELATING THE EMC ANALYSIS AND TESTING METHODS FOR SPACE SYSTEMS IN MIL-STD-1541A
REINALDO J. PEREZ (JPL, Pasadena, CA) IN: IEEE 1990 International Symposium on Electromagnetic Compatibility, Washington, DC, Aug. 21-23, 1990, Record 1990 8 p refs
Copyright

A study was conducted to improve the correlation between the electromagnetic compatibility (EMC) analysis models stated in MIL-STD-1541A and the suggested testing methods used for space systems. The test and analysis methods outlined in MIL-STD-1541A are described, and a comparative assessment of testing and analysis techniques as they relate to several EMC areas is presented. Suggestions on present analysis and test methods are introduced to harmonize and bring the analysis and testing tools in MIL-STD-1541A into closer agreement. It is suggested that test procedures in MIL-STD-1541A must be improved by providing alternatives to the present use of shielded enclosures as the primary site for such tests. In addition, the alternate use of anechoic chambers and open field test sites must be considered. I.E.

A92-14724 National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SPACE APPLICATIONS OF HIGH TEMPERATURE SUPERCONDUCTIVITY TECHNOLOGY
D. J. CONNOLLY, P. R. ARON, R. F. LEONARD (NASA, Lewis Research Center, Cleveland, OH), and E. G. WINTUCKY (NASA, Washington, DC) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p refs
(IAF PAPER 91-307) Copyright

A review is presented of the present status of high temperature superconductivity (HTS) technology and related areas of potential space application. Attention is given to areas of application that include microwave communications, cryogenic systems, remote sensing, and space propulsion and power. Consideration is given to HTS phase shifters, miniaturization of microwave filters, far-IR bolometers, and magnetic refrigeration using flux compression. R.E.P.

A92-16310* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ON THE REFLECTIVITY OF COMPLEX MESH SURFACES
WILLIAM A. IMBRIALE, VICTOR GALINDO-ISRAEL (JPL, Pasadena, CA), and YAHYA RAHMAT-SAMII (California, University, Los Angeles) IEEE Transactions on Antennas and Propagation (ISSN 0018-926X), vol. 39, Sept. 1991, p. 1352-1365. Sep. 1991 14 p refs
Copyright

Poorer than expected surface reflectivity was observed in an early Tracking and Data Relay Satellite System antenna utilizing a tricot mesh weave. This poor reflectivity was determined to be caused by inadequate electrical contact at wire crossover points. A proper mathematical and numerical approach to assess the impact of wire junctions on reflectivity performance is developed. A mathematical method is presented for computing the surface reflectivity of complex mesh configurations like those on unfurlable-type spacecraft antennas. The method is based on the Floquet mode expansion to establish an integral equation for mesh wire currents. The equation is solved using the method of moments with triangular basis functions. It is observed that it is necessary to give special attention to the junction treatment among different branches of the mesh configurations. A vector junction current approach that resulted in satisfactory solutions for the current is described. The results of numerical simulations are compared against measured data and excellent agreement is observed. I.E.

A92-24359#
APPLICATIONS OF SMARTLY DESIGNED RADIATION HARDENED GATE ARRAYS IN SPACE MAINTENANCE AND LOGISTICS SUPPORT OF SPACE STATION FREEDOM
F. SEPEHRY-FARD (F.S.F. Research Technologies, Inc., Pierrefonds, Canada) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 4 p refs
(AIAA PAPER 91-4104) Copyright

It is shown that smartly designed radiation-hardened application-specific integrated circuits (ASICs) with their high complexity, can easily support large systems with embedded BIT to detect and isolate failures. The use of redundancy does not limit the designer as far as weight, space, and power requirements are concerned. These advantages translate to a system that is more reliable for use in Space Station Freedom and is available with considerably reduced life cycle costs. ASICs also reduce crew maintenance time, either by reducing intravehicular activity or EVA. C.D.

N92-11139*# Sverdrup Technology, Inc., Brook Park, OH.
EVALUATION OF KAPTON PYROLYSIS, ARC TRACKING, AND ARC PROPAGATION ON THE SPACE STATION FREEDOM (SSF) SOLAR ARRAY FLEXIBLE CURRENT CARRIER (FCC) Final Report
THOMAS J. STUEBER Nov. 1991 8 p Presented at the 22nd Photovoltaic Specialists Conference, Las Vegas, NV, 7-11 Oct. 1991; sponsored by IEEE
(Contract NAS3-25266; RTOP 474-46-10)
(NASA-CR-189056; E-6655; NAS 1.26:189056) Avail: CASI HC A02/MF A01

Recent studies involving the use of polyimide Kapton coated wires indicate that if a momentary electrical short circuit occurs between two wires, sufficient heating of the Kapton can occur to thermally char (pyrolyze) the Kapton. Such charred Kapton has sufficient electrical conductivity to create an arc which tracks down the wires and possibly propagates to adjoining wires. These studies prompted an investigation to ascertain the likelihood of the Kapton pyrolysis, arc tracking and propagation phenomena, and the magnitude of destruction conceivably inflicted on Space Station Freedom's (SSF) Flexible Current Carrier (FCC) for the photovoltaic array. The geometric layout of the FCC, having a planar-type orientation as opposed to bundles, may reduce the probability of sustaining an arc. An experimental investigation was conducted to simulate conditions under which an arc can occur on the FCC of SSF, and the consequences of arc initiation. Author

N92-13158# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
INPUT FILTER DESIGN MADE EASY WITH AVERAGED CURRENT CONDUCTANCE CONTROL
P. PEROL and A. CRAUSAZ *In its* European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 33-38 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

The Y model for an average current programmmed buck regulator (also called conductance control) is established, and the conditions of minimum influence of an input filter on the characteristics of the converter in this type of regulation are presented. All these conditions can be reduced to a single one which is that the output impedance of the input filter should be kept low as compared to the input impedance of the converter. As the conductance control technique is very much design oriented, it is easy to design the converter in such a way that the current loop is damping the input impedance of the converter so much that it is reduced to the output load reflected in the input. A straightforward method to design an input filter with the electromagnetic compatibility requirements is described and some ratios on input filters for MKL capacitors and massively parallel processor cores are given. ESA

N92-13160# Universidad Politecnica de Catalunya (Spain). Dept. de Ingenieria Electronica.
LARGE SIGNAL MODELLING AND ANALYSIS OF SEPIC CONVERTER USING CONTINUOUS FORMULATION APPROACH
F. GUINJOAN (Universidad Politecnica de Catalunya (Spain).), A. POVEDA (Universidad Politecnica de Catalunya (Spain).), L. MARTINEZ (Universidad Politecnica de Catalunya (Spain).), L. G. DEVICUNA (Universidad Politecnica de Catalunya (Spain).), J. MAJO (Universidad Politecnica de Catalunya (Spain).), J. C. MARPINARD (Laboratoire d'Automatique et d'Analyse des Systemes, Toulouse (France).), and M. VALENTIN (Laboratoire d'Automatique et d'Analyse des Systemes, Toulouse, France) *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 47-52 Aug. 1991 Sponsored by Accion Integrada Hispano-Francesca
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

The continuous formulation approach was developed for large signal modeling and analysis of switching DC-DC converters operating in both continuous and discontinuous conduction mode. This technique can also be applied to the modeling and analysis of a complex power stage such as the SEPIC power converter. As a result, a nonlinear continuous formulation is obtained in the form of block diagram, which can be used to simulate this converter behavior under large signal conditions by means of general purpose programs such as CSMP. ESA

N92-13161# Machine-Building Inst., Severodvinsk (USSR).
SWITCHING DC-DC CONVERTERS WITH MAXIMAL SPEED OF RESPONSE WITH POWER SOURCE ON BASE OF ON-BOARD POWER SUPPLIES IMITATOR
A. S. ISKHAKOV (Marine Engineering Univ., Leningrad (USSR).), Y. N. KIREEV (Marine Engineering Univ., Leningrad (USSR).), S. G. OBUKHOV (Academy of Sciences, USSR, Moscow), and A. V. USHAKOV *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 53-55 Aug. 1991
Copyright Avail: CASI HC A01/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

The onboard power supplies imitation in the ground conditions require the power source and the onboard power supply be designed with external characteristics. When the load is powered from the imitator, for the purpose of stable voltage, a voltage controller with high fast response is necessary. One in fast response controller structure, built on the basis of a Pulse Width Modulator (PWM), is described. The fast response controller synthesis was performed by using difference equations, describing the closed loop system dynamics. ESA

N92-13163# Escuela Tecnica Superior de Ingenieros Industriales, Madrid (Spain). Div. de Ingeneria Electronica.
DESIGN OF A FORWARD ZVS-MRC. PRACTICAL CONSIDERATIONS
J. A. COBOS (Universidad Politecnica de Madrid (Spain).), J. ARAU (Instituto de Investigaciones Electricas, Mexico City (Mexico).), J. SEBASTIAN (Universidad Politecnica de Madrid (Spain).), J. UCEDA (Universidad Politecnica de Madrid (Spain).), R. LORENZO (Alcatel Standard Electrica S.A., Madrid (Spain).), and L. R. CASTELL (Alcatel Standard Electrica S.A., Madrid, Spain) *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 63-68 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

Keeping in mind necessary size reduction in computer equipment, ZVS-MRC (Zero Voltage Switching - Multi Resonant Converters) have taken a strategic place in onboard power supply developments, due to the feasibility of working at high frequencies. The effect in the forward ZVS-MRC performance of the most critical parameters, design guidelinees, and several practical considerations are presented. ESA

N92-13164# Universidad Nacional Autonoma de Mexico, Cuernavaca. Inst. de Investigaciones Electricas.
PULSED LOAD OPERATION IN DC/DC CONVERTERS. A CRITICAL EVALUATION
J. ARAU (Instituto de Investigaciones Electricas, Mexico City (Mexico).), J. UCEDA (Universidad Politecnica de Madrid (Spain).), J. SEBASTIAN (Universidad Politecnica de Madrid (Spain).), J. A. COBOS (Universidad Politecnica de Madrid (Spain).), and F. ALDANA (Escuela Tecnica Superior de Ingenieros Industriales, Madrid, Spain) *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 69-74 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

The nonlinear nature of the DC/DC converters makes accurate study of them difficult when using common small signal techniques to linearize the converter about a quiescent operating point in which the nonlinear terms are neglected (assume infinitesimal variations in the averaged state variables). The importance of this assumption appears strongly affected when it is found that it is not possible to ensure the complete large signal stability about

the quiescent operating point by designing with small signal techniques when the converter works in a large perturbation environment of the state variables. Using large signal modeling techniques, a critical evaluation about a pulsed load operation on the basic DC/DC converters is presented. The necessary constraints which use small signal techniques to study the transient response with acceptable accuracy in typical large signal operation are explored. ESA

N92-13165# TRW Space Technology Labs., Redondo Beach, CA.
FURTHER PROGRESS IN IMPROVING THE EFFICIENCY OF HIGH-FREQUENCY SATURABLE-CORE OUTPUT REGULATORS
HORACIO E. GAVIRA *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 77-82 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

Refinements on the design of high frequency saturable core output regulators are discussed. Improved passive techniques to minimize the detrimental effect of parasitic reset are introduced. The new breakthrough improves the efficiency and utilization of saturable core output regulators, or magamp post regulators, in ways which the performance and efficiency remain optimal even when the power converter is working under conditions of minimum input voltage. The results show an improvement of more than 18 percent on the utilization of magamp post regulator operating at 5000 kHZ. This is achieved by a simple magnetic timer element that provides a brief, controlled surge of current that balances, on cycle by cycle basis, the rectifier's recovered charge thus ensuring that the volt seconds capability of the saturable reactor is maximized. A computer model is created that shows an excellent match between analysis and test results. This model clearly identifies several circuit characteristics which add valuable information to the overall findings. ESA

N92-13166# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
LOW IMPEDANCE PWM SWITCH AND SOLID STATE SWITCH
M. MARTINALFONSO and INIGO SEGURAYDIAZDEESPADAS *In its* European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 83-88 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

Two of the main concerns in the design of any of the components of a spacecraft subsystem are its mass and its size. That is why the use of any magnetic element has to be justified by a gain in the efficiency of the subsystem and has to be avoided as long as the efficiency is not degradated. This is applicable to protection devices such as Limit Cycle Current Control (LCCC) and the Solid State Power Controller (SSPC) type. The advantage of LCCC type current limiter is the capability of poviding current limitation indefinitely while the SSPC has a limited current capability in order to keep the device operation in its rated temperature. Two different types of current limiters which are actually the state of the art, the Pulse Width Modulated (PWM) switch and the SSPC, are dealt with. ESA

N92-13169# Surrey Univ., London (England). Dept. of Electronic and Electrical Engineering.
AN EFFICIENT STEP-UP/DOWN DC PREREGULATOR FOR SPACE APPLICATIONS
T. G. FOLEY and D. C. HAMILL *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 99-105 Aug. 1991 Sponsored by RAE
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

When a DC-DC converter is fed by a widely varying input voltage, it is sometimes advantageous to employ a preregulator rather than include this function in the main converter. A suitable preregulator topology consists of a standard buck converter and boost converter in cascade, with a shared choke. The circuit is capable of both step up and step down operations, and can have high efficiency and low choke mass. An experimental preregulator power circuit employing MOSFET's switching at 100 kHz accepts an input voltage of 25 to 100 V and delivers 50 V at 3.5 to 14A. Its measured efficiency is 94 to 98 pct., depending on input voltage and output current. ESA

N92-13170# Kobe Univ. (Japan). Dept. of Electrical Engineering.
A NOVEL SOFT-SWITCHING SINEWAVE PWM CONVERSION CIRCUIT AND SYSTEM WITH HIGH-FREQUENCY LINK
H. YONEMORI, K. MUNETO, A. CHIBANI, and M. NAKAOKA *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 107-112 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

A newly improved sinewave CVCF Power Conversion conditioning System (PCS) based upon a high frequency (HF) isolated AC link cycloconversion circuit using softswitching phase shifted pulse width modulation and instantaneous voltage regulation schemes is presented. This advanced circuit topology of voltage clamped quasi-resonant (QR) switch, which comprises two cascaded power conversion stages operating under the principle of Zero Voltage Switching (ZVS), is introduced in order to minimize switching losses, device stresses, electromagnetic interference noise, and remove a complicated HFAC snubber. A considerable improvement in power density output performance and power conversion efficiency is achieved employing a HF link soft switched cycloinversion concept. Its working principle is described including control processing strategy. A voltage clamped QR sinewave PSM HFAC inverter is analyzed under load dependent current source model and its approximate circuit design approach is discussed theoretically. The computer aided simulating and experimental results are illustrated and evaluated for UPS and utility lineinterfaced power supply systems. ESA

N92-13175# Universidad Politecnica de Barcelona (Spain). Industrial Electronics Group.
ALTERNATIVE PHOTOVOLTAIC ENERGY CONTROL BY 16 BIT MICROPROCESSORS: PERFORMANCES AND TIME CONSTRAINTS
JOSEP BORDONAU and JUAN PERACAULA *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 151-156 Aug. 1991
(Contract CICYT-87-0193)
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

Eesults obtained with an experimental system using microcomputer control of a DC/DC switched mode power converter fed from photovoltaic solar panels are presented. The control system maintains a constant output voltage regardless of the illumination and charge variations. The digital control presents the advantages of: avoiding derivation of reference values; the ease of controller parameter adjustment and facility to cover a large number of working regimes of photovoltaic panels; and the DC/DC power converter. A Proportional Integral Derivative (PID) algorithm is used for the controller. Optional offline pre-use test, PID parameter adjustment and output voltage fixing are very easy to carry through by means of an externally connectable terminal keyboard. ESA

N92-13177# Kobe Univ. (Japan). Dept. of Electrical Engineering.
ZERO-VOLTAGE SOFT-SWITCHED PWM HIGH-FREQUENCY AC-LINK DC-DC CONVERTERS INCORPORATING SATURABLE REACTOR-ASSISTED CAPACITIVE LOSSLESS SNUBBER TOPOLOGY FOR DISTRIBUTED POWER SUPPLY SYSTEMS
S. NAGAI (Kobe Univ. (Japan).), T. YAMAMOTO (Kobe Univ. (Japan).), M. NAKAOKA (Kobe Univ. (Japan).), and S. HAMADA

(Sansha Electric Mfg. Co. Ltd., Japan) *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 165-171 Aug. 1991
 Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

A new constant frequency soft switching phase shifted mode Pulse Width Modulated (PWM) DC-DC power converter topology suitable for high power applications, which incorporates two phase half bridge high frequency inverter and saturable reactor in series with rectifier, is described. The newly proposed high power density converter with high frequency isolation link is capable of accomplishing an efficient and reliable Zero Voltage Switching (ZVS) under a considerable variation range from no load to full load and a wide voltage regulation range. Its steady state operating characteristics are evaluated and discussed through computer aided simulation which are required for an optimum converter design and experimental results. ESA

N92-13179# Birmingham Univ. (England). School of Electronic and Electrical Engineering.
A COMPARISON OF PHASE-SHIFT CONTROLLED RESONANT AND SQUARE-WAVE CONVERTERS FOR HIGH POWER ION ENGINE CONTROL
A. J. FORSYTH, P. D. EVANS, M. R. AL-MOTHAFAR, and K. W. E. CHENG *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 179-185 Aug. 1991
 Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

Two alternative power converter topologies which are under consideration for the constituent modules of the UK-25 ion thruster main beam supply are compared. Both converter topologies operate at fixed frequency and with zero voltage switching conditions. The first is a square wave topology, while the second is a series resonant converter. The converter operation and characteristics are described, the zero voltage switching load range is quantified and practical results are included to illustrate the attainable performance. ESA

N92-13180# Alcatel Kirk ASD A/S, Ballerup (Denmark).
SMALL SIZE DC/DC CONVERTER FOR REGULATED POWER BUSES
P. T. FREDERIKSEN (Alcatel Kirk ASD A/S, Ballerup (Denmark).), M. NYMAND (Alcatel Kirk ASD A/S, Ballerup (Denmark).), O. S. SEIERSEN (Scanpower, Horsholm (Denmark).), and ALAN H. WEINBERG (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 187-190 Aug. 1991
 Avail: CASI HC A01/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

A standardized board mountable power supply module is presented. The converter is optimized for regulated power buses using a low headroom linear regulator followed by a fixed frequency multiresonant zero voltage zero current switching converter. The converter has three output voltages featuring extremely good cross regulation obtained by a new patented distributed tuning technique. Other features are: very low switching noise, inherent input short circuit protection, no overvoltage failure mode, active inrush current limiting, power density 10 W/cubic in. using space qualified or qualifiable components. ESA

N92-13182# Rockwell International Corp., Canoga Park, CA. Rocketdyne Div.
PRIMARY POWER CONVERSION IN THE SPACE STATION FREEDOM
HENRY LEE (Rockwell International Corp., Canoga Park, CA.), C. Q. LEE (Illinois Univ., Chicago.), S. SOOKSATRA (Illinois Univ., Chicago.), K. SIRI (Illinois Univ., Chicago.), and T. F. WU (Illinois Univ., Chicago.) *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 199-204 Aug. 1991
 Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

The overall system requirements of the power converter system designed to supply the power needed for the station loads are presented. The converter module used for this application is the current fed push pull converter. The converter analysis is presented. This includes the large signal, small signal closed loop control. Simulations and experimental results are used to confirm the theoretical work. The prototype unit was developed by using specially designed power components, which exhibits power conversion efficiency of more than 92 percent. In the closed loop control, small signal analysis for the converter using the state space averaging method is presented. The interaction between the line filter and the power stage input impedance in the closed loop system was also investigated. ESA

N92-13183# Santa Catarina Univ., Florianopolis (Brazil).
A FAMILY OF HALF-BRIDGE PWN ZERO-VOLTAGE SWITCHING CONVERTERS, EMPLOYING SWITCHED CAPACITOR SNUBBER
IVO BARBI and HELIO LEAES HEY (Universidade Federal de Uberlandia, Brazil) *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 205-210 Aug. 1991
 Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

A class of soft switching half bridge DC-DC Converters regulated by Pulse Width Modulation (PWM), where the transistors commutate at zero voltage are introduced. The full bridge DC-DC Converter, because of three level modulation, can be regulated by PWM with ZVS (Zero Voltage Switching), employing the phase shift technique. However, the same technique is not applicable to the half bridge converters because each commutation cell can provide only two voltage levels. In this case, a switched capacitor snubber is proposed to allow ZVS and PWM simultaneously. Principle of operation, theoretical analysis, commutation analysis, design procedure and example and experimental results of the new class of converters are presented. It is believed that the proposed technique is suitable for high power isolated multi output power supplies applications. ESA

N92-13185# Wisconsin Univ., Madison. Applied Superconductivity Center.
SUPERCONDUCTIVE MAGNETIC ENERGY STORAGE (SMES) FOR SPACE APPLICATIONS
Y. M. EYSSA (Wisconsin Univ., Madison.), R. W. BOOM (Wisconsin Univ., Madison.), X. HUANG (Wisconsin Univ., Madison.), M. A. HILAL (Wisconsin Univ., Madison.), M. K. ABDELSALAM (Wisconsin Univ., Madison.), L. O. EL-MARAZKI (Wisconsin Univ., Madison.), and M. J. SUPERCZYMSKI (David Taylor Research Center, Annapolis, MD.) *In* ESA, European Space Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 219-224 Aug. 1991
(Contract N00167-87-K-0095)
 Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

SMES conceptual designs of solenoids and toroids for space use are developed and assessed as to: storage efficiency versus weight and volume, power capability, cooling requirements; and storage system reliability. Innovative uses of light weight structures and conductors are explored. A credible solenoid design demonstrates energy/weight densities comparable to batteries and power/weight densities and lifetimes far superior to batteries. Example systems described are: a rippled solenoid storage unit sized to fit in the Space Shuttle, and toroidal or multisolenoidal units with minimum external fields. ESA

N92-13198# Fabrica Italiana Apparecchiature Radioelettriche S.p.A., Milan. Space Div.
NEW EPC FOR 130W RF TWTA FOR KU-BAND DBS APPLICATIONS
M. GAMBARARA and L. CERUTI *In* ESA, European Space

Power Conference. Volume 1: Power Systems, Power Electronics, Batteries and Fuel Cells p 311-316 Aug. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, Noordwijk, Netherlands, HC 120 Dutch guilders (2 vols)

A new Electric Power Converter (EPC) developed in the frame of an ESA contract aimed at the design, manufacture and qualification of a 130W RF Travelling Wave Tube Amplifier (TWTA) for Direct Broadcast Satellites (DBS) applications is presented. The main objective was the improvement of the most important characteristics requested to today's EPCs, in particular the mass, the efficiency and the cost. The EPC was designed to interface both regulated and unregulated buses in a range from 27 to 50 V with an efficiency measured on the breadboard of 91.8 pct. at 43 V MB. The unit is able to operate also during critical pressure conditions; in spite of the penalities that this performance gives (the complete potting of the high voltage circuits is needed), the mass has been maintained below 2800 grams. ESA

N92-14294*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MULTI-MEGAWATT INVERTER/CONVERTER TECHNOLOGY FOR SPACE POWER APPLICATIONS
IRA T. MYERS (Schafer (W. J.) Associates, Inc., Arlington, VA.), ERIC D. BAUMANN, ROBERT KRAUS, and AHMAD N. HAMMOUD (Sverdrup Technology, Inc., Brook Park, OH.) 1992 11 p Proposed for presentation at the Ninth Symposium on Space Nuclear Power Systems, Albuquerque, NM, 12-16 Jan. 1992; sponsored by the Institute for Space Nuclear Power Studies
(Contract NAS3-25266; RTOP 506-41-41)
(NASA-TM-105307; E-6543; NAS 1.15:105307) Avail: CASI HC A03/MF A01

Large power conditioning mass reductions will be required to enable megawatt power systems envisioned by the Strategic Defense Initiative, the Air Force, and NASA. Phase 1 of a proposed two phase interagency program has been completed to develop an 0.1 kg/kW DC/DC converter technology base for these future space applications. Three contractors, Hughes, General Electric (GE), and Maxwell were Phase 1 contractors in a competitive program to develop a megawatt lightweight DC/DC converter. Researchers at NASA Lewis Research Center and the University of Wisconsin also investigated technology in topology and control. All three contractors, as well as the University of Wisconsin, concluded at the end of the Phase 1 study, which included some critical laboratory work, that 0.1-kg/kW megawatt DC/DC converters can be built. This is an order of magnitude lower specific weight than is presently available. A brief description of each of the concepts used to meet the ambitious goals of this program are presented. Author

N92-14775*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CUSTOM MICROCIRCUITS
In its Center for Space Microelectronics Technology p 83-87 15 Jul. 1991
Avail: CASI HC A01/MF A01

The goals of this program are to develop custom microcircuit technology, also known as Application Specific Integrated Circuit (ASIC) technology, for use in flight and ground programs. Supporting this effort are activities to investigate the effects of the space environment, and particularly ionizing radiation, on microcircuits and to develop a space qualification methodology. Another aspect of the program emphasizes innovative applications of custom microcircuit technology to image and signal processing and communications. Author

N92-15305*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EXPERIMENTAL MEASUREMENTS OF SPACE STATION ANTENNA PATTERNS AT 60 GHZ FOR EM ANALYSIS VERIFICATION
W. ROBERT YOUNG, BERKLEY A. LANGFORD, JR., and ROGER K. VAUGHAN (Lockheed Engineering and Sciences Co., Hampton, VA.) Oct. 1991 23 p
(Contract RTOP 505-64-70-01)
(NASA-TM-102632; NAS 1.15:102632) Avail: CASI HC A03/MF A01

Complex body scattering is a major problem facing the electromagnetic researcher today. Computer codes are one important method for predicting such scattering. With funding from Langley, Ohio State University has developed such a code. A 30:1 scale model of the Space Station was constructed to be used as a scattering target in the verification of this code. The purpose here is to document the methods used to make these measurements and present the results which will be used by others for code verification. Author

N92-19253# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Etudes et de Recherches en Technologie Spatiale.
DIELECTRICAL DISCHARGES, PLASMA PRODUCED, AND FUNCTIONAL ANOMALIES ON SATELLITES [DECHARGES ELECTRIQUES, PLASMA EMIS ET ANOMALIES DE FONCTIONNEMENT SUR SATELLITES]
LEON LEVY (Centre d'Etudes et de Recherches, Toulouse (France).), A. R. FREDERICKSON (Centre d'Etudes et de Recherches, Toulouse (France).), and C. L. ENLOE (Air Force Geophysics Lab., Hanscom AFB, MA.) 1991 18 p In FRENCH; ENGLISH summary Sponsored by Direction des Recherches, Etudes et Techniques
(ETN-92-90862) Avail: CASI HC A03/MF A01

Many satellites have suffered from anomalies ascribed to charging and discharging reactions with their environment. The plasma expelled in these discharges is studied in the laboratory. Secondary discharges appear in the vicinity of the plasma of the primary discharge. The electrical charge levels required to produce these secondary discharges are calculated. The geometric and volumetric extension of the plasma necessary to give rise to secondary discharges is determined. Ways in which such primary and secondary discharges could be the cause of anomalies are investigated. ESA

N92-19254# Centre d'Etudes et de Recherches, Toulouse (France). Dept. d'Etudes et de Recherches en Technologie Spatiale.
THE ROLE OF HIGH PENETRATION ELECTRONS IN PRODUCING ANOMALIES IN SATELLITES Final Report [ROLE DES ELECTRONS ENERGETIQUES (PENETRANTS) DANS LE DECLENCHEMENT D'ANOMALIES SUR SATELLITES. RAPPORT FINAL]
LEON LEVY Mar. 1991 45 p In FRENCH
(Contract DRET-89-1454-DS-SR)
(CERT-430300/RF; ETN-92-90863) Avail: CASI HC A03/MF A01

Discharge induced anomalies in satellites are studied from an original perspective. Working under the hypothesis that a plasma is the product of a discharge or that it is the vector of discharge propagation, the electric charge of the discharge is measured. Secondary discharges are found at charge levels as low as 50 volts. The plasma ejected and the charge pressure build up that accompany the primary discharges are determined to be the most likely causes of these low energy level secondary discharges. ESA

14

DATA & COMMUNICATION SYSTEMS

Communication and data storage or retrieval systems. Includes control systems and also computer networks and software.

A92-12449
ARIADNE: MUSC MICROGRAVITY INFORMATION SYSTEM - APPLICABLE FOR REAL-TIME EXPERIMENT OPERATIONS TO BIBLIOGRAPHIC RETRIEVAL
T. WEBER, D. PADEKEN, H. HANZ, S. OHM, H. DUWE, and D. WILKE (DLR, Cologne, Federal Republic of Germany) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p refs
(IAF PAPER 91-028) Copyright

MUSC's information system Ariadne, which will accompany the complete life cycle of a microgravity experiment, is discussed. Ariadne's hierarchically grouped software processing functions are based on a database consisting of a relational, a bibliographical, and a real-time part, and includes an application program library. The Ariadne database architecture is examined, and each function of the function hierarchy is explained and its input and output are described. A flow diagram of the experiment execution is shown and discussed. C.D.

A92-12494
A COMPREHENSIVE APPROACH FOR COLUMBUS DMS VERIFICATION
D. PERARNAUD, J. P. CAU, and J. C. GUILLEN (Matra Marconi Space, Toulouse, France) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 11 p. Oct. 1991 11 p
(IAF PAPER 91-087) Copyright

An overview of the data management system (DMS) hardware and software architecture is presented and the development cycle is analyzed. The approach, methods and tools employed in the successive phases of specification, design, manufacturing, integration and test are discussed. It is shown how the DMS supports a key role in the development, integration and verification of the other subsystems, the payloads and the overall system. R.E.P.

A92-17603#
SPACE STATION FREEDOM ARTIFICIAL INTELLIGENCE ENGINEERING AND INTEGRATION
DONALD WOODS (McDonnell Douglas Corp., Houston, TX) IN: AIAA Computing in Aerospace Conference, 8th, Baltimore, MD, Oct. 21-24, 1991, Technical Papers. Vol. 1 1991 9 p refs
(AIAA PAPER 91-3852) Copyright

Space Station Freedom will be one of the most complex engineered systems ever taken into a hostile environment, compounding this is the fact that it will also be assembled in that environment over a period of years. The Data Management System (DMS) of Space Station Freedom (SSF) will provide a distributed real time computational environment built from commercially available technology (but adapted to the space environment) which will be able to support the deployment of Knowledge Based Systems (KBS). Various projects are leveraging Artificial Intelligence (AI) technology to enhance the capabilities of the Space Station. Author

A92-17630*# 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 (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA Computing in Aerospace Conference, 8th, Baltimore, MD, Oct. 21-24, 1991, Technical Papers. Vol. 2 1991 10 p refs
(AIAA PAPER 91-3770) Copyright

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 386/387 DX memory hierarchy appears to be the most beneficial change to the current DMS design at this time. Author

A92-17631*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NASA INFORMATION SYSTEMS COMMONALITY AND CONVERGENCE
THOMAS H. HANDLEY, JR. and LARRY E. PREHEIM (JPL, Pasadena, CA) IN: AIAA Computing in Aerospace Conference, 8th, Baltimore, MD, Oct. 21-24, 1991, Technical Papers. Vol. 2 1991 13 p refs
(AIAA PAPER 91-3771) Copyright

Efforts to identify high payback functions performed by the Office of Space Science Applications (OSSA) data systems package existing operationally proven implementations as system building blocks and foster their use in the OSSA environment. An overview is given of the current state of OSSA data systems and the major challenges facing system developers over the next five years. Current trends in system commonality are discussed, and development is examined in the context of system design. Central system engineering approaches to solving the commonality and interoperability challenges are described. Efforts to package three diverse building blocks and to foster their reuse are documented. C.D.

A92-17646*# Mitre Corp., Houston, TX.
A FAILURE DIAGNOSIS AND RECOVERY PROTOTYPE FOR SPACE STATION FREEDOM
CHRISTOPHER A. MARSH, C. J. GUYSE, DAVID G. HAMMEN, and CHRISTINE M. KELLY (Mitre Corp., Houston, TX) IN: AIAA Computing in Aerospace Conference, 8th, Baltimore, MD, Oct. 21-24, 1991, Technical Papers. Vol. 2 1991 14 p refs
(Contract NAS9-18057)
(AIAA PAPER 91-3790) Copyright

NASA is investigating the use of advanced automation to enhance crew productivity for Space Station Freedom in numerous areas, one being failure management. This paper describes a prototype that diagnoses failure sources, assesses the future impacts of those failures on other Freedom entities, and generates courses of action whose intents are to recover from the failure within Freedom's operating conditions. Author

A92-17669#
DESIGNING A REAL-TIME SOFTWARE TESTBED FOR THE SPACE STATION FREEDOM PROGRAM
ROGER RACINE (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: AIAA Computing in Aerospace Conference, 8th, Baltimore, MD, Oct. 21-24, 1991, Technical Papers. Vol. 2 1991 6 p
(AIAA PAPER 91-3825) Copyright

This paper discusses the design of a real-time software testbed for the Space Station Freedom program. Standard, off-the-shelf components were used to create a low-cost, compact, yet powerful computer system. Using commercial software on development computers, and nearly all custom Ada software, along with a modified version of a vendor-supplied Ada runtime environment on real-time computers, a realistic model of the Space Station Freedom computer system was created. Author

A92-17672#
ADA AND AI COMPATIBILITY ISSUES
ANNE BARRETTE (Northrop Corp., Electronics Systems Div., Hawthorne, CA) AIAA, Computing in Aerospace Conference, 8th, Baltimore, MD, Oct. 21-24, 1991. 8 p. Oct. 1991 8 p refs
(AIAA PAPER 91-3854) Copyright

Recently, some concern has arisen both in the artificial intelligence (AI) community and throughout industry and government regarding the compatibility of the languages LISP and Ada. This issue has arisen due to the recent maturity of many AI technologies coupled with the rapidly increasing complexity of future software systems. These maturing AI technologies offer potential solutions to the complex problems previously considered not solvable. As a result, AI algorithms are beginning to find their way into more government and defense related applications, e.g. the Space Station and advanced pilot decision support aids. The DOD has mandated the use of Ada for such applications. However, the primary AI development language of choice is LISP. In addition, the artificial intelligence community has not historically dealt with many of the constraints imposed by the environments now being targeted. Hence, a controversy exists regarding the use of Ada for artificial intelligence. This paper explores some of the issues related to that controversy. Author

A92-17676*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE ROLE OF RELIABILITY GRAPH MODELS IN ASSURING DEPENDABLE OPERATION OF COMPLEX HARDWARE/SOFTWARE SYSTEMS
F. A. PATTERSON-HINE, GLORIA J. DAVIS, and A. PEDAR (NASA, Ames Research Center, Moffett Field, CA) AIAA, Computing in Aerospace Conference, 8th, Baltimore, MD, Oct. 21-24, 1991. 8 p. Oct. 1991 8 p refs
(AIAA PAPER 91-3793) Copyright

The complexity of computer systems currently being designed for critical applications in the scientific, commercial, and military arenas requires the development of new techniques for utilizing models of system behavior in order to assure 'ultra-dependability'. The complexity of these systems, such as Space Station Freedom and the Air Traffic Control System, stems from their highly integrated designs containing both hardware and software as critical components. Reliability graph models, such as fault trees and digraphs, are used frequently to model hardware systems. Their applicability for software systems has also been demonstrated for software safety analysis and the analysis of software fault tolerance. This paper discusses further uses of graph models in the design and implementation of fault management systems for safety critical applications. Author

A92-18561* Massachusetts Inst. of Tech., Cambridge.
AN EXPERT SYSTEM FOR ASTRONAUT SCIENTISTS
L. R. YOUNG (MIT, Cambridge, MA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 3 p. Oct. 1991 3 p
(Contract NCC2-570)
(IAF PAPER 91-569) Copyright

A novel application of expert system technology is developed for real-time advice to an astronaut during the performance of a crew intensive experiment. The provision of an on-board computer expert, containing much of the reasoning base of the real Principal Investigator, will permit the astronaut to act more as a scientist co-worker in future Spacelab and Space Station missions. The long duration of flight increments and the large number of experiments envisioned for Space Station Freedom make the increase in astronaut productivity particularly valuable. A first version of the system was evaluated on the ground during the recent Spacelab SLS-1 flight. Author

A92-19080
SIMULATION ANALYSIS USING THE SPACE STATION INFORMATION SYSTEM PROTOCOL PERFORMANCE MODEL
SUSAN W. PALOCSAY (Mitre Corp., McLean, VA) IN: 1990 Annual Summer Computer Simulation Conference, 22nd, Calgary, Canada, July 16-18, 1990, Proceedings 1990 6 p refs
Copyright

NASA is developing the Space Station Information System (SSIS) to provide the operational communications and information processing services for the NASA Space Station Freedom Program (SSFP). The SSIS will be composed of a number of subnetworks which must be integrated to meet end-to-end SSFP network service requirements. This paper describes the SSIS architecture that is modeled, the modeling methodology, the SIMSCRIPT II.5 implementation of the model, and the results from an initial simulation analysis of several measures of performance including the latency time for SSIS users and the utilization of SSIS components. These results illustrate how latency is affected by SSIS component processing delays, priority processing schemes, and packet sizes. Author

A92-19086
FLEXIBLE FLIGHT COMPUTER INTERFACE ARCHITECTURE FOR SPACE FLIGHT SIMULATIONS
WILLIAM J. BRYAN and JAMES H. TREYBIG (IBM Corp., Systems Integration Div., Houston, TX) IN: 1990 Annual Summer Computer Simulation Conference, 22nd, Calgary, Canada, July 16-18, 1990, Proceedings 1990 6 p refs
Copyright

A flexible interface architecture for connecting actual flight computers to host simulation environments is discussed. Studies performed to develop a flexible flight computer interface architecture for integration of existing and future flight computers into space flight simulation environments is described. The possible application of this flexible interface architecture concept within the existing Space Shuttle Software Development Facility and future simulation environments is explored. C.D.

A92-19087* Mitre Corp., Houston, TX.
NETWORK MODELLING FOR THE SPACE STATION TRAINING FACILITY
ANKUR R. HAJARE and DANIEL T. WICK (Mitre Corp., Houston, TX) IN: 1990 Annual Summer Computer Simulation Conference, 22nd, Calgary, Canada, July 16-18, 1990, Proceedings 1990 6 p refs
(Contract NAS9-18057)
Copyright

Simulation models for LANs to be used in the proposed Space Station Training Facility, including models developed for Ethernet, Starlan, token ring, and Fiber Distributed Data Interface LANs, are discussed. Results of model runs for the basic configuration, for burst traffic, and for a growth scenario are presented. The PAWS and Network II.5 modeling tools are compared. C.D.

A92-19090
AUTOMATED IV&V OF LSAR DATA - AEROSPACE AND COMMERCIAL APPLICATIONS
RICHARD H. PRITCHARD, FRANK M. WERAVETZ, and RICHARD D. FRANKLIN (BDM International, Inc., Huntsville Technology Center, AL) IN: 1990 Annual Summer Computer Simulation Conference, 22nd, Calgary, Canada, July 16-18, 1990, Proceedings 1990 5 p
Copyright

This paper discusses the automated Logistics Support Analysis Record (LSAR) independent verification and validation (IV&V) upgrade to Multipurpose Integrating Data System (MIDS). The potential application of automated IV&V to important ongoing programs such as Army Computer-Aided Acquisition and Logistics Support (CALS) and Space Station Freedom is addressed. C.D.

A92-19234
THE UNIX OPERATING SYSTEM FOR TELEMETRY APPLICATIONS
JOSEPH J. PFEIFFER, JR. (New Mexico State University, Las Cruces) IN: ITC/USA/'90; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 29-Nov. 2, 1990

1990 8 p refs
Copyright

UNIX is a very popular operating system, in use on a wide variety of hardware platforms, in a wide variety of environments, for a wide variety of problems. It has certain well known deficiencies, however, for time-critical applications where guaranteed response time is required. This paper considers the use of UNIX and related systems for telemetry applications. Of particular interest will be UNIX as a possible operating system for NASA's Data Handling Service. Author

A92-19241
A PARALLEL COMPUTER APPROACH FOR PROCESSING SPACE STATION TELEMETRY PACKETS
JOHN T. POLSON (New Mexico State University, Las Cruces) IN: ITC/USA/'90; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 29-Nov. 2, 1990 1990 11 p refs
Copyright

A research effort aimed at designing and simulating the data handling service function for data processing is discussed. The research is based on a global memory message passing (GMMP) parallel computer architecture. The GMMP computer is capable of moving data into and out of new memory at the peak rate. The processing is partitioned by virtual channel number. O.G.

A92-19242
PACKET TELEMETRY GROUND STATION SIMULATION
JOHN C. WATSON (New Mexico State University, Las Cruces) IN: ITC/USA/'90; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 29-Nov. 2, 1990 1990 8 p
Copyright

The Packet Telemetry Ground Station which receives telemetry data from the Space Station must be able to receive and process various data types including high-rate video, audio, instrumentation, electronic mail, telecommand, and engineering. The Packet Telemetry Ground Station must also be flexible to accommodate changing missions and payloads. Computer simulations of the Packet Telemetry Ground Station provide information about device specifications required to achieve an acceptable level of performance under changing telemetry data traffic configurations. This paper describes a computer simulation model for a Packet Telemetry Ground Station architecture which was tested using ten different traffic components randomly transmitting data. The Packet Telemetry Ground Station simulation status and utilization plots are discussed in terms of interpreting the simulation results. Author

A92-23658* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FUNDAMENTAL RESEARCH IN ARTIFICIAL INTELLIGENCE AT NASA
PETER FRIEDLAND (NASA, Ames Research Center, Moffett Field, CA) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p

This paper describes basic research at NASA in the field of artificial intelligence. The work is conducted at the Ames Research Center and the Jet Propulsion Laboratory, primarily under the auspices of the NASA-wide Artificial Intelligence Program in the Office of Aeronautics, Exploration and Technology. The research is aimed at solving long-term NASA problems in missions operations, spacecraft autonomy, preservation of corporate knowledge about NASA missions and vehicles, and management/analysis of scientific and engineering data. From a scientific point of view, the research is broken into the categories of: planning and scheduling; machine learning; and design of and reasoning about large-scale physical systems. Author

A92-23690
APPROACH IN CONSTRUCTION OF DIAGNOSTIC EXPERT SYSTEM FOR ENVIRONMENTAL CONTROL EQUIPMENT IN SPACE
NOBUYOSHI MUROI, YUICHI MIYAMOTO, and IKUO AKEYAMA (Kawasaki Heavy Industries, Ltd., Gifu, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

The development of a fault-diagnosis expert system is described in terms of the component systems such as the inference engine and aerospace applications. The fault-diagnosis system is a knowledge-based system that employs functions of qualitative and continuous simulations and the inference engine to construct the suitable knowledge base. The concept is applied to the construction of a knowledge base for environmental control equipment. Rules for directed relationships between the functional blocks are generated automatically, interrelations between factors are extracted, and state changes are identified that can cause problems. A backtrack function is also incorporated which permits the system to trace the cause and effects of the problem phenomenon. The environmental control system shows the effectiveness of the general-purpose expert-systems building tool. C.C.S.

A92-23694
VERIFICATION OF PRACTICAL RULE-BASED SYSTEMS FOR SPACE
TOMIHIRO TAKANO, KEINOSUKE MATSUMOTO, SHIGEKI KUZUOKA, and EIICHI OGAWA (Mitsubishi Electric Corp., Amagasaki, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

This paper proposes an approach to automatically verify rule-based expert systems developed for space in which no system errors can be permitted. The problem of detecting bugs in developed rule-based systems is mentioned. A dynamic verification method of rule-based systems is proposed. This method enables the detection of system errors automatically by making rule-based systems infer and by watching over their reasoning process. To realize this method, a verifying module is developed. This traces the reasoning process by watching systems working memory, which is the storehouse of reasoning results. The system specification is transformed into the constraints to the working memory and adopt them as evaluation criteria of inference. Author

A92-23696
STRUCTURING A KNOWLEDGE BASE FOR REAL-TIME DIAGNOSIS
RICK SMITH (Gensym Corp., Long Beach, CA) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

This paper describes a knowledge base (KB) organization useful for real-time diagnostic systems. The organization is based upon previous work in diagnostic systems, and is modeled after the typical diagnostic process employed by human experts. The basic structure involves breaking the KB into three major sections: information gathering, hypothesizing, and solutions. Benefits of this KB organization include efficient use of the system knowledge, a structured KB which helps verification and validation, and a 'natural' knowledge organization which helps simplify the knowledge acquisition process. The organization is most readily applied to rule-based knowledge representations, however, the general concepts are applicable for other knowledge representations. To illustrate these concepts, a knowledge-based system (KBS) for real-time monitoring and diagnosis in the spacecraft electrical power domain is described. Author

A92-24050
OPERATION OF COMMERCIAL R3000 PROCESSORS IN THE LOW EARTH ORBIT (LEO) SPACE ENVIRONMENT
J. L. KASCHMITTER, D. L. SHAEFFER, N. J. COLELLA (Lawrence Livermore National Laboratory, Livermore, CA), C. L. MCKNETT, and P. G. COAKLEY (JAYCOR, Inc., Santa Monica, CA) (1991 IEEE Annual Conference on Nuclear and Space Radiation Effects,

28th, San Diego, CA, July 15-19, 1991, Proceedings. A92-24025 08-33) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 38, pt. 1, Dec. 1991, p. 1415-1420. Dec. 1991 6 p refs
(Contract W-7405-ENG-48)
Copyright

Spacecraft processors must operate with minimal degradation of performance in the LEO radiation environment, which includes the effects of total accumulated ionizing dose and single event phenomena (SEP) caused by protons and cosmic rays. Commercially available microprocessors can offer a number of advantages relative to radiation-hardened devices but are not normally designed to tolerate effects induced by the LEO environment. Extensive testing of the MIPS R3000 Reduced Instruction Set Computer (RISC) microprocessor family for operation in LEO environments is reported. The authors have characterized total dose and SEP effects for altitudes and inclinations of interest to systems operating in LEO, and they postulate techniques for detection and alleviation of SEP effects based on experimental results. I.E.

A92-24056* National Aeronautics and Space Administration, Washington, DC.
SEU HARDENED MEMORY CELLS FOR A CCSDS REED-SOLOMON ENCODER
STERLING WHITAKER, JOHN CANARIS, and KATHY LIU (NASA, Space Engineering Research Center for VLSI System Design; Idaho, University, Moscow) (1991 IEEE Annual Conference on Nuclear and Space Radiation Effects, 28th, San Diego, CA, July 15-19, 1991, Proceedings. A92-24025 08-33) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 38, pt. 1, Dec. 1991, p. 1471-1477. Dec. 1991 7 p refs
(Contract NAGW-1406)
Copyright

A design technique to harden CMOS memory circuits against single event upset (SEU) in the space environment is reported. The design technique provides a recovery mechanism which is independent of the shape of the upsetting event. A RAM cell and flip-flop design are presented to demonstrate the method. The flip-flop was used in the control circuitry for a Reed-Solomon encoder designed for the Space Station and Explorer platforms. I.E.

A92-24059
ON THE SUITABILITY OF NON-HARDENED HIGH DENSITY SRAMS FOR SPACE APPLICATIONS
R. KOGA, W. R. CRAIN, K. B. CRAWFORD, D. D. LAU, S. D. PINKERTON (Aerospace Corp., Space and Environment Technology Center, El Segundo, CA), B. K. YI (Fairchild Space Co., Germantown, MD), and R. CHITTY (CTA, Rockville, MD) (1991 IEEE Annual Conference on Nuclear and Space Radiation Effects, 28th, San Diego, CA, July 15-19, 1991, Proceedings. A92-24025 08-33) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 38, pt. 1, Dec. 1991, p. 1507-1513. Dec. 1991 7 p refs
Copyright

Several non-radiation-hardened high-density static RAMs (SRAMs) were tested for susceptibility to single event upset (SEU) and latchup. Test results indicate that at present only a few such device types are suitable for use in space applications. Several additional factors such as susceptibility to multiple-bit upsets and to radiation induced permanent damage need to be taken into consideration before these device types can be recommended. One nonhardened SRAM device type has recently been used on an LEO satellite, enabling the upset rate measured in space to be compared to that predicted from ground-based testing. I.E.

A92-26995*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
SECOND TRACKING AND DATA RELAY SATELLITE SYSTEM (TDRSS) GROUND TERMINAL - STGT
ALLEN K. BERNDT and DAWN R. LOWE (NASA, Goddard Space Flight Center, Greenbelt, MD) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 8 p. Jan. 1992 8 p
(AIAA PAPER 92-0595) Copyright

The STGT will provide high availability command and control and improved services to users of NASA's Space Network in the 1990s and beyond. The Space Network, comprising the TDRSS, will be the primary communications gateway for Space Station Freedom and other user's spacecraft and their ground support elements. The STGT will contain a redundant, distributed computer system providing configuration and control of redundant RF to baseband equipment chains for throughput of user data, for user tracking services and for control and monitoring of the TDR Satellites. An interface with NASA's Network Control Center, located at the Goddard Space Flight Center, provides automated scheduling and control of the STGT. A local TDRSS Operations Control Center for local monitoring and back-up control and an interface with the Domestic Satellite for data distribution will be provided by the STGT. This paper describes the STGT, with emphasis on configuration, control and monitoring of those elements providing TDRSS services to user spacecraft. Author

A92-29165* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ARTIFICIAL NEURAL NETWORKS AND APPROXIMATE REASONING FOR INTELLIGENT CONTROL IN SPACE
HAMID R. BERENJI (NASA, Ames Research Center; Sterling Software, Inc., Moffett Field, CA) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 2 1991 6 p refs
Copyright

A method is introduced for learning to refine the control rules of approximate reasoning-based controllers. A reinforcement-learning technique is used in conjunction with a multi-layer neural network model of an approximate reasoning-based controller. The model learns by updating its prediction of the physical system's behavior. The model can use the control knowledge of an experienced operator and fine-tune it through the process of learning. Some of the space domains suitable for applications of the model such as rendezvous and docking, camera tracking, and tethered systems control are discussed. I.E.

A92-29630*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
FUZZY LOGIC AND NEURAL NETWORK TECHNOLOGIES
JAMES A. VILLARREAL, ROBERT N. LEA, and ROBERT T. SAVELY (NASA, Johnson Space Center, Houston, TX) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 12 p. Jan. 1992 12 p refs
(AIAA PAPER 92-0868) Copyright

Applications of fuzzy logic technologies in NASA projects are reviewed to examine their advantages in the development of neural networks for aerospace and commercial expert systems and control. Examples of fuzzy-logic applications include a 6-DOF spacecraft controller, collision-avoidance systems, and reinforcement-learning techniques. The commercial applications examined include a fuzzy autofocusing system, an air conditioning system, and an automobile transmission application. The practical use of fuzzy logic is set in the theoretical context of artificial neural systems (ANSs) to give the background for an overview of ANS research programs at NASA. The research and application programs include the Network Execution and Training Simulator and faster training algorithms such as the Difference Optimized Training Scheme. The networks are well suited for pattern-recognition applications such as predicting sunspots, controlling posture maintenance, and conducting adaptive diagnoses. C.C.S.

A92-29632*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
FAULT MANAGEMENT FOR THE SPACE STATION FREEDOM CONTROL CENTER
COLIN CLARK, STEVEN JOWERS, ROBERT MCNENNY

(McDonnell Douglas Space Systems Co., Houston, TX), CHRIS CULBERT, SARAH KIRBY, and JANET LAURITSEN (NASA, Johnson Space Center, Houston, TX) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 11 p. Jan. 1992 11 p
(AIAA PAPER 92-0870) Copyright

This paper describes model based reasoning fault isolation in complex systems using automated digraph analysis. It discusses the use of the digraph representation as the paradigm for modeling physical systems and a method for executing these failure models to provide real-time failure analysis. It also discusses the generality, ease of development and maintenance, complexity management, and susceptibility to verification and validation of digraph failure models. It specifically describes how a NASA-developed digraph evaluation tool and an automated process working with that tool can identify failures in a monitored system when supplied with one or more fault indications. This approach is well suited to commercial applications of real-time failure analysis in complex systems because it is both powerful and cost effective. Author

A92-29791#
SPACE STATION FREEDOM BASEBAND SIGNAL PROCESSORS
BILL HABER and PETER EMMONS (Motorola, Inc., Government Electronics Group, Chandler, AZ) IN: AIAA International Communication Satellite Systems Conference and Exhibit, 14th, Washington, DC, Mar. 22-26, 1992, Technical Papers. Pt. 1 1992 11 p
(AIAA PAPER 92-1850) Copyright

Motorola is providing two baseband signal processors for NASA's Space Station Freedom. These two processors take dramatically different approaches to solving the same problem, formatting and multiplexing baseband audio, video, and experimental packet or bitstream data according to the Consultative Committee for Space Data Systems communications standard. The lower data rate (less than 1 Mbps) processor uses a microprocessor approach while the higher data rate processor utilizes a state machine implemented in ASICs. The relative advantages of the two approaches are discussed. Author

A92-29819#
THE EUROPEAN DATA RELAY SYSTEM
S. E. DINWIDDY and A. DICKINSON (ESTEC, Noordwijk, Netherlands) IN: AIAA International Communication Satellite Systems Conference and Exhibit, 14th, Washington, DC, Mar. 22-26, 1992, Technical Papers. Pt. 1 1992 8 p
(AIAA PAPER 92-1883) Copyright

ESA's planned European Data Relay System (DRS), intended to prove in-orbit communications to the European Polar Platform satellites, the Columbus Free Flying Laboratory, the Hermes Space Plane, and others, is discussed. The DRS mission, programmatics, system design, satellite design, and ground segment are described. C.D.

A92-29868*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
SCATTERING EFFECTS OF SOLAR PANEL ON SPACE STATION SPACE-TO-GROUND (SGS) ANTENNA PERFORMANCE
SHIAN U. HWU, LARRY A. JOHNSON, JON S. FOURNET (Lockheed Engineering and Sciences Co., Houston, TX), ROBERT J. PANNETON, DONALD S. EGGERS, and G. D. ARNDT (NASA, Johnson Space Center, Houston, TX) IN: AIAA International Communication Satellite Systems Conference and Exhibit, 14th, Washington, DC, Mar. 22-26, 1992, Technical Papers. Pt. 2 1992 5 p refs
(AIAA PAPER 92-1941) Copyright

The purpose of this study is to characterize the scattering effects of a solar panel on the Space Station Space-to-Ground Subsystem reflector antenna when the antenna is operated in the RF tracking (difference) mode. This analysis is based on a combination of geometrical theory of diffraction and aperture integration techniques. The advantage of this combination method is its capability in predicting reflector antenna patterns not only in the forward region but also in the far-out sidelobes and backlobes. To verify the analytical model, measurements were performed on the Johnson Space Center far-field antenna test facility. Good agreement between computed and measured results was obtained. It was shown from computation and experiment that the solar panel scattering interference causes a shift in null position, a decrease in the depth of the null, as well as a decrease in the gain on the antenna difference mode patterns. Author

A92-29869#
PAYLOAD TEST CAPABILITIES OF A LARGE COMPENSATED COMPACT RANGE
E. DUDOK, J. HABERSACK, F. HARTMANN, and H.-J. STEINER (MBB GmbH, Munich, Federal Republic of Germany) IN: AIAA International Communication Satellite Systems Conference and Exhibit, 14th, Washington, DC, Mar. 22-26, 1992, Technical Papers. Pt. 2 1992 8 p refs
(AIAA PAPER 92-1942) Copyright

A large compact-antenna test range is described in terms of the facility and its use for antenna-pattern and gain measurements as well as payload testing. The feeds at the Compensated Compact Range (CCR) are defocused relative to the reflector optics to generate scanned and tilted plane waves for independent quiet zones separated in frequency and space. Payload tests are conducted to assess scanned plane-wave quality, antenna-measurement accuracy, and the EIRP of the transmitting antennas. A multiaxis positioner is employed to test antenna patterns, the pointing subsystem, the transponders, group delay, and the amplitude/frequency response. The CCR is shown to be suitable for the application of scanned plane waves, and the CCR provides good linear and circular polarization when the feeds are defocused to about an 8-deg scan angle. The CCR facilitates the testing of disturbances in the antenna patterns for satellites with diameters of up to 8 m without having to move the spacecraft. C.C.S.

N92-10036*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
MANAGEMENT OF THE SPACE STATION FREEDOM ONBOARD LOCAL AREA NETWORK
FRANK W. MILLER and RANDY C. MITCHELL (Mitre Corp., Houston, TX.) Nov. 1991 18 p
(NASA-TM-104741; S-649; NAS 1.15:104741) Avail: CASI HC A03/MF A01

An operational approach is proposed to managing the Data Management System Local Area Network (LAN) on Space Station Freedom. An overview of the onboard LAN elements is presented first, followed by a proposal of the operational guidelines by which management of the onboard network may be effected. To implement the guidelines, a recommendation is then presented on a set of network management parameters which should be made available in the onboard Network Operating System Computer Software Configuration Item and Fiber Distributed Data Interface firmware. Finally, some implications for the implementation of the various network management elements are discussed. Author

N92-10038*# Research Inst. for Advanced Computer Science, Moffett Field, CA.
MODELING OF THE SPACE STATION FREEDOM DATA MANAGEMENT SYSTEM
MARJORY J. JOHNSON Aug. 1990 31 p Submitted for publication
(Contract NCC2-387)
(NASA-CR-188869; NAS 1.26:188869; RIACS-TR-90-32) Avail: CASI HC A03/MF A01

The Data Management System (DMS) is the information and communications system onboard Space Station Freedom (SSF). Extensive modeling of the DMS is being conducted throughout NASA to aid in the design and development of this vital system. Activities discussed at NASA Ames Research Center to model the DMS network infrastructure are discussed with focus on the

modeling of the Fiber Distributed Data Interface (FDDI) token-ring protocol and experimental testbedding of networking aspects of the DMS. Author

N92-10040# Sandia National Labs., Albuquerque, NM.
AN ASSESSMENT OF THE RADIATION TOLERANCE OF LARGE SATELLITE MEMORIES IN LOW EARTH ORBITS
J. S. BROWNING (Los Alamos National Lab., NM.), J. W. GRIFFEE, D. B. HOLTKAMP, and W. C. PRIEDHORSKY (Los Alamos National Lab., NM.) 1991 10 p Presented at the RADECS 91: Radiation Effects on Components and Systems, Montpellier, France, 9-12 Sep. 1991
(Contract DE-AC04-76DP-00789)
(DE91-018353; SAND-89-0167C; CONF-9109232-2) Avail: CASI HC A02/MF A01

A procedure is described that assures the reliable operation in space radiation environments of memory systems that are approximately ten times larger and can be built at about one tenth of the cost of recent, comparable satellite projects. The procedure accounts for combined radiation effects, permitting the radiation tolerance of the memory system to be accurately estimated. Using the procedure a 1-gigabit memory with error detection and correction capability has been designed for miniature satellite applications. The memory system is constructed entirely out of commercial grade microelectronics. DOE

N92-10313*# Research Inst. for Computing and Information Systems, Houston, TX.
INTEGRITY AND SECURITY IN AN ADA RUNTIME ENVIRONMENT
RODNEY L. BOWN Jun. 1991 9 p
(Contract NCC9-16; RICIS PROJ. SE-26)
(NASA-CR-188826; NAS 1.26:188826) Avail: CASI HC A02/MF A01

A review is provided of the Formal Methods group discussions. It was stated that integrity is not a pure mathematical dual of security. The input data is part of the integrity domain. The group provided a roadmap for research. One item of the roadmap and the final position statement are closely related to the space shuttle and space station. The group's position is to use a safe subset of Ada. Examples of safe sets include the Army Secure Operating System and the Penelope Ada verification tool. It is recommended that a conservative attitude is required when writing Ada code for life and property critical systems. Author

N92-11641*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
MAKING INTELLIGENT SYSTEMS TEAM PLAYERS: CASE STUDIES AND DESIGN ISSUES. VOLUME 2: FAULT MANAGEMENT SYSTEM CASES
JANE T. MALIN, DEBRA L. SCHRECKENGHOST, DAVID D. WOODS, SCOTT S. POTTER, LEILA JOHANNESEN, and MATTHEW HOLLOWAY (Ohio State Univ., Columbus.) Oct. 1991 230 p Original contains color illustrations
(NASA-TM-104738; S-652; NAS 1.15:104738)

Observations from a case study of intelligent systems are reported as part of a multi-year, interdisciplinary effort to provide guidance and assistance for designers of intelligent systems and their user interfaces. The objective of this case study was to identify preliminary guidance for the design of effective human-computer interaction (HCI) with intelligent fault management systems in aerospace applications. Fifteen intelligent fault management systems within NASA were studied. Author

N92-11652*# Southwest Research Inst., San Antonio, TX.
CONTINUATION OF RESEARCH INTO LANGUAGE CONCEPTS FOR THE MISSION SUPPORT ENVIRONMENT Final Report
5 Sep. 1991 306 p
(Contract NAG9-435; SWRI PROJ. 05-3531)
(NASA-CR-187818; NAS 1.26:187818) Avail: CASI HC A14/MF A03

A concept for a more intuitive and graphically based Computation (Comp) Builder was developed. The Graphical Comp Builder Prototype was developed, which is an X Window based graphical tool that allows the user to build Comps using graphical symbols. Investigation was conducted to determine the availability and suitability of the Ada programming language for the development of future control center type software. The Space Station Freedom Project identified Ada as the desirable programming language for the development of Space Station Control Center software systems. Author

N92-11664*# Research Inst. for Computing and Information Systems, Houston, TX.
DEPLOYING EXPERT SYSTEMS IN ADA
S. DANIEL LEE and BRADLEY P. ALLEN (Inference Corp., Los Angeles, CA.) Oct. 1989 14 p Presented at the TRI-Ada '89 Conference, Pittsburgh, PA, 22-26 Oct. 1989 Submitted for publication
(Contract NCC9-16; RICIS PROJ. SE-19)
(NASA-CR-188938; NAS 1.26:188938) Avail: CASI HC A03/MF A01

As the Department of Defense Ada mandate begins to be enforced actively, interest in deploying expert systems in Ada has increased. A prototype Ada based expert system tool is introduced called ART/Ada. This prototype was built to support research into the language and operational issues of expert systems in Ada. ART/Ada allows applications of a conventional expert system tool called ART-IM (Automated Reasoning Tool for Information Management) to be deployed in various Ada environments with efficient use of time and space. ART-IM, a C-based expert system tool, is used to generate Ada source code which is compiled and linked with an Ada base inference engine to produce an Ada executable image. ART/Ada will be used to implement several prototype expert systems for the Space Station Freedom Program testbeds. Author

N92-11667*# Research Inst. for Computing and Information Systems, Houston, TX.
ART-ADA DESIGN PROJECT, PHASE 2 Final Report
S. DANIEL LEE and BRADLEY P. ALLEN (Inference Corp., Los Angeles, CA.) Feb. 1990 44 p
(Contract NCC9-16; RICIS PROJ. SE-19)
(NASA-CR-188940; NAS 1.26:188940) Copyright Avail: CASI HC A03/MF A01

Interest in deploying expert systems in Ada has increased. An Ada based expert system tool is described called ART-Ada, which was built to support research into the language and methodological issues of expert systems in Ada. ART-Ada allows applications of an existing expert system tool called ART-IM (Automated Reasoning Tool for Information Management) to be deployed in various Ada environments. ART-IM, a C-based expert system tool, is used to generate Ada source code which is compiled and linked with an Ada based inference engine to produce an Ada executable image. ART-Ada is being used to implement several expert systems for NASA's Space Station Freedom Program and the U.S. Air Force. Author

N92-11702*# Computer Sciences Corp., Beltsville, MD.
GROUND SYSTEMS DEVELOPMENT ENVIRONMENT (GSDE) INTERFACE REQUIREMENTS ANALYSIS Final Report
VICTOR E. CHURCH, JOHN PHILIPS, RAY HARTENSTEIN, MITCHELL BASSMAN, LESLIE RUSKIN, and ALFREDO PEREZ-DAVILA Jun. 1991 106 p Prepared in cooperation with Computer Sciences Corp., Beltsville, MD and Computer Sciences Corp., and Computer Sciences Corp., Falls Church, VA
(Contract NCC9-16; RICIS PROJ. SE-34)
(NASA-CR-188822; NAS 1.26:188822; CSC/TM-91/6102) Avail: CASI HC A06/MF A02

A set of procedural and functional requirements are presented for the interface between software development environments and software integration and test systems used for space station ground systems software. The requirements focus on the need for centralized configuration management of software as it is transitioned from development to formal, target based testing. This concludes the GSDE Interface Requirements study. A summary is

presented of findings concerning the interface itself, possible interface and prototyping directions for further study, and results of the investigation of the Cronus distributed applications environment. Author

N92-12425*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
SPACE AND EARTH SCIENCE DATA COMPRESSION WORKSHOP
JAMES C. TILTON, ed. Washington Nov. 1991 85 p Workshop held in Snowbird, UT, 11 Apr. 1991; sponsored by NASA and IEEE
(Contract RTOP 590-32-14-01)
(NASA-CP-3130; REPT-91B00149; NAS 1.55:3130) Avail: CASI HC A05/MF A01

The workshop explored opportunities for data compression to enhance the collection and analysis of space and Earth science data. The focus was on scientists' data requirements, as well as constraints imposed by the data collection, transmission, distribution, and archival systems. The workshop consisted of several invited papers; two described information systems for space and Earth science data, four depicted analysis scenarios for extracting information of scientific interest from data collected by Earth orbiting and deep space platforms, and a final one was a general tutorial on image data compression.

N92-12431*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
DATA COMPRESSION FOR DATA ARCHIVAL, BROWSE OR QUICK-LOOK
JEFF DOZIER (Universities Space Research Association, Greenbelt, MD.) and JAMES C. TILTON *In its* Space and Earth Science Data Compression Workshop p 61-65 Nov. 1991
Avail: CASI HC A01/MF A01

Soon after space and Earth science data is collected, it is stored in one or more archival facilities for later retrieval and analysis. Since the purpose of the archival process is to keep an accurate and complete record of data, any data compression used in an archival system must be lossless, and protect against propagation of error in the storage media. A browse capability for space and Earth science data is needed to enable scientists to check the appropriateness and quality of particular data sets before obtaining the full data set(s) for detailed analysis. Browse data produced for these purposes could be used to facilitate the retrieval of data from an archival facility. Quick-look data is data obtained directly from the sensor for either previewing the data or for an application that requires very timely analysis of the space or Earth science data. Two main differences between data compression techniques appropriate to browse and quick-look cases, are that quick-look can be more specifically tailored, and it must be limited in complexity by the relatively limited computational power available on space platforms. Author

N92-13346*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Electrical Engineering.
FEASIBILITY STUDY OF A SYNTHESIS PROCEDURE FOR ARRAY FEEDS TO IMPROVE RADIATION PERFORMANCE OF LARGE DISTORTED REFLECTOR ANTENNAS Semiannual Status Report
W. L. STUTZMAN, K. TAKAMIZAWA, P. WERNTZ, J. LAPEAN, R. BARTS, and B. SHEN Aug. 1991 48 p
(Contract NAG1-859)
(NASA-CR-188797; NAS 1.26:188797; SATCOM-91-5) Avail: CASI HC A03/MF A01

Virginia Tech is involved in a number of activities with NASA Langley related to large aperture radiometric antenna systems. These efforts are summarized and the focus of this report is on the feasibility study of a synthesis procedure for array feeds to improve radiation performance of large distorted reflector antennas; however, some results for all activities are reported. Author

N92-13869*# Polytechnic Univ., Brooklyn, NY. Dept. of Civil Engineering.
OBJECT ORIENTED DEVELOPMENT OF ENGINEERING SOFTWARE USING CLIPS
C. JOHN YOON *In* Old Dominion Univ., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1991 p 248-249 Sep. 1991
Avail: CASI HC A01/MF A03

Engineering applications involve numeric complexity and manipulations of a large amount of data. Traditionally, numeric computation has been the concern in developing an engineering software. As engineering application software became larger and more complex, management of resources such as data, rather than the numeric complexity, has become the major software design problem. Object oriented design and implementation methodologies can improve the reliability, flexibility, and maintainability of the resulting software; however, some tasks are better solved with the traditional procedural paradigm. The C Language Integrated Production System (CLIPS), with deffunction and defgeneric constructs, supports the procedural paradigm. The natural blending of object oriented and procedural paradigms has been cited as the reason for the popularity of the C++ language. The CLIPS Object Oriented Language's (COOL) object oriented features are more versatile than C++'s. A software design methodology based on object oriented and procedural approaches appropriate for engineering software, and to be implemented in CLIPS was outlined. A method for sensor placement for Space Station Freedom is being implemented in COOL as a sample problem. Author

N92-14894*# Research Inst. for Advanced Computer Science, Moffett Field, CA.
EVALUATING THE OPERATIONS CAPABILITY OF FREEDOM'S DATA MANAGEMENT SYSTEM
HENRY A. SOWIZRAL Oct. 1990 16 p
(Contract NCC2-387)
(NASA-CR-187315; NAS 1.26:187315; RIACS-TR-90-48) Avail: CASI HC A03/MF A01

Three areas of Data Management System (DMS) performance are examined: raw processor speed, the subjective speed of the Lynx OS X-Window system, and the operational capacity of the Runtime Object Database (RODB). It is concluded that the proposed processor will operate at its specified rate of speed and that the X-Window system operates within users' subjective needs. It is also concluded that the RODB cannot provide the required level of service, even with a two-order of magnitude (100 fold) improvement in speed. Author

N92-15266# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
PERFORMANCE OF DRS S-BAND IOL WITH FEC CODING IN AN RFI ENVIRONMENT: TESTBED DESIGN AND MEASUREMENT
JEAN-LUC GERNER and JOHN QUAN *In its* Second European Conference on Satellite Communications (ECSC-2) p 377-382 Oct. 1991
Copyright Avail: CASI HC A02/MF A04; ESA, EPD, ESTEC, Noordwijk, Netherlands, HC 90 Dutch guilders

The versatile Data Relay Satellite (DRS) Radio Frequency Interference (RFI) testbed with its built in flexible capabilities for the simulation of the communication links between low Earth orbit satellites such as Hermes, Columbus, and ground as well as Inter Orbit Links (IOL) in an RFI environment is introduced. The DRS S-Band Inter-Orbit link (IOL) has Forward Error Correction (FEC) coding to combat RFI. Extensive results obtained from the testing of various communication link scenarios under different RFI environments are presented. The impact of various coding schemes under these circumstances are analyzed and the appropriate methods trading off the performance resulted, the power, the bandwidth needed, and the system complexity involved are recommended. ESA

N92-15468*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MICROWAVE SENSING TECHNOLOGY ISSUES RELATED TO A GLOBAL CHANGE TECHNOLOGY ARCHITECTURE TRADE STUDY
THOMAS G. CAMPBELL, JIM SHIUE, DENIS CONNOLLY, and KEN WOO (Jet Propulsion Lab., California Inst. of Tech., Pasadena.) *In its* Global Change Technology Architecture Trade Study p 181-186 Sep. 1991
Avail: CASI HC A01/MF A04

The objectives are to enable the development of lighter and less power consuming, high resolution microwave sensors which will operate at frequencies from 1 to 200 GHz. These systems will use large aperture antenna systems (both reflector and phased arrays) capable of wide scan angle, high polarization purity, and utilize sidelobe suppression techniques as required. Essentially, the success of this technology program will enable high resolution microwave radiometers from geostationary orbit, lightweight and more efficient radar systems from low Earth orbit, and eliminate mechanical scanning methods to the fullest extent possible; a main source of platform instability in large space systems. The Global Change Technology Initiative (GCTI) will develop technology which will enable the use of satellite systems for Earth observations on a global scale. Author

N92-15888*# Marquette Univ., Milwaukee, WI. Dept. of Electrical and Computer Engineering.
SPACE STATION INTERNAL PROPAGATION
J. E. RICHIE *In* Alabama Univ., Research Reports: 1991 NASA/ASEE Summer Faculty Fellowship Program 4 p Oct. 1991
(Contract NGT-01-008-021)
Avail: CASI HC A01/MF A03

The Space Station Freedom (SSF) is planned with a wireless communication system in place for the transmission of information between crew members on board. The clarity of transmission is paramount to an effective system of communication. A short overview is presented of the system including the requirements of interest, and a statement of the problem. The theory used to solve the problem is explored. The results given are for the experiments performed on a mockup of the proposed structure at NASA-Marshall. The requirements on the signal level are that there is a 45 dB signal to noise ratio from end to end, and that coverage over 99 pct. of the volume be maintained. The Rice probability distribution function, a simple extension of the Rayleigh distribution, is used to estimate the field strength inside a volume, where a significant line of sight from the transmitter to the receiver exists. For the SSF, this distribution will correspond to the summation of a coherent line of sight path between the transmitter and the receiver and an incoherent portion. The incoherent portion is the sum of reflections from the walls and the equipment inside the SSF. The Rice distribution was found to be the optimal distribution from the results. Author

N92-17351*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
SOFTWARE LIFE CYCLE METHODOLOGIES AND ENVIRONMENTS
ERNEST FRIDGE *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 2: Space Station Freedom, Part 2 p 1037-1103 Sep. 1991
Avail: CASI HC A04/MF A04

Products of this project will significantly improve the quality and productivity of Space Station Freedom Program software processes by: improving software reliability and safety; and broadening the range of problems that can be solved with computational solutions. Projects brings in Computer Aided Software Engineering (CASE) technology for: Environments such as Engineering Script Language/Parts Composition System (ESL/PCS) application generator, Intelligent User Interface for cost avoidance in setting up operational computer runs, Framework programmable platform for defining process and software development work flow control, Process for bringing CASE technology into an organization's culture, and CLIPS/CLIPS Ada language for developing expert systems; and methodologies such as Method for developing fault tolerant, distributed systems and a method for developing systems for common sense reasoning and for solving expert systems problems when only approximate truths are known. Author

N92-17418*# Jet Propulsion Lab., California Inst. of Tech., Pasadena. High Speed Optical Systems Group.
OPTICAL PROTOCOLS FOR ADVANCED SPACECRAFT NETWORKS
LARRY A. BERGMAN *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 1: Space Station Freedom, Part 2 p 583-638 Sep. 1991
Avail: CASI HC A04/MF A03

Most present day fiber optic networks are in fact extensions of copper wire networks. As a result, their speed is still limited by electronics even though optics is capable of running three orders of magnitude faster. Also, the fact that photons do not interact with one another (as electrons do) provides optical communication systems with some unique properties or new functionality that is not readily taken advantage of with conventional approaches. Some of the motivation for implementing network protocols in the optical domain, a few possible approaches including optical code-division multiple-access (CDMA), and how this class of networks can extend the technology life cycle of the Space Station Freedom (SSF) with increased performance and functionality are described. Author

N92-18624# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Cologne (Germany).
SYSTEM SAFETY APPROACH IN MANNED SPACELAB MISSIONS FOR CONTROL OF HAZARDS BY SOFTWARE
D. BOHLE (Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Bochum (Germany, F.R.).), W. ZIESMANN (Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Bochum (Germany, F.R.).), and W. MARTIN (Dornier System G.m.b.H., Friedrichshafen, Germany, F.R.) *In* ESA, Space Product Assurance for Europe in the 1990s: An ESA Symposium p 103-108 Aug. 1991
Copyright Avail: CASI HC A02/MF A03

In European manned missions, hazard control of safety critical systems are not realized entirely by software. At least one hardware inhibition exists. With the increasing capabilities of microprocessor systems, more and more hazards are controlled by S/W (software) in addition to be required H/W (hardware) inhibit. In previous missions this has been the exception. Wherever fault tolerance had to be assured, a failure of the S/W control meant termination of the mission for the affected facility. From a performance point of view this is a very undesirable solution. A software feature developed to overcome this situation in order to gain flexibility and to increase performance reliability is described. The necessary steps in safety certification are discussed using the D2 facility GFQ (Gradient Furnace with Quenching) as an example. An overwiew of S/W safety in space station applications is presented. ESA

N92-18625# Erno Raumfahrttechnik G.m.b.H., Bremen (Germany).
SOFTWARE PRODUCT ASSURANCE: CURRENT SITUATION AND FUTURE TRENDS WITHIN EUROPE SPACE ACTIVITIES
H. NORRENBROCK *In* ESA, Space Product Assurance for Europe in the 1990s: An ESA Symposium p 109-114 Aug. 1991
Copyright Avail: CASI HC A02/MF A03

Based on the fact that more and more system aspects are to be implemented via the use of software based systems, the importance of standardization and product assurance of software is increasing as well. Various international organizations are defining software related standards. The current international standards are used to derive the Columbus software product assurance program. Although a lot of work has been done, some areas of concern still remain. Resolution of the highlighted open fields and

coverage of future trends is predicted to influence the work of the software product assurance community. ESA

N92-18626# Canadian Space Agency, Ottawa (Ontario).
CANADIAN SPACE STATION SOFTWARE PRODUCT ASSURANCE PROGRAM
RICHARD STORM (Canadian Space Agency, Ottawa (Ontario).) and MICHAEL EVANS (Computers and Concepts Associates, Ontario) *In* ESA, Space Product Assurance for Europe in the 1990s: An ESA Symposium p 115-120 Aug. 1991
Copyright Avail: CASI HC A02/MF A03

Innovative Software Product Assurance (SPA) procedures applied to the development of the Mobile Servicing System (MSS), including the Space Station Remote Manipulator System (SSRMS), are discussed. Successful implementation of the MSS requires development of state of the art robotic hardware controlled through approximately 50,000 lines of Ada code and formware. The MSS must perform reliably and consistently within stringent safety, interface, and performance constraints as specified. In order to assure the software products during specification, development, and test, the Canadian Space Agency (CSA) has applied an active and effective SPA program to the prime contractor and each of seven subcontractors supporting the project. The MSS SPA approach utilizes an integrated set of reviews, inspections, audits, and independent assessments of the LSS products and the processes used to develop them. The unique methods and tools developed by CSA to support the effort are described. The MSS SPA approach places emphasis on software engineering and software to the systems engineering functions, and the NASA space station project. How these interfaces are defined and assured and what standards had to be developed to enable the various functions are discussed. Lessons learned based on the Canadian Space Station Program (CSSP) experience are discussed. These lessons learned concern experience, corrective action, and results. ESA

N92-19433*# IBM Federal Systems Div., Houston, TX.
COST AND QUALITY PLANNING FOR LARGE NASA PROGRAMS
KYLE Y. RONE *In* NASA. Goddard Space Flight Center, Proceedings of the 15th Annual Software Engineering Workshop 25 p Nov. 1990
Avail: CASI HC A03/MF A06

The Software Cost and Quality Engineering methodology developed over the last two decades at IBM Federal Sector Div. is used to plan the NASA Space Station Data Management System (DMS). An ongoing project to capture this methodology, which is built on a foundation of experiences and lessons learned, has resulted in the development of a PC-based tool that integrates cost and quality forecasting methodologies and data in a consistent manner. This tool, Software Cost and Quality Engineering Starter Set (SCQESS), is being used to assist in the DMS costing exercises. At the same time, DMS planning serves as a forcing function and provides a platform for the continuing, iterative development, calibration, and validation and verification of SCQESS. The data that forms the cost and quality engineering data base is derived from more than 17 years of development of NASA Space Shuttle software, ranging from low criticality, low complexity support tools to highly complex and highly critical onboard software. Author

N92-20591 Aeritalia S.p.A., Turin (Italy). Space Systems Group.
SOFTWARE INTEGRATION, VERIFICATION, AND QUALIFICATION FOR MANNED SPACE LABORATORIES: STRATEGIES AND TECHNIQUES
NICHOLAS INNES and LORENZO SARLO *In* CNES, The Management of Large Software Projects in the Space Industry p 33-45 Jun. 1991 Previously announced in IAA as A91-47753
Copyright Avail: CEPADUES-Editions, 111 Rue Nicolas-Vauquelin, 31100 Toulouse, France

The increasing role of software in manned spacecraft means that software forms a major system component within the entire system development life cycle, both on ground and in orbit. For manned space laboratories the use of software is even greater. Requirements placed upon these systems, in terms of autonomy and support to crew performance, are summarized. The Integration, Verification, and Qualification (IVQ) of such large, complex software systems, containing safety and/or operational critical software is discussed. Human system interface and support software, having a long expected operational life, presents some demanding challenges to the developing organizations. The success of the IVQ program is imperative for the success of the program as a whole. Some strategies and approaches to the management and implementation of the IVQ process are presented. The strategic allocation of IVQ resources throughout the software development lifecycle is examined. The role of software IVQ activities in relation to other system level and subcontractor activities is discussed and recommendations are made as to how these relationships can be made more effective for the implementation of a comprehensive IVQ program. The approach taken to the performance of IVQ activities is discussed, and ways in which the subcontractor integrator relationship can be made complementary are outlined. ESA

N92-20600 European Space Agency. European Space Operations Center, Darmstadt (Germany).
DEVELOPMENT OF A CONFIGURABLE INFRASTRUCTURE FOR THE CONTROL OF A LARGE VARIETY OF SPACECRAFT: THE SCOS
B. MULLET *In* CNES, The Management of Large Software Projects in the Space Industry p 155-165 Jun. 1991 Previously announced in IAA as A91-47762
Copyright Avail: CEPADUES-Editions, 111 Rue Nicolas-Vauquelin, 31100 Toulouse, France

Aspects specific to the development of infrastructure software systems are outlined. Guidelines and recommendations which have been adopted for the SCOS (Spacecraft Control and Operation System) project or which are deduced from the experience gained in the ongoing course of the project are presented. The SCOS example demonstrated that the initial cost overhead implied by the increased project complexity is largely compensated by the advantage of re-using and maintaining a single large system kernel for 3 or more missions. ESA

N92-20601 European Space Agency. European Space Operations Center, Darmstadt (Germany).
THE INTEGRATION AND TEST OF MODERN SPACECRAFT CONTROL SYSTEMS
N. HEAD and M. JONES *In* CNES, The Management of Large Software Projects in the Space Industry p 167-174 Jun. 1991 Previously announced in IAA as A91-47763
Copyright Avail: CEPADUES-Editions, 111 Rue Nicolas-Vauquelin, 31100 Toulouse, France

The implementation and testing of modern spacecraft control systems as a major part of overall ground segment preparation efforts are discussed. As spacecraft become more complex and their operations more ambitious, the scope of the control systems required to support them is increasing. Modern spacecraft are characterized by increasingly intensive launch and early orbit phase operations, complex and lengthy checkout and calibration activities and autonomous, frequently isolated, nominal operations. Multiple telemetry data rates and formats are a normal part of a mission as are command modes both with and without the assistance of onboard software. The extent of the differences between these various mission phases and the resulting differences in the operational modes of the ground segment (including the spacecraft control system) are summarized. Difficulties encountered, if the traditional approach to testing a control system is followed, are summarized. ESA

N92-20606 Dornier System G.m.b.H., Friedrichshafen (Germany).
MANAGEMENT OF SOFTWARE DEVELOPMENT FROM MULTIPLE SOURCES (EXPERIENCES GAINED FROM THE ERS-1 PROGRAM)
FRANZ SASSE *In* CNES, The Management of Large Software Projects in the Space Industry p 215-226 Jun. 1991 Previously

announced in IAA as A91-47768

Management aspects experienced during the development of the onboard software for the European Remote Sensing (ERS-1) satellite are described. The complete software lifecycle is considered starting from the design phase, passing over to the development-running phase and ending in the maintenance phase. Special emphasis is laid on the difficulties and constraints that show up during the different software life cycle phases and which are mainly caused by the individual approach of software development applied to each part of the ERS-1 on board software. Based on the experiences, difficulties and constraints an evaluation is performed in view of advantages and disadvantages of the selected individual approach for the software development. A short outlook on future projects is given in which the common software development approach is discussed. This approach is planned to be applied for the Columbus and Hermes programs. The common approach is compared with the individual ERS-1 approach. ESA

N92-20610 Aeritalia S.p.A., Turin (Italy). Space Systems Group.
SOFTWARE MANAGEMENT STRATEGIES AND PRACTICES FOR SPACE SYSTEMS DEVELOPMENT
LORENZO SARLO *In* CNES, The Management of Large Software Projects in the Space Industry p 263-270 Jun. 1991 Previously announced in IAA as A91-47772

Planning, coordination and control of the design and development of the software systems supporting the onboard and ground operations of a space system are discussed. Software management strategies, policies and practices are reviewed. The strategies act horizontally within the committing industrial organization and vertically down the subcontractor tree. The strategies are implemented through program level policies for software development. The ultimate objectives of the management effort are to assure that the deliverable software meet technical and programmatic requirements. Issues related to the insertion of new technologies as well as the transfer process from the development organization to flight operations are considered. Software management from the start of the system life cycle is discussed. Work breakdown and software industrial structures are discussed. Software management, engineering, and verification organizations are defined. Relationships between the software and other system disciplines are reviewed. Assessment of which standards shall be used is presented. The perspective taken is mainly oriented to the design and development of large software systems for space manned laboratories and related ground centers. Lessons learnt so far on the Columbus Attached Laboratory flight and ground infrastructures program and studies are reported. ESA

N92-20612 Computer Resources International A/S (Denmark).
MANAGEMENT IN SDE-BASED ORGANISATIONS
J. LANGELAND-KNUDSEN and J. GULDBERG *In* CNES, The Management of Large Software Projects in the Space Industry p 281-286 Jun. 1991 Previously announced in IAA as A91-47774

The management of Software Development Environment (SDE) based organizations is discussed. Issues expected to be substantially influenced by the use of comprehensive engineering environments are addressed. These include the introduction of computer based tools leading to increased specialization in other engineering activities; project planning and tool investment tradeoffs as likely to modify the financial structure of software engineering project. Conclusions are that the introduction of tools will change the economic conditions of software productions in the direction of spending more on investments, less on pure manpower costs; the complexity of the process of producing software will be moved to management of the design process (requirement specification, architectural design) and towards the test and validation process, but will also ease the management of subcontracting within large international projects. ESA

N92-20623 Aeritalia S.p.A., Turin (Italy). Space Systems Group.
COLUMBUS SOFTWARE: TRANSITION FROM SOFTWARE DEVELOPMENT TO SYSTEM OPERATIONS
VITTORIO CIAMPOLINI, DAVID R. HARRIS, NICHOLAS INNES, and CARLO PACCAGNINI *In* CNES, The Management of Large Software Projects in the Space Industry p 395-403 Jun. 1991 Previously announced in IAA as A91-47785

An approach to the Columbus Attached Laboratory, focusing on the integrated use of the software development environment, software and system verification facilities and mission preparation tools, is presented. The following issues are particularly addressed: transfer of software from the subcontractor development and testing facilities to the system integration authority; integration of the 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. The scenarios of involvement of the Attached Laboratory Engineering Support Center in software maintenance during Space Station Freedeom flight operations are presented. ESA

N92-20625 European Space Agency. European Space Operations Center, Darmstadt (Germany).
A STRATEGY FOR DATA PROCESSING WITHIN THE GROUND SEGMENT OF ESA'S IN ORBIT INFRASTRUCTURE
M. CLENDINING *In* CNES, The Management of Large Software Projects in the Space Industry p 421-433 Jun. 1991 Previously announced in IAA as A91-47787

ESA's In Orbit Infrastructrure (IOI) comprises the Hermes Spaceplane, the Columbus Attached Laboratory and Free Flying Laboratory, the Polar Platform, and the data relay system. The approach taken in identifying all IOI ground segment Data Processing (DP) requirements is described. Traceability of DP requirements to higher level documents is discussed. Development of an overall ground segment DP architecture is outlined. Allocation of DP subsystems to three categories: common, shared, and facility specific is described. Tailoring the DP architecture for individual facilities is discussed. Concepts for data and software security are considered. ESA

N92-20626 Logica Ltd., London (England).
WHY IS SPACE SOFTWARE SPECIAL?
P. NORRIS *In* CNES, The Management of Large Software Projects in the Space Industry p 435-441 Jun. 1991 Previously announced in IAA as A91-47788

Two of the implications of the uniqueness of space software are discussed: software development environments tailored for space software; and research to address the specific requirements of space software. Characteristics of onboard software are discussed including the space environment and constraints on onboard software. A discussion that these suggest that spaceborne software is different from other forms of software is given. ESA

N92-20627 Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France).
THE ELECTRONIC COPILOT: A FRUITFUL EXPERIENCE TOWARD COMPLEX PROJECT MANAGEMENT USING ARTIFICIAL INTELLIGENCE IN THE SPACE DOMAIN
YANN RENAULT and GILLES CHAMPIGNEUX *In* CNES, The Management of Large Software Projects in the Space Industry p 443-462 Jun. 1991 Previously announced in IAA as A91-47789

 Avail: CEPADUES-Editions, 111 Rue Nicolas-Vauquelin, 31100 Toulouse, France

Crew involvement in future European manned space mission with Hermes and Columbus is discussed. The effects of high workloads on astronauts in orbit are evaluated. Extensive mission support by a large group of skilled ground personnel is predicted. In order to maximize the mission efficiency and the cost effectiveness of space operations, good management of limited and valuable crew time is recommended. Good allocation of functions between astronauts and automatic systems, and an effective man-machine interface (MMI) design are presented. Automatic systems and robots which should eventually significantly reduce the astronauts workload are described. They are necessary for actions that require fast and highly accurate response, and for tedious and repetitive tasks. The role for humans in such a control loop is discussed. ESA

N92-20756# MATRA Espace, Toulouse (France).
DATA PROCESSING SYSTEM FOR EUROPEAN MANNED SPACE FLIGHT CONTROL CENTRES
DANIEL HERLEMONT and G. MACE *In* ESA, Launch Bases and Control Infrastructures for Spacecraft p 257-263 Oct. 1991
 Avail: CASI HC A02/MF A04; ESA, EPD, ESTEC, Noordwijk, Netherlands, HC 90 guilders

The Data Processing System (DPS) for the IOI (In Orbit Infrastructure) Ground Segment (GS) is presented. An overview of the generic DPS architectuire is given. The DPS architecture proposes guidelines to the various control centers of the IOI mainly: the central mission control center; the manned Space Laboratory control center for Columbus; the Hermes Flight Control Center. This architecture was used to estimate savings in the development of those facilities. This common approach is a key design factor that contributes to service in terms of operational efficiency and cost savings. ESA

N92-21267*# City Univ. of New York, Bronx. Dept. of Physics and Astronomy.
INVESTIGATION OF TECHNIQUES FOR SIMULATING COMMUNICATIONS AND TRACKING SUBSYSTEMS ON SPACE STATION FREEDOM Final Report
LOUIS A. DEACETIS *In* Texas A and M Univ., NASA/ASEE Summer Faculty Fellowship Program, 1991, Volume 1 8 p Dec. 1991
Avail: CASI HC A02/MF A03

The need to reduce the costs of Space Station Freedom has resulted in a major redesign and downsizing of the Station in general, and its Communications and Tracking (C&T) components in particular. Earlier models and simulations of the C&T Space-to-Ground Subsystem (SGS) in particular are no longer valid. There thus exists a general need for updated, high fidelity simulations of C&T subsystems. This project explored simulation techniques and methods that might be used in developing new simulations of C&T subsystems, including the SGS. Three requirements were placed on the simulations to be developed: (1) they run on IBM PC/XT/AT compatible computers; (2) they be written in Ada as much as possible; and (3) since control and monitoring of the C&T subsystems will involve communication via a MIL-STD-1553B serial bus, that the possibility of commanding the simulator and monitoring its sensors via that bus be included in the design of the simulator. The result of the project is a prototype of a simulation of the Assembly/Contingency Transponder of the SGS, written in Ada, which can be controlled from another PC via a MIL-STD-1553B bus. Author

N92-22020*# National Aeronautics and Space Administration, Washington, DC.
ADVANCED TRACKING AND DATA RELAY SATELLITE SYSTEM
DANIEL STERN *In* NASA. Lewis Research Center, Advanced Modulation and Coding Technology Conference p 307-313 Feb. 1992
Avail: CASI HC A02/MF A03

The purpose of this communication satellite system are as follows: to provide NASA needs for satellite tracking and communications through the year 2012; to maintain and augment the current TDRS system when available satellite resources are expended in the latter part of the decade; to provide the necessary ground upgrade to support the augmented services; and to introduce new technology to reduce the system life cycle cost. It is concluded that no ATDRS spacecraft requirement for new modulation techniques, that data rate of 650 MBps is required, and that Space Station Freedom requirement is for 650 MBps data some time after the year 2000. Author

15

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.

A92-12495* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ASSURED CREW RETURN VEHICLE
D. A. STONE, J. W. CRAIG, B. DRONE, R. H. GERLACH, and R. J. WILLIAMS (NASA, Johnson Space Center, Houston, TX) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 14 p. Oct. 1991 14 p refs
(IAF PAPER 91-088)

The developmental status is discussed regarding the 'lifeboat' vehicle to enhance the safety of the crew on the Space Station Freedom (SSF). NASA's Assured Crew Return Vehicle (ACRV) is intended to provide a means for returning the SSF crew to earth at all times. The 'lifeboat' philosophy is the key to managing the development of the ACRV which further depends on matrixed support and total quality management for implementation. The risk of SSF mission scenarios are related to selected ACRV mission requirements, and the system and vehicle designs are related to these precepts. Four possible ACRV configurations are mentioned including the lifting-body, Apollo shape, Discoverer shape, and a new lift-to-drag concept. The SCRAM design concept is discussed in detail with attention to the 'lifeboat' philosophy and requirements for implementation. C.C.S.

A92-12510* National Aeronautics and Space Administration, Washington, DC.
TECHNOLOGY FOR INCREASED HUMAN PRODUCTIVITY AND SAFETY ON ORBIT
JUDITH AMBRUS (NASA, Office of Aeronautics, Exploration, and Technology, Washington, DC) and CHARLES F. GARTRELL (General Research Corp., Vienna, VA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 14 p. Oct. 1991 14 p refs
(IAF PAPER 91-107)

Technologies are addressed that can facilitate the efficient performance of station operations on the Space Station Freedom (SSF) and thereby optimize the utilization of SSF for scientific research. The dedication of SSF capabilities to scientific study and to the payload-user community is a key goal of the program. Robotics applications are discussed in terms of automating the processing of experiment materials on-orbit by transferring ampules to a furnace system or by handling plant-tissue cultures. Noncontact temperature measurement and medical support technology are considered important technologies for maximizing time for scientific purposes. Detailed examinations are conducted of other technologies including advanced data systems and furnace designs. The addition of the listed technologies can provide an environment in which scientific research is more efficient and accurate. C.C.S.

A92-12572* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE PERSONNEL LAUNCH SYSTEM - A LIFTING BODY APPROACH
THEODORE A. TALAY and HOWARD W. STONE (NASA, Langley Research Center, Hampton, VA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 11 p. Oct. 1991 11 p refs
(IAF PAPER 91-202)
A lifting-body approach to the sign of a Personnel Launch System spacecraft for Space Station crew missions is defined. This paper reviews the characteristics and capabilities of this spacecraft the HL-20. Launch vehicle options are examined and recent findings from wind tunnel tests, tests of landing dynamics and handling qualities, and human factors research using a full-scale research model are reviewed. C.D.

A92-13801
MEASUREMENT OF THE RADIATION DOSE ON THE MIR STATION DURING SOLAR PROTON EVENTS IN SEPTEMBER-OCTOBER 1989 [IZMERENIE DOZY RADIATSII NA STANTSII 'MIR' VO VREMIA SOLNECHNYKH PROTONNYKH SOBYTII V SENTIABRE-OKTIABRE 1989 G.]
L. V. TVERSKAIA, M. V. TEL'TSOV, and V. I. SHUMSHUROV (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR) Geomagnetizm i Aeronomiia (ISSN 0016-7940), vol. 31, Sept.-Oct. 1991, p. 928-930. In Russian. Oct. 1991 3 p In RUSSIAN refs
Copyright
An analysis is made of variations of the radiation dose of the Mir orbital station under exposure to solar cosmic rays during September-October 1989. It is shown that increases in the dose which represent a significant radiation hazard are associated with approach of the solar-proton penetration boundary toward the earth during strong magnetic disturbances. L.M.

A92-16601* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE IMPLICATIONS OF EXPERIMENTALLY CONTROLLED GRAVITATIONAL ACCELERATIONS FOR COMBUSTION SCIENCE
KURT R. SACKSTEDER (NASA, Lewis Research Center, Cleveland, OH) IN: Symposium (International) on Combustion, 23rd, Orleans, France, July 22-27, 1990, Proceedings 1991 8 p refs
Copyright
An overview of basic combustion problems which have been investigated under the condition of reduced gravity is presented to identify promising research directions. Attention is given to the broad categories of gas-jet diffusion flames, droplet combustions, particle clouds, flame spreading over liquid pools, smoldering, and flame spreading over solid fuels. Fire safety in spacecraft is the primary application that is addressed by the studies of combustion under microgravity. The need for more complete testing of the issues discussed in orbiting spacecraft is identified in the light of limited earth-based testing. Attention is also directed toward the need for advanced diagnostic methods for in-flight and other combustion investigations. C.C.S.

A92-17599*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
PORTABLE COMPUTERS AS COMPANIONS IN SPACE
DEBRA MURATORE (NASA, Johnson Space Center, Houston, TX), KRITINA HOLDEN, and ROBERT WILMINGTON (Lockheed Engineering and Sciences Co., Houston, TX) IN: AIAA Computing in Aerospace Conference, 8th, Baltimore, MD, Oct. 21-24, 1991, Technical Papers. Vol. 1 1991 6 p
(Contract NAS9-17900)
(AIAA PAPER 91-3732) Copyright
The paper describes a Space Shuttle Program payload that uses a Macintosh portable computer to gather human performance data for a cursor control device experiment and to test prototype software applications for the Space Station Freedom (SSF). The payload is the first phase of a NASA research and development project to operationally test human-computer interface requirements and crew support applications for an advanced portable computer for the SSF. Author

A92-17772
SURGERY IN SPACE - SURGICAL PRINCIPLES IN A NEUTRAL BUOYANCY ENVIRONMENT
RICHARD M. SATAVA (Silas B. Hays Army Hospital, Monterey, CA) IN: Space manufacturing 8 - Energy and materials from space; Proceedings of the 10th Princeton/AIAA/SSI Conference, Princeton, NJ, May 15-18, 1991 1991 3 p refs
Copyright
Surgical procedures were experimentally conducted on 20 rats in a simulated weightlessness environment, using neutral buoyancy to identify those factors which could affect the conduct of such procedures in space. Tissue planes are found to separate; organs float in the operative region, rendering clamping, cutting, and suturing very different from conventional operations. Blood dispersion in weightlessness easily obscures the surgeon's vision. The difficulties inherent in a comparison of neutral buoyancy to the true zero gravity of outer space are addressed. O.C.

A92-17786* National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, FL.
BIOREGENERATIVE TECHNOLOGIES FOR WASTE PROCESSING AND RESOURCE RECOVERY IN ADVANCED SPACE LIFE SUPPORT SYSTEM
DENNIS CHAMBERLAND (NASA, Kennedy Space Center, Cocoa Beach, FL) IN: Space manufacturing 8 - Energy and materials from space; Proceedings of the 10th Princeton/AIAA/SSI Conference, Princeton, NJ, May 15-18, 1991 1991 4 p refs
Copyright
The Controlled Ecological Life Support System (CELSS) for producing oxygen, water, and food in space will require an interactive facility to process and return wastes as resources to the system. This paper examines the bioregenerative techologies for waste processing and resource recovery considered for a CELSS Resource Recovery system. The components of this system consist of a series of biological reactors to treat the liquid and solid material fractions, in which the aerobic and anaerobic reactors are combined in a block called the Combined Reactor Equipment (CORE) block. The CORE block accepts the human wastes, kitchen wastes, inedible refractory plant materials, grey waters from the CELLS system, and aquaculture solids and processes these materials in either aerobic or anaerobic reactors depending on the desired product and the rates required by the integrated system. I.S.

A92-17975
SPACE SAFETY AND RESCUE 1990; PROCEEDINGS OF THE 23RD INTERNATIONAL SYMPOSIUM, DRESDEN, FEDERAL REPUBLIC OF GERMANY, OCT. 6-12, 1990
GLORIA W. HEATH, ED. (SAR-ASSIST, Inc., Greenwich, CT) Symposium sponsored by IAA. San Diego, CA, Univelt, Inc. (Science and Technology Series. Vol. 79), 1991, 232 p. No individual items are abstracted in this volume. 1991 232 p
Copyright
Consideration is given to critical safety assurance factors for a manned spacecraft, rocket-space technology safety, a strategy for identification and development of safety critical software embedded in complex space systems, design aspects of a rescue system for manned spaceflight, and an airlock-based architecture for Space Station Freedom assured crew return capability. Attention is also given to dispersion of debris clouds from on-orbit fragmentation events, an assessment of active removal as an option for mitigating the space debris environment, and classification of debris orbits with regard to collision hazard in geostationary region. O.G.

A92-18539
C.E.B.A.S.-AQUARACK - THE 'SECOND GENERATION HARDWARE' AND SELECTED RESULTS OF THE SCIENTIFIC FRAME PROGRAM

V. BLUEM, E. STREZKE (Bochum, Ruhr-Universitaet, Federal Republic of Germany), and K. KREUZBERG (DLR, Cologne, Federal Republic of Germany) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 10 p. Research supported by BMFT and Ministerium fuer Wissenschaft und Forschung des Landes Nordrhein-Westfalen. Oct. 1991 10 p refs
(IAF PAPER 91-537) Copyright

The 'Closed Equilibrated Biological Aquatic System' (C.E.B.A.S.) is a long-term multigeneration experimental system for aquatic organisms which represents a German option for the Columbus Space Station and which was further developed to fit into the device of a so-called AQUARACK. The paper presents the current status of the hardware development of the second laboratory prototype and shows some selected examples of the scientific frame program. In this context, special attention is paid to the predominant subproject of the reproductive biology of X. helleri where results of investigations are presented on all three levels of the brain-pituitary-gonadal axis. Moreover, the possible role of the project in the development of a combined aquaculture system for utilization in a lunar or planetary base is discussed. Author

A92-18544* National Aeronautics and Space Administration, Washington, DC.
MEDICAL CONCERNS FOR EXPLORATION-CLASS MISSIONS
DONALD F. STEWART and BARBARA LUJAN (NASA, Washington, DC) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 11 p. Oct. 1991 11 p refs
(IAF PAPER 91-546) Copyright

The Space Exploration initiative will challenge life scientists with a diverse set of crew medical risks. The varied sources of this cumulative risk are identified and briefly discussed in terms of risk assessment and preliminary plans for risk management. The roles of Space Station Freedom and other flight programs are discussed in the context of exploration medical objectives. The significant differences between Space Station era (second generation) and exploration medical support systems (third generation) are reviewed. Author

A92-18545
MAJOR MEDICAL RESULTS OF EXTENDED FLIGHTS ON SPACE STATION MIR IN 1986-1990
A. I. GRIGOR'EV, S. A. BUGROV, V. V. BOGOMOLOV, A. D. EGOROV, V. V. POLIAKOV, I. K. TARASOV, and E. B. SHUL'ZHENKO (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 7 p. Oct. 1991 7 p refs
(IAF PAPER 91-547) Copyright

In 1986-1990 seven prime spacecrews (16 cosmonauts) flew on board Mir orbital complex. The longest duration of space mission was 366 days. Microgravity effects on the cardiovascular, motor, endocrine, blood, immune and metabolic were studied. The performed investigations point to the human possibility to adapt well to a year-long stay in space and to maintain good health and adequate performance. The readaptation has occurred in a similar way as it was after other long-term space flight up to 8 months in duration. Author

A92-18549
CIRCULATION AND FLUID ELECTROLYTE BALANCE IN EXTENDED SPACE MISSIONS
A. I. GRIGOR'EV and A. D. EGOROV (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 15 p. Oct. 1991 15 p refs
(IAF PAPER 91-552) Copyright

This paper presents the results of studies and possible mechanisms underlying changes of human circulation and fluid electrolyte balance in long duration space missions. Circulation changes were measured at rest, in response to graded exercise tests and lower body negative pressure tests. Fluid electrolyte balance before and after flight was measured with reference to changes in plasma electrolytes, spontaneous renal excretion of fluids and electrolytes in response to water and water salt supplements. Author

A92-18562* Lockheed Missiles and Space Co., Sunnyvale, CA.
EVOLUTIONARY DEVELOPMENT OF A LUNAR CELSS
STEVEN H. SCHWARTZKOPF, THOMAS E. STYCZYNSKI (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA), and MARIANN F. BROWN (NASA, Johnson Space Center, Houston, TX) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p refs
(IAF PAPER 91-572) Copyright

This paper describes a method of evolving the life support technologies of an early lunar base into an advanced life support system. The initial design is a partially-closed regenerative life support system based upon Space Station Freedom physicochemical technology. The paper describes the stepwise evolution of this baseline system into a closed-loop, lunar base Controlled Ecological Life Support System, a hybrid design which incorporates both advanced physicochemical and bioregenerative technologies. Author

A92-18564
DEVELOPMENT OF BIOLOGICAL LIFE SUPPORT SYSTEMS
R. KLINTWORTH, J. WARRELMANN, and S. WALTHER (MBB-ERNO, Bremen, Federal Republic of Germany) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 6 p. Oct. 1991 6 p
(IAF PAPER 91-574) Copyright

Life support systems for studying botanical and zoological objects are being developed by inhouse activities of MBB/ERNO. Scientific research on behavior or response of a versatile range of biological samples will now be accessible for experimenters through employing very cost-efficient multiuser facilities. Both Biomaus and Aquazelle are designed modular with respect to their core component composition and flight options. Author

A92-18565
THE FIRST 'SPACE' VEGETABLES HAVE BEEN GROWN UP IN THE 'SVET' GREENHOUSE BY MEANS OF CONTROLLED ENVIRONMENTAL CONDITIONS
T. N. IVANOVA (Bulgarian Academy of Sciences, Space Research Institute, Sofia, Bulgaria), IU. A. BERKOVICH, A. L. MASHINSKII, and G. I. MELESHKO (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 7 p. Oct. 1991 7 p refs
(IAF PAPER 91-575) Copyright

The paper describes the project Svet, the creating of a small dimensions space greenhouse of new generation. By means of minicomputer, Svet is full-automatically operating and controlling environmental conditions system in the higher plants growth unit. A number of studies have selected the radish and cabbage vegetables as a potentially important crop for CELSS. The Svet space greenhouse has been mounted on the 'Crystal' technological module docked to the Mir orbital space station on June 10, 1990. The preliminary results of the seeds cultivation for the first 54-day period in Svet are presented. Morphometrical characteristics of the plants, brought back to the earth are given. The vegetation peculiarities, such as the plants growth and the development slow-down, or the dry-substance content increase are noted. For the first time, the root crop of radish plants at microgravity conditions are produced. Characteristics of controlled plants' environment parameters and an estimation of functional properties of control and regulation systems of the Svet greenhouse in space flight are given in terms of telemetry data. Author

A92-18567* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE BIOLOGICAL FLIGHT RESEARCH FACILITY
CATHERINE C. JOHNSON (NASA, Ames Research Center, Moffett Field, CA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 8 p. Oct. 1991 8 p refs
(IAF PAPER 91-578) Copyright

NASA Ames Research Center is building a research facility, the Biological Flight Research Facility (BFRF), to meet the needs of life scientists to study the long-term effects of variable gravity on living systems. The facility will be housed on Space Station Freedom and is anticipated to operate for the lifetime of the station, approximately 30 years. It will allow plant and animal biologists to study the role of gravity, or its absence, at varying gravity intensities for varying periods of time and with various organisms. The principal difference between current Spacelab missions and those on Space Station Freedom, other than length of mission, will be the capability to perform on-orbit science procedures and the capability to simulate earth gravity. Initially, the facility will house plants and rodents in habitats which can be maintained at microgravity or can be placed on a 2.5-m diam centrifuge. However, the facility is also being designed to accommodate future habitats for small primates, avian, and aquatic specimens. The centrifuge will provide 1 g for controls and will also be able to provide gravity from 0.01 to 2.0 g for threshold gravity studies as well as hypergravity studies. The BFRF will provide the means to conduct basic experiments to gain an understanding of the effects of microgravity on the structure and function of plants and animals, as well as investigate the role of gravity as a potential countermeasure for the physiological changes observed in microgravity. Author

A92-18568
SPACECRAFT OPERATIONS - THE HUMAN FACTOR
DAVID E. B. WILKINS (ESA, European Space Operations Centre, Darmstadt, Federal Republic of Germany) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p refs
(IAF PAPER 91-580) Copyright

The issues of on-board complexity and human-induced errors are discussed in terms of operational effectiveness by considering human reliability as a system element. The study focuses on incorporating operator error into distinct levels of development including design, integration, testing, and operation. Improved methods of flight control result from the study, but other necessary activities are identified to enhance reliability, error tolerance, and operability. C.C.S.

A92-18569
SPACE RESCUE SYSTEM ANALYSIS AND DESIGN
JOHN LLOYD, SAM HOUSTEN (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA), PATRICK EYMAR, and MAX GRIMARD (Aerospatiale, Les Mureaux, France) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 11 p. Oct. 1991 11 p refs
(IAF PAPER 91-581) Copyright

The development of a space-based rescue system is presented, focusing on the results of a systems analysis and design study conducted in 1990. This rescue system has been designed to respond to three classes of space contingencies: space station, medical, and transportation element. Objectives of the study include attention to the Hermes alternative, analysis of a space-based rescue system for a space station, and capsule concepts derived from the study performed for ESA. R.E.P.

A92-18572* Sterling Software, Palo Alto, CA.
MAN OVERBOARD - WHAT NEXT?
ADAM R. BRODY, RICK JACOBY (Sterling Software, Inc., Palo Alto, CA), and STEPHEN R. ELLIS (NASA, Ames Research Center, Moffett Field, CA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. Oct. 1991 12 p refs
(IAF PAPER 91-584) Copyright

A study was performed in the Virtual Interactive Environment Workstation (VIEW) at NASA Ames Research Center. Simulations were conducted to assess the feasibility and quantify the fuel and time requirements for a stranded crewperson to return himself to a space station after an accidental separation. A hand-held thruster, similar to the Hand-Held Maneuvering Unit from the Gemini Program was used for propulsion. Thirty different separation scenarios were composed of three separation rates, five initial spin rates, and ability to use an attitude hold mode in a repeated measures design. Statistically significant results were produced by separation velocity. Fuel, maximum range, time to maximum range, maximum axial range, and final axial velocity increased with separation rate. VIEW was determined to be a useful device for simulating accidental separations, and a hand-held thruster is a viable alternative for accomplishing a self rescue. Author

A92-20456
TRAINING FOR INTERNATIONAL SPACE STATION 'FREEDOM' - A NEW PERSPECTIVE
J. MUCCIO (Booz, Allen and Hamilton, Inc., Wassenaar, Netherlands), W. OCKELS (ESTEC, Noordwijk, Netherlands), and E. GIBSON (OHB System GmbH, Bremen, Federal Republic of Germany) ESA Bulletin (ISSN 0376-4265), no. 68, Nov. 1991, p. 85-92. Nov. 1991 8 p
Copyright

The International Space Station 'Freedom' involves several unique challenges which must be addressed if an effective and affordable training program is to be developed. Compared with past programs, 'Freedom' will be much larger, will involve much longer stays in space for the crew, and will operate more like a ground-based laboratory than a space vehicle. Although they may initially seem insignificant, these three parameters will have a profound impact on both the structure and content of the Space Station training program. Author

A92-20862
A COMPACT BODY MASS MEASURING DEVICE FOR SPACE FLIGHT APPLICATIONS
P. V. PISTECKY, H. F. VAN BEEK (Delft University of Technology, Netherlands), J. F. F. KLINKHAMER (TNO, Delft, Netherlands), and F. BRECHIGNAC (ESTEC, Noordwijk, Netherlands) (Life sciences and space research XXIV/1/ - Gravitational biology; Proceedings of the Symposia 10 and 13 of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F1 and F2/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20827 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 1, 1992, p. 259-262. 1992 4 p refs
(Contract ESA-3-6399/89/NL/PB)
Copyright

A device developed for measuring an astronaut's body mass in space is described. The body-mass measuring device is based on initiating an artificial acceleration; it is compact and user friendly and has an absolute measuring accuracy better than 60 g. The device is battery operated and consumes less than 20 W. The measurement accuracy is restricted only by the way a human body is configured by nature and not by the instrument itself. I.S.

A92-20863
SPACE EXPERIMENT ON BEHAVIORS OF TREEFROG
AKEMI IZUMI-KUROTANI, MASAMICHI YAMASHITA (Institute of Space and Astronautical Science, Sagamihara, Japan), and YUKISHIGE KAWASAKI (Mitsubishi Kasei Institute of Life Sciences, Machida, Japan) (Life sciences and space research XXIV/1/ - Gravitational biology; Proceedings of the Symposia 10 and 13 of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F1 and F2/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20827 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 1, 1992, p. 263-266. 1992 4 p
Copyright

The paper describes the experimental system and the methods developed for observing the behavior of Japanese tree frogs (Hyla japonica), the species selected for space experiments aboard the MIR space station, under conditions of microgravity and under the effects of external stimuli. The system, which follows the same safety regulations as those applied for payloads on manned space vehicles, contains large number of instruments for passive observation and for observations of behavioral responses to various

stimuli, such as visual or mechanical, and during feeding or courtship. I.S.

A92-20865* Texas Univ., San Antonio.
LONG-TERM EFFECTS OF MICROGRAVITY AND POSSIBLE COUNTERMEASURES
JAMES W. WOLFE (Texas, University, San Antonio) and JOHN D. RUMMEL (NASA, Life Sciences Div., Washington, DC) (Life sciences and space research XXIV/1/ - Gravitational biology; Proceedings of the Symposia 10 and 13 of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F1 and F2/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20827 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 1, 1992, p. 281-284. 1992 4 p refs
Copyright
The measures that can be taken to counteract the effect of long-term exposures to microgravity are discussed. It is noted that, although it was shown that specially designed exercise programs can counteract the effect of exposures of up to one year in space, is it questionable whether U.S. astronauts could or should have to maintain such regimes for extremely prolonged missions. The methods considered by NASA Life Sciences Division are to provide an artificial gravity environment by the generation of centrifugal forces by means of either the continuous rotation of the whole spacecraft or using a short-arm centrifuge on board a zero-g spacecraft. Results obtained in studies of these two methods are discussed, and the centrifuge research facility that is presently being developed by NASA is described. I.S.

A92-20866
GLOBAL APPROACH TO SIMULATION - A GATEWAY TO LONG-TERM HUMAN PRESENCE IN SPACE
J. COLLET (ESA, Paris, France) and M. NOVARA (ESTEC, Noordwijk, Netherlands) (Life sciences and space research XXIV/1/ - Gravitational biology; Proceedings of the Symposia 10 and 13 of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F1 and F2/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20827 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 1, 1992, p. 285-299. 1992 15 p refs
Copyright
In preparation for the next century's European long-duration manned space missions, simulation activities in space-analogous environments were identified by the ESA Long-Term Program Office (LTPO) as the necessary pathway toward building a substantial knowledge data base. Several exploratory studies on problems related to human factors in long-duration space missions were initiated by the LTPO. The paper reports preliminary results of the SIMIS group (an ad-hoc group of experts) that was focusing on the physiological, psychological, and operational problems of long-duration exposure to microgravity and isolation/confinement, during planning in 1989-1990 for simulation of long-term missions. The human factors data base being gathered is of a fundamental nature, unbiased by as yet poorly defined mission-specific constraints. I.S.

A92-20870* National Aeronautics and Space Administration, Washington, DC.
DEVELOPMENT OF COUNTERMEASURES FOR MEDICAL PROBLEMS ENCOUNTERED IN SPACE FLIGHT
ARNAULD E. NICOGOSSIAN, JOHN D. RUMMEL (NASA, Life Sciences Div., Washington, DC), LAUREN LEVETON, and RON TEETER (Lockheed Corp., Washington, DC) (Life sciences and space research XXIV/1/ - Gravitational biology; Proceedings of the Symposia 10 and 13 of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F1 and F2/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20827 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 1, 1992, p. 329-337. 1992 9 p refs
Copyright
Past experience with piloted space missions is reviewed to develop potential countermeasures to the medical problems associated with a long-duration space flight. Particular attention is given to the Extended Duration Orbiter Medical Program, which is aimed at ensuring crew health and safety on Space Shuttle missions; Soviet experience with long-duration space flights; and a variety of countermeasures including physiological, psychological, environmental health, radiation protection, and artificial gravity countermeasures. O.G.

A92-20871
LONG-TERM SPACE FLIGHTS - PERSONAL IMPRESSIONS
V. V. POLIAKOV (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) (Life sciences and space research XXIV/1/ - Gravitational biology; Proceedings of the Symposia 10 and 13 of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F1 and F2/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20827 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 1, 1992, p. 339-341. 1992 3 p
Copyright
The author who participated in a one-year space flight onboard the Mir orbital complex as a physician shares his impressions. Scientific investigations and experiments performed by the physician included an evaluation of adaptation reactions of the human body at different stages of the flight using physiological and biochemical methods and testing alternative regimes of exercise and new countermeasures to prevent an unfavorable effect of long-term weightlessness. O.G.

A92-20872
SOME MEDICAL ASPECTS OF AN 8-MONTH'S SPACE FLIGHT
O. IU. ATKOV (All-Union Cardiology Research Center, Moscow, USSR) (Life sciences and space research XXIV/1/ - Gravitational biology; Proceedings of the Symposia 10 and 13 of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F1 and F2/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20827 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 1, 1992, p. 343-345. 1992 3 p
Copyright
Results of medical experiments performed on the Salyut-7-Soyuz-T orbital complex and the Mir station are briefly discussed with particular attention given to cardiovascular studies and hematological examinations. It is concluded that an increase in flight time to eight months produced no qualitatively new physiological changes as compared to the previous prolonged flights. O.G.

A92-20873
SELECTION AND BIOMEDICAL TRAINING OF COSMONAUTS
S. A. BUGROV, L. I. VORONIN, IU. I. VORONKOV, M. M. KOROTAEV, and IU. A. SENKEVICH (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) (Life sciences and space research XXIV/1/ - Gravitational biology; Proceedings of the Symposia 10 and 13 of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F1 and F2/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20827 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 1, 1992, p. 347-350. 1992 4 p refs
Copyright
A Soviet concept of cosmonaut selection and training based on twenty-eight years experience of supporting the safety of manned space missions is reviewed. Major stages of medical selection system and biomedical preparation of cosmonauts for long-duration missions are discussed. It is concluded that the existing systems for selection and biomedical training made it possible to provide safety for space missions lasting up to a year. Training programs aimed at cosmonaut preparation for long-duration interplanetary flights will reflect a significant shift toward biomedical aspects. O.G.

A92-20874* National Aeronautics and Space Administration, Washington, DC.
DEVELOPMENT OF LIFE SUPPORT REQUIREMENTS FOR LONG-TERM SPACE FLIGHT
JOHN D. RUMMEL (NASA, Life Sciences Div., Washington, DC) (Life sciences and space research XXIV/1/ - Gravitational biology; Proceedings of the Symposia 10 and 13 of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F1 and F2/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20827 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 1, 1992, p. 351-353. 1992 3 p

Life support system requirements for future long-term space flights are discussed. These requirements include overall reliability in the space environment, providing maintenance and component replacement in space; reduced supply mass of consumables and spares; the ability to utilize local resources for increased self-sufficiency on planetary surfaces; and minimized mass power and volume requirements necessary for all space flight systems. O.G.

A92-20895* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
HUMAN REPRODUCTIVE ISSUES IN SPACE
PATRICIA A. SANTY and RICHARD T. JENNINGS (NASA, Johnson Space Center, Houston, TX) (Life sciences and space research XXIV/2/ - Radiation biology; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F3, F4, F5, F6 and F1/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20879 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 2-3, 1992, p. 151-155. 1992 5 p refs

A review of reproductive functioning in animal species studied during space flight demonstrated that most species were affected significantly by the absence of gravity and/or the presence of radiation. These two factors induced alterations in normal reproductive functioning independently of, as well as in combination with, each other. Based on animal models, several potential problem areas regarding human reproductive physiology and functioning in the space environment were identified. While there are no current space flight investigations, the animal studies suggest priorities for future research in human reproduction. Such studies will be critical for the successful colonization of the space frontier. Author

A92-20896
COMBINED INJURY SYNDROME IN SPACE-RELATED RADIATION ENVIRONMENTS
R. F. DONS and U. FOHLMEISTER (USAF, Medical Center, Lackland AFB, TX) (Life sciences and space research XXIV/2/ - Radiation biology; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F3, F4, F5, F6 and F1/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20879 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 2-3, 1992, p. 157-163. 1992 7 p refs

The risk of combined injury (CI) to space travelers is a function of exposure to anomalously large surges of a broad spectrum of particulate and photon radiations, conventional trauma (T), and effects of weightlessness including decreased intravascular fluid volume, and myocardial deconditioning. CI may occur even at relatively low doses of radiation which can synergistically enhance morbidity and mortality from T. Without effective countermeasures, prolonged residence in space is expected to predispose most individuals to bone fractures as a result of calcium loss in the microgravity environment. Immune dysfunction may occur from residence in space independent of radiation exposure. Thus, wound healing would be compromised if infection were to occur. Survival of the space traveler with CI would be significantly compromised if there were delays in wound closure or in the application of simple supportive medical or surgical therapies. Author

A92-20897
PROTOCOL FOR THE TREATMENT OF RADIATION INJURIES
D. BROWNE, J. F. WEISS, T. J. MACVITTIE, and M. V. PILLAI (DNA, Armed Forces Radiobiology Research Institute, Bethesda, MD) (Life sciences and space research XXIV/2/ - Radiation biology; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F3, F4, F5, F6 and F1/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20879 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 2-3, 1992, p. 165-168. Research supported by DNA. 1992 4 p refs

Despite adequate precautionary measures and high-quality safeguard devices, many accidental radiation exposures continue to occur and may pose greater risks in the future, including radiation exposure in the space environment. The medical management of radiation casualties is of major concern to health care providers. Such medical management was addressed at The First Consensus Development Conference on the Treatment of Radiation Injuries, Washington, DC, 1989. The conference addressed the most appropriate treatment for the hematopoietic and infectious complications that accompany radiation injuries and for combined radiation and traumatic/burn injuries. Based on the evidence presented at the conference, a consensus statement was formulated by expert physicians and scientists. The recommended therapies, including a suggested algorithm incorporating these recommendations for the treatment of radiation injuries, are discussed. Author

A92-20900* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
RADIATION ISSUES FOR PILOTED MARS MISSION
GAUTAM D. BADHWAR, D. S. NACHTWEY (NASA, Johnson Space Center, Houston, TX), and TRACY C. YANG (Lawrence Berkeley Laboratory, Berkeley, CA) (Life sciences and space research XXIV/2/ - Radiation biology; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F3, F4, F5, F6 and F1/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20879 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 2-3, 1992, p. 195-200. 1992 6 p refs

Current radiation risk for a piloted Mars mission is estimated using the idea of absorbed dose and ICRP-26, LET-dependent quality factors. In a spacecraft with aluminum walls (2 g/sq cm) at solar minimum the calculated dose equivalent is 0.73 Sv for a 406-day mission. Based on the current thinking this leads to an excess cancer mortality in a 35-year male of about 1 percent. About 75 percent of the dose equivalent is contributed by HZE particles and target fragments with average quality factors of 10.3 and 20, respectively. The entire concept of absorbed dose, quality factor, and dose equivalent as applied to such missions needs to be reexamined, in light of the fact that less than 50 percent of the nuclei in the body of the astronaut would have been traversed by a single GCR nuclei in the 406-day mission. Author

A92-20908
BEHAVIORAL TOXICITY OF SELECTED RADIOPROTECTORS
M. R. LANDAUER, H. D. DAVIS, K. S. KUMAR, and J. F. WEISS (DNA, Armed Forces Radiobiology Research Institute, Bethesda, MD) (Life sciences and space research XXIV/2/ - Radiation biology; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F3, F4, F5, F6 and F1/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20879 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 2-3, 1992, p. 273-283: Research supported by DNA. 1992 11 p refs

Effective radioprotection with minimal behavioral disruption is essential for the selection of protective agents to be used in

manned spaceflight. This overview summarizes the studies on the behavioral toxicity of selected radioprotectors classified as phosphorothioates, bioactive lipids, platelet activating factor (PAF), and immunomodulators (glucan, synthetic trehalose dicorynomycolate, and interleukin-1). Behavioral toxicity was examined in laboratory mice using a locomotor activity test. For all compounds tested, there was a dose-dependent decrease in locomotor behavior that paralleled the dose-dependent increase in radioprotection. While combinations of radioprotective compounds increased radioprotection, they also decreased locomotor activity. The central nervous system stimulant, caffeine, was able to mitigate the locomotor decrement produced by phosphorothioates or PAF. Author

A92-20912
'MIR' RADIATION DOSIMETRY RESULTS DURING THE SOLAR PROTON EVENTS IN SEPTEMBER-OCTOBER 1989
TS. P. DACHEV, IU. N. MATVIICHUK, N. G. BANKOV, I. V. SEMKOVA, R. T. KOLEVA, IA. IVANOV, B. T. TOMOV (Bulgarian Academy of Sciences, Space Research Institute, Sofia, Bulgaria), V. M. PETROV, V. A. SHURSHAKOV, V. V. BENGIN (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) et al. (Life sciences and space research XXIV/2/ - Radiation biology; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F3, F4, F5, F6 and F1/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20879 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 2-3, 1992, p. 321-324. 1992 4 p refs
Copyright

Using data from dosimetry-radiometry system 'Liulin' onboard the 'Mir' Space Station, the particle flux and dose rate during September-October, 1989 has been studied. The orbit of the station was 379 km perigee, 410 km apogee and 51.6 deg inclination. Special attention has been paid to the flux and dose rate changes inside the station after intensive solar proton events (SPE) on 29 September, 1989. The comparison between the doses before and after the solar flares shows increase of the calculated mean dose per day by factors of 10 to 200. During the SPE on the 29th of September the additional dose was 310 mrad. The results of the experiment are compared with the data for the solar proton fluxes obtained on the GOES-7 satellite. Author

A92-20916* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HUMAN EXPOSURE TO LARGE SOLAR PARTICLE EVENTS IN SPACE
L. W. TOWNSEND, J. W. WILSON, J. L. SHINN (NASA, Langley Research Center, Hampton, VA), and S. B. CURTIS (Lawrence Berkeley Laboratory, Berkeley, CA) (Life sciences and space research XXIV/2/ - Radiation biology; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F3, F4, F5, F6 and F1/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20879 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 2-3, 1992, p. 339-348. 1992 10 p refs
Copyright

Whenever energetic solar protons produced by solar particle events traverse bulk matter, they undergo various nuclear and atomic collision processes which significantly alter the physical characteristics and biologically important properties of their transported radiation fields. These physical interactions and their effect on the resulting radiation field within matter are described within the context of a recently developed deterministic, coupled neutron-proton space radiation transport computer code (BRYNTRN). Using this computer code, estimates of human exposure in interplanetary space, behind nominal (2 g/sq cm) and storm shelter (20 g/sq cm) thicknesses of aluminum shielding, are made for the large solar proton event of August 1972. Included in these calculations are estimates of cumulative exposures to the skin, ocular lens, and bone marrow as a function of time during the event. Risk assessment in terms of absorbed dose and dose equivalent is discussed for these organs. Also presented are estimates of organ exposures for hypothetical, worst-case flare scenarios. The rate of dose equivalent accumulation places this situation in an interesting region of dose rate between the very low values of usual concern in terrestrial radiation environments and the high-dose-rate values prevalent in radiation therapy. Author

A92-20920
***QUALITY FACTOR AND DOSE EQUIVALENT* INVESTIGATIONS ABOARD THE SOVIET SPACE STATION MIR**
P. BOUISSET, V. D. NGUYEN, N. PARMENTIER (CEA, Fontenay-aux-Roses, France), IA. A. AKATOV, V. V. ARKHANGEL'SKII, A. S. VOROZHTSOV, V. M. PETROV, E. E. KOVALEV (Institut Mediko-Biologicheskikh Problem, Moscow, USSR), and M. SIEGRIST (CNES, Toulouse, France) (Life sciences and space research XXIV/2/ - Radiation biology; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F3, F4, F5, F6 and F1/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20879 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 2-3, 1992, p. 363-367. 1992 5 p refs
Copyright

Since Dec 1988, date of the French-Soviet joint space mission 'ARAGATZ', the CIRCE device, had recorded dose equivalent and quality factor values inside the Mir station (380-410 km, 51.5 deg). After the initial gas filling two years ago, the low pressure tissue equivalent proportional counter is still in good working conditions. Some results of three periods are presented. The average dose equivalent rates measured are respectively 0.6, 0.8 and 0.6 mSv/day with a quality factor equal to 1.9. Some detailed measurements show the increasing of the dose equivalent rates through the SAA and near polar horns. The real time determination of the quality factors allows to point out high linear energy transfer events with quality factors in the range 10-20. Author

A92-20921
PRELIMINARY TOTAL DOSE MEASUREMENTS ON LDEF
G. REITZ (DLR, Institut fuer Flugmedizin, Cologne, Federal Republic of Germany) (Life sciences and space research XXIV/2/ - Radiation biology; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F3, F4, F5, F6 and F1/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20879 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 2-3, 1992, p. 369-373. 1992 5 p refs
Copyright

Data are presented on the measurements of absorbed dose of cosmic rays with the lithium fluoride thermoluminescence dosimeters (TLDs) that are part of the Free Flyer Biostack Experiment which is part of the NASA Long Duration Exposure Facility (LDEF). The twenty stacks of the Biostack are back on earth after spending nearly 6 yrs in the earth orbit. The paper discusses the major objectives of the Free Flyer Biostacks attached to the surface of the LDEF, the Biostack experimental units, and the flight parameters of the LDEF. Absorbed dose measurements are presented for three TLDs behind different shieldings in front of the dosimeters. Since most of the exposure time was spent during a period of minimal solar activity, the results can be regarded as representative for a solar minimum situation. I.S.

A92-20926
RADIATION QUALITY AND RISK ESTIMATION IN RELATION TO SPACE MISSIONS
R. J. M. FRY (Oak Ridge National Laboratory, TN) (Life sciences and space research XXIV/2/ - Radiation biology; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F3, F4, F5, F6 and F1/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20879 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 2-3, 1992, p. 403-406. 1992 4 p refs

(Contract DE-AC05-84OR-21400)
Copyright

While Q is specified as a function of linear energy transfer (LET), in practice the Q for neutrons is selected by a judgment decision based on the relative biological effectiveness (RBE) to induce stochastic effects. There are no RBE values for tumor induction by heavy ions or protons in humans. Thus, selection of Q values is based either on LET (or lineal energy) or RBEs from animal experiments. Estimates of Q for heavy ions in low earth orbit (LEO) range from about 5 to 14. The average Q value of all radiation in LEO is estimated to be about 1.3. There is a lack of experimental data for RBEs for heavy ions but RBE increases as a function of LET. In the case of the Harderian gland the RBE reaches a maximum of 25-30 between about 100-200 keV/microns but does not appear to decrease at higher LETs. The International Commission of Radiological Protection proposes the use of radiation weighting factors in lieu of quality factors. The weighting factors range from 1 to 20. Author

A92-20932
EFFECTS OF INCREASED SHIELDING ON GAMMA-RADIATION LEVELS WITHIN SPACECRAFT
P. S. HASKINS, J. E. MCKISSON, A. G. WEISENBERGER, D. W. ELY, T. A. BALLARD (Florida, University, Gainesville), C. S. DYER, P. R. TRUSCOTT (Royal Aerospace Establishment, Farnborough, England), R. B. PIERCEY (Mississippi State University, Mississippi State), A. V. RAMAYYA (Vanderbilt University, Nashville, TN), and D. C. CAMP (Lawrence Livermore National Laboratory, Livermore, CA) (Life sciences and space research XXIV/2/ - Radiation biology; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F3, F4, F5, F6 and F1/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20879 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 2-3, 1992, p. 461-464. Research sponsored by SDIO. 1992 4 p refs
Copyright

The Shuttle Activation Monitor (SAM) experiment was flown on the Space Shuttle Columbia from 8-13 August, 1989 in a 57-deg, 300-km orbit. One objective of the SAM experiment was to determine the relative effect of different amounts of shielding on the gamma-ray backgrounds measured with similarly configured sodium iodide and bismuth germante detectors. To achieve this objective, twenty-four hours of data were taken with each detector in the middeck of the Shuttle on the ceiling of the airlock (a high-shielding location) as well as on the sleep-station wall (a low-shielding location). For the cosmic-ray induced background, the results indicate an increased overall count rate in the 0.2 to 10 MeV energy range at the more highly shielded location, while in regions of trapped radiation the low shielding configuration gives higher rates at the low-energy end of the spectrum. Author

A92-20979* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE CELSS TEST FACILITY PROJECT - AN EXAMPLE OF A CELSS FLIGHT EXPERIMENT SYSTEM
R. D. MACELROY (NASA, Ames Research Center, Moffett Field, CA) and C. L. STRAIGHT (Bionetics Corp., Moffett Field, CA) (Life sciences and space research XXIV/4/ - Natural and artificial ecosystems; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F10, F11, F1 and F12/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20969 07-54) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 5, 1992, p. 75-81. 1992 7 p refs
Copyright

The design of the facility is described in terms of its use as an investigation tool for evaluating crop growth in space with reference to required emerging technologies. NASA's CELSS Test Facility (CTF) is designed to permit the measurement of crop-plant productivity under microgravity conditions including biomass production, food production, water transpiration, and O2/CO2 exchanges. Crucial hardware tests and qualifications are identified to assure the operation of CTF technologies in space including the nutrient-delivery, water-condensation, and gas-liquid-mixing subsystems. The design concept and related scientific requirements are described and shown to provide microgravity crop research. The CTF is expected to provide data for plant research and for concepts for bioregenerative life-support systems for applications to Martian, lunar, and space-station missions. C.C.S.

A92-21757
PRELIMINARY ASSESSMENT OF BIOLOGICALLY-RECLAIMED WATER
D. S. JANIK (Cetus Research, El Cerrito, CA), J. DEMARCO, S. KRISHNAN (Pyraponics Industries, Inc., San Diego, CA), and B. BENSON (Alabama, University, Huntsville) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 9 p. Jul. 1991 9 p refs
(SAE PAPER 911326) Copyright

Organic, inorganic and physical water quality data are reported for water transpired by several species of higher plants using an engineering and scientific testbed for high-fidelity, biological water reclamation and recycling. Biologically-reclaimed water met NASA Shuttle potable and Space Station/Manned Systems Integration hygiene standards with regard to parameters tested without post-treatment. Water reclaimed from 10-percent urine showed a 100-fold reduction in organics and inorganics, demonstrating the efficiency of biological water reclamation and the usefulness of this testbed for scientific and engineering studies. Author

A92-21761
THE EFFECT OF REDUCED CABIN PRESSURE ON THE CREW AND THE LIFE SUPPORT SYSTEM
KRISTIN B. MCCARTHY and JAMES A. GREEN (Rockwell International Corp., El Segundo, CA) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 7 p. Jul. 1991 7 p refs
(SAE PAPER 911331) Copyright

The impacts of reduced atmospheric pressures on crew health, safety, and operations have been evaluated. There are no known long-term physiological or psychological impediments to living at low pressure. Cabin pressures less than 8 psi (55.16 kPa) permit the use of low pressure suits without pre-breathing, which enhances Extra-Vehicular Activity (EVA) and contingency response. Fire hazards at reduced pressures are not as severe as once feared due to the reduced thermal capacity of the gases, lack of convection, and the tendency of the flame to 'cocoon' around the 'fuel'. These factors tend to make the fire self-extinguishing. Cold plating may be necessary for thermal control of components. Analysis of gas volume, leakage, and EVA show a significant resupply cost savings and EVA operations simplification. Additional studies are required to establish the optimum cabin pressure. Author

A92-21762* Krug Life Sciences, Inc., Houston, TX.
DETERMINING THE IV FLUIDS REQUIRED FOR A TEN DAY MEDICAL EMERGENCY ON SPACE STATION FREEDOM - COMPARISON OF PACKAGED VS. ON-ORBIT PRODUCED SOLUTIONS
GERALD J. CREAGER (Krug Life Sciences, Houston, TX) and CHARLES W. LLOYD (NASA, Johnson Space Center, Houston, TX) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 11 p. Jul. 1991 11 p refs
(SAE PAPER 911333) Copyright

To aid planning for the storage of supplies onboard Space Station Freedom, an estimate was made of the amount of intravenous (IV) fluid required to support a patient who has suffered a medical emergency for a period of up to 10 days. Six different medical scenarios were evaluated, and the volume of IV fluids required for each scenario was estimated. Up to 220 liters of fluid would be required to support a patient for all of the scenarios. When optimizing the volumes to support any single scenario, a total of 123 liters is required. Use of a water polishing system to produce sterile water for injection from potable supplies and

on-station formulation of IV fluids results in a smaller mass and volume requirement for the Fluid Therapy Subsystem than carrying prepackaged bags of fluid. Author

A92-21764
LASER MEDICINE AND SURGERY IN MICROGRAVITY
RICHARD CALEEL (Chicago, University, IL), PAUL QUO (Loyola University, Chicago, IL), MICHAEL COLVARD, and COLETTE COZEAN SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 8 p. Jul. 1991 8 p refs
(SAE PAPER 911336) Copyright

For space based surgery, lasers may permit methods for rapid stabilization of traumatic or emergency injuries, surgical fluid control, and hemostasis, and reduce contamination of the aircraft environment. An outline is presented of the basic concept of laser surgery in an aviation and microgravity environment utilizing carbon dioxide, ND:YAG, KTP and Excimer laser incisions within high altitude, military, aviation and microgravity aviation environments. Present research indicates that surgical lasers will play a significant role in the development and application of space medicine and surgery procedures due to their small size, reusability and ability to provide expedient control of surgical events in space. R.E.P.

A92-21769* Boeing Co., Huntsville, AL.
COMPUTER AIDED RADIATION ANALYSIS FOR MANNED SPACECRAFT
MATTHEW H. APPLEBY, BRAND N. GRIFFIN, ERNEST R. TANNER, II (Boeing Advanced Civil Space Systems Group, Huntsville, AL), WILLIAM R. POGUE (CAMUS, Inc., Huntsville, AL), and MICHAEL J. GOLIGHTLY (NASA, Johnson Space Center, Houston, TX) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 11 p. Jul. 1991 11 p refs
(SAE PAPER 911353) Copyright

In order to assist in the design of radiation shielding an analytical tool is presented that can be employed in combination with CAD facilities and NASA transport codes. The nature of radiation in space is described, and the operational requirements for protection are listed as background information for the use of the technique. The method is based on the Boeing radiation exposure model (BREM) for combining NASA radiation transport codes and CAD facilities, and the output is given as contour maps of the radiation-shield distribution so that dangerous areas can be identified. Computational models are used to solve the 1D Boltzmann transport equation and determine the shielding needs for the worst-case scenario. BREM can be employed directly with the radiation computations to assess radiation protection during all phases of design which saves time and ultimately spacecraft weight. C.C.S.

A92-21775
ECLSS COMPUTER AIDED TESTING USING KNOWLEDGE BASED SYSTEMS
BOB M. THORNTON, JAMES B. SCHULTZ, II (Micro Craft, Inc., Huntsville, AL), and EDSON A. WORDEN (Boeing Aerospace and Electronics, Huntsville, AL) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 14 p. Jul. 1991 14 p
(SAE PAPER 911359) Copyright

Design and implementation of a computer-aided test and a knowledge base/object-oriented data base for Space Station Freedom is discussed. Described within the paper is the design and development of 'C'/SQL language software and programmable logic needed to acquire data and provide system control functions. Creation of a user interface for an intelligent report generator, a data base of test anomalies with interactive alarming and an expert system for system trouble-shooting is outlined. Author

A92-21782* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
FLIGHT TEST OF AN IMPROVED SOLID WASTE COLLECTION SYSTEM
W. THORNTON, H. BRASSEAUX (NASA, Johnson Space Center, Houston, TX), and H. WHITMORE (Whitmore Enterprises, San Antonio, TX) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 6 p. Jul. 1991 6 p refs
(SAE PAPER 911367) Copyright

A system for human waste collection is described and evaluated on the basis of a prototype employed for the shuttle flight STS-35. The manually operated version of the unit is designed to collect, compact, and store human waste and cleaning material in replaceable volumes. The system is presented with illustrations and descriptions of the disposable pads that are used to clean the cylinder and occlusive air valves as well as seal the unit. Temporary retention and waste entrainment are provided by the variable airflow in the manual unit tested. The prototype testing indicates that sufficient airflow is achieved at 45 CFM and that the stowage volume (18.7 cu in.) is adequate for storing human waste with minimal logistical support. Higher compaction pressure and the use of a directed airstream are proposed for improving the packing efficiency of the unit. C.C.S.

A92-21783
PRELIMINARY DESIGN OF HEALTH CARE SYSTEMS FOR SPACE EXPLORATION
BRUCE A. MCKINLEY, KAREN L. MATHES, and SCOTT C. SIMMONS (Krug Life Sciences, Inc., Houston, TX) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 20 p. Jul. 1991 20 p refs
(SAE PAPER 911369) Copyright

The discussion of spaceborne health facilities addresses the need for health care for crewmembers on long-duration missions by defining such facilities and identifying protocols and related effects on hardware development. The Health Maintenance Facility (HMF) concept is described in terms of its planned support services for the SSF. Experimental medical devices are listed for studying fluid formulation, ventilator control, fluid-sample processing, and for acquiring X-ray images. Other key issues are mentioned including dedicated work volume and work-area guidelines, and the capabilities of such health-care facilities are listed and found to be substantial. Proposed concepts for the HMF are given with graphic illustrations to specify the listed requirements and functions. C.C.S.

A92-21784* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE NASA RADIATION HEALTH PROGRAM
WALTER SCHIMMERLING (JPL, Pasadena, CA) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 7 p. Jul. 1991 7 p
(SAE PAPER 911371) Copyright

The Space Radiation Health Program (SRHP) is defined in terms of motivation and methodology with specific reference given to the impacts of HZE particles and solar energetic particles. The biological hazards are mentioned that can be associated with the two particle types and ionizing radiation in general. The lack of data on the impact of such radiation and effective shielding countermeasures is identified as the primary motivation for worst-case assumptions. However, the resulting shielding designs can potentially overestimate the thickness by a factor of 10 and add unnecessarily to vehicle take-off mass. A space-based validation system is proposed to complement ground-based investigations of the effects of ionizing radiation in interplanetary space. The Lifesat satellite is proposed as a part of the SRHP effort to determine the requirements for protection and future shielding specifications. C.C.S.

A92-21787
UPPER BODY EXERCISE - PHYSIOLOGY AND TRAINING APPLICATION FOR HUMAN PRESENCE IN SPACE
MICHAEL N. SAWKA and KENT B. PANDOLF (U.S. Army, Research Institute of Environmental Medicine, Natick, MA) SAE, International Conference on Environmental Systems, 21st, San

Francisco, CA, July 15-18, 1991. 21 p. Jul. 1991 21 p refs
(SAE PAPER 911461) Copyright

The physiological responses to the upper body exercises and the control mechanisms involved in these responses are examined. A comparison with the physiological responses to the lower-body exercise showed that the upper body exercise requires a greater oxygen uptake at a given power output and that, at a given oxygen uptake, the heart rate, the blood pressure, and the total peripheral resistance responses during the upper body exercise are greater than those during the lower body exercise, while the stroke volume responses are lower. Body-temperature responses to both types of exercise are similar, but the temperatures are regulated by different heat exchange mechanisms. It is recommended that the unique physiology associated with the upper body exercise should be considered in developing exercise regimes for the manned space program. I.S.

A92-21789* Houston Univ., TX.
ASTRONAUT ADAPTATION TO 1 G FOLLOWING LONG DURATION SPACE FLIGHT
JOHN WALKER (Houston, University, TX), MICHAEL GREENISEN (NASA, Johnson Space Center, Houston, TX), LYNDA L. COWELL (Texas College of Osteopathic Medicine, Fort Worth), and WILLIAM G. SQUIRES (Texas Lutheran College, Seguin) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 14 p. Jul. 1991 14 p refs
(SAE PAPER 911463) Copyright

The paper reviews the results of studies of changes undergone by several physiological systems (including the cardiovascular system, the fluid and electrolyte characteristics, the red blood cells, the bone and the muscle tissues, and the exercise capacity) due to the exposures to microgravity and to the adaptation to 1 G after a long-duration space flight. Special attention is given to the effects of various training protocols and countermeasures used to attenuate the physiological problems encountered upon return from space. I.S.

A92-21790
ECLSS CONTAMINATION MONITORING STRATEGIES AND TECHNOLOGIES
S. KLINGELE (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) and G. B. TAN (ESTEC, Noordwijk, Netherlands) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 8 p. Research supported by ESA. Jul. 1991 8 p refs
(SAE PAPER 911464) Copyright

A mobile trace gas monitoring system, consisting of a combined gaschromatograph/mass spectrometer, employing air as carrier gas, was modified and tested. Performance test results, obtained in ECLSS testbed trials and recorded during a four weeks isolation experiment of a six man crew in a test chamber, are reported. Intermediate results of a trace gas monitoring study, in which various monitoring strategies and applicable state-of-the-art methods are investigated for their applicability to near-term and long-term manned space missions are presented. R.E.P.

A92-21791
A GAS CHROMATOGRAPHIC SEPARATOR FOR COLUMBUS TRACE GAS CONTAMINATION MONITORING ASSEMBLY
G. BAYKUT, J. FRANZEN, H.-P. VETTERS (Bruker-Franzen Analytik GmbH, Bremen, Federal Republic of Germany), and H. ABELE (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 8 p. Jul. 1991 8 p refs
(SAE PAPER 911465) Copyright

A development model gas chromatographic separator is being designed and built for the Trace Gas Contamination Monitoring Assembly of Columbus Man Tended Free Flyer MTFF. The analysis of atmospheric contaminations in the space module will be performed by a separator/analyzer system of a gas chromatograph/mass spectrometer (GCMS). The gas chromatograph (GC) being developed at this stage is compact, lightweight, ruggedized and low-power-consuming. Furthermore, it operates fast, and the cool-down period (preparation for the next operation) is very short. The Columbus GC can also easily be connected to the mass spectrometer (MS), and its separation performance is very good for the GCMS analysis. Author

A92-21792
COLUMBUS CABIN VENTILATION CONCEPT - FIRST TEST RESULTS
KARL-OTTO HIENERWADEL (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 9 p. Research supported by ESA. Jul. 1991 9 p
(SAE PAPER 911466) Copyright

Two ventilation concepts are investigated for conformity with the stringent air velocity requirements for the cabin of the Columbus module. The ventilation concepts are tested for a rectangular volume with a cross section of 2.2 x 2.2 m and a length of 4.24 m. The first concept examined utilizes the velocity of the air passing through inlet diffusers into the volume. The second concept is based on the same technique but employs additional fans within the volume to accelerate air motion. The relevant performance requirements are set forth including air velocity, maximum flow rate per diffuser, and generally uniform distribution throughout the module mock-up. Despite the difficult boundary conditions the ventilation concept in most areas of the cabin with deviations in the range of 25 percent of the allowable minimum. The test results serve as the basis for the Columbus project selecting the system without recirculation fans to be operated at the nominal flow rate during human occupancy. C.C.S.

A92-21793
MEMBRANE SEPARATION PRINCIPLE USED FOR GAS DRYING PROCESSES IN FUEL CELLS AND LIFE SUPPORT SYSTEMS
H. A. NIGSCH and W. U. FLECK (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 9 p. Jul. 1991 9 p refs
(SAE PAPER 911467) Copyright

Different membrane separation principles as applied to fuel cell powerplants and ECLSS are described. A new separator type that enables smaller weight and geometries and requires less energy than conventional mechanical separator techniques for space applications is presented. Module optimization and investigations concerning ECLSS applications are discussed. R.E.P.

A92-21796* Minnesota Univ., Minneapolis.
AIRBORNE PARTICULATE MATTER AND SPACECRAFT INTERNAL ENVIRONMENTS
BENJAMIN Y. H. LIU, KENNETH L. RUBOW, PETER H. MCMURRY, THOMAS J. KOTZ (Minnesota, University, Minneapolis), and DANE RUSSO (NASA, Johnson Space Center, Houston, TX) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 13 p. Jul. 1991 13 p refs
(SAE PAPER 911476) Copyright

Instrumentation, consisting of a Shuttle Particle Sampler (SPS) and a Shuttle Particle Monitor (SPM), has been developed to characterize the airborne particulate matter in the Space Shuttle cabin during orbital flight. The SPS size selectively collects particles in four size fractions (0-2.5, 2.5-10, 10-100, and greater than 100 microns) which are analyzed postflight for mass concentration and size distribution, elemental composition, and morphology. The SPM provides a continuous record of particle concentration through photometric light scattering. Measurements were performed onboard Columbia, OV-102, during the flight of STS-32 in January 1990. No significant changes were observed in the particle mass concentration, size distribution, or chemical composition in samples collected during flight-day 2 and flight-day 7. The total mass concentration was 56 microg/cu cm with approximately half of the particles larger than 100 microns. Elemental analysis showed

that roughly 70 percent of the particles larger than 2.5 microns were carbonaceous with small amounts of other elements present. The SPM showed no temporal or spatial variation in particle mass concentration during the mission. Author

A92-21798* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
USING VAPEPS FOR NOISE CONTROL ON SPACE STATION FREEDOM
GLORIA BADILLA, THOMAS BERGEN, and TERRY SCHARTON (JPL, Pasadena, CA) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 9 p. Jul. 1991 9 p refs
(SAE PAPER 911478) Copyright

Noise environmental control is an important design consideration for Space Station Freedom (SSF), both for crew safety and productivity. Acoustic noise requirements are established to eliminate fatigue and potential hearing loss by crew members from long-term exposure and to facilitate speech communication. VAPEPS (VibroAcoustic Payload Environment Prediction System) is currently being applied to SSF for prediction of the on-orbit noise and vibration environments induced in the 50 to 10,000 Hz frequency range. Various sources such as fans, pumps, centrifuges, exercise equipment, and other mechanical devices are used in the analysis. The predictions will be used in design tradeoff studies and to provide confidence that requirements will be met. Preliminary predictions show that the required levels will be exceeded unless substantial noise control measures are incorporated in the SSF design. Predicted levels for an SSF design without acoustic control treatments exceed requirements by 25 dB in some one-third octave frequency bands. Author

A92-21799* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
A COMBUSTION PRODUCTS ANALYZER FOR CONTINGENCY USE DURING THERMODEGRADATION EVENTS ON SPACECRAFT
THOMAS LIMERO, JOHN T. JAMES, STEVEN BECK (NASA, Johnson Space Center, Houston, TX), and RAYMOND CROMER (Exidyne Instrumentation Technologies, Exton, PA) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 12 p. Jul. 1991 12 p refs
(SAE PAPER 911479) Copyright

This paper will describe the Combustion Products Analyzer (CPA), which is being developed under the direction of the Toxicology Laboratory at Johnson Space Center to provide necessary data on air quality in the Shuttle following a thermodegradation incident. Using separate electrochemical sensors, the CPA monitors four gases (hydrogen fluoride/carbonyl fluoride, hydrogen chloride, hydrogen cyanide, and carbon monoxide), which were selected as the most hazardous compounds likely to be released during thermodegradation of synthetic materials. Electrochemical sensors have been available for several years; the CPA sensors, which are unique because of their small size and zero-gravity compatibility, will be described in detail. Author

A92-21807* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SHIFTWORK IN SPACE - BRIGHT LIGHT AS A CHRONOBIOLOGIC COUNTERMEASURE
PHILIPPA H. GANDER (NASA, Ames Research Center, Moffett Field, CA) and ALEXANDER SAMEL (DLR, Institut fuer Flugmedizin, Cologne, Federal Republic of Germany) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 17 p. Jul. 1991 17 p refs
(SAE PAPER 911496) Copyright

The potential of timed exposures to bright light as a countermeasure to the changes in the work/rest schedules during space missions was investigated. In the experiments, four human subjects were exposed to two sessions of eleven days of simulated weightlessness (6-deg head-down-tilt bedrest) with 6-hr extensions of the scheduled wake time on days 3 and 4 (a 12-hr phase delay). In a blind crossover design, subjects were exposed to bright light (greater than 3500 lux) for 5 hrs on each of the two shift days and on the following day, at times expected to accelerate adaptation to the phase delay (experimental group), or have no phase shifting effect (control group). Results indicate that bright light may accelerate the rate of adaptation to work/rest schedule delays under simulated weightlessness conditions. However, such effect was found to be largely independent of the timing of the light exposure. I.S.

A92-21813* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ION EXCHANGE - SIMULATION AND EXPERIMENT
CAL C. HERRMANN (NASA, Ames Research Center; Bionetics Corp., Moffett Field, CA) and JOHN E. FINN (NASA, Ames Research Center, Moffett Field, CA) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 10 p. Research supported by Department of Water Resources of California. Jul. 1991 10 p refs
(SAE PAPER 911508) Copyright

A FORTRAN program for simulating multicomponent adsorption by ion-exchange resins was adapted for use as both an ASPEN-callable module and as a free-standing simulator of the ion-exchange bed. Four polystyrene-divinylbenzene sulfonic acid resins have been characterized for three principal ions. It is concluded that a chelating resin appears appropriate as a heavy-metal trap. The same ASPEN-callable module is used to model this resin when Wilson parameters can be obtained. O.G.

A92-21822 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ANALYSIS OF AN INITIAL LUNAR OUTPOST LIFE SUPPORT SYSTEM PRELIMINARY DESIGN
MARK G. BALLIN, WILLIAM C. LIKENS, CORY K. FINN, VINCENT J. BILARDO, JR. (NASA, Ames Research Center, Moffett Field, CA), and YAT S. NG (Sterling Federal Systems, Inc., Palo Alto, CA) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 19 p. Research sponsored by NASA. Jul. 1991 19 p refs
(SAE PAPER 911395) Copyright

A preliminary design of a life-support system (LSS) was developed as part of an ongoing comprehensive trade study of advanced processor technologies and system architectures for an initial lunar outpost. The design is based on a mission scenario requiring intermittent occupation of a lunar-surface habitat by a crew of four. It incorporates physiochemical process technologies that were considered for Space Station Freedom. A system-level simulation model of the design was developed to obtain steady-state material balances for each LSS processor. The mass-flow rate predictions were used to obtain estimates of the LSS mass, volume, and power consumption by means of processor-sizing correlations that were extrapolated from Space Station Freedom processor designs. The results were used to analyze the impacts of varying crew size, mission duration, processor-operation strategy, and crew-cabin loads on the LSS mass, average power consumption, volume, periodic resupply mass, and waste-accumulation rates. The merits of the design were quantified relative to an open-loop LSS, and the implications of this assessment for future LSS research and technology development were identified. Author

A92-21823 Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HARDWARE SCALEUP PROCEDURES FOR P/C LIFE SUPPORT SYSTEMS
ROHATGI NARESH, P. K. SESHAN, JOSEPH FERRALL (JPL, Pasadena, CA), MARK G. BALLIN, and VINCENT J. BILARDO (NASA, Ames Research Center, Moffett Field, CA) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 17 p. Jul. 1991 17 p refs
(SAE PAPER 911396) Copyright

This paper compares scaleup correlations developed at the Jet Propulsion Laboratory and at the Langley Research Center

for various life-support hardware to estimate mass, volume, and power-consumption values as a function of feed or product-mass flow rates. The scaleup correlations are provided for a few selected advanced life-support technologies developed for the Space Station Freedom. In addition, correlation-validity limits and sources of data on various life-support hardware are also discussed. Author

A92-21825
PRIORITIZING AUTOMATION AND ROBOTICS APPLICATIONS IN LIFE SUPPORT SYSTEM DESIGN
STEVEN H. SCHWARTZKOPF (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 8 p. Jul. 1991 8 p refs
(SAE PAPER 911398) Copyright

Operational, servicing, and maintenance tasks anticipated for a controlled ecological life support system are described using data from the Soviet Bios experiments. The data show that the Bios higher plant culture system operations required about 6.2 crew-hours per day, the algal culture system operations required approximately 7.5 crew-hours per day, and miscellaneous domestic operations required about 7.5 crew-hours per day. Based upon potential reduction in crew time requirements, a recommended prioritization for the automation and robotics applications for a plant growth system includes nutrient solution maintenance, plant observation, planting/harvesting, and preventive maintenance. A recommended prioritization for the application of automation and robotics to algal reactor procedures includes nutrient solution preparation, culture observation, culture sampling and analysis, and preventive maintenance. O.G.

A92-21826
PRELIMINARY ANALYSIS OF LIFE SUPPORT RESOURCES AND WASTES AS RADIATION SHIELDING
SUSAN C. DOLL and MATTHEW H. APPLEBY (Boeing Defense and Space Group, Seattle, WA) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 11 p. Jul. 1991 11 p refs
(SAE PAPER 911399) Copyright

Life support and radiation shielding are two critical technologies for manned exploration missions. For long duration missions, life support resources, such as water and food, must be provided to keep the crew alive and shelter must be provided to protect the crew from radiation. The large amounts of food and water required for long duration missions have been the major reason for developing closed loop life support systems. However, preliminary findings indicate that food and water can be effective as radiation shielding and may result in significant mass savings over dedicated shielding. This dual use of life support resources overall system mass as well as the mass penalty associated with open loop life support. Author

A92-21832
SMALL LIFE SUPPORT SYSTEM FOR FREE FLYER
TOSHIYOSHI KIMURA, HARUHI SHIMIZU, YOSHIHITO NISHIO, MASAHIRO TAKAYANAGI, NAOTO KAWASE (Fujitsu, Ltd., Tokyo, Japan), MASAMICHI YAMASHITA, and AKEMI IZUMI-KUROTANI (Institute of Space and Astronautical Science, Sagamihara, Japan) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 9 p. Jul. 1991 9 p refs
(SAE PAPER 911428) Copyright

A self-contained closed-loop life support system has been developed for biological experiments conducted on the Japanese Space Flyer Unit (SFU). The modular and flexible system design is described, and the experiment's objectives regarding the effects of microgravity and space environment on the development of fertilized eggs are reviewed. The life support system and the control and information system are described. C.D.

A92-21834
CONCEPTUAL DESIGN OF SNAIL BREEDER ABOARD SPACE VEHICLE
T. FUJII, Y. MIDORIKAWA (JGC Corp., Tokyo, Japan), A. OHIRA (Institute of Highland Agriculture, Japan), and KEIJI NITTA (National Aerospace Laboratory, Tokyo, Japan) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 9 p. Jul. 1991 9 p refs
(SAE PAPER 911430) Copyright

A snail-breeding module is described which will serve as a subsystem of the Closed Ecological Life Support System (CELSS), providing the space crew with animal nutrients. Automated operations for feeding the animals, treating their wastes, and taking care of their offspring are described. A submodule which processes the snails for food production is also presented. C.D.

A92-21840
COLUMBUS ECS AND RECENT DEVELOPMENTS IN THE INTERNATIONAL IN-ORBIT INFRASTRUCTURE
H. P. LEISEIFER, G. SARRI (ESTEC, Noordwijk, Netherlands), S. VENERI, S. DOLCE (Alenia Spazio S.p.A., Turin, Italy), and K. O. HIENERWADEL (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 16 p. Jul. 1991 16 p refs
(SAE PAPER 911444) Copyright

The role of the Environmental Control System in the international in-orbit infrastructure, including the Space Station Freedom with the Columbus Attached Laboratory, the Free-Flying Laboratory, Hermes, and the Ariane-5 launcher, is discussed in the context of recent developments. Recent development objectives for these infrastructures are reviewed, giving special attention to resource management for payload and housekeeping heat loads, the use of the recirculation fans in cabin ventilation, and the distributed air cooling concept for the Columbus Attached Laboratory. C.D.

A92-21841
THE COLUMBUS FREE FLYER THERMAL CONTROL AND LIFE SUPPORT
U. LAUX, B. BEHRENS, H. P. HAFKEMEYER, and B. MIEDZA (MBB-ERNO, Bremen, Federal Republic of Germany) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 15 p. Research supported by ESA. Jul. 1991 15 p
(SAE PAPER 911445) Copyright

The thermal control and life support design of the Columbus Free Flyer (FF) are described. The design and functioning of the FF active and passive thermal control are examined, and the FF thermal and atmosphere condition requirements are given. The design and function of the FF environmental control and life support subsystem are described. C.D.

A92-21847* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
LOCOMOTOR EXERCISE IN WEIGHTLESSNESS
W. THORNTON (NASA, Johnson Space Center, Houston, TX) and H. WHITMORE (Whitmore Enterprises, San Antonio, TX) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 9 p. Jul. 1991 9 p refs
(SAE PAPER 911457) Copyright

The requirements for exercise in space by means of locomotion are established and addressed with prototype treadmills for use during long-duration spaceflight. The adaptation of the human body to microgravity is described in terms of 1-G locomotor biomechanics, the effects of reduced activity, and effective activity-replacement techniques. The treadmill is introduced as a complement to other techniques of force replacement with reference given to the angle required for exercise. A motor-driven unit is proposed that can operate at a variety of controlled speeds and equivalent grades. The treadmills permit locomotor exercise as required for long-duration space travel to sustain locomotor and cardiorespiratory capacity at a level consistent with postflight needs. C.C.S.

A92-21848* National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, FL.
EXERCISE TRAINING - BLOOD PRESSURE RESPONSES IN SUBJECTS ADAPTED TO MICROGRAVITY
VICTOR A. CONVERTINO (NASA, Kennedy Space Center, Cocoa Beach, FL) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 9 p. Jul. 1991 9 p refs
(SAE PAPER 911458) Copyright

Conventional endurance exercise training that involves daily workouts of 1-2 hr duration during exposure to microgravity has not proven completely effective in ameliorating postexposure orthostatic hypotension. Single bouts of intense exercise have been shown to increase plasma volume and baroreflex sensitivity in ambulatory subjects through 24 hr postexercise and to reverse decrements in maximal oxygen uptake and syncopal episodes following exposure to simulated microgravity. These physiological adaptations to acute intense exercise were opposite to those observed following exposure to microgravity. These results suggest that the 'exercise training' stimulus used to prevent orthostatic hypotension induced by microgravity may be specific and should be redefined to include single bouts of maximal exercise which may provide an acute effective countermeasure against postflight hypotension. Author

A92-21850* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
EXERCISE THERMOREGULATION - POSSIBLE EFFECTS OF SPACEFLIGHT
SUZANNE M. FORTNEY (NASA, Johnson Space Center, Houston, TX) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 13 p. Jul. 1991 13 p refs
(SAE PAPER 911460) Copyright

Changes in thermoregulation during spaceflight could result in an inability to tolerate ambient conditions or exercise tasks that were readily tolerated preflight. Weightlessness may alter heat production by changing metabolic rate, circadian rhythms of heat production, or work efficiency. It may impair heat loss by reducing convective and evaporative heat exchange. In addition, crewmembers may become less fit, less heat acclimated, hypohydrated, or have altered thermal sensitivity. Three scenarios are described: exercise conditioning in the mid deck, EVA, and emergency egress. Each scenario is discussed in terms of potential thermal challenges and possible consequences on crew performance. Author

A92-21852
ZOONOSES AND ENCLOSED ENVIRONMENTS
GARY N. JOINER (Texas A & M University, College Station) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 6 p. Jul. 1991 6 p refs
(SAE PAPER 911513) Copyright

The likelihood of transmission of potential disease agents between animals and man during spaceflight is a real concern. Development of disease exclusion lists for animals and refinement of animal containment units have been the principal means of providing protection to the crew members. Awareness of potential latent infections and a judicious use of the higher risk category of animals such as wild-caught nonhuman primates provides another level of protection. Use of high efficiency filters, gasketing, and differential air pressures have all enabled increasing levels of safety through containment of potential aerosol escape from animal habitats. Author

A92-21853
HEALTH RISKS FROM SAPROPHYTIC BIOAEROSOLS ON SPACE STATION FREEDOM
HARRIET A. BURGE (Michigan, University, Ann Arbor) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 10 p. Jul. 1991 10 p refs
(SAE PAPER 911514) Copyright

In order to develop monitoring standards for the Space Station Freedom (SSF) the health risks and standards are listed for bioaerosol disease agents. Descriptions are given for Legionnaires' disease, hypersensitivity pneumonitis, and fungal toxicoses in terms of disease indicators and conditions for organism development. These parameters are then directly translated into requirements for control on the SSF, proposals for monitoring and standards for spaceflight, and the availability of technology for identifying the disease. High-risk organisms are identified such as Legionella pneumophila and thermophilic actinomycetes, and some of the bioaerosol-related organisms cannot be detected at present. It is emphasized that a precise monitoring technology for the SSF is needed that provides for routine samples of total fungus spores and bacterial counts. C.C.S.

A92-21855* Krug Life Sciences, Inc., Houston, TX.
DISINFECTANTS FOR SPACECRAFT APPLICATIONS - AN OVERVIEW
DAVID W. KOENIG, LAURA L. MALLARY (Krug Life Sciences, Inc., Houston, TX), and DUANE L. PIERSON (NASA, Johnson Space Center, Houston, TX) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 17 p. Jul. 1991 17 p refs
(SAE PAPER 911516) Copyright

The review of disinfectants for use on manned missions emphasizes the need for contamination control to prevent the detrimental effects of bacteria growth on crew health. Microbial control is possible by means of biocides, but the selected product has to meet stringent toxicity requirements for the small environments in spacecraft. The testing and evaluation is described of four biocide candidates: hydrogen peroxide, quaternary ammonium compounds, iodine, and glutaraldehyde. The effectiveness of the disinfectants are analyzed in terms of the ability to treat typical microbial counts from Skylab missions in a closed environment. It is shown that many biocide candidates are not compatible with the ECLSS, water-recovery management, and air-revitalization subsystems of the Space Station Freedom. The use of hydrogen peroxide is proposed with a secondary stronger agent for microbial spills from biological experiments. C.C.S.

A92-21856
RATIONALE FOR COMMON CONTAMINATION CONTROL GUIDELINES FOR CREW HABITATION AND LIFE SCIENCES RESEARCH
TERI SCHNEPP, PAUL WARD-DOLKAS, and CYNTHIA HAVENS (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 8 p. Jul. 1991 8 p refs
(SAE PAPER 911517) Copyright

The Augustine advisory committee on the future of the U.S. Space Program has recommended that 'Space Station Freedom be revamped to emphasize life sciences and human space operations'. An important component of life sciences research involves the housing, care and maintenance of research specimens. Microbial and odor contamination control measures are necessary to ensure that cross contamination between the crew and specimens is controlled and limited. The bioisolation requirements being applied to life sciences specimen handling facilities are more stringent than those applied in the past. This paper examines the designs and operational features which have been used during previous spaceflight missions to contain and control crew and research specimen wastes. Because crew wastes also require microbial and odor control, the same measures which are used to control crew wastes may be directly applied in a cost-effective, minimal-risk manner to controlling contamination generated by research specimens. Author

A92-21857
THE APPLICATION OF STERILE FILTRATION TECHNOLOGY IN THE ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS OF SPACE STATION FREEDOM
PAUL I. KEYSER and GLENN W. HOWARD (Pall Corp., Glen Cove, NY) SAE, International Conference on Environmental

Systems, 21st, San Francisco, CA, July 15-18, 1991. 9 p. Jul. 1991 9 p refs
(SAE PAPER 911518) Copyright

The major subsystems for air, water, and temperature and humidity control of the Environmental Control and Life Support Systems designed for Space Station Freedom will require control of particulate and microbial contaminants, that can be achieved by appropriately placed microbially retentive filters. This paper reviews state of the art technologies of gas and liquid filtration used in the semiconductor, pharmaceutical, health-care, and food/beverage industries and discusses the ways in which similar advanced filtration technology can be adapted for Space Station Freedom. Using these technologies, liquids can be filtered to exclude particles that are 0.04 micron in size, and gases can be filtered to exclude particles as small as 0.01 micron. I.S.

A92-21858* Harvard Univ., Cambridge, MA.
CORROSION CONSEQUENCES OF MICROFOULING IN WATER RECLAMATION SYSTEMS
TIM FORD and RALPH MITCHELL (Harvard University, Cambridge, MA) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 10 p. Jul. 1991 10 p refs
(Contract NCC8-17)
(SAE PAPER 911519) Copyright

This paper examines the potential fouling and corrosion problems associated with microbial film formation throughout the water reclamation system (WRS) designed for the Space Station Freedom. It is shown that the use of advanced metal sputtering techiques combined with image analysis and FTIR spectroscopy will present realistic solutions for investigating the formation and function of biofilm on different alloys, the subsequent corrosion, and the efficiency of different treatments. These techniques, used in combination with electrochemical measurements of corrosion, will provide a powerful approach to examinations of materials considered for use in the WRS. I.S.

A92-21864
COLOURS: FROM THEORY TO ACTUAL SELECTION - AN EXAMPLE OF APPLICATION TO COLUMBUS ATTACHED LABORATORY INTERIOR ARCHITECTURAL DESIGN
ENRICO GAIA, FABIANA BOBBA, and DAVID ANTONELLI (Alenia Spazio S.p.A., Turin, Italy) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 11 p. Jul. 1991 11 p refs
(SAE PAPER 911532) Copyright

The paper presents an analysis of the color concept and discusses color systems and physiological processes related to the shape and color perception, followed by the topological analysis of the Columbus Attached Laboratory internal architecture based on the application of the theory of color to the system configuration. The methodology of tests carried out to assess the color choices is described. The results are used to design two palettes of colors for interior surfaces, on the basis of which a list of seven colors is selected for the application to the Columbus Attached Pressurized Module habitability mock-up. I.S.

A92-21865
EFFECTS ON MAN OF 46-DAY LIFE IN A CONFINED SPACE AT NORMAL PRESSURE
E. RADZISZEWSKI (Direction des Constructions Navales, Centre d'Etudes et de Recherches Techniques Sous-Marines, Toulon, France) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 10 p. Jul. 1991 10 p refs
(SAE PAPER 911533) Copyright

The ramifications of humans subjects being confined to a limited space is investigated with 6 subjects in a climatic chamber by studying biological parameters and psychomotor test results. The subjects spend 46 days in the controlled reference environment measuring 100 cu m, and CO2 pressure is maintained at about zero. The examinations conducted emphasize respiratory-gas exchange, resting metabolism, acid-base balance in capillary arterialized blood, and hydromineral balance. The results indicate that urinary and electrolyte output increase dramatically during the first 2-3 days, and a slight decrease is noted throughout the experiment of red blood cells and plasma potassium. No degradation is reported in psychomotor performance, although a sensation of fatigue is noted by the subjects. The results are of value to determining the expected effects of confinement and degrees of biological vartiation during space missions. C.C.S.

A92-21866
SIMULATION IN A POLAR ENVIRONMENT FOR A SPACE STATION
JEAN L. ETIENNE (Ocean Polaire, Paris, France), JACQUES COLLET (ESA, Paris, France), and H. URSIN (Bergen, University, Norway) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 5 p. Jul. 1991 5 p
(SAE PAPER 911534) Copyright

The physiological and psychological issues related to long-duration space missions are considered in a proposal to utilize an Arctic expedition as a mission simulation. In order to develop a testbed concept for a Mars mission an expedition is proposed that is predicated on two years of crewmembers living in close proximity in a dangerous environment. The long Arctic drift is expected to yield important data on the capacity for efficient teamwork and good performance in a low-stress environment for a long period of time. C.C.S.

A92-21867
REVIEW OF FRENCH COSMONAUTS TRAINING ASPECTS RELATED TO ACTIVITIES IN MIR STATION ENVIRONMENT
NADINE LAVAL (ESA; CNES, Toulouse, France) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 10 p. Jul. 1991 10 p
(SAE PAPER 911536) Copyright

The instruction and preparation of the French cosmonauts is discussed in terms of crew operations and activities with comparisons made to space shuttle and Spacelab training programs. Mission training for the cosmonauts is broken down into theoretical study, practical work, and simulator experience to prepare for payload operations, test-pilot proficiency, and spacecraft-systems study. Data regarding the training is analyzed in terms of hours of training, lost time, and levels achieved of resistance, efficiency, and learning. The training is compared to actual flight-crew operations, and inadequate preparation is cited for noise constraints, crowding in the station, and return to earth. NASA training procedures are compared and found to be fundamentally identical except for the ratio of theoretical to practical study, which is lower for the U.S. space missions. This fact is attributed to the fact that the space shuttle is a highly sophisticated spacecraft requiring less maintenance and simpler operational procedures. C.C.S.

A92-21868
REQUIREMENTS FOR ECLSS SIMULATION SOFTWARE
R. SCHRICKE, R. SIMON (Dornier GmbH, Friedrichshafen, Federal Republic of Germany), and M. NOVARA (ESTEC, Noordwijk, Netherlands) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 11 p. Jul. 1991 11 p refs
(SAE PAPER 911542) Copyright

The Environmental Control and Life Support System (ECLSS) contains a number of loop-type structures where the multiple components and assemblies of the system mutually influence each other. The computer software required to support the ECLSS engineer falls into two categories: (1) the design software, employed on the component and assembly level; and (2) the simulation software, employed on subsystem and system level, making it possible to analyze each given layout and obtain performance data for a wide range of conditions. This paper examines the requirements concerning the analytical and technical capabilities of the simulation software and its user friendliness, flexibility,

interfacing capability, graphics and preprocessing and postprocessing features. I.S.

A92-21874
DEVELOPMENT OF A RECIRCULATION EJECTOR FOR A CRYOGENIC HEAT SINK FOR ECLSS
JAMES F. FORT and MICHAEL J. HELDMANN (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 9 p. Jul. 1991 9 p
(SAE PAPER 911558) Copyright

In the development of advanced thermal control systems for use in hydrogen-powered space vehicles, utilization of the onboard hydrogen fuel as a heat sink for equipment cooling has many advantages. There are, however, significant challenges preventing the cryogenic temperatures of the stored fuel from causing heat transport fluid freezing. A shell and tube heat exchanger was developed to transfer heat from an ECLSS thermal control coolant loop to the cryogenic hydrogen fuel. To mitigate the potential for coolant freezing, it was necessary to recycle hydrogen from the heat exchanger outlet back to the inlet to moderate heat exchanger inlet temperatures. A recycle compressor could have been used with penalties in weight and reliability due to its complexity. A superior solution was to use an ejector which has no moving parts, and uses the pressure head of the incoming hydrogen to develop the necessary pumping head and transport the hydrogen through the heat exchanger. This paper will present the design, development and testing of a recirculating ejector for a cryogenic heat sink for ECLSS. Author

A92-21878* Texas Univ., Dallas.
CARDIOVASCULAR ADAPTATION TO O-G (EXPERIMENT 294) - INSTRUMENTATION FOR INVASIVE AND NONINVASIVE STUDIES
JAY C. BUCKEY, LYNDA D. LANE, BENJAMIN D. LEVINE, WILLIE E. MOORE, F. A. GAFFNEY, C. G. BLOMQVIST (Texas, University, Southwestern Medical Center, Dallas), and DONALD E. WATENPAUGH (NASA, Ames Research Center, Moffett Field, CA) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 6 p. Jul. 1991 6 p refs
(SAE PAPER 911563) Copyright

Many astronauts returning from space have difficulties regulating blood pressure, some to the point of fainting during quiet standing. Experiment 294 was designed to study this and other cardiovascular effects of adaptation to microgravity and to understand the mechanisms behind it. To accomplish this several cardiovascular variables had to be measured accurately. Heart rate, blood pressure, cardiac output (blood pumped by the heart each minute), stroke volume (blood pumped by the heart with each beat), limb flow, limb compliance, heart size and central venous pressure all had to been recorded during various stresses to understand fully the adaptation to space and the readaptation to earth's gravity. Numerous pieces of equipment were used. Some were purpose-built for the Spacelab mission and others were derived from commercial hardware. Developing spaceflight hardware is challenging and costly, but can lead to significant new information in the unique environment of space. Author

A92-21886* Sterling Software, Palo Alto, CA.
SIMULATION OF EXTRA-VEHICULAR ACTIVITY (EVA) SELF-RESCUE
ADAM R. BRODY, RICK JACOBY (Sterling Software, Inc., Palo Alto, CA), and STEPHEN R. ELLIS (NASA, Ames Research Center, Moffett Field, CA) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 10 p. Jul. 1991 10 p refs
(SAE PAPER 911574) Copyright

Self-rescue during EVA is examined in terms of the use of a hand-held thruster that is similar to the hand-held maneuvering units HHMU developed for earlier programs. The problem of assessing velocity-increment requirements is addressed by means of examples of simulation technologies for studying EVA. The technologies evaluated include virtual reality systems such as the Virtual Interactive Environment Workstation (VIEW) and the Space Operations Simulator, and standard approaches like the air-bearing floor and the space shuttle. The VIEW is employed for a study of five trained NASA subjects that conduct a simulated return to a spacecraft with an HMMU under variable conditions. The study demonstrates the efficacy of VIEW for obtaining fuel-consumption values, and separation velocity is identified as the most significant determinant of the fuel and time requirements for a self-rescue operation. C.C.S.

A92-21895
POST-RESTRUCTURE U.S. LABORATORY AND HABITATION MODULE CONFIGURATION FOR SPACE STATION FREEDOM
RAMZY BOUTROS and RICHARD L. OLSON (Boeing Defense and Space Group, Missiles and Space Div., Huntsville, AL) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 12 p. Jul. 1991 12 p
(SAE PAPER 911594) Copyright

The overall design concepts are described for the restructured program including the U.S. Laboratory (Lab) and Habitation (Hab) modules as well as the topologies of the pressurized logistics element. An outline is given of the primary subsystems, and the components of the modules are illustrated. The implementation program comprises three phases including: (1) man-tended capability for early support; (2) permanently manned capability with a Hab for a crew of four over 90 days; and ultimately (3) eight-man crew capability (EMCC). It is shown that the incremental approach allows the full development of ECLSS technologies with minimized risk. The EMCC program is similar to the baseline configuration before the restructure, and the incremental approach presents an economical version for developing the Lab and Hab capabilities. C.C.S.

A92-21896
SPACE STATION FREEDOM RESOURCE NODE STATUS - FIRST QUARTER 1991
RAYMOND J. LEVESQUE, II and JOHN B. LAUGER (McDonnell Douglas Space Systems Co., Space Station Div., Huntington Beach, CA) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 10 p. Jul. 1991 10 p
(SAE PAPER 911595) Copyright

The paper discusses the outfitting of the Resource Nodes for Space Station Freedom. The driving functional and design requirements are discussed briefly in relation to the current overall configuration and internal outfitting. The major features of the Resource-Node internal architecture, distributed system packaging, crew accommodations, utility distribution, and the centrifuge facility are described. This current design approach meets the program requirements for crew accommodations, on-orbit maintainability, and growth of the re-structured Space Station Freedom over its projected 30-year life. Author

A92-24205
TRAINING FOR MANNED SPACEFLIGHT
J. M. WIDDOWSON and D. TAYLOR (Vega Space Systems Engineering, Ltd., Harpenden, England) British Interplanetary Society, Journal (ISSN 0007-094X), vol. 45, Feb. 1992, p. 77-80. Feb. 1992 4 p refs
Copyright

As part of the commitment to the activities associated with the Space Station Freedom, ESA is developing an independent European manned spaceflight capability at the European Astronaut Center in Germany. This paper discusses the training concept and the structure of the European Astronaut Training Program and describes the details of the operations training, the technologies involved, and the training facilities used in training the European astronauts. I.S.

A92-24363#
CIRCADIAN RHYTHMS AS AN ORGANIZATIONAL MANAGEMENT CONSIDERATION

MICHAEL C. GALLUZZI (Rockwell International Corp., Cocoa Beach, FL) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 6 p refs
(AIAA PAPER 91-4108) Copyright

The implementation of a circadian rhythm work schedule in industry is addressed. Experiences with such implementation in potash mines are reviewed and the advantages are described. The applications of circadian rhythm management to the Space Station are considered. C.D.

A92-25272
DEVELOPMENT OF NEW TECHNOLOGY FOR CONDUCTING COMPUTER-CONTROLLED COMPLEX MEDICAL INVESTIGATIONS ABOARD MIR WITHIN THE FRAMEWORK OF THE SHIPKA PROJECT [SOZDANIE NOVOI TEKHNOLOGII PROVEDENIIA I REALIZATSII UPRAVLIAEMYKH AVTONOMNYKH KOMPLEKSNYKH MEDITSINSKIKH ISSLEDOVANII NA BORTU STANTSII 'MIR' PO PROEKTU 'SHIPKA']
R. D. NEDKOV, V. M. SHALAMANOV, S. D. SIMEONOV, S. K. TANEV, V. I. KOZHARINOV, and V. V. BOGOMOLOV Kosmicheskaia Biologiia i Aviakosmicheskaia Meditsina (ISSN 0321-5044), vol. 25, Sept.-Oct. 1991, p. 56-58. In Russian. Oct. 1991 3 p In RUSSIAN refs
Copyright

The technology of conducting computer-controlled neurophysiological and psychophysiological studies during the Soviet-Bulgarian Shipka project aboard Mir is discussed. The Shipka project includes the following experiments: (1) the Labirint experiment, for studying mechanisms of the development of deficiencies in the relationship between the vestibulatory and the visual systems due to space flight; (2) the Statokinetica experiment, for studying the mechanism of the body-position regulation; (3) the Potential experiment, for studying the condition of excitable muscle-fiber membranes; and (4) a study of the characteristics of psychological adaptation in individual cosmonauts by means of a questionnaire, and of the effects of relaxation and entertainment on the psychological adaptation. Block diagrams of the experimental software support are presented. I.S.

A92-26004
EXTERNAL RESPIRATION AND GAS EXCHANGE DURING SPACE FLIGHTS [VNESHNEE DYKHANIE I GAZOOBMEN V KOSMICHESKIKH POLETAKH]
V. M. BARANOV, M. A. TIKHONOV, N. M. ASIAMOLOVA, M. IU. VOLKOV, A. N. KOTOV, G. E. SAVCHENKO, and K. S. KHAIDAKOV Kosmicheskaia Biologiia i Aviakosmicheskaia Meditsina (ISSN 0321-5044), vol. 25, Nov.-Dec. 1991, p. 4-8. In Russian. Dec. 1991 5 p In RUSSIAN refs
Copyright

Using results obtained in earlier space flights and simulated flight studies, the effects of microgravity, acceleration, and changes in the composition and pressure of the spacecraft-cabin and the space suit atmospheres on the parameters of the respiratory function of humans are examined. It is shown that the effects include changes in the respiration biomechanics, the gas-diffusion and ventilation-perfusion ratios in lungs, the regulation of respiration and of respiratory muscles, the degrees of the hydration and blood filling of lungs, and the acid-base equilibrium and blood gases. In addition, a combination of these effects may cause functional and morphological changes in the lung tissue. I.S.

A92-26005
INVESTIGATION OF MENTAL WORK CAPACITY OF COSMONAUTS ABOARD THE MIR ORBITAL COMPLEX [ISSLEDOVANIE PSIKHICHESKOI RABOTOSPOSOBNOSTI KOSMONAVTOV NA ORBITAL'NOM KOMPLEKSE 'MIR']
K. K. IOSELIANI, A. L. NARINSKAIA, SH. R. KHISAMBEEV, and G. RADKOVSKI Kosmicheskaia Biologiia i Aviakosmicheskaia Meditsina (ISSN 0321-5044), vol. 25, Nov.-Dec. 1991, p. 8-11. In Russian. Dec. 1991 4 p In RUSSIAN refs
Copyright

In the framework of the Prognoz experiment, changes in the mental performance occurring after 3 to 5 days of stay aboard Mir and 190 days after the mission, were evaluated in four cosmonauts visiting the station, using a computer-based psychodiagnostic unit Pleven-87. Mental performance was estimated from the ability of the subject to quickly solve the following problems: continuous counting in optimal, prescribed, or self-regulated rhythm; a complex sensorimotor reaction having psychological feedback; a conditional motor reaction to several combinations of color stimuli; and a reaction to a moving object. Results demonstrated the ability of the Pleven-87 system to provide reliable predictions concerning the mental work capacity of cosmonauts. All subjects demonstrated high mental stability during and after the flight. I.S.

A92-26019
A METHOD FOR A COMPREHENSIVE ASSESSMENT OF TECHNICAL EQUIPMENT FOR THE MEDICAL COMPARTMENT OF A SPACECRAFT [METODIKA KOMPLEKSNOI OTSENKI TEKHNICHESKOGO OSNASHCHENIIA KOSMICHESKOGO MEDITSINSKOGO BLOKA]
A. V. PERKOVSKII and B. A. ADAMOVICH Kosmicheskaia Biologiia i Aviakosmicheskaia Meditsina (ISSN 0321-5044), vol. 25, Nov.-Dec. 1991, p. 49-53. In Russian. Dec. 1991 5 p In RUSSIAN refs
Copyright

The paper describes the development of a model of a bacterial defense system (BDS) to be included in the medical compartment or medical section of a spacecraft. The BDS is designed to maintain, in the area designated for medical treatments, conditions of constant temperature, relative humidity, gas exchange, and desired ratios of atmospheric gases, as well as to keep low the levels of bacterial and particle contamination. Special attention is given to the method used for the assessment of the BDS, the set of factors to be assessed, and a model of a data base for computing the cost efficiency of the BDS. I.S.

A92-28133
SPACECRAFT IN-ORBIT IDENTIFICATION USING EIGENSYSTEM REALIZATION METHODS
J. E. COOPER and J. R. WRIGHT (Manchester, Victoria University, England) (Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990, p. 629-643) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 15, Mar.-Apr. 1992, p. 352-359. Previously cited in issue 04, p. 527, Accession no. A92-15410. Apr. 1992 8 p refs
Copyright

A92-28207*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MOTION-BASED CARRIAGE SIMULATION OF EXTRA-VEHICULAR ACTIVITY (EVA) RESCUE
ADAM R. BRODY (NASA, Ames Research Center; Sterling Software, Inc., Moffett Field, CA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 5 p. Jan. 1992 5 p refs
(AIAA PAPER 92-0593) Copyright

A research program was outlined for a series of Extra-Vehicular Activity (EVA) rescue studies. The general purpose is to get a better appreciation of the characteristics describing an EVA rescue scenario. Several studies have been completed in the Virtual Interactive Environment Workstation (VIEW) at NASA Ames Research Center. Similar studies are planned for a variety of simulators both to get more reliable results for the EVA rescue problem and to baseline the simulators against one another. Work is planned for a motion-based carriage to expand the validity of the previously obtained results. Author

A92-29994
HEMODYNAMIC AND HORMONAL EFFECTS OF PROLONGED ANTI-G SUIT INFLATION IN HUMANS
GHISLAINE GEELEN, PHILIPPE ARBEILLE, JEAN-LOUIS

SAUMET, JEAN-MARIE COTTET-EMARD, FREDERIC PATAT, and MADELEINE VINCENT (Lyon I, Universite, Lyons; Tours, Universite; Angers, Universite, France) Journal of Applied Physiology (ISSN 8750-7587), vol. 72, March 1992, p. 977-984. Research supported by Universite Lyon I, CNES, and DRET. Mar. 1992 8 p refs
Copyright

The hemodynamic effects caused in humans by applying lower body positive pressure (LBPP) were examined together with the relationship between these effects and changes observed in blood-plasma concentrations of major vasoactive hormones. Results obtained on six human subjects showed that prolonged application of LBPP induces a transient increase in cardiac output and a marked and sustained decrease in blood-plasma activities of norepinephrine and renin, indicating an inflation-induced decrease in sympathetic activity. I.S.

A92-30325
THEORETICAL ASSESSMENT OF THE RISK OF DECOMPRESSION SICKNESS IN THE CASE OF SINGLE-STAGE PRESSURE DROPS [TEORETICHESKAIA OTSENKA RISKA ZABOLEVANIIA DEKOMPRESSIONNOI BOLEZN'IU PRI ODNOSTUPENCHATYKH PEREPADAKH DAVLENIIA]
V. P. NIKOLAEV (Institut Mediko-Biologicheskikh Problem, Moscow, Russia) Akademiia Nauk SSSR, Doklady (ISSN 0002-3264), vol. 321, no. 6, 1991, p. 1291-1295. In Russian. 1991 5 p In RUSSIAN refs
Copyright

The risk of decompression sickness in the case of single-stage pressure drops is evaluated on the basis of a mathematical model of the formation and growth of gas bubbles in the organism (i.e., the 'embolization' process). Curves showing the dependence of the risk of decompression sickness on the magnitude of pressure drop are plotted. It is suggested that the probability (with a confidence of 0.95) of decompression sickness in connection with EVA does not exceed 0.04. L.M.

A92-31326
SPACECRAFT WATER QUALITY: MAINTENANCE AND MONITORING; PROCEEDINGS OF THE 21ST INTERNATIONAL CONFERENCE ON ENVIRONMENTAL SYSTEMS, SAN FRANCISCO, CA, JULY 15-18, 1991
Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-874), 1991, 208 p. For individual items see A92-31327 to A92-31344. 1991 208 p
(ISBN 1-56091-154-9; SAE SP-874) Copyright

The present conference on the maintenance and monitoring of spacecraft water quality examines the engineering and biomedical issues related to the recycling of water directly from waste-water products, and the papers presented focus on: (1) designing and testing reclamation systems; (2) determining the health-related requirements for recycled water; and (3) verifying that the requirements can be met for the U.S. manned space program. Specific issues addressed include the water-quality program for the Space Station Freedom, the thyroid effects of iodine and iodide in water, the formation and control of biofilm in spacecraft water systems, a total organic carbon analyzer, and an analysis of urine- and thermal-pretreatment methods. Also reported are a preliminary ECLSS waste-water model, water reclamation by means of multifiltration, mercury and polar-organics monitoring in water-quality analysis, a regenerable biocide delivery unit, and the destruction of biofilm with Pseudomonas aeruginosa as architect. C.C.S.

A92-31327* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
WATER QUALITY PROGRAM ELEMENTS FOR SPACE STATION FREEDOM
RICHARD L. SAUER (NASA, Johnson Space Center, Houston, TX), RAGHUPATHY RAMANATHAN, JOHN E. STRAUB, and JOHN R. SCHULTZ (Krug International Corp., Technology Life Sciences Div., Houston, TX) IN: Spacecraft water quality: Maintenance and monitoring; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 21 p refs
(SAE PAPER 911400) Copyright

A strategy is outlined for the development of water-quality criteria and standards relevant to recycling and monitoring the in-flight water for the Space Station Freedom (SSF). The water-reclamation subsystem of the SSF's ECLSS is described, and the objectives of the water-quality are set forth with attention to contaminants. Quality parameters are listed for potable and hygiene-related water including physical and organic parameters, inorganic constituents, bactericides, and microbial content. Comparisons are made to the quality parameters established for the Shuttle's potable water and to the EPA's current standards. Specific research is required to develop in-flight monitoring techniques for unique SSF contaminants, ECLSS microbial control, and on- and off-line monitoring. After discussing some of the in-flight water-monitoring hardware it is concluded that water reclamation and recycling are necessary and feasible for the SSF. C.C.S.

A92-31328* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
THYROID EFFECTS OF IODINE AND IODIDE IN POTABLE WATER
RICHARD J. BULL, KARLA D. THRALL, and TODD T. SHERER (Washington State University, Pullman) IN: Spacecraft water quality: Maintenance and monitoring; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 4 p refs
(Contract NAG9-226)
(SAE PAPER 911401) Copyright

Experiments are reviewed which examine the comparative toxicological effects of iodide (I) and iodine (I2) when used to disinfect drinking water. References are made to a subchronic study in rats, a comparison of the distribution of radiolabeled I and I2, and a demonstration of thyroxine formation in the gastrointestinal tract. The results of the study of the rats are examined in detail; the findings show that I and I2 have opposite effects on the concentrations of thyroid hormones in blood. Iodide slightly decreases circulating thyroxine, while I2 significantly increases the thyroxine concentrations, decreases triiodothyronine levels, and does not change the weight of the thyroid gland. The related effects of I2 ingestion are set forth in detail and are shown to be unique to I2 contamination. Iodine can counteract the effects of iodide and should therefore be used as a disinfectant in drinking water. C.C.S.

A92-31329* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
DISINFECTION SUSCEPTIBILITY OF WATERBORNE PSEUDOMONADS AND LEGIONELLAE UNDER SIMULATED SPACE VEHICLE CONDITIONS
GORDON A. MCFETERS, BARRY H. PYLE, SHELLEY K. WATTERS, KARI L. CARGILL, and FEIPENG P. YU (Montana State University, Bozeman) IN: Spacecraft water quality: Maintenance and monitoring; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 6 p refs
(Contract NAS9-17346)
(SAE PAPER 911402) Copyright

The sensitivity of waterborne bacteria from iodinated systems to iodine is examined with particular attention to the recovery of the organisms. The use of iodine as a disinfectant for space-vehicle water is described, and references are made to studies of iodine sensitivity and the relationship between growth rate and iodine sensitivity. Growth following iodination is discussed, and bacterial responses to nutrient restriction are examined for both P aeruginosa and Legionella pneumophila. The low level of organic nutrients in spacecraft water allows the selection for bacteria that are less sensitive to halogens. The formation of biofilms within the water-treatment system enhances bacterial resistance to iodine, and in the case of high-quality water it is shown that sublethal doses of iodine can stimulate bacterial growth. Water treatment

should therefore be based on antecedent growth conditions, nutrient limitation, biofilm formation, and ambient selective pressures. C.C.S.

A92-31330* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
BIOFILM FORMATION AND CONTROL IN A SIMULATED SPACECRAFT WATER SYSTEM - TWO-YEAR RESULTS
JOHN R. SCHULTZ, ROBERT D. TAYLOR, DAVID T. FLANAGAN, SANDRA E. CARR, REBEKAH J. BRUCE, JUDY V. SVOBODA, M. H. HULS (Krug International Corp., Technology Life Sciences Div., Houston, TX), RICHARD L. SAUER, and DUANE L. PIERSON (NASA, Johnson Space Center, Houston, TX) IN: Spacecraft water quality: Maintenance and monitoring; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 11 p refs
(SAE PAPER 911403) Copyright

The ability of iodine to maintain microbial water quality in a simulated spacecraft water system is being studied. An iodine level of about 2.0 mg/L is maintained by passing ultrapure influent water through an iodinated ion exchange resin. Six liters are withdrawn daily and the chemical and microbial quality of the water is monitored regularly. Stainless steel coupons used to monitor biofilm formation are being analyzed by culture methods, epifluorescence microscopy, and scanning electron microscopy. Results from the first two years of operation show a single episode of high bacterial colony counts in the iodinated system. This growth was apparently controlled by replacing the iodinated ion exchange resin. Scanning electron microscopy indicates that the iodine has limited but not completely eliminated the formation of biofilm during the first two years of operation. Significant microbial contamination has been present continuously in a parallel noniodinated system since the third week of operation. Author

A92-31331* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
DEVELOPMENT AND (EVIDENCE FOR) DESTRUCTION OF BIOFILM WITH PSEUDOMONAS AERUGINOSA AS ARCHITECT
VALERIE N. UZCATEGUI, JOHN J. DONADEO, DANIEL R. LOMBARDI, MICHAEL J. COSTELLO (New York, State University, Binghamton), and RICHARD L. SAUER (NASA, Johnson Space Center, Houston, TX) IN: Spacecraft water quality: Maintenance and monitoring; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 16 p refs
(Contract NAG9-307)
(SAE PAPER 911404) Copyright

Disinfection and maintenance of an acceptable level of asepsis in spacecraft potable water delivery systems is a formidable task. The major area of research for this project has been to monitor the formation and growth of biofilm, and biofilm attached microorganisms, on stainless steel surfaces (specifically coupons), and the use of ozone for the elimination of these species in a closed loop system. A number of different techniques have been utilized during the course of a typical run. Scraping and sonication of coupon surfaces with subsequent plating as well as epifluorescence microscopy have been utilized to enumerate biofilm protected Pseudomonas aeruginosa. In addition, scanning electron microscopy is the method of choice to examine the integrity of the biofilm. For ozone determinations, the indigo decolorization spectrophotometric method seems most reliable. Both high- and low-nutrient cultured P. aeruginosa organisms were the target species for the ozone disinfection experiments. Author

A92-31332* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
BIOBURDEN CONTROL FOR SPACE STATION FREEDOM'S ULTRAPURE WATER SYSTEM
DONALD W. SNODGRASS (Teledyne Brown Engineering, Huntsville, AL), ELIZABETH B. RODGERS (NASA, Marshall Space Flight Center, Huntsville, AL), DON OBENHUBER, and TIM HUFF (Sverdrup Technology, Inc., Huntsville, AL) IN: Spacecraft water quality: Maintenance and monitoring; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 7 p refs
(SAE PAPER 911405) Copyright

Bioburden control is one of the challenges for the Ultrapure Water System on Space Station Freedom. Bioburden control must enable the system to deliver water with a low bacterial count as well as maintain biological contamination at a manageable level, to permit continued production of quality water. Ozone has been chosen as the primary means of Bioburden control. Planned tests to determine the effectiveness of ozone on free-floating microbes and biofilms are described. Author

A92-31333* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
REGENERABLE BIOCIDE DELIVERY UNIT
GERALD V. COLOMBO, CLIFFORD D. JOLLY (Umpqua Research Co., Myrtle Creek, OR), and RICHARD L. SAUER (NASA, Johnson Space Center, Houston, TX) IN: Spacecraft water quality: Maintenance and monitoring; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 5 p
(SAE PAPER 911406) Copyright

The Microbial Check Valve (MCV) is used on the Space Shuttle to impart an iodine residual to the drinking water to maintain microbial control. Approximately twenty MCV locations have been identified in the Space Station Freedom design, each with a 90-day life. This translates to 2400 replacement units in 30 years of operation. An in situ regeneration concept has been demonstrated that will reduce this replacement requirement to less than 300 units based on data to date. A totally automated system will result in significant savings in crew time, resupply requirements, and replacement costs. An additional feature of the device is the ability to provide a concentrated biocide source (200 mg/liter of I2) that can be used to superiodinate systems routinely or after a microbial upset. Author

A92-31334
DEVELOPMENT OF THE PROCESS CONTROL WATER QUALITY MONITOR FOR SPACE STATION FREEDOM
E. L. JEFFERS (Astro International Corp., Houston, TX) and CLIFFORD D. JOLLY (Umpqua Research Co., Myrtle Creek, OR) IN: Spacecraft water quality: Maintenance and monitoring; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 27 p refs
(SAE PAPER 911432) Copyright

On-line monitoring of the effluent from the Space Station Freedom (SSF) water reclamation process determines acceptable quality for delivery to tanks supplying the crew's potable and hygiene water needs. TOC, pH, conductivity and iodine (biocide) are continuously monitored by the integrated, computer-controlled Process Control Water Quality Monitor (PCWQM). This paper describes the development of the system with emphasis on membrane gas-liquid separation and reagentless oxidation necessary to adapt standard TOC analysis to the unique requirements of the space environment. Author

A92-31335* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
TOTAL ORGANIC CARBON ANALYZER
RICHARD G. GODEC, PAUL P. KOSENKA, BRIAN D. SMITH, RICHARD S. HUTTE (Sievers Research, Inc., Boulder, CO), JOHANNA V. WEBB (McDonnell Douglas Space Systems Co., Huntington Beach, CA), and RICHARD L. SAUER (NASA, Johnson Space Center, Houston, TX) IN: Spacecraft water quality: Maintenance and monitoring; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 12 p refs
(SAE PAPER 911434) Copyright

The development and testing of a breadboard version of a highly sensitive total-organic-carbon (TOC) analyzer are reported. Attention is given to the system components including the CO2

sensor, oxidation reactor, acidification module, and the sample-inlet system. Research is reported for an experimental reagentless oxidation reactor, and good results are reported for linearity, sensitivity, and selectivity in the CO2 sensor. The TOC analyzer is developed with gravity-independent components and is designed for minimal additions of chemical reagents. The reagentless oxidation reactor is based on electrolysis and UV photolysis and is shown to be potentially useful. The stability of the breadboard instrument is shown to be good on a day-to-day basis, and the analyzer is capable of 5 sample analyses per day for a period of about 80 days. The instrument can provide accurate TOC and TIC measurements over a concentration range of 20 ppb to 50 ppm C. C.C.S.

A92-31336* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
THE DEVELOPMENT OF A VOLATILE ORGANICS CONCENTRATOR FOR USE IN MONITORING SPACE STATION WATER QUALITY
ITAMAR BODEK, DANIEL J. EHNTHOLT, THOMAS J. STOLKI, JAMES R. VALENTINE (Arthur D. Little, Inc., Cambridge, MA), RUDY TRABANINO, JOHANNA V. WEBB (McDonnell Douglas Space Systems Co., Huntington Beach, CA), and RICHARD L. SAUER (NASA, Johnson Space Center, Houston, TX) IN: Spacecraft water quality: Maintenance and monitoring; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 15 p refs
(SAE PAPER 911435) Copyright

A breadboard concept of a volatile organics concentrator (VOC) is manufactured and tested for optimized water-quality analysis in a space environment. The VOC system is attached to a gas chromatograph/mass spectrometer to analyze the volatile chemicals relevant to the operation of Space Station Freedom. The preliminary tests include: (1) comparisons with analyses based on direct on-column injections of standards; (2) analyses of iodinated volatile organics; (3) comparisons of nitrogen vs helium as the chromatography carrier gas; and (4) measurements of collection efficiency. The VOC can analyze EPA method-624 analytes at comparable detection using flame-ionization detection and can analyze volatile iodinated compounds. The breadboard has good reproducibility and can use nitrogen as a carrier gas; good results are noted for the collection and concentration levels and for water removal. C.C.S.

A92-31337
ULTRAPURE WATER TOTAL ORGANIC CARBON ANALYZER - ADVANCED COMPONENT DEVELOPMENT
CLIFFORD D. JOLLY (Umpqua Research Co., Myrtle Creek, OR) and ELDEN L. JEFFERS (Astro Resources International, Houston, TX) IN: Spacecraft water quality: Maintenance and monitoring; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 7 p
(SAE PAPER 911436) Copyright

A reagentless separator and other on-line gravity-independent components for the analysis of total organic carbon (TOC) in Space Station water are investigated. The designs and characteristics are described for the reagentless separator, passive total inorganic carbon (TIC) removal, and for the TOC/TIC functional check module. The TOC analyzer removes TIC by acidification and oxidizes the organics and measures CO2, and test results are given for solid-phase acids and challenge tests of TIC and organic/inorganic levels. The prototypes of the reagentless separator are found to remove TIC from sample water to low ppb levels with low levels of organic contaminant loss. The optimal configuration includes a solid-phase inorganic acid integrated with a hydrophobic hollow-fiber membrane degasser which acidifies the water and removes carbon in one step. The TOC/TIC functional check module is shown to be effective and capable of imparting 10 mg/1 TOC to an influent stream as a TOC standard. C.C.S.

A92-31338
SELECTED TOPICS IN WATER QUALITY ANALYSIS - MERCURY AND POLAR ORGANICS MONITORING
DAVID E. BURCHFIELD, LEIGH EVANS, WILLIAM NIU (Perkin-Elmer Corp., Pomona, CA), ITAMAR BODEK, and DANIEL J. EHNTHOLT (Arthur D. Little, Inc., Cambridge, MA) IN: Spacecraft water quality: Maintenance and monitoring; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 7 p refs
(SAE PAPER 911437) Copyright

A breadboard system is described and tested that can detect total mercury levels in water by means of microgravity-compatible variations of standard methods. The total mercury sensor is based on solid-phase sorption of mercury metal from the analyte followed by determination at a gold-film electrode. Sodium borohydride is utilized as the reagent for decomposing organomercury compounds and generating mercury reduction. A volatile organic concentrator extracts the organics and gas chromatography/mass spectroscopy is used to detect phenols at levels below 1 ppb. Detection levels below 500 ppb are reported for short-chain aliphatic alcohols in samples injected directly on a DB624 column. Although the methods assume that the water supply to be tested in the spacecraft is relatively clean, the present processes are shown to require minimum sample preparation and relatively simple extractions and analyses. C.C.S.

A92-31339
TECHNICAL REVIEW - COMPARISON OF IC AND CE FOR MONITORING IONIC WATER CONTAMINANTS ON SSF
RANDOLPH W. SCHWEICKART (McDonnell Douglas Space Systems Co., Huntington Beach, CA), SANDRA E. CARR, and PAUL D. MUDGETT (Krug International Corp., Dayton, OH) IN: Spacecraft water quality: Maintenance and monitoring; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 9 p refs
(SAE PAPER 911438) Copyright

The use of ion chromatography (IC) is compared to that of capillary electrophoresis (CE) for measuring ionic contaminants in the Space Station Freedom (SSF) water system. The principles of IC and CE are set forth with illustrations of system components and descriptions of their respective processes. The capabilities of IC and CE analyses are examined in the context of the SSF requirements for contaminant monitoring as defined by NASA for anion, cation, and transition-metal analyses. IC methods are shown to be generally more precise than CE methods based on their respective relative standard deviations for retention time and peak area. A comparison of the performances of IC and CE designs demonstrates that CE is more efficient in terms of operation under microgravity, the mass and volume of system components, and automation potential. CE instrumentation is shown to be accurate and suitable for the SSF environment, although more testing is required to prove the long-term suitability of CE testing. C.C.S.

A92-31340
AN ANALYSIS OF URINE PRETREATMENT METHODS FOR USE ON SPACE STATION FREEDOM
STANLEY G. HOWARD and JANIE H. MIERNIK (Boeing Defense and Space Group, Huntsville, AL) IN: Spacecraft water quality: Maintenance and monitoring; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 10 p refs
(SAE PAPER 911549) Copyright

Water reclamation from human urine will be the basis of the closed loop Water Recovery Management (WRM) system on Space Station Freedom (SSF). Pretreatment is necessary to collect and process urine, fix and prevent ammonia formation, inhibit microbial growth and prevent solids precipitation. Pretreatment must be accomplished immediately upon collection to prevent damage to urine collection and handling equipment. Currently, a chemical injection scheme is an integral part of the SSF Urinal design. The reagents used will be based on compatibility with Urinal and Urine Processor components, performance of necessary pretreatment functions, quality of reclaimed water, resupply costs and development risks. These factors are compared for various pretreatment methods currently under consideration for use on SSF. Author

A92-31341* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
PRELIMINARY ECLSS WASTE WATER MODEL
DONALD L. CARTER, DONALD W. HOLDER, JR. (NASA, Marshall Space Flight Center, Huntsville, AL), KEVIN ALEXANDER, R. G. SHAW, and JOHN K. HAYASE (Boeing Aerospace Co., Seattle, WA) IN: Spacecraft water quality: Maintenance and monitoring; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 7 p refs
(SAE PAPER 911550) Copyright

A preliminary waste water model for input to the Space Station Freedom (SSF) Environmental Control and Life Support System (ECLSS) Water Processor (WP) has been generated for design purposes. Data have been compiled from various ECLSS tests and flight sample analyses. A discussion of the characterization of the waste streams comprising the model is presented, along with a discussion of the waste water model and the rationale for the inclusion of contaminants in their respective concentrations. The major objective is to establish a methodology for the development of a waste water model and to present the current state of that model. Author

A92-31342
FUNCTIONAL DESCRIPTION OF THE ION EXCHANGE AND SORBENT MEDIA USED IN THE ECLSS WATER PROCESSOR UNIBEDS
CLARENCE D. COLLEY (Boeing Defense and Space Group, Huntsville, AL) IN: Spacecraft water quality: Maintenance and monitoring; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 14 p refs
(SAE PAPER 911551) Copyright

This paper reviews some of the historical data and background surrounding the evolution and development of the Multifiltration Unibeds utilized in the ECLSS WRM water processors. Data will be presented illustrating some of the problem areas associated with previous Unibed designs and some of the progress being made toward development of flight hardware used in the treatment of water for crew use aboard Space Station Freedom (SSF). The ECLSS Water Recovery Management system (WRM) supplies water for the crew and for scientific experimentation. Specific problem areas will be discussed with recommendations that will avoid some of the pitfalls that may be encountered in design. Author

A92-31343
SPACE STATION HYGIENE WATER RECLAMATION BY MULTIFILTRATION
DAVID F. PUTNAM, WILLIAM F. MICHALEK (Umpqua Research Co., Myrtle Creek, OR), and TERRI VAN PELT (Hamilton Standard, Windsor Locks, CT) IN: Spacecraft water quality: Maintenance and monitoring; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 6 p refs
(SAE PAPER 911553) Copyright

The multifiltration subsystem for baseline hygiene-water reclamation on the Space Station Freedom (SSF) is described in terms of requirements, waste-water sources, and technology. The subsystem utilizes sorbents to remove organic and inorganic contaminants, a sterilization unit to kill microorganisms, and a cold filter to remove particulate contaminates larger than at least 0.5 micron. Specific attention is given to the 'unibed' replaceable sorption units and to the placement of the units for maximum saturation and utility. A process-control water quality analyzes the hygiene water which the multifiltration system processes from wash water and urine. Testing of the unibed shows that the concept permits low-energy reclamation of 100 percent of the water and that further testing is needed to identify the optimal sorbents for expected contaminants. The multifiltration subsystem uses relatively few components and moving parts and is suitable for the SSF hygiene-water reclamation system. C.C.S.

A92-31344
THERMAL PRETREATMENT OF WASTE HYGIENE WATER
FRANK C. GARMON and ROBERT K. AMES (Umpqua Research Co., Myrtle Creek, OR) IN: Spacecraft water quality: Maintenance and monitoring; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 6 p
(SAE PAPER 911554) Copyright

Thermal pretreatment is examined as part of the microbial-control methodology for waste hygiene water as a way to minimize the energy required for microbial control. Experimental studies are conducted which describe the reduction of microbial populations corresponding to various thermal cycles with attention given to water inoculated with thermophilic bacteria. Biofilm formation is then studied with and without thermal cycling by examining the surfaces of materials to be used in the large-scale spacecraft system. Most microbes in combined wastewater are killed by temperatures above 85 C, although naturally occurring thermophiles can survive 4 hr at 95 C. The survivability of the thermophilic population at temperatures below autoclave levels shows that lower-temperature treatment is not adequate for total microbial eradication. Biofilm formation and subsequent sloughing are shown to be significant factors in maintaining wastewater-treatment equipment. C.C.S.

A92-31352* National Aeronautics and Space Administration, Washington, DC.
INTEGRATED ENERGY BALANCE ANALYSIS FOR SPACE STATION FREEDOM
JOHN TANDLER (Grumman Corp., Reston, VA) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 10 p
(Contract NASW-4300)
(SAE PAPER 911338) Copyright

An integrated simulation model is described which characterizes the dynamic interaction of the energy transport subsystems of Space Station Freedom for given orbital conditions and for a given set of power and thermal loads. Subsystems included in the model are the Electric Power System (EPS), the Internal Thermal Control System (ITCS), the External Thermal Control System (ETCS), and the cabin Temperature and Humidity Control System (THC) (which includes the avionics air cooling, cabin air cooling, and intermodule ventilation systems). Models of the subsystems were developed in a number of system-specific modeling tools and validated. The subsystem models are then combined into integrated models to address a number of integrated performance issues involving the ability of the integrated energy transport system of Space Station Freedom to provide power, controlled cabin temperature and humidity, and equipment thermal control to support operations. Author

A92-31355* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
DEVELOPMENT OF A NONAZEOTROPIC HEAT PUMP FOR CREW HYGIENE WATER HEATING
DAVID H. WALKER and GLENN I. DEMING (Foster-Miller, Inc., Waltham, MA) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 9 p
(SAE PAPER 911341) Copyright

A heat pump system is currently under development to produce hot water for crew hygiene on future manned space missions. The heat pump uses waste heat sources and a nonazeotropic working fluid in a highly efficient cycle. The potential benefits include a reduction in peak power draw from 2 to 5 kW for electric cartridge heaters to just more than 100 W for the heat pump. As part of the heat pump development project, a unique high efficiency compressor was developed to maintain lubrication in a zero-gravity environment. R.E.P.

A92-31358* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
PHASE III INTEGRATED WATER RECOVERY TESTING AT MSFC - PARTIALLY CLOSED HYGIENE LOOP AND OPEN POTABLE LOOP RESULTS AND LESSONS LEARNED
R. M. BAGDIGIAN, M. S. TRAWEEK (NASA, Marshall Space Flight Center, Huntsville, AL), G. K. GRIFFITH, and M. R. GRIFFIN (NASA, Marshall Space Flight Center; Sverdrup Technology, Inc., Huntsville, AL) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 16 p refs
(SAE PAPER 911375) Copyright

A series of tests has been conducted at the NASA Marshall Space Flight Center (MSFC) to evaluate the performance of a predevelopment water recovery system. Potable, hygiene, and urine reclamation subsystems were integrated with end-use equipment items and successfully operated in open and partially closed-loop modes, with man-in-the-loop, for a total of 28 days. Several significant subsystem physical anomalies were encountered during testing. Reclaimed potable and hygiene water generally met the current Space Station Freedom (SSF) water quality specifications for inorganic and microbiological constituents, but exceeded the maximum allowable concentrations for Total Organic Carbon (TOC). This paper summarizes the test objectives, system design, test activities/protocols, significant results/anomalies, and major lessons learned. Author

A92-31359* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
THE CHARACTERIZATION OF ORGANIC CONTAMINANTS DURING THE DEVELOPMENT OF THE SPACE STATION WATER RECLAMATION AND MANAGEMENT SYSTEM
H. COLE, M. HABERCOM, M. CRENSHAW, S. JOHNSON, S. MANUEL, W. MARTINDALE, G. WHITMAN (Boeing Co., Missiles and Space Div., Huntsville, AL), and M. TRAWEEK (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 32 p refs
(SAE PAPER 911376) Copyright

Examples of the application of various methods for characterizing samples for alcohols, fatty acids, detergents, and volatile/semivolatile basic, neutral, and phenolic acid contaminants are presented. Data, applications, and interpretations are given for a variety of methods including sample preparation/cleanup procedures, ion chromatography, and gas chromatography with various detectors. Summaries of the major organic contaminants that contribute to the total organic carbon content are presented. R.E.P.

A92-31360* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
MICROBIAL DISTRIBUTION IN THE ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM WATER RECOVERY TEST CONDUCTED AT NASA, MSFC
J. J. GAUTHIER (Alabama, University, Birmingham), M. C. ROMAN (NASA, Marshall Space Flight Center, Huntsville, AL), B. A. KILGORE, T. L. HUFF, D. C. OBENHUBER, D. W. TERRELL (NASA, Marshall Space Flight Center; Sverdrup Technology, Inc., Huntsville, AL), M. E. WILSON, and N. E. JACKSON (Boeing Co., Missiles and Space Div., Huntsville, AL) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 14 p refs
(SAE PAPER 911377) Copyright

NASA/MSFC is developing a physical/chemical treatment system to reclaim wastewater for reuse on Space Station Freedom (SSF). Integrated testing of hygiene and potable water subsystems assessed the capability to reclaim water to SSF specifications. The test was conducted from May through July 1990 with a total of 47 days of system test operation. Water samples were analyzed using standard cultural methods employing membrane filtration and spread plate techniques and epifluorescence microscopy. Fatty acid methyl ester and biochemical profiles were used for microbial identification. Analysis of waste and product water produced by the subsystems demonstrated the effective reduction of viable microbial populations greater than 8.0E + 06 colony forming units (CFU) per 100 mL to an average of 5 CFU/100 mL prior to distribution into storage tanks. Author

A92-31361* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
MICROBIAL BIOFILM STUDIES OF THE ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM WATER RECOVERY TEST FOR SPACE STATION FREEDOM
D. C. OBENHUBER, T. L. HUFF (NASA, Marshall Space Flight Center; Sverdrup Technology, Inc., Huntsville, AL), and E. B. RODGERS (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 5 p refs
(SAE PAPER 911378) Copyright

Analysis of biofilm accumulation, studies of iodine disinfection of biofilm, and the potential for microbially influenced corrosion in the water recovery test (WRT) are presented. The analysis of WRT components showed the presence of biofilms and organic deposits in selected tubing. Water samples from the WRT contained sulfate-reducing and acid-producing organisms implicated in corrosion processes. Corrosion of an aluminum alloy was accelerated in the presence of these water samples, but stainless steel corrosion rates were not accelerated. R.E.P.

A92-31362* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
SPACE STATION FREEDOM ENVIRONMENTAL DATABASE SYSTEM (FEDS) FOR MSFC TESTING
GAIL S. STORY (NASA, Marshall Space Flight Center; Sverdrup Technology, Inc., Huntsville, AL), WENDY WILLIAMS (NASA, Marshall Space Flight Center, Huntsville, AL), and CHARLES CHIU (ION Systems, Inc., Huntsville, AL) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 14 p refs
(SAE PAPER 911379) Copyright

The Water Recovery Test (WRT) at Marshall Space Flight Center (MSFC) is the first demonstration of integrated water recovery systems for potable and hygiene water reuse as envisioned for Space Station Freedom (SSF). In order to satisfy the safety and health requirements placed on the SSF program and facilitate test data assessment, an extensive laboratory analysis database was established to provide a central archive and data retrieval function. The database is required to store analysis results for physical, chemical, and microbial parameters measured from water, air and surface samples collected at various locations throughout the test facility. The Oracle Relational Database Management System (RDBMS) was utilized to implement a secured on-line information system with the ECLSS WRT program as the foundation for this system. The database is supported on a VAX/VMS 8810 series mainframe and is accessible from the Marshall Information Network System (MINS). This paper summarizes the database requirements, system design, interfaces, and future enhancements. Author

A92-31363* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
SPACE STATION FREEDOM WATER RECOVERY TEST TOTAL ORGANIC CARBON ACCOUNTABILITY
MICHAEL W. DAVIDSON (ION Systems, Inc., Huntsville, AL), LAURENCE SLIVON (Battelle Memorial Institute, Columbus, OH), LINDA SHELDON (Research Triangle Institute, Research Triangle Park, NC), and MARY TRAWEEK (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 19 p refs
(SAE PAPER 911380) Copyright

Marshall Space Flight Center's (MSFC) Water Recovery Test (WRT) addresses the concept of integrated hygiene and potable reuse water recovery systems baselined for Space Station Freedom (SSF). To assess the adequacy of water recovery system designs and the conformance of reclaimed water quality to established specifications, MSFC has initiated an extensive water characterization program. MSFC's goal is to quantitatively account for a large percentage of organic compounds present in waste and reclaimed hygiene and potable waters from the WRT and in humidity condensate from Spacelab missions. The program is coordinated into Phase A and B. Phase A's focus is qualitative and semi-quantitative. Precise quantitative analyses are not emphasized. Phase B's focus centers on a near complete quantitative characterization of all water types. Technical approaches along with Phase A and partial Phase B investigations on the compositional analysis of Total Organic Carbon (TOC) Accountability are presented. Author

A92-31364
SYSTEM STERILIZATION FOR SPACE STATION ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM, WATER RECOVERY TEST
RAYMOND F. PARHAM and TONY R. TIPPS (Micro Craft, Inc., Huntsville, AL) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 33 p refs
(SAE PAPER 911381) Copyright

This paper addresses the methods, procedures, and results of the system sterilization associated with the Environmental Control and Life Support System Phase III, Water Recovery Test, Stages 1A/2A/3A, which took place at the Marshall Space Flight Center, Huntsville, Alabama. Sterilization was required for several purposes in this test: to provide a microbially free baseline in the test bed for evaluation of the Environmental Control and Life Support System water recovery design, to recover any portion of the system in the event of a microbial upset, and to provide a source of facility water to be used by test subjects for showers and handwashes. Typical components in the system include tubing, water storage tanks, pumps, valves, instrumentation, heat exchangers, and sample ports. Author

A92-31365* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
SPACE STATION FREEDOM ECLSS DESIGN CONFIGURATION - A POST RESTRUCTURE UPDATE
ALLEN S. BACSKAY (NASA, Marshall Space Flight Center, Huntsville, AL) and ROBERT C. DALEE (McDonnell Douglas Space Systems Co., Huntsville, AL) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 18 p refs
(SAE PAPER 911414) Copyright

The Space Station Freedom Program (SSFP) has undergone major design changes within the last year due to reduced budget appropriations imposed by Congress. This paper outlines the impacts of the design changes on the Environmental Control and Life Support System (ECLSS), with emphasis on the system aspects of the ECLSS. Brief descriptions of design impacts to all six ECLSS subsystems are provided in addition to interactions with other distributed systems such as Data Management, Electrical Power, and Man Systems. The assembly sequence for SSF is addressed with emphasis on key flights with respect to the ECLSS. Author

A92-31366* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
ECLSS REGENERATIVE SYSTEMS COMPARATIVE TESTING AND SUBSYSTEM SELECTION
ROBYN L. CARASQUILLO, DONALD L. CARTER, DONALD W. HOLDER, JR., CINDY F. MCGRIFF, and KATHRYN Y. OGLE (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 16 p
(SAE PAPER 911415) Copyright

In support of Space Station Freedom Phase C/D Environmental Control and Life Support Systems (ECLSS) regenerative systems development, comparative testing was performed on predevelopment hardware of competing technologies for each regenerative function. The purpose of the test program was to collect data on latest generation hardware in order to make final technology selections for each subassembly in the oxygen recovery and water reclamation strings. This paper discusses the testing performed, test results, and evaluation of these results relative to subsystem selections for CO2 reduction, O2 generation, potable water processing, hygiene water processing, and urine processing. Author

A92-31367* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
WASTE WATER PROCESSING TECHNOLOGY FOR SPACE STATION FREEDOM - COMPARATIVE TEST DATA ANALYSIS
JANIE H. MIERNIK, BURT H. SHAH (Boeing Defense and Space Group, Huntsville, AL), and CINDY F. MCGRIFF (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 12 p refs
(SAE PAPER 911416) Copyright

Comparative tests were conducted to choose the optimum technology for waste water processing on SSF. A thermoelectric integrated membrane evaporation (TIMES) subsystem and a vapor compression distillation subsystem (VCD) were built and tested to compare urine processing capability. Water quality, performance, and specific energy were compared for conceptual designs intended to function as part of the water recovery and management system of SSF. The VCD is considered the most mature and efficient technology and was selected to replace the TIMES as the baseline urine processor for SSF. R.E.P.

A92-31368
MASS BALANCE SENSITIVITY FOR SPACE STATION FREEDOM - CLOSED LOOP LIFE SUPPORT
JANIE H. MIERNIK and DAVID L. BAER-PECKHAM (Boeing Defense and Space Group, Huntsville, AL) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 12 p refs
(SAE PAPER 911417) Copyright

Mass balance for atmosphere, water and solids pertaining to Environmental and Life Support Systems (ECLSS) on SSF has been modeled on a Lotus 123 spreadsheet. Parameters are varied to analyze the sensitivity of the mass balance to various hardware combinations, metabolic rates and crew configurations. This program has been utilized to estimate system integration, capacity and tank sizing of ECLSS hardware. ECLSS will provide optimization and flexibility of water management to minimize or eliminate the necessity to vent water or other fluids in the vicinity of SSF. R.E.P.

A92-31369
OPTIMIZATION OF THE BOSCH CO2 REDUCTION PROCESS
CHARLES T. BUNNELL, ROBERT B. BOYDA, and M. G. LEE (Life Systems, Inc., Cleveland, OH) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 7 p refs
(SAE PAPER 911451) Copyright

Extensive development testing to support the design of the SSF Carbon Dioxide Reduction Assembly (CReA) has been conducted. Both dual and single reactor eight-person capacity systems, supported by experimental test setups, have been used to broaden the design data base. Multiple catalysts were evaluated. Of significant importance was data that showed that operation of the Bosch reaction at elevated pressure 150-205 kPa (7-15 psig)

provides significant increases in process efficiency. These improvements significantly reduce the recycle gas rate necessary to achieve a 99 percent + CO2 reduction efficiency. Data presented illustrates the improvements realized and defines the benefits that the new technology offers in terms of savings in power, weight and volume as illustrated by the SSF CReA.
Author

A92-31370
SPE WATER ELECTROLYZERS FOR CLOSED ENVIRONMENT LIFE SUPPORT
J. F. MCELROY, T. M. MOLTER, and R. J. ROY (Hamilton Standard, Windsor Locks, CT) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 10 p
(SAE PAPER 911453) Copyright

A review is presented of the research and development of the SPE water electrolyzer project that evolved from a fuel cell project when the first chemically stable, long life, perfluorocarbon ion exchange membranes became available. The system design features microgravity liquid/gas static phase separators and the utilization of processed hygiene water as the feedstock. A top level system schematic is given along with details of the static phase separators and a summary of overall electrolyzer performance.
R.E.P.

A92-31371
AN ASSESSMENT OF THE READINESS OF VAPOR COMPRESSION DISTILLATION FOR SPACECRAFT WASTEWATER PROCESSING
LAWRENCE D. NOBLE, JR., FRANZ H. SCHUBERT, REX E. GRAVES (Life Systems, Inc., Cleveland, OH), and JANIE H. MIERNIK (Boeing Defense and Space Group, Huntsville, AL) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 12 p refs
(SAE PAPER 911454) Copyright

Exhaustive testing and analysis of Vapor Compression Distillation technology has proven its overall readiness as a wastewater processor for the recovery of water in orbiting and interplanetary spacecraft. In conjunction with Boeing Aerospace and Electronics and the National Aeronautics and Space Administration, Life Systems' technical team has been focusing on verifying and improving performance characteristics, microgravity compatibility, reliability and maintainability aspects of the Vapor Compression Distillation design. Amassing thousands of hours of testing and recent breakthroughs in the area of peristaltic pump design, product water conductivity sensing and gas/liquid separation concepts have substantially increased the engineering and scientific database that has been accumulating over the past 29 years. Boeing Aerospace and Electronics recently selected the Vapor Compression Distillation concept as baseline for water reclamation via urine processing for the Space Station Freedom, indicating that Vapor Compression Distillation will be a key to providing wastewater regeneration essential for long-term human survival in space.
Author

A92-31372
SHOWER WATER RECOVERY BY UF/RO
DOUG SNOWDON (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 5 p refs
(SAE PAPER 911455) Copyright

An ultrafiltration/reverse osmosis (UF/RO) membrane breadboard system is presented. The purpose of this breadboard UF/RO testing was to demonstrate the chemical performance of the membranes when processing actual shower water. It is shown that although the system suffered degradation in hydraulic performance during the system testing, the resultant permeate consistently demonstrated a total organic compound of less than 10 ppm.
R.E.P.

A92-31373* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
LEAK DETECTION OF THE SPACE STATION FREEDOM U.S. LAB VACUUM SYSTEM USING REVERSE FLOW LEAK DETECTION METHODOLOGY
JEFFREY D. MOORE, JAMES E. SHEPHERD, and DARRELL E. MASDEN (Teledyne Brown Engineering, Huntsville, AL) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 7 p refs
(SAE PAPER 911456) Copyright

A vacuum system leak detection technique (reverse flow leak detection) under development for use aboard Space Station Freedom is presented. The technique will be applied to the Vacuum System (VS) and Waste Gas Management Subsystem (WGMS) of the U.S. Lab Module. These two systems contain over 45.7 m of distributed vacuum tubing located in remote utility runs. Fluid flow calculations which utilize known system geometry and measured steady state pressure measurements from the VS and WGMS can be used to identify leak sites within +/- 38 cm. Exact leak position can then be pinpointed by conventional tracer gas leak detection in the identified region. Tests have been performed using a simple, unrestricted 12.8 m length of vacuum tubing with a calibrated air leak attached.
Author

A92-31374
MATHEMATICAL MODELLING OF A FOUR-BED MOLECULAR SIEVE WITH CO2 AND H2O COLLECTION
R. S. BARKER, M. R. RUSSELL, and L. R. WHITMER (Boeing Aerospace and Electronics, Huntsville, AL) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 17 p refs
(SAE PAPER 911470) Copyright

An analytical model of the Four-Bed Molecular Sieve (4BMS) proposed for SSF is described. Attention is given to the system description, carbon dioxide removal assembly performance requirements, the 4BMS subsystem, the vacuum pump model, and the molecular sieve bed model. Representative plotted transient performance data for the baseline 4BMS are presented. It is shown that a simple control logic scheme will maintain the CO2 accumulator pressure within a satisfactory operating range, and the dessicant bed nearly breaks through at the specified maximum normal operation inlet dewpoint.
R.E.P.

A92-31376* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
DEVELOPING REAL-TIME CONTROL SOFTWARE FOR SPACE STATION FREEDOM CARBON DIOXIDE REMOVAL
STEVEN A. ROWE, ALEXANDER R. MORANDO (Allied-Signal Aerospace Co., AiResearch Los Angeles Div., Torrance, CA), and JIM JOHNSON (Boeing Defense and Space Group, Huntsville, AL) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 16 p refs
(Contract NAS8-50000)
(SAE PAPER 911418) Copyright

This paper presents AiResearch experience to date in using the NASA/Boeing Application Generator (AG) to develop real-time control systems for the Carbon Dioxide Removal Assembly (CDRA) in Work Package 01. The AG provides an integrated design and development tool encompassing: system analysis, modeling, control law design, simulation, code generation, real-time hardware-in-the-loop simulation and operation, and documentation. This allows rapid interactive prototyping of real-time control systems in a single, integrated, environment. Advantages and disadvantages of using the AG for real-time control system development will be addressed, with the CDRA specification to delivery cycle serving as a basis for discussion. Suggestions for improving the AG are offered and observations on its potential as a top-level system specification tool are made.
Author

A92-31377
DEVELOPMENT OF A G189A MODEL OF THE SPACE STATION FREEDOM ATMOSPHERE
R. S. BARKER and R. G. VON JOUANNE (Boeing Defense and Space Group, Huntsville, AL) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 7 p refs
(SAE PAPER 911469) Copyright

An advanced ECLSS Model has been developed using the G189A Environmental/Thermal Control and Life Support Systems Computer Program for simulating the atmospheric conditions on board Space Station Freedom. Significant changes have been applied to the previous model which allow for refined atmospheric simulation, while retaining the overall objective of avoiding rigorous models of individual components. The highlights of the advanced atmospheric model center around the intermodule linkage and ventilation, and the Atmosphere Revitalization System. Progressive techniques employed in the present model include the following: (1) segregation of the open cabin air from the air volume within racks and standoffs, with an approximate air exchange rate between the two volumes (in each Freedom element); (2) refinement of the Four Bed Molecular Sieve (4BMS) modeling technique, such that the effects upon the Freedom atmosphere are essentially identical to those experienced with an actual cycling 4BMS (while still retaining a simple steady-state black box for modeling 4BMS operations; and (3) the tracking of the cumulative CO2 exposure to which every individual crewmember is subjected during every mission day, as dictated by that person's work schedule and location within the Freedom elements (including the international elements). Author

A92-31378
REGENERATIVE LIFE SUPPORT SYSTEMS AND PROCESSES; PROCEEDINGS OF THE 21ST INTERNATIONAL CONFERENCE ON ENVIRONMENTAL SYSTEMS, SAN FRANCISCO, CA, JULY 15-18, 1991
Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-873), 1991, 197 p. For individual items see A92-31379 to A92-31398. 1991 197 p
(ISBN 1-56091-563-0; SAE SP-873) Copyright

The present volume discusses controlled ecological life support systems (CELSS) design considerations, the evolutionary development of a lunar CELSS, regenerative life support system (RLSS) performance, iodine-based microbial control of a hydroponic nutrient solution, RLSSs for space exploration, water vapor recovery for plant-growth chambers, and advanced air revitalization systems for optimized crew and plant environments. Also discussed are trace hydrocarbon contaminant removal from recycled water via biological reactors, advancements in immobilized enzyme reactors, a proton-exchange membrane electrochemically-reclaimed water posttreatment system, catalytic oxidation of closed life support systems' waste streams, Sabatier CO2 reduction for long-duration manned spaceflights, and the RLSS testbed at NASA-Johnson. O.C.

A92-31379* National Aeronautics and Space Administration, Washington, DC.
BIOREGENERATIVE LIFE SUPPORT - THE INITIAL CELSS REFERENCE CONFIGURATION
JOHN D. RUMMEL and MEL AVERNER (NASA, Life Sciences Div., Washington, DC) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 5 p
(SAE PAPER 911420) Copyright

The next major step in the development of an operational Controlled Ecological Life-Support System (CELSS) is the creation of a human-rated ground-based demonstrator able to constitute a CELSS's proof-of-concept. The reference configuration recently devised for such a ground facility by NASA will furnish a common reference to all investigators in the field, thereby facilitating performance comparisons among candidate subsystems and clarifying system-level modeling. A detailed NASA reference CELSS flowcharting is presented. O.C.

A92-31380* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
EVOLUTIONARY DEVELOPMENT OF A LUNAR CELSS
STEVEN H. SCHWARTZKOPF (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) and MARIANN F. BROWN (NASA, Johnson Space Center, Houston, TX) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 8 p refs
(SAE PAPER 911422) Copyright

An evolutionary technology-integration process has been applied to a baseline, partially-closed regenerative life support system (LSS) based on Space Station Freedom-typified physicochemical (PC) technology; the result of this evolution is the Lunar-base Controlled Ecological LSS (LCELSS), which is a hybrid system incorporating both bioregenerative (BR) and PC technologies. The evolution of the LCELSS has proceeded through a sequence of additions involving (1) bioregenerative functions, (2) supplementing specific PC functions with BR ones, (3) replacement of initial PC technologies with more advanced ones, and (4) the addition of new PC technologies. O.C.

A92-31381* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
OPTIONS FOR TRANSPIRATION WATER REMOVAL IN A CROP GROWTH SYSTEM UNDER ZERO GRAVITY CONDITIONS
C. C. BLACKWELL (NASA, Ames Research Center, Moffett Field, CA; Texas, University, Arlington), M. KLISS, B. YENDLER (NASA, Ames Research Center, Moffett Field, CA), B. BORCHERS (Bionetics Corp., Cocoa Beach, FL), BORIS S. YENDLER, THOI K. NGUYEN, and AHMAD WALEH (Applied Sciences Consultants, Inc., San Jose, CA) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 4 p
(SAE PAPER 911423) Copyright

The operation of a microgravity crop-growth system is a critical feature of NASA's Closed Ecological Life Support System (CELSS) development program. Transpiration-evolved water must be removed from the air that is recirculated in such a system, perhaps supplying potable water in the process. The present consideration of candidate systems for CELSS water removal gives attention to energy considerations and to a mechanical, inertial-operation water-separation system that was chosen due to the depth of current understanding of its operation. O.C.

A92-31382* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
DIET EXPERT SUBSYSTEM FOR CELSS
BORIS S. YENDLER (NASA, Ames Research Center, Moffett Field; Applied Sciences Consultants, Inc., San Jose, CA), THOI K. NGUYEN, and AHMAD WALEH (Applied Sciences Consultants, Inc., San Jose, CA) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 9 p refs
(Contract NAS2-12991; NAS2-13260)
(SAE PAPER 911424) Copyright

An account is given of the mathematical basis of a diet-controlling expert system, designated 'Ceres' for the human crews of a Controlled Ecological Life Support System (CELSS). The Ceres methodology can furnish both steady-state and dynamic diet solutions; the differences between Ceres and a conventional nutritional-modeling method is illustrated by the case of a three-component, potato-wheat-soybean food system. Attention is given to the role of food processing in furnishing flexibility in diet-planning management. Crew diet solutions based on simple

optimizations are not necessarily the most suitable for optimum CELSS operation. O.C.

A92-31383* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
REGENERATIVE LIFE SUPPORT SYSTEMS (RLSS) TEST BED PERFORMANCE - CHARACTERIZATION OF PLANT PERFORMANCE IN A CONTROLLED ATMOSPHERE
MARYBETH EDEEN and DONALD HENNINGER (NASA, Johnson Space Center, Houston, TX) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 6 p
(SAE PAPER 911426) Copyright

By growing higher plants for food, lunar and Martian manned habitats will not only reduce resupply requirements but obtain CO2 removal and both oxygen-production and water-reclamation requirements. Plants have been grown in the RLSS at NASA-Johnson in order to quantitatively evaluate plant CO2 accumulation, O2 generation, evapotranspiration, trace-contaminant generation, and biomass productivity. Attention is presently given to test conditions and anomalies in these RLSS trials; areas where performance must be improved have been identified. O.C.

A92-31384* National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, FL.
MICROBIOLOGICAL CHARACTERIZATION OF THE BIOMASS PRODUCTION CHAMBER DURING HYDROPONIC GROWTH OF CROPS AT THE CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEM (CELSS) BREADBOARD FACILITY
RICHARD F. STRAYER (NASA, Kennedy Space Center; Bionetics Corp., Cocoa Beach, FL) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 14 p refs
(SAE PAPER 911427) Copyright

A92-31385
IODINE MICROBIAL CONTROL OF HYDROPONIC NUTRIENT SOLUTION
TIMOTHY L. STROUP, STEVEN H. SCHWARTZKOPF (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA), and GEORGE L. MARCHIN (Kansas State University, Manhattan) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 4 p refs
(SAE PAPER 911490) Copyright

Experimental results are presented which demonstrate the substantial reduction of microbial contamination of hydroponic nutrient solutions by means of the addition of either a triiodide resin or pentaiodide; these treatments respectively reduced leaf lettuce plant fresh weights by 0.2 and 0.04 percent, relative to control plants. Because neuron-activation tissue analysis indicated iodide concentrations of 0.47-0.6 percent in experimental plants, these resins should not be used alone in conjunction with plant-growth systems. O.C.

A92-31386
A CANOPY MODEL FOR PLANT GROWTH WITHIN A GROWTH CHAMBER - MASS AND RADIATION BALANCE FOR THE ABOVE GROUND PORTION
ROBERT L. HEATH (California, University, Riverside) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 13 p refs
(SAE PAPER 911494) Copyright

A generalized plant-growth model is developed that encompasses, in addition to mass transfer of gases, radiation/heat balance, and photosynthetic carbohydrate production, the interactions of layers of leaf layers which differentially absorb radiation and gases. Energy balances are used to calculate gas-exchange patterns, and carbohydrate production is derived from light intensity and CO2/O2 concentrations. Productivity is then divided into respiration growth, maintenance storage, structural growth, and export to other growing plant portions. O.C.

A92-31387
ADVANCED REGENERATIVE LIFE SUPPORT FOR SPACE EXPLORATION
H. T. COUCH, J. W. AUMAN, JR., and T. C. FALVEY (Hamilton Standard, Windsor Locks, CT) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 11 p refs
(SAE PAPER 911500) Copyright

An evaluation is conducted of regenerative Environmental Control and Life Support System technologies promising mass reductions in LEO for long range exploration spacecraft missions, with attention to in situ resource utilization and closed ecological life support system features. Advanced technological development recommendations are made for higher-efficiency urine processing, single-processing methods for both potable and hygiene water, electrolytic oxygen and potable water recovery, chemical N2 storage, and membrane gas separation processes, on the basis of projected expendable, consumable, and installed subsystem LEO mass savings. O.C.

A92-31388* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ADVANCED AIR REVITALIZATION FOR OPTIMIZED CREW AND PLANT ENVIRONMENTS
M. G. LEE, DAVID J. GRIGGER (Life Systems, Inc., Cleveland, OH), and MARIANN F. BROWN (NASA, Johnson Space Center, Houston, TX) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 9 p refs
(Contract NAS9-17913)
(SAE PAPER 911501) Copyright

The Hybrid Air Revitalization System (HARS) closed ecosystem concept presented encompasses electrochemical CO2 and O2 separators, in conjunction with a mechanical condenser/separator for maintaining CO2, O2, and humidity levels in crew and plant habitats at optimal conditions. HARS requires no expendables, and allows flexible process control on the bases of electrochemical cell current, temperature, and airflow rate variations. HARS capacity can be easily increased through the incorporation of additional chemical cells. Detailed system flowcharts are provided. O.C.

A92-31389* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
WATER VAPOR RECOVERY FROM PLANT GROWTH CHAMBERS
R. J. RAY, D. D. NEWBOLD, R. H. COLTON, and S. B. MCCRAY (Bend Research, Inc., OR) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 9 p refs
(Contract NAS2-13345)
(SAE PAPER 911502) Copyright

NASA is investigating the use of plant growth chambers (PGCs) for space missions and for bases on the moon and Mars. Key to successful development of PGCs is a system to recover and reuse the water vapor that is transpired from the leaves of the plants. A design is presented for a simple, reliable, membrane-based system that allows the recovery, purification, and reuse of the transpired water vapor through control of temperature and humidity levels in PGCs. The system is based on two membrane technologies: (1) dehumidification membrane modules to remove water vapor from the air, and (2) membrane contactors to return water vapor to the PGC (and, in doing so, to control the humidity and temperature within the PGC). The membrane-based system promises to provide an ideal, stable growth environment for a variety of plants, through a design that minimizes energy usage, volume, and mass, while maximizing simplicity and reliability. Author

A92-31390
USING BIOLOGICAL REACTORS TO REMOVE TRACE HYDROCARBON CONTAMINANTS FROM RECYCLED WATER
GARY P. MILLER, RALPH J. PORTIER, DAVID P. DICKEY (Louisiana State University, Baton Rouge), and HOWARD L. SLEEPER (Lockheed Missiles and Space Co., Inc., Research and Development Div., Palo Alto, CA) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 9 p refs
(SAE PAPER 911504) Copyright

The validity of immobilized-bed biological-reactor concepts for the removal of trace contaminants from recycled water is experimentally tested for three groups of target organics, namely aliphatics, aromatics, and chlorinated aliphatics. The experimental results obtained demonstrate the removal of 99.9 percent of the 100 ppm phenol content of a water stream. A 10 ppm phenol-feed stream was reduced to less than 500 ppb using a recycle-mode reactor over a retention time of 13 hours; the same reactor was able to remove over 99.88 percent of the phenol in plug-flow mode. O.C.

A92-31391* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
ADVANCED DEVELOPMENT OF IMMOBILIZED ENZYME REACTORS
CLIFFORD D. JOLLY, LEONARD J. SCHUSSEL (Umpqua Research Co., Myrtle Creek, OR), and LAYNE CARTER (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 9 p refs
(Contract NAS8-38421)
(SAE PAPER 911505) Copyright

Fixed-bed reactors have been used at NASA-Marshall to purify wastewater generated by an end-use equipment facility, on the basis of a combination of multifiltration unibeds and enzyme unibeds. The enzyme beds were found to effectively remove such targeted organics as urea, alcohols, and aldehydes, down to levels lying below detection limits. The enzyme beds were also found to remove organic contaminants not specifically targeted. O.C.

A92-31392 National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
THE USE OF MEMBRANES IN LIFE SUPPORT SYSTEMS FOR LONG-DURATION SPACE MISSIONS
S. B. MCCRAY, R. J. RAY, and D. D. NEWBOLD (Bend Research, Inc., OR) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 12 p refs
(Contract NAS9-17031; NAS9-17611; NAS9-17581; NAS9-18085; NAS9-18477; NAS2-13345; NAS8-38902)
(SAE PAPER 911537) Copyright

The use of membrane processes in a long-duration manned mission's regenerative environmental control and life-support system is presently discussed, in the cases of treatment for hygiene water, urine, humidity condensate, and phase-change distillate, as well as of water-vapor and CO2 removal from spacecraft air. Attention is given to the design of a tube-side-feed hollow-fiber module for membrane support and fluids-feed, as well as to the schematics for a membrane-based urine processor, an air recirculator, a potable-water producer, and a two-stage urine treater. O.C.

A92-31393* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
DEVELOPMENT OF A PROTON-EXCHANGE MEMBRANE ELECTROCHEMICAL RECLAIMED WATER POST-TREATMENT SYSTEM
LAMINE KABA (Texas A & M University, College Station), CHARLES E. VEROSTKO (NASA, Johnson Space Center, Houston, TX), G. D. HITCHENS, and OLIVER J. MURPHY (Lynntech, Inc., Bryan, TX) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 10 p refs
(Contract NAG9-427)
(SAE PAPER 911538) Copyright

A single-cell electrochemical reactor that utilizes a proton exchange membrane (PEM) as a solid electrolyte is being investigated for posttreatment of reclaimed waste waters with low or negligible electrolyte content. Posttreatment is a final 'polishing' of reclaimed waste waters prior to reuse, and involves removing organic impurities at levels as high as 100 ppm to below 500 ppb total organic carbon (TOC) content to provide disinfection. The system does not utilize or produce either expendable hardware components or chemicals and has no moving parts. Test data and kinetic analysis are presented. The feasibility and application for water reclamation processes in controlled ecological environments (e.g., lunar/Mars habitats) are also presented. Test results show that the electrochemical single cell reactor provides effective posttreatment. Author

A92-31394* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
CATALYTIC OXIDATION FOR TREATMENT OF ECLSS AND PMMS WASTE STREAMS
JAMES R. AKSE and CLIFFORD D. JOLLY (Umpqua Research Co., Myrtle Creek, OR) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 10 p refs
(Contract NAS8-38038; NAS8-38490)
(SAE PAPER 911539) Copyright

It is shown that catalytic oxidation is an effective technique for the removal of trace organic contaminants in a multifiltration potable processor's effluent. Essential elements of this technology are devices that deliver oxygen to the influent, and remove gaseous reaction byproducts from the effluent, via hollow-tube, gas-permeable membranes. Iodine, which poisons existing catalysis, is removed by a small deiodination bed prior to catalytic reactor entrance. The catalyst used is a mixture of Pt and Ru deposited on carbon, operating at 125-160 C and 39-90 psi pressures. O.C.

A92-31395* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
AIRBORNE TRACE ORGANIC CONTAMINANT REMOVAL USING THERMALLY REGENERABLE MULTI-MEDIA LAYERED SORBENTS
JAMES E. ATWATER and JOHN T. HOLTSNIDER (Umpqua Research Co., Myrtle Creek, OR) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 8 p refs
(Contract NAS9-18337)
(SAE PAPER 911540) Copyright

A cyclic two-step process is described which forms the basis for a simple and highly efficient air purification technology. Low molecular weight organic vapors are removed from contaminated airstreams by passage through an optimized sequence of sorbent media layers. The contaminant loaded sorbents are subsequently regenerated by thermal desorption into a low volume inert gas environment. A mixture of airborne organic contaminants consisting of acetone, 2-butanone, ethyl acetate, Freon-113 and methyl chloroform has been quantitatively removed from breathing quality air using this technique. The airborne concentrations of all contaminants have been reduced from initial Spacecraft Maximum Allowable Concentration (SMAC) levels to below the analytical limits of detection. No change in sorption efficiency was observed through multiple cycles of contaminant loading and sorbent regeneration via thermal desorption. Author

A92-31396
SABATIER CARBON DIOXIDE REDUCTION SYSTEM FOR LONG-DURATION MANNED SPACE APPLICATION
HAL J. STRUMPF, C. Y. CHIN (Allied-Signal Aerospace Co., AiResearch Los Angeles Div., Torrance, CA), GEORGE R. LESTER, and STEPHEN T. HOMEYER (Allied-Signal Aerospace Co., Des Plaines, IL) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 12 p refs
(SAE PAPER 911541) Copyright

A carbon dioxide reduction system is being developed for long-duration manned space missions. The system incorporates a Sabatier methanation reactor, utilizing previously developed catalyst materials, and a hollow fiber membrane unit to separate the products of reaction. Heat produced by the exothermic Sabatier reaction is absorbed by an air stream, which also regulates the reactor temperature to maximize yield. This absorbed heat can be utilized elsewhere in the carbon dioxide management system to reduce power requirements. The Sabatier process combines carbon dioxide and hydrogen to form methane and water. In a manned space environment, the water is then either electrolyzed to form oxygen for breathing and hydrogen to drive the reaction, or recycled to the potable water system. A computer-based performance model using finite elements has been developed to evaluate reactor design and catalyst performance. Laboratory testing of the Sabatier reaction using various catalyst materials is ongoing, with preliminary results reported in this paper. Author

A92-31397* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
REGENERATIVE LIFE SUPPORT SYSTEMS (RLSS) TEST BED DEVELOPMENT AT NASA-JOHNSON SPACE CENTER
TERRY O. TRI, MARIANN F. BROWN, MICHAEL K. EWERT, SANDRA L. FOERG (NASA, Johnson Space Center, Houston, TX), and MELISSA K. MCKINLEY (Lockheed Engineering and Sciences Co., Houston, TX) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 8 p
(SAE PAPER 911425) Copyright

NASA-Johnson's RLSS testbed employs higher plants in a closed environment, in conjunction with a physicochemically-based life-support system, to create an integrated, biological/physicochemical RLSS. Crew presence is simulated by a human metabolic simulator, and operation is sufficiently automated for crops to be grown from seed to harvest without human intervention. Attention is given to the Variable Pressure Growth Chamber, which will be operable at both ambient atmospheric pressures and at the reduced pressures representative of operations in lunar and Martian environments. O.C.

A92-31398
DEVELOPMENT OF IMMOBILIZED CELL BIOREACTOR TECHNOLOGY FOR WATER RECLAMATION IN A REGENERATIVE LIFE SUPPORT SYSTEM
GLENN E. PETRIE (Allied-Signal Aerospace Co., Des Plaines, IL) and MAURENA S. NACHEFF-BENEDICT (Allied-Signal Aerospace Co., AiResearch Los Angeles Div., Torrance, CA) IN: Regenerative life support systems and processes; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 13 p refs
(SAE PAPER 911503) Copyright

The applicability of immobilized microbial cell bioreactor technology to primary water processing in a regenerative life-support system's waste-water streams is presently investigated; such a bioreactor could in principle leave only trace contaminants, whose final removal would then be effected depending on intended water use. Specific microorganisms have been adapted for expected waste stream compositions; these enriched aerobic microorganisms were immobilized in packed-bed reactor configurations that were then operated in a continuous-process mode. Reactor performance is evaluated as a function of reactor vessel geometry, support material, pH, and hydraulic detention time. O.C.

A92-32455
HUMAN PHYSIOLOGY IN MICROGRAVITY - AN OVERVIEW
GUGLIELMO ANTONUTTO and PIETRO E. DI PRAMPERO (Udine, Universita, Italy) (Columbus VII - Symposium on Space Station Utilization, 7th, Anacapri, Italy, July 1-6, 1991, Proceedings. A92-32451 12-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, p. 145-147. Apr. 1992 3 p
Copyright

In microgravity a thorough readjustment of several physiological functions takes place. As an example, the cardiovascular system adapts in a relatively short time to the new condition, leading to a persisting 'cardiovascular deconditioning' upon return on earth after long term space missions. Moreover, the prevention of the musculoskeletal decay related associated with long term space flights still represents a problem. Both cardiovascular deconditioning and musculoskeletal decay have been partially prevented during space flights by appropriate programs of physical exercise. A more successful prevention would be probably attained if exercise could be coupled with artificial gravity. A system is proposed consisting of two mechanically coupled counter rotating bicycles, moving on the inner wall of a cylindrical space module. The two pedalling subjects generate a centrifugal acceleration vector simulating gravity. By selecting appropriately the radial dimensions of the space module in order to minimize the vestibular disturbances, the head to feet centrifugal acceleration gradients and the manufacturing costs, it will be possible to combine exercise and simulated gravity, with no need for additional external power. Author

N92-10161*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NUMERICAL ANALYSIS AND SIMULATION OF AN ASSURED CREW RETURN VEHICLE FLOW FIELD
K. JAMES WEILMUENSTER, ROBERT E. SMITH, JR., and FRANCIS A. GREENE Washington Sep. 1991 37 p
(Contract RTOP 506-40-91-01)
(NASA-TP-3101; L-16836; NAS 1.60:3101) Avail: CASI HC A03/MF A01

A lifting body was proposed as a candidate for the Assured Crew Return Vehicle (ACRV) which will serve as a crew rescue vehicle for the Space Station Freedom. The focus is on body surface definition, both surface and volume grid definition, and the computation of inviscid flow fields about the vehicle at wind tunnel conditions. Very good agreement is shown between the computed aerodynamic characteristics of the vehicle at M(sub infinity) = 10 and those measured in wind tunnel tests at high Reynolds numbers. Author

N92-11115*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SAFETY ISSUES
R. ROHAL *In its* Nuclear Thermal Propulsion: A Joint NASA/DOE/DOD Workshop p 441-444 1991
Avail: CASI HC A01/MF A04

The purpose of the NASA safety review process is to make sure that any system hazards that can endanger the manned flight system are precluded. The systems that address manned flight in a payload safety review process are discussed. The types of basic hazards that are normally addressed on any of the payloads are: contamination, electrical shock, explosions, radiation, and temperature extremes. Author

N92-12416*# Lockheed Engineering and Sciences Co., Houston, TX.
THE EFFECT OF ON/OFF INDICATOR DESIGN ON STATE CONFUSION, PREFERENCE, AND RESPONSE TIME PERFORMANCE, EXECUTIVE SUMMARY
KIMBERLY A. DONNER, KRITINA L. HOLDEN, and MEERA K.

MANAHAN Mar. 1991 36 p Original contains color illustrations
(Contract NAS9-17900)
(NASA-CR-185662; NAS 1.26:185662; LESC-29239)

Investigated are five designs of software-based ON/OFF indicators in a hypothetical Space Station Power System monitoring task. The hardware equivalent of the indicators used in the present study is the traditional indicator light that illuminates an ON label or an OFF label. Coding methods used to represent the active state were reverse video, color, frame, check, or reverse video with check. Display background color was also varied. Subjects made judgments concerning the state of indicators that resulted in very low error rates and high percentages of agreement across indicator designs. Response time measures for each of the five indicator designs did not differ significantly, although subjects reported that color was the best communicator. The impact of these results on indicator design is discussed. Author

N92-12418# National Research Council of Canada, Ottawa (Ontario). Systems Lab.
ERGONOMICS APPLIED TO OPERATIONAL SYSTEMS IN SPACE STATIONS
BETTY ANN M. TURPIN Feb. 1988 21 p
(NRC-28710; NRC-TR-SYS-016; CTN-91-60293) Avail: CASI HC A03/MF A01

The aim of the ergonomist is to analyze the complete system, including the operator, the machine, and the environment, and to design it in a manner which maximizes its efficiency and safety. The ergonomic approach to the design of jobs, equipment, tasks, and operating procedures is that of fitting the task to the operator. The operator should be considered as operating in parallel with other system operations, rather than as a component operating in series with other system operations. An ergonomic approach to the development of any system requires task analysis, necessitates inclusion of the operator in development, implementation, and test phases, and requires critical evaluation of existing technologies. The unique environment of zero gravity in space poses a unique challenge for space station ergonomics. Major questions in space operation systems focus on feedback and errors, their integration with technology, design of workstations for activities within and outside of a space station with specific reference to generic prescription needs, and the pros and cons of automation and computerization. CISTI

N92-13581*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
RISKS, DESIGNS, AND RESEARCH FOR FIRE SAFETY IN SPACECRAFT
ROBERT FRIEDMAN (National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.), KURT R. SACKSTEDER, and DAVID URBAN (Sverdrup Technology, Inc., Brook Park, OH.) 1991 22 p Presented at the Fall Meeting of the National Fire Protection Association, Inc., Montreal, Quebec, 19 Nov. 1991
(Contract NAS3-25266; RTOP 323-53-62)
(NASA-TM-105317; E-6672; NAS 1.15:105317) Avail: CASI HC A03/MF A01

Current fire protection for spacecraft relies mainly on fire prevention through the use of nonflammable materials and strict storage controls of other materials. The Shuttle also has smoke detectors and fire extinguishers, using technology similar to aircraft practices. While experience has shown that the current fire protection is adequate, future improvements in fire safety technology to meet the challenges of long duration space missions, such as the Space Station Freedom, are essential. All spacecraft fire protection systems, however, must deal with the unusual combustion characteristics and operational problems in the low gravity environment. The features of low gravity combustion that affect spacecraft fire safety, and the issues in fire protection for Freedom that must be addressed eventually to provide effective and conservative fire protection systems are discussed. Author

N92-13834*# Hampton Univ., VA. Dept. of Mass Media Arts.
THE HL-20 AS THE PERSONNEL LAUNCH SYSTEM
SHERILEE F. BEAM *In* Old Dominion Univ., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1991 p 61-67 Sep. 1991
Avail: CASI HC A02/MF A03

To ensure manned access to space, the Personnel Launch System (PLS) is under consideration by NASA as a complement to the Space Shuttle. Its primary mission will be to transport crew and passengers to and from the Space Station Freedom in low earth orbit (LEO). There are currently two design studies being funded: a biconic, ballistic-shaped vehicle at JSC and a lifting body concept at LaRC. In the late 1950's, both NASA and the Air Force were engaged in the study of lifting bodies for LEO vehicles. Projects included the M2F2 series, the X24 series, and the HL-10. These lifting bodies derive their lift solely from the shape of the fuselage. By the mid-1960's, full scale models were actually built and tested with some success and some failure. Langley's HL-10 was one of the most successful of these projects. However, these studies were temporarily shelved while work progressed on the Space Shuttle. Some of the test results from these studies actually led to concept refinements on certain aspects of the Space Shuttle development. Due to the more recent successes of the Space Shuttle Program and a directive to place a Space Station in orbit, there has been renewed interest in developing a lifting body vehicle as the PLS. The vehicle, the HL-20, is an LaRC Project in the Space Systems Division, involving the efforts of a number of individuals. Data on the research carried out for peer and lay review has been available in hard copy format, but a need existed for actual video footage, combined with scientific visualization technology, for presentation and archival purposes. The purpose of this project was to satisfy this need. Author

N92-14591*# Spectra Research Systems, Inc., Huntsville, AL.
INITIAL ASSESSMENTS OF LIFE SUPPORT TECHNOLOGY EVOLUTION AND ADVANCED SENSOR REQUIREMENTS, VOLUME 2, APPENDIX A
EDWARD E. MONTGOMERY 3 Sep. 1991 53 p
(Contract NAS8-38781)
(NASA-CR-184248; NAS 1.26:184248;
SRS/STG-TR92-01-VOL-2-APP-A) Avail: CASI HC A04/MF A01

The primary issues studied were how the transition from a physical/chemical (P/C) to hybrid to a Closed Ecological Life Support System (CELSS) could be achieved, what sensors and monitors are needed for a P/C -CELSS hybrid system, and how a CELSS could be automated and what controls would be needed to do so. Author

N92-14592*# Spectra Research Systems, Inc., Huntsville, AL.
APPENDICES B THRU F, VOLUME 3
3 Sep. 1991 164 p
(Contract NAS8-38781)
(NASA-CR-184249; NAS 1.26:184249; SRS/STG-TR92-01-VOL-3)
Avail: CASI HC A08/MF A02

The purpose of this investigation was to determine if the intermodule ventilation (IMV) systems and water distribution systems of Space Station Freedom (SSF) modules and nodes should be connected as they are interfaced with those already in operation. It was concluded that the AC configuration and attached LAB and HAB modules and nodes should be interconnected. The H2O circuits should also be interconnected. Interconnecting the air and water provides flexibility of operation and safety comparable to the Assembly Complete (AC) configuration. This requires only only that valves and ducts be provided in the AC nodes. The AC node interfaces should also be scarred to provide for water transfer across these interfaces. Penalties for not connecting the Intermodular Ventilation (IMV) system and water circuits include an additional AR unit, possible increased water storage requirements, and considerable reduction in crew flexibility.
Author

N92-14593*# Spectra Research Systems, Inc., Huntsville, AL.
ADVANCED INSTRUMENTATION: TECHNOLOGY DATABASE ENHANCEMENT, VOLUME 4, APPENDIX G
3 Sep. 1991 225 p
(Contract NAS8-38781)
(NASA-CR-184250; NAS 1.26:184250;
SRS/STG-TR92-01-VOL-4-APP-G) Avail: CASI HC A10/MF A03

The purpose of this task was to add to the McDonnell Douglas Space Systems Company's Sensors Database, including providing additional information on the instruments and sensors applicable to physical/chemical Environmental Control and Life Support System (P/C ECLSS) or Closed Ecological Life Support System (CELSS) which were not previously included. The Sensors Database was reviewed in order to determine the types of data required, define the data categories, and develop an understanding of the data record structure. An assessment of the MDSSC Sensors Database identified limitations and problems in the database. Guidelines and solutions were developed to address these limitations and problems in order that the requirements of the task could be fulfilled. Author

N92-14594*# Spectra Research Systems, Inc., Huntsville, AL.
CLEAN ROOM SURVEY AND ASSESSMENT, VOLUME 5, APPENDIX H
3 Sep. 1991 110 p
(Contract NAS8-38781)
(NASA-CR-184251; NAS 1.26:184251;
SRS/STG-TR92-01-VOL-5-APP-H) Avail: CASI HC A06/MF A02

The scope of this task is to perform a comparative analysis of the various Environmental Control Life Support System (ECLSS) options for different growth scenarios. The Space Station Freedom ECLSS design and existing ground-based clean room facilities are used as a baseline for comparison. Specifically addressed here are the ground based clean room facilities at the Marshall Space Flight Center (MSFC). Given here is an evaluation of the facilities, equipment, technologies, and procedures used to maintain specified environments in typical aerospace industrial areas. Twenty-five specific clean rooms are evaluated. The objectives were to collect, compare, and catalog data for each specified facility in the areas of engineering and design, construction materials, work stations, contamination control, particulate elimination, entry systems, and instrumentation, and to make recommendations concerning enhancements required to assure an efficient and orderly evolution of MSFC clean room environmental control facilities. Author

N92-14595*# Spectra Research Systems, Inc., Huntsville, AL.
ADVANCED LIFE SUPPORT STUDY Final Report
3 Sep. 1991 46 p
(Contract NAS8-38781)
(NASA-CR-184247; NAS 1.26:184247; SRS/STG-TR92-01)
Avail: CASI HC A03/MF A01

Summary reports on each of the eight tasks undertaken by this contract are given. Discussed here is an evaluation of a Closed Ecological Life Support System (CELSS), including modeling and analysis of Physical/Chemical Closed Loop Life Support (P/C CLLS); the Environmental Control and Life Support Systems (ECLSS) evolution - Intermodule Ventilation study; advanced technologies interface requirements relative to ECLSS; an ECLSS resupply analysis; the ECLSS module addition relocation systems engineering analysis; an ECLSS cost/benefit analysis to identify rack-level interface requirements of the alternate technologies evaluated in the ventilation study, with a comparison of these with the rack level interface requirements for the baseline technologies; advanced instrumentation - technology database enhancement; and a clean room survey and assessment of various ECLSS evaluation options for different growth scenarios. Author

N92-15886*# Alabama Univ., Tuscaloosa. Industrial Engineering.
EMERGENCY EGRESS REQUIREMENTS FOR SPACE STATION FREEDOM
PAUL S. RAY *In* Alabama Univ., Research Reports: 1991 NASA/ASEE Summer Faculty Fellowship Program 5 p Oct. 1991
(Contract NGT-01-008-021)
Avail: CASI HC A01/MF A03

An objective was to determine if the pressurized elements and hatchways of the Space Station Freedom support the emergency egress of crewmembers during operation of the station at the stage of Permanently Manned Capacity. Emergency egress was defined as the exit from a pressurized element when an event occurs which makes that element uninhabitable. The possible egress paths for four emergency scenarios considered were: (1) accident occurs in a module and crewmembers translate to the attached node; (2) accident occurs at a node and crewmembers translate through it to the safe node; (3) accident occurs at a module close to a node and crewmembers are not able to translate through the affected area; and (4) accident occurs at a node and crewmembers cannot translate through it. The structural design of the pressurized elements and the hatches studied is adequate for the emergence egress translation requirement. The current location of a few racks may cause some obstruction for egress to the orbiter. The egress time required in the worst situation is estimated to be about 3 mins. There is a chance of getting crewmembers trapped in a module in case of a severe accident. Aids are needed for emergency egress translation. Author

N92-17352*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
INTELLIGENT COMPUTER-AIDED TRAINING (ICAT)
ROBERT T. SAVELY and R. BOWEN LOFTIN *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 2: Space Station Freedom, Part 2 p 1105-1155 Sep. 1991 Prepared in cooperation with Houston Univ., TX
Avail: CASI HC A03/MF A04

The Software Technology Branch has developed and demonstrated a number of ICAT System for a variety of complex procedural tasks in the NASA operational environment. A general ICAT architecture was developed and shown to be adaptable across this spectrum of tasks. Currently underway is the assembly of a suite of software tools that will permit the training community to rapidly develop and deploy ICAT systems for a variety of Space Station training tasks. The use of ICAT technology for selected training applications within the Space Station Freedom program can significantly reduce the costs of training system development. Once developed ICAT systems can be more readily and efficiently evolved and maintained than many conventional training systems. ICAT systems can be delivered for both ground based and on-orbit training. The availability of sophisticated on-orbit training will serve to reduce EVA time and can be especially useful in preparing crew for the performance on infrequent, mission critical tasks. ICAT systems can deliver uniform but individualized training to large numbers of personnel in a workstation environment.
Author

N92-17355*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM EVOLUTION ANALYSIS
PAUL WIELAND and SANDY MONTGOMERY *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 2: Space Station Freedom, Part 2 p 1237-1270 Sep. 1991
Avail: CASI HC A03/MF A04

The Space Station Freedom Environmental Control and Life Support System (ECLSS) will have to accommodate the changes made to Freedom as it evolves over 30 years or more. Requirements will change as pressurized modules are added, crew numbers increase, and as the tasks to be performed change. This evolution will result in different demands on the ECLSS which will have to adapt to these changes. Technologies other than the baselined ones may be better able to perform the various ECLSS functions and technological advances will result in improved life support hardware better able to meet the new requirements.
Author

N92-17356*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
THE ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM ADVANCED AUTOMATION PROJECT
BRANDON S. DEWBERRY *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 2: Space Station Freedom, Part 2 p 1271-1309 Sep. 1991
Avail: CASI HC A03/MF A04

The objective of the ECLSS Advanced Automation project includes reduction of the risk associated with the integration of new, beneficial software techniques. Demonstrations of this software to baseline engineering and test personnel will show the benefits of these techniques. The advanced software will be integrated into ground testing and ground support facilities, familiarizing its usage by key personnel. Author

N92-17357*# Jet Propulsion Lab., California Inst. of Tech., Pasadena. Artificial Intelligence Group.
ECLSS PREDICTIVE MONITORING
RICHARD J. DOYLE and STEVE A. CHIEN *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 2: Space Station Freedom, Part 2 p 1311-1351 Sep. 1991
Avail: CASI HC A03/MF A04

On Space Station Freedom (SSF), design iterations have made clear the need to keep the sensor complement small. Along with the unprecendented duration of the mission, it is imperative that decisions regarding placement of sensors be carefully examined and justified during the design phase. In the ECLSS Predictive Monitoring task, we are developing AI-based software to enable design engineers to evaluate alternate sensor configurations. Based on techniques from model-based reasoning and information theory, the software tool makes explicit the quantitative tradeoffs among competing sensor placements, and helps designers explore and justify placement decisions. This work is being applied to the Environmental Control and Life Support System (ECLSS) testbed at MSFC to assist design personnel in placing sensors for test purposes to evaluate baseline configurations and ultimately to select advanced life support system technologies for evolutionary SSF. Author

N92-18609# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Columbus System and Project Dept.
ESTABLISHMENT AND IMPLEMENTATION OF COMMON PRODUCT ASSURANCE AND SAFETY REQUIREMENTS FOR THE CONTRACTORS OF THE COLUMBUS PROGRAMME
H. WESSELS (European Space Research Lab., Noordwijk (Netherlands).) and H.J. STEPHAN (Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen, Germany, F.R.) *In its* Space Product Assurance for Europe in the 1990s: An ESA Symposium p 9-16 Aug. 1991
Copyright Avail: CASI HC A02/MF A03

When establishing the Columbus Product Assurance (PA)/safety requirements, the international environment of the Space Station Freedom program has to be taken into account. Considerations given to multiple ways of requirement definition and stages within the European Space Agency (ESA) Procedures, Specifications, and Standards (PSS-01) series of documents and the NASA Space Station requirements are discussed. A series of adaptations introduced by way of tailoring the basic ESA and NASA requirement sets to the Columbus program's needs are described. For the implementation of these tailored requirements, a scheme is developed, which recognizes the PA/safety approach within the European industries by way of various company handbooks and manuals. The changes introduced in the PSS-01 series and the applicable NASA Space Station requirements in recent years, has coincided with the establishment of Columbus PA/safety requirements. To achieve the necessary level of cooperation between ESA and the Columbus industries, a PA Working Group (PAWG) is established. The PAWG supervises the establishement of the Common PA/Safety Plan and the Standards to be used. Due to the high number of European industries participating in the Columbus program, a positive influence on the evolution of the industrial approaches in PA/safety can be expected. Cooperation in the PAWG has brought issues to light which are related to the ESA PSS-01 series and its requirements. Due to the rapid changes of recent years, basic company documentation has not followed the development, specifically as various recent ESA projects use different project specifc issues of the evolving PSS-01 documents. ESA

N92-18617*# National Aeronautics and Space Administration, Washington, DC.
NASA PRODUCT ASSURANCE IN THE 1990S
GEORGE A. RODNEY and JAMES H. EHL *In* ESA, Space Product Assurance for Europe in the 1990s: An ESA Symposium p 61-65 Aug. 1991
Copyright Avail: CASI HC A01/MF A03

The objectives of NASA product assurance in the 1990s are identified. They are to provide for personnel safety, and safe and reliable operation of hardware and software during the lifetime of a program or mission. The NASA product assurance program, a multi-discipline effort that focuses on safety, reliability, maintainability, and quality assurance expertise to meet NASA operational requirements is described. This program supports NASA 's unmanned launch vehicles such as satellites and planetary probes, manned spacecraft (such as the Space Shuttle and Space Station Freedom), and ground support equipment. ESA

N92-18635# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
SAFETY RISK MANAGEMENT FOR ESA SPACE SYSTEMS
K. M. WRIGHT *In its* Space Product Assurance for Europe in the 1990s: An ESA Symposium p 169-174 Aug. 1991
Copyright Avail: CASI HC A02/MF A03

ESA's safety program as defined in ESA PSS-01-40, system safety requirements for ESA space systems, comprise the systematic identification and evaluation of space system hazardous characteristics and their associated risks, together with a process of safety optimization through hazard and risk reduction, and implementation verification. This safety optimization and verification process is termed safety risk management. The fundamental principles of safety risk management are discussed. ESA

N92-18649# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
SPECIFYING PA/SAFETY DESIGN TO REQUIREMENTS FOR THE COLUMBUS PROJECT AND GENERAL CONCLUSIONS
M. KASPER (European Space Research Lab., Noordwijk (Netherlands).) and W. GERICKE (Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen, Germany, F.R.) *In its* Space Product Assurance for Europe in the 1990s: An ESA Symposium p 253-258 Aug. 1991
Copyright Avail: CASI HC A02/MF A03

Product assurance (PA) and safety design to requirements are provided by the System Requirements Document (SRD) on the system level. These system level requirements contain technical requirements related to reliability, availability, maintainability, safety, PMP, and EEE parts in dedicated sections. In order to implement these requirements, the contractor needs to elaborate and refine them for the detailed design of the system. The requirements are to be apportioned further when establishing system, subsystem, and equipment level specifications. The Columbus process for establishing, refining, and tracing the requirements from ESA generated sets to industry (prime and lower tier contractors) generated design control requirements is described. ESA

N92-18927*# FWG Associates, Inc., Tullahoma, TN.
CHEMICAL HAZARDS DATABASE AND DETECTION SYSTEM FOR MICROGRAVITY AND MATERIALS PROCESSING FACILITY (MMPF) Final Report
JIMMY STEELE and ROBERT E. SMITH 14 Oct. 1991 67 p

(Contract NAS8-37746)
(NASA-CR-184274; NAS 1.26:184274) Avail: CASI HC A04/MF A01

The ability to identify contaminants associated with experiments and facilities is directly related to the safety of the Space Station. A means of identifying these contaminants has been developed through this contracting effort. The delivered system provides a listing of the materials and/or chemicals associated with each facility, information as to the contaminant's physical state, a list of the quantity and/or volume of each suspected contaminant, a database of the toxicological hazards associated with each contaminant, a recommended means of rapid identification of the contaminants under operational conditions, a method of identifying possible failure modes and effects analysis associated with each facility, and a fault tree-type analysis that will provide a means of identifying potential hazardous conditions related to future planned missions. Author

N92-20993*# *National Aeronautics and Space Administration*, Washington, DC.
AEROSPACE SAFETY ADVISORY PANEL Annual Report
Mar. 1992 80 p
(NASA-TM-107798; NAS 1.15:107798) Avail: CASI HC A05/MF A01

The results of the Panel's activities are presented in a set of findings and recommendations. Highlighted here are both improvements in NASA's safety and reliability activities and specific areas where additional gains might be realized. One area of particular concern involves the curtailment or elimination of Space Shuttle safety and reliability enhancements. Several findings and recommendations address this area of concern, reflecting the opinion that safety and reliability enhancements are essential to the continued successful operation of the Space Shuttle. It is recommended that a comprehensive and continuing program of safety and reliability improvements in all areas of Space Shuttle hardware/software be considered an inherent component of ongoing Space Shuttle operations. Author

N92-21246*# Kansas State Univ., Manhattan. Dept. of Mechanical Engineering.
AUTOMATION OF CLOSED ENVIRONMENTS IN SPACE FOR HUMAN COMFORT AND SAFETY Report, for Academic Year 1990-1991
25 Nov. 1991 156 p
(Contract NASW-4435)
(NASA-CR-190016; NAS 1.26:190016) Avail: CASI HC A08/MF A02

The results of the second year of a three year design project on the automation of the Environmental Control and Life Support System (ECLSS) of the Space Station Freedom (SSF) are presented. The results are applicable to other space missions that require long duration space habitats. A description of conceptual controls which are developed for the Water Recovery and Management (WRM) Subassembly is given. Mathematical modeling of the Air Revitalization (AR) Subassembly is presented. The work done by the Kansas State University NASA/USRA interdisciplinary student design team is concluded with a discussion of the expert system which was developed for the AR Subassembly. Author

N92-21270*# Houston Univ., Clear Lake, TX. Dept. of Biological and Allied Health Sciences.
EVALUATION OF FUNGAL METABOLIC COMPOUNDS RELEASED TO THE AIR IN A RESTRICTED ENVIRONMENT Final Report
ROBERT N. FEREBEE *In* Texas A and M Univ., NASA/ASEE Summer Faculty Fellowship Program, 1991, Volume 1 7 p Dec. 1991
Avail: CASI HC A02/MF A03

The metabolic action of selected fungi species on common components of the interior of Space Station Freedom (SSF) will be tested. When present, volatile organic chemicals will be collected on porous polymer adsorbent columns. Using thermal desorption, the volatile compounds will be passed onto a gas chromatographic column for analysis. The Space Station Freedom (SSF) modular complex will largely be individually self contained and the established air environment will not be easily adjusted. The development and maintenance of a safe working environment offers a considerable challenge. Present plans for use of SSF acknowledge periods of manned activities and alternate times when the station is unmanned. The obvious necessity for clean and safe air and water during periods of use have been pursued as fundamental systems to SSF success. Somewhat less obvious, although perhaps of no less importance to the success of long term cyclic usage, are those periods of inactivity. It is during these periods when spores from microorganisms may be afforded the best conditions to germinate and in the vegetative form react with the complex synthetic chemical polymers which compose the furnishings and hardware of SSF nodes. Biodegradation could constitute a real hygiene problem, if the organisms form and release volatile organic chemicals. Similar problems have been documented *in closed and improperly ventilated buildings and work spaces.* Many of the metabolic products of fungi and bacterial growth create a variety of health problems. Analytical chemical techniques will first be used to document the growth of Aspergillus, Penicillium, and Cladosporium fungal species on the potential substrates Nomex and Kevlar. Any volatile organics that are released will be measured using the spectrum of gas adsorption chromatography. The level of microbial contamination that is necessary to produce such volatile compounds and the relative amounts expected to accumulate will be estimated. Author

N92-21304*# Pennsylvania State Univ., University Park. Dept. of Industrial and Systems Engineering.
TOTAL QUALITY MANAGEMENT: ANALYSIS, EVALUATION AND IMPLEMENTATION WITHIN ACRV PROJECT TEAMS Final Report
LAURA B. RAIMAN *In* Texas A and M Univ., NASA/ASEE Summer Faculty Fellowship Program, 1991, Volume 2 12 p Dec. 1991
Avail: CASI HC A03/MF A02

Total quality management (TQM) is a cooperative form of doing business that relies on the talents of everyone in an organization to continually improve quality and productivity, using teams and an assortment of statistical and measurement tools. The Assured Crew Return Vehicle (ACRV) Project Office was identified as an excellent project in which to demonstrate the applications and benefits of TQM processes. As the ACRV Program moves through its various stages of development, it is vital that effectiveness and efficiency be maintained in order to provide the Space Station Freedom (SSF) crew an affordable, on-time assured return to Earth. A critical factor for the success of the ACRV is attaining the maximum benefit from the resources applied to the program. Through a series of four tutorials on various quality improvement techniques, and numerous one-on-one sessions during the SSF's 10-week term in the project office, results were obtained which are aiding the ACRV Office in implementing a disciplined, ongoing process for generating fundamental decisions and actions that shape and guide the organization. Significant advances were made in improving the processes for two particular groups - the correspondence distribution team and the WATER Test team. Numerous people from across JSC were a part of the various team activities including engineering, man systems, and safety. The work also included significant interaction with the support contractor to the ACRV Project. The results of the improvement activities can be used as models for other organizations desiring to operate under a system of continuous improvement. In particular, they have advanced the ACRV Project Teams further down the path of continuous improvement, in support of a working philosophy of TQM. Author

N92-21371*# Maryland Univ., College Park. Dept. of Aerospace Engineering.
DART: DELTA ADVANCED REUSABLE TRANSPORT. AN ALTERNATE MANNED SPACE SYSTEM PROPOSAL Final Report
13 May 1991 349 p

(Contract NASW-4435)
(NASA-CR-189978; NAS 1.26:189978) Avail: CASI HC A15/MF A03

The Delta Advanced Reusable Transport (DART) craft is being developed to add, multiple, rapid, and cost effective space access to the U.S. capability and to further the efforts towards a permanent space presence. The DART craft provides an augmentative and an alternative system to the Shuttle. As a supplement launch vehicle, the DART adds low cost and easily accessible transport of crew and cargo to specific space destinations to the U.S. program. This adds significant opportunities for manned rated missions that do not require Shuttle capabilities. In its alternative role, the DART can provide emergency space access and satellite repair, the continuation of scientific research, and the furthering of U.S. manned efforts in the event of Shuttle incapabilities. In addition, the DART is being designed for Space Station Freedom compatibility, including its use as a 'lifeboat' emergency reentry craft for Freedom astronauts, as well as the transport of crew and cargo for station resupply. Author

N92-21372*# University of Central Florida, Orlando. Dept. of Mechanical and Aerospace Engineering.
DESIGN, BUILDING, AND TESTING OF THE POST LANDING SYSTEMS FOR THE ASSURED CREW RETURN VEHICLE Final Report
LOREN A. ANDERSON 1991 252 p
(Contract NASW-4435)
(NASA-CR-189977; NAS 1.26:189977) Avail: CASI HC A12/MF A03

The design, building, and testing of the post landing support systems for a water landing Assured Crew Return Vehicle (ACRV) are presented. One ACRV will be permanently docked to Space Station Freedom, fulfilling NASA's commitment to Assured Crew Return Capability in the event of an accident or illness. The configuration of the ACRV is based on an Apollo Command Module (ACM) derivative. The 1990 to 91 effort concentrated on the design, building, and testing of a 1/5 scale model of the egress and stabilization systems. The objective was to determine the feasibility of: (1) stabilizing the ACM out of the range of motions which cause sea sickness; and (2) the safe and rapid removal of a sick or injured crewmember from the ACRV. The ACRV model construction is presented along with a discussion of the water test facility. The rapid egress system is also presented along with a discussion of the ACRV stabilization control systems. Results are given and discussed in detail. Author

N92-21999* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ASSURED CREW RETURN VEHICLE Patent
CHRISTOPHER J. CERIMELE, inventor (to NASA), ROBERT C. RIED, inventor (to NASA), WAYNE L. PETERSON, inventor (to NASA), GEORGE A. ZUPP, JR., inventor (to NASA), MICHAEL J. STAGNARO, inventor (to NASA), and BRIAN P. ROSS, inventor (to NASA) 12 Nov. 1991 54 p Filed 28 Dec. 1989 Supersedes N91-13480 (29 - 5, p 629)
(NASA-CASE-MSC-21536-1; US-PATENT-5,064,151; US-PATENT-APPL-SN-458476; US-PATENT-CLASS-244-160; US-PATENT-CLASS-244-163; US-PATENT-CLASS-244-162; INT-PATENT-CLASS-B64G-1/62) US Patent and Trademark Office

A return vehicle is disclosed for use in returning a crew to Earth from low earth orbit in a safe and relatively cost effective manner. The return vehicle comprises a cylindrically-shaped crew compartment attached to the large diameter of a conical heat shield having a spherically rounded nose. On-board inertial navigation and cold gas control systems are used together with a de-orbit propulsion system to effect a landing near a preferred site on the surface of the Earth. State vectors and attitude data are loaded from the attached orbiting craft just prior to separation of the return vehicle.

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

16

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.

A92-10469
STATITE - A SPACECRAFT THAT DOES NOT ORBIT
ROBERT L. FORWARD (Forward Unlimited, Malibu, CA) Oct. 1991 6 p refs
(Contract F04611-87-C-0029; F04611-83-C-0013; F04611-86-C-0039)
Copyright

A92-12434
THE DEVELOPMENT OF RENDEZ-VOUS AND DOCKING TECHNOLOGY FOR JAPANESE FUTURE SPACE SYSTEMS
YASUAKI TANIGUCHI, RYUJI SAKATA, KENJI OGIMOTO (Kawasaki Heavy Industries, Ltd., Gifu, Japan), OSAMU MIKI, and SUMIHIRO UEDA (Kawasaki Heavy Industries, Ltd., Akashi, Japan) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 8 p. Research supported by NASDA, Institute of Space and Astronautical Science, and National Aerospace Laboratory. Oct. 1991 8 p refs
(IAF PAPER 91-009) Copyright

The development of rendezvous and docking (RVD) technology to realize in-orbit servicing technologies such as the exchange of ORUs, the resupply of coolant and or/fuel and the construction of large space structures is presented. Studies on docking mechanisms, proximity sensors and a RVD system on board a small rocket are discussed. This system consists of various softwares and hardwares including a laser radar, an on-board computer, a proximity sensor, docking mechanisms, path planning, and navigation softwares. R.E.P.

A92-12577
HERMES RENDEZ-VOUS AND DOCKING PROXOPS CONCEPTS
G. BRONDINO, P. MARCHAL, and L. MARECHAL (CNES, Toulouse, France) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 6 p. Oct. 1991 6 p refs
(IAF PAPER 91-216) Copyright

A report focusing on the results of two campaigns on the docking dynamics test facility (DDTF) for docking conditions assessment, and the state-of-the-art involving the control modes and strategies during proxops derived from PROXSIM simulations is presented. Two manual control test campaigns on the DDTF provide information on the capabilities and performance of a human operator controlling the Hermes spaceplane in the final rendezvous operations. Results are presented on the man-machine interface definition and on the statistical performance achieved by astronauts with the Hermes soft docking baseline, e.g., docking speeds and misalignments, fuel consumption and time duration. R.E.P.

A92-12588
APPLICATIONS OF MAGNETIC SAILS
S. G. LOVE (Washington, University, Seattle) and D. G. ANDREWS (Boeing Defense and Space Group, Seattle, WA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 11 p. Oct. 1991 11 p refs
(IAF PAPER 91-245) Copyright

The interplanetary magnetic sail is a low-thrust propulsion device that derives its motive power from the interaction of solar wind ions with the magnetic field of a circular current-bearing loop of superconducting cable. The principal advantage of a magnetic sail is that it produces thrust in opposition to the sun's gravity without consuming any propellant whatsoever. The low acceleration of a magnetic sail restricts its applicability to missions that do not demand rapid changes in velocity. In many cases, though, that disadvantage is overwhelmed by the desirability of a system that

does not have to be refuelled. Missions well suited for magnetic sails include propulsion for a robot asteroid surveyor, orbital correction for structures in unstable libration points, motive power for orbital correction near planets with magnetic fields, and aerobraking in planetary ionospheres. Author

A92-12590
HIGH PERFORMANCE BIPROPELLANT ENGINES FOR ORBIT TRANSFER AND ATTITUDE CONTROL PROPULSION
SANDERS D. ROSENBERG and LEONARD SCHOENMAN (Aerojet, Propulsion Div., Sacramento, CA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 8 p. Oct. 1991 8 p refs
(IAF PAPER 91-249) Copyright

The life and performance characteristics are described for three bipropellant engines including two attitude-control engines and one orbit-transfer engine. The development of the class of storable engines is reviewed in terms of relevant technologies emphasizing the materials for the combustion-chamber design and metallurgical joints and the valve design. The Aerojet platelet injector is introduced, and performance enhancement is associated with the elimination of fuel-film cooling. The iridium/rhenium chamber materials increase the thermal margin without changing the engine-duty cycle flexibility. Specific improvements are discussed for the 22.3-N and 66.8-N attitude-control engines and the 423-N orbit-transfer engine over equivalent columbium-chamber engines. The engines have achieved a development level that qualifies them for a wide range of candidate missions. C.C.S.

A92-14741
EUROPEAN RENDEZVOUS AND DOCKING SYSTEM
J. M. PAIROT, M. FREZET, J. TAILHADES (Matra Marconi Space, Toulouse, France), W. FEHSE, A. TOBIAS (ESTEC, Noordwijk, Netherlands), and A. GETZSCHMANN (MBB-ERNO, Bremen, Federal Republic of Germany) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 14 p. Oct. 1991 14 p refs
(IAF PAPER 91-328) Copyright

The Rendezvous and Docking (RVD) concept and the results of proof-of-concept testing are presented including software prototypes, hardware breadboards, and the development of test facilities. The four primary elements of development addressed are: (1) a front-end mock-up to test the docking mechanism; (2) a closed-loop test of the prototype RVD control software; (3) kinematic testing with 6 DOF for the RVD sensors; and (4) a test of both the supervisory and manual-control modes designed for the system. The Rendezvous Onboard Control Simulator is utilized to validate the defined concept for all aspects of automatic RVD, and the test facilities can provide the means for future verification/validation. Risks associated with development are minimized by means of the tests, and in-orbit demonstrations of the concept are proposed. C.C.S.

A92-14742
GRAVITY-GRADIENT COMPENSATION FOR A SOLAR-POWERED, ELECTRIC ORBITAL TRANSFER VEHICLE
ALAN B. JENKIN (Aerospace Corp., Los Angeles, CA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 20 p. Oct. 1991 20 p refs
(Contract F04701-88-C-0089)
(IAF PAPER 91-329) Copyright

Attitude control requirements of solar-powered, electric orbital transfer vehicles have been studied in detail. This involved evaluation of the control torques needed to simultaneously steer the vehicle thrust vector and point the solar array toward the sun during a baseline low earth orbit to geosynchronous orbit transfer mission. Due to the large solar arrays needed to generate power for the electric main thrusters, the gravity-gradient disturbance torque is relatively large for such vehicles, and must be compensated. It is concluded that directly controlling the vehicle to follow desired attitude profiles is preferable to using gravity-gradient torques to indirectly control the vehicle by maintaining oscillation in three axes. A method is presented which determines propellant mass required for attitude control using averaged orbital elements of the optimized trajectory. This method divides the problem into two time scales, which is a technique frequently used in the analysis of low-thrust trajectories and orbital perturbations. It is shown that solar array panel aspect ratio can be selected to minimize vehicle control torque, permitting considerable reduction in attitude control propellant mass. Three types of control actuators - reaction wheels, gas jets, and gimballed main electric thrusters - then are traded against each other for several electric orbital transfer vehicle designs. Author

A92-14751
HERMES-SPACE STATION PHASING STRATEGIES OPTIMIZATION
FRANCOIS DUFOUR, JEAN M. GARCIA, JACQUES BERNUSSOU (CNRS, Laboratoire d'Automatique et d'Analyse des Systemes, Toulouse, France), and JEROME LEGENNE (CNES, Toulouse, France) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 11 p. Oct. 1991 11 p refs
(IAF PAPER 91-345) Copyright

A LEO coplanar rendezvous between a shuttle and a space station is considered. A four-maneuver phasing strategy has been optimized by a dynamic programming algorithm in the nominal case (deterministic trajectories). The model used is characterized by a gravitational perturbation, an atmospheric drag, and a crew activity schedule. It is demonstrated that the chaser is always able to complete a rendezvous mission within two days for all the range of injection phase angles. Rendezvous sequences are characterized with emphasis placed on optimal costs, maneuver dates, and drift orbit specifications. O.G.

A92-16634
ATTITUDE DETERMINATION FOR SPACE TRANSFER VEHICLES USING GPS
KEVIN D. KEIERLEBER and STANLEY C. MAKI (General Dynamics Corp., Space Systems Div., San Diego, CA) IN: Institute of Navigation, National Technical Meeting, 47th, Phoenix, AZ, Jan. 22-24, 1991, Proceedings 1991 17 p refs

GPS can be employed to update space transfer vehicle (STV) attitude to exacting mission requirements. Attitude determination for an STV by means of the carrier-phase attitude determination method entails the availability of at least four satellites. A geometrical approach is presented for selecting a satellite that possesses the highest available elevation angle, in order to obtain good antenna baseline azimuth/elevation sensitivities and good distribution of the unit vector differences. The calculation of azimuth/elevation sensitivities after a key satellite is chosen is demonstrated. O.C.

A92-18348
THE PROBLEM OF SPACECRAFT DOCKING IN ELLIPTICAL ORBIT [K ZADACHE O STYKOVKE KOSMICHESKIKH APPARATOV NA ELLIPTICHESKOI ORBITE]
V. I. POPADINETS, V. S. BURLAKA, A. V. ISHCHENKO, and I. G. TSEN'KUSH (AN USSR, Institut Kibernetiki, Kiev, Ukrainian SSR) Prikladnaia Mekhanika (ISSN 0032-8243), vol. 27, Oct. 1991, p. 105-112. In Russian. Oct. 1991 8 p In RUSSIAN refs
Copyright

A general mathematical model is proposed for the docking of spacecraft in elliptical orbit. The system of the docked spacecraft is treated as a discrete system whose motion is described by ordinary differential equations. The accuracy of the model is evaluated. V.L.

A92-20100
ORBITAL MECHANICS
VLADIMIR A. CHOBOTOV, ED. (Northrop University; Aerospace Corp., Los Angeles, CA) Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1991, 379 p. No individual items are abstracted in this volume. 1991 379 p
Copyright

The present work on the 'applied', or engineering-related aspects of orbital mechanics gives attention to the geographic

and azimuth-elevation coordinate systems, as well as their transformations; the orbital parameters of a satellite; the universal approach to a body's position and velocity as a function of time, and geodetic and geocentric altitudes; and such issues in orbital maneuvering as the general three-impulse plane change maneuver for circular orbits. Also discussed are complications encountered in the implementation of impulsive maneuvers, relative motion problems in orbit, the mathematical foundations of orbit perturbations, launch windows, lunar and interplanetary trajectories, and space debris. O.C.

A92-20392* Sterling Software, Palo Alto, CA.
ACCELERATION AND PULSE CONTROL IN SIMULATED SPACECRAFT DOCKING MANEUVERS
ADAM R. BRODY (Sterling Software, Inc., Palo Alto, CA) and STEPHEN R. ELLIS (NASA, Ames Research Center, Moffett Field, CA) Dec. 1991 3 p refs
Copyright

A92-21183* Lockheed Engineering and Sciences Co., Houston, TX.
RESULTS IN ORBITAL EVOLUTION OF OBJECTS IN THE GEOSYNCHRONOUS REGION
LARRY J. FRIESEN, ALBERT A. JACKSON (Lockheed Engineering and Sciences Co., Houston, TX), HERBERT A. ZOOK, and DONALD J. KESSLER (NASA, Johnson Space Center, Houston, TX) Feb. 1992 5 p refs
(Contract NAS9-17900)
Copyright

A92-21278
THE DETERMINATIONS OF STATION COORDINATES FROM DOPPLER OBSERVATIONS
WALDEMAR JAKS and KRZYSZTOF ZELLER (Astronomical Latitude Observatory, Borowiec, Poland) Artificial Satellites - Planetary Geodesy (no. 15) (ISSN 0208-841X), vol. 26, no. 1, 1991, p. 77-90. 1991 14 p refs
Copyright
This paper presents contribution of Astronomical Latitude Observatory in Borowiec to Doppler observations performance and elaboration. Analysis of periodical variation of Borowiec coordinates and changes of Borowiec-Borowa Gora vector are described more closely. Author

A92-21645
APPROXIMATE CALCULATION OF ORBIT-FORMATION MANEUVERS FOR AN EARTH SATELLITE WITH A LOW-THRUST ENGINE [PRIBLIZHENNYI RASCHET MANEVROV FORMIROVANIIA ORBITY SPUTNIKA ZEMLI S DVIGATELEM MALOI TIAGI]
V. V. SALMIN and V. O. SOKOLOV Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, Nov.-Dec. 1991, p. 872-888. In Russian. Dec. 1991 17 p In RUSSIAN refs
Copyright
The problem of finding control laws for an earth satellite with a low-thrust engine in a noncentral gravitational field is considered. The optimal control structure for a selected orbit is established, and approximate analytical solutions for the control of orbit evolution are obtained. In addition, analytical relationships are obtained for calculating expenditures of characteristic velocity needed to change the orbit and to bring the spacecraft to a specified point in the orbit. L.M.

A92-22639
HOPE RENDEZVOUS AND DOCKING SYSTEM
YASUFUMI WAKABAYASHI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 39, no. 454, 1991, p. 622-628. In Japanese. 1991 7 p In JAPANESE refs
The concept of the HOPE (H-II Orbiting Plane) rendezvous and docking (RVD) system is addressed. Basic RVD concepts for low earth orbit activities are described. The guidance and control system is also presented. Y.P.Q.

A92-23699
PILOT-IN-THE-LOOP SIMULATION OF AN ORBITAL DOCKING MANEUVER
BERND SCHMIDT (Technologie Zentrum Nord, Unterluess, Federal Republic of Germany) and ERNST HERZOG (MBB-ERNO, Bremen, Federal Republic of Germany) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p
The dynamic docking maneuver with a pilot in the loop is discussed in terms of a real-time simulated representation that permits the study of the event. The simulation is performed on a computer with an independent CPU for the simulation computations, a graphic readout, and a sensor ball for applying pilot-induced torques and forces. The pilot sends the forces to the thruster unit or indirectly through the Intelligent Control Thruster Unit for an LEO docking involving homing, waiting, approach, and final-approach phases. The real-time display provides data on the effects of the pilot's actions, air drag, and camera parameters. The system is expected to yield important information regarding the suitability of the sensor ball and/or other input devices as well as data on the problems of rendezvous and docking maneuvers. Presently the simulator can be used in the autopilot mode, although the manual mode is expected to be available for the pilot-in-the-loop simulation. C.C.S.

A92-24353*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
LOGISTICS AND OPERATIONS IMPLICATIONS OF MANUAL CONTROL OF SPACECRAFT DOCKING MANEUVERS
ADAM R. BRODY (NASA, Ames Research Center; Sterling Software, Inc., Moffett Field, CA) and STEPHEN R. ELLIS (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 6 p refs
(AIAA PAPER 91-4094) Copyright
The implications of logistics and operations on the manual control of spacecraft docking are discussed. The results of simulation studies to investigate fuel and time cost tradeoffs are reviewed and discussed. Comparisons of acceleration control and pulse control are presented to evaluate the effects of astronauts being instructed to use pulse mode for fuel conservation. The applications of the findings to moon and Mars missions are addressed. C.D.

A92-24813
DOCKING DYNAMICS OF A SPACECRAFT
XUEXIAO WANG, ZHANGQING CHEN, CHENGXUN SHAO (Harbin Institute of Technology, People's Republic of China), and QINGRUI ZHU (Harbin, Worker Institute, People's Republic of China) Chinese Society of Astronautics, Journal (ISSN 1000-1328), no. 3, 1991, p. 15-24. In Chinese. 1991 10 p In CHINESE refs
The docking dynamics of a spacecraft with androgynous, peripheral docking mechanism is investigated. The spacecraft may be flexible with or without flexible appendages. The docking dynamic equations are derived by Jourdain-Bertrand theory in three stages: capture stage, regulating stage, and post-docking stage, respectively. A numerical simulation is also given and some conclusions are obtained. Author

A92-26819
ERS-1 OPERATIONAL ORBIT DETERMINATION AND PREDICTION AT ESOC
R. C. A. ZANDBERGEN (Logica Space and Communications, Ltd., London, England), J. M. DOW (ESA, European Space Operations Centre, Darmstadt, Federal Republic of Germany), and S. D. MARTIN (Logica Space and Communications, Ltd., London, England) British Interplanetary Society, Journal (ISSN 0007-094X), vol. 45, March 1992, p. 117-120. Mar. 1992 4 p
Copyright
The ESA remote-sensing satellite ERS-1 is described in terms of the features of the position-determination systems and their relation to providing data relevant to the mission. The ERS-1 is in

a near-polar orbit and is tracked during the present launch and early orbit phase by means of an orbit-determination system which generates station predictions, events files, scheduling printouts, and orbit files. The orbit-determination subsystem is shown to function effectively during the phase with orbit software running adequately. C.C.S.

A92-29125
A SPACECRAFT DOCKING PROBLEM - POSITION AND ORIENTATION ESTIMATION USING A COMPUTER VISION APPROACH
CHI-CHANG J. HO and N. H. MCCLAMROCH (Michigan, University, Ann Arbor) IN: 1991 American Control Conference, 10th, Boston, MA, June 26-28, 1991, Proceedings. Vol. 1 1991 6 p refs
Copyright

A computer-vision-based method for estimating the position and orientation of a spacecraft (camera) relative to a fixed mark on the space station in three-dimensions is developed. This method represents an extension of the authors' previous work where orientation estimation was not considered; the requirement to maintain the axial axis of the camera pointed at the center of the mark on the space station, inherent in this previous work, is eliminated. A system of eight nonlinear measurement equations with two constraints in the unknown position and orientation parameters is obtained. Either a single-stage nonlinear constrained optimization algorithm or a two-stage nonlinear least squares estimation algorithm can be used to obtain position and orientation estimates simultaneously. The development assumes noisy measurements of four feature points of the single mark on the space station. I.E.

A92-31097* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ANALYSIS OF ORBITAL PERTURBATIONS ACTING ON OBJECTS IN ORBITS NEAR GEOSYNCHRONOUS EARTH ORBIT
LARRY J. FRIESEN, ALBERT A. JACKSON, IV (Lockheed Engineering and Sciences Co., Houston, TX), HERBERT A. ZOOK, and DONALD J. KESSLER (NASA, Johnson Space Center, Houston, TX) Journal of Geophysical Research (ISSN 0148-0227), vol. 97, no. E3, March 25, 1992, p. 3845-3863. 25 Mar. 1992 19 p refs
(Contract NAS9-17900)
Copyright

The paper presents a numerical investigation of orbital evolution for objects started in GEO or in orbits near GEO in order to study potential orbital debris problems in this region. Perturbations simulated include nonspherical terms in the earth's geopotential field, lunar and solar gravity, and solar radiation pressure. Objects simulated include large satellites, for which solar radiation pressure is insignificant, and small particles, for which solar radiation pressure is an important force. Results for large satellites are largely in agreement with previous GEO studies that used classical perturbation techniques. The orbit plane of GEO satellites placed in a stable plane orbit inclined approximately 7.3 deg to the equator experience very little precession, remaining always within 1.2 percent of their initial orientation. Solar radiation pressure generates two major effects on small particles: an orbital eccentricity oscillation anticipated from previous research, and an oscillation in orbital inclination. C.A.B.

N92-11084*# Axiomatix, Los Angeles, CA.
SPACE STATION TRACKING REQUIREMENTS FEASIBILITY STUDY, VOLUME 2 Final Report
SERGEI UDALOV and JAMES DODDS 27 Jul. 1988 364 p
(Contract NAS9-17414)
(NASA-CR-185641-VOL-2; NAS 1.26:185641-VOL-2; R8807-3-VOL-2) Avail: CASI HC A16/MF A03

The objective of this feasibility study is to determine analytically the accuracies of various sensors being considered as candidates for Space Station use. Specifically, the studies were performed whether or not the candidate sensors are capable of providing the required accuracy, or if alternate sensor approaches should be investigated. Other topics related to operation in the Space Station environment were considered as directed by NASA-JSC. The following topics are addressed: (1) Space Station GPS; (2) Space Station Radar; (3) Docking Sensors; (4) Space Station Link Analysis; (5) Antenna Switching, Power Control, and AGC Functions for Multiple Access; (6) Multichannel Modems; (7) FTS/EVA Emergency Shutdown; (8) Space Station Information Systems Coding; (9) Wanderer Study; and (10) Optical Communications System Analysis. Brief overviews of the abovementioned topics are given. Wherever applicable, the appropriate appendices provide detailed technical analysis. The report is presented in two volumes. This is Volume 2, containing Appendices K through U. Author

N92-11085*# Axiomatix, Los Angeles, CA.
SPACE STATION TRACKING REQUIREMENTS FEASIBILITY STUDY, VOLUME 1 Final Report
SERGEI UDALOV and JAMES DODDS 27 Jul. 1988 381 p
(Contract NAS9-17414)
(NASA-CR-185641-VOL-1; NAS 1.26:185641-VOL-1; R8807-3-VOL-1) Avail: CASI HC A17/MF A03

The objective of this feasibility study is to determine analytically the accuracies of various sensors being considered as candidates for Space Station use. Specifically, the studies were performed whether or not the candidate sensors are capable of providing the required accuracy, or if alternate sensor approaches be investigated. Other topics related to operation in the Space Station environment were considered as directed by NASA-JCS. The following topics are addressed: (1) Space Station GPS; (2) Space Station Radar; (3) Docking Sensors; (4) Space Station Link Analysis; (5) Antenna Switching, Power Control, and AGC Functions for Multiple Access; (6) Multichannel Modems; (7) FTS/EVA Emergency Shutdown; (8) Space Station Information Systems Coding; (9) Wanderer Study; and (10) Optical Communications System Analysis. Brief overviews of the abovementioned topics are given. Wherever applicable, the appropriate appendices provide detailed technical analysis. The report is presented in two volumes. This is Volume 1, containing the main body and Appendices A through J. Author

N92-12043# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany). Berichtsstelle
MTFF OPERATIONS
HELMUT LUTTMANN (Erno Raumfahrttechnik G.m.b.H. Bremen, Germany, F.R.) 1991 134 p Presented at Space Courses on Low Earth Orbit Transportation and Orbital Systems, Aachen, Fed. Republic of Germany, 18 Feb. - 3 Mar. 1991
(MBB-UO-0075-91-PUB; OTN-033127; ETN-91-90189) Avail: CASI HC A07/MF A02

The operational implications and the proposed concepts for the various flight phases of the Columbus Man Tended Free Flyer (MTFF) are described. For the different operational phase, the operational concepts, the different levels of monitoring and control as well as the related degree of autonomy and involvement and authorities of ground and flight crew are described. For the normal operations phase the following are described: the overall command and control concept of the MTFF, the generic software organizations, the implementation of the operation concepts using mastertimeline, operational tasks, actions, etc., the execution principles, resource management and fault management. Short descriptions of the prelaunch ground processing, the launch phase and the initial activation phase are given. The servicing activities are described for the servicing execution. ESA

N92-14076*# Rockwell Space Operations Co., Houston, TX.
NAVIGATION OF THE TSS-1 MISSION
TIMOTHY C. JACKSON, JOHN G. PIDO, and PATRICK L. ZIMMERMAN *In* NASA. Goddard Space Flight Center, Flight Mechanics/Estimation Theory Symposium, 1991 p 97-121 Oct. 1991
Avail: CASI HC A03/MF A04

The Tethered Satellite System Mission was analyzed to determine its impacts on the Mission Control Center (MCC) Navigation section's ability to maintain an accurate state vector

for the Space Shuttle during nominal and off-nominal flight operations. Tether dynamics expected on the Shuttle introduces new phenomena when determining the best estimation of its position and velocity. In the analysis, emphasis was placed on determining the navigation state vectors accuracies resulting when the tether induced forces were and were not modeled as an additional acceleration upon processing tracking measurements around a TSS-1 trajectory. Results of the analyses show that when the forces are not modeled in the state vector generation process, the resulting solution state reflects a solution about the center of gravity of the tethered system and not that of the orbiter. The Navigation team's ability to provide accurate state vector estimates necessary for trajectory planning are impeded. In addition to this consequent, is an impact on Onboard Navigation state vector accuracies. These analyses will show that in order to preserve an accurate state onboard the orbiter a new operational procedure would have to be adopted. Author

N92-15466*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SATELLITE ORBIT CONSIDERATIONS FOR A GLOBAL CHANGE TECHNOLOGY ARCHITECTURE TRADE STUDY
EDWIN F. HARRISON (Lockheed Engineering and Sciences Co., Hampton, VA.), GARY G. GIBSON (Flight Mechanics and Control, Inc., Hampton, VA.), JOHN T. SUTTLES, JAMES J. BUGLIA, and ISRAEL TABACK (Bionetics Corp., Hampton, VA.) *In its* Global Change Technology Architecture Trade Study p 91-108 Sep. 1991 Previously announced as N91-25557
Avail: CASI HC A03/MF A04

A study was conducted to determine satellite orbits for Earth observation missions aimed at obtaining data for assessing 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-latitude 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. Two or more geosynchronous satellites can be relocated in longitude to study processes over selected regions of Earth. Author

N92-15858*# Alabama Univ., Huntsville. Dept. of Mathematical Sciences.
A MINIMUM PROPELLANT SOLUTION TO AN ORBIT-TO-ORBIT TRANSFER USING A LOW THRUST PROPULSION SYSTEM
SHANNON S. COBB *In its* Research Reports: 1991 NASA/ASEE Summer Faculty Fellowship Program 4 p Oct. 1991
(Contract NGT-01-008-021)
Avail: CASI HC A01/MF A03

The Space Exploration Initiative is considering the use of low thrust (nuclear electric, solar electric) and intermediate thrust (nuclear thermal) propulsion systems for transfer to Mars and back. Due to the duration of such a mission, a low thrust minimum-fuel solution is of interest; a savings of fuel can be substantial if the propulsion system is allowed to be turned off and back on. This switching of the propulsion system helps distinguish the minimal-fuel problem from the well-known minimum-time problem. Optimal orbit transfers are also of interest to the development of a guidance system for orbital maneuvering vehicles which will be needed, for example, to deliver cargoes to the Space Station Freedom. The problem of optimizing trajectories for an orbit-to-orbit transfer with minimum-fuel expenditure using a low thrust propulsion system is addressed. Author

N92-17732# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
AN ANALYTIC METHOD OF PROPAGATING A COVARIANCE MATRIX TO A MANEUVER CONDITION FOR LINEAR COVARIANCE ANALYSIS DURING RENDEZVOUS M.S. Thesis
JESSE R. GOSSNER Jun. 1991 96 p
(AD-A243354; AFIT/CI/CIA-91-084) Avail: CASI HC A05/MF A01

This study develops a method for analytically propagating a covariance matrix to a maneuver condition to be used in linear covariance analysis for planning the rendezvous phase of a space mission. With the generalized formulation of a condition transition matrix, an analytic method of propagating an augmented covariance matrix to any scalar terminal maneuver condition is presented. The twenty-six dimensional augmented covariance matrix used in this study includes navigation state errors, state dispersions, and time errors for both the chaser and target craft. The method is first analytically developed. The vehicles are brought to the desired rendezvous condition by linearizing motion at the maneuver condition point and allowing the time of flight to vary slightly. The analytic propagation technique is then validate by comparison to a stochastic Monte Carlo simulation for the case of several elevation angle conditions which might be used to trigger an initial rendezvous intercept burn. The validity of linearizing the motion about the terminal point is substantiated with the same situation. GRA

N92-18653# Europea de Tecnologia y Sistemas, Madrid (Spain).
HAZARD ANALYSIS FOR HERMES MISSION TO MTFF
FRANCOIS BAUDOIN *In* ESA, Space Product Assurance for Europe in the 1990s: An ESA Symposium p 277-281 Aug. 1991
Copyright Avail: CASI HC A01/MF A03

System hazard analysis performed for the orbital phases of the mission of the Hermes Space Vehicle to the Columbus Man Tended Free Flyer (MTFF) is discussed. The methodology followed, based on a hazard matrix, is described. The list of hazards and system constituents is given. The undesired scenario and proposed corrective actions identified using the hazard matrix are presented. Examples of lists and formats are given. A summary of the methodological lessons learned is presented. ESA

N92-19438# Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil).
ORBIT TRANSFER: DYNAMIC ANALYSIS M.S. Thesis
DANIEL LEVI DEFIGUEI RODRIGUES Oct. 1991 209 p In PORTUGUESE; ENGLISH summary
(INPE-5352-TDI/461) Avail: CASI HC A10/MF A03

Orbit transfers are analyzed and structural and dynamic aspects not normally presented in the literature are considered. Among others, these aspects involve orbital motion, attitude motion, distribution of torques due to the misalignment of the propulsive force with the center of mass, attitude control and stabilization, and variable thrust magnitude during the transfer. Bibliographic research was done on these topics. Equations of motion relative to the above situations were written. Numerical simulations for representative cases are presented. It is concluded that the aspects presented are of great importance and that they must be included in the mission analysis of real projects. Author

N92-21266*# Military Academy, West Point, NY. Dept. of Physics.
OPTICAL CORRELATION Final Report
STEVEN S. COTARIU *In* Texas A and M Univ., NASA/ASEE Summer Faculty Fellowship Program, 1991, Volume 1 12 p Dec. 1991
Avail: CASI HC A03/MF A03

Pattern recognition may supplement or replace certain navigational aids on spacecraft in docking or landing activities. The need to correctly identify terrain features remains critical in preparation of autonomous planetary landing. One technique that may solve this problem is optical correlation. Correlation has been

successfully demonstrated under ideal conditions; however, noise significantly affects the ability of the correlator to accurately identify input signals. Optical correlation in the presence of noise must be successfully demonstrated before this technology can be incorporated into system design. An optical correlator is designed and constructed using a modified 2f configuration. Liquid crystal televisions (LCTV) are used as the spatial light modulators (SLM) for both the input and filter devices. The filter LCTV is characterized and an operating curve is developed. Determination of this operating curve is critical for reduction of input noise. Correlation of live input with a programmable filter is demonstrated. Author

N92-21268*# Houston Univ., TX. Dept. of Industrial Engineering.
AN EXPLORATORY EXERCISE IN TAGUCHI ANALYSIS OF DESIGN PARAMETERS: APPLICATION TO A SHUTTLE-TO-SPACE STATION AUTOMATED APPROACH CONTROL SYSTEM Final Report
DON E. DEAL *In* Texas A and M Univ., NASA/ASEE Summer Faculty Fellowship Program, 1991, Volume 1 10 p Dec. 1991
Avail: CASI HC A02/MF A03

The chief goals of the summer project have been twofold - first, for my host group and myself to learn as much of the working details of Taguchi analysis as possible in the time allotted, and, secondly, to apply the methodology to a design problem with the intention of establishing a preliminary set of near-optimal (in the sense of producing a desired response) design parameter values from among a large number of candidate factor combinations. The selected problem is concerned with determining design factor settings for an automated approach program which is to have the capability of guiding the Shuttle into the docking port of the Space Station under controlled conditions so as to meet and/or optimize certain target criteria. The candidate design parameters under study were glide path (i.e., approach) angle, path intercept and approach gains, and minimum impulse bit mode (a parameter which defines how Shuttle jets shall be fired). Several performance criteria were of concern: terminal relative velocity at the instant the two spacecraft are mated; docking offset; number of Shuttle jet firings in certain specified directions (of interest due to possible plume impingement on the Station's solar arrays), and total RCS (a measure of the energy expended in performing the approach/docking maneuver). In the material discussed here, we have focused on single performance criteria - total RCS. An analysis of the possibility of employing a multiobjective function composed of a weighted sum of the various individual criteria has been undertaken, but is, at this writing, incomplete. Results from the Taguchi statistical analysis indicate that only three of the original four posited factors are significant in affecting RCS response. A comparison of model simulation output (via Monte Carlo) with predictions based on estimated factor effects inferred through the Taguchi experiment array data suggested acceptable or close agreement between the two except at the predicted optimum point, where a difference outside a rule-of-thumb bound was observed. We have concluded that there is most likely an interaction effect not provided for in the original orthogonal array selected as the basis for our experimental design. However, we feel that the data indicates that this interaction is a mild one and that inclusion of its effect will not alter the location of the optimum. Author

17

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.

A92-12592* Alabama Univ., Huntsville.
GRAVITY PROBE-B SPACECRAFT ATTITUDE CONTROL BASED ON THE DYNAMICS OF SLOSH WAVE-INDUCED FLUID STRESS DISTRIBUTION ON ROTATING DEWAR CONTAINER OF CRYOGENIC PROPELLANT
R. J. HUNG, C. C. LEE (Alabama, University, Huntsville), and F. W. LESLIE (NASA, Marshall Space Flight Center, Huntsville, AL) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 10 p. Oct. 1991 10 p refs
(Contract NAG8-035; NAG8-129)
(IAF PAPER 91-256) Copyright

The dynamical behavior of fluids, in particular the effect of surface tension on partially-filled rotating fluids, in a full-scaie Gravity Probe-B Spacecraft propellant dewar tank imposed by various frequencies of gravity jitters have been investigated. Results show that fluid stress distribution exerted on the outer and inner walls of rotating dewar are closely related to the characteristics of slosh waves excited on the liquid-vapor interface in the rotating dewar tank. This can provide a set of tool for the spacecraft dynamic control leading toward the control of spacecraft unbalance caused by the uneven fluid stress distribution due to slosh wave excitations. Author

A92-13158* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ELECTRIC PROPULSION - AN EVOLUTIONARY TECHNOLOGY
FRANCIS M. CURRAN, JAMES S. SOVEY (NASA, Lewis Research Center, Cleveland, OH), and ROGER M. MYERS (NASA, Lewis Research Center, Cleveland; Sverdrup Technology, Inc., Brookpark, OH) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 25 p. Oct. 1991 25 p refs
(IAF PAPER 91-241) Copyright

The NASA Lewis Research Center conducts and directs an electric propulsion research and technology program aimed at providing high-performance electric propulsion system options for a broad range of near- and far-term missions. This evolutionary program emphasizes the development of propulsion systems for three classes of missions: (1) near-term auxiliary propulsion applications such as North-South Stationkeeping for next generation communications satellites and orbit maintenance for orbiting platforms such as Space Station Freedom; (2) advanced solar electric propulsion and SP-100-class nuclear electric propulsion (NEP) for earth-space orbit transfer and robotic planetary missions; and (3) very high power systems to support major space missions including the Space Exploration Initiative. To cover widely disparate mission requirements, the program includes research on electrothermal, electrostatic, and electromagnetic systems. This paper provides an overview of the program with a focus on recent progress. Author

A92-13338* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SCIENCE AND APPLICATIONS OF HE-II IN SPACE
PETER V. MASON (JPL, Pasadena, CA) IN: Advances in cryogenic engineering. Vol. 35A - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 11 p refs
Copyright

Applications of He II in space environment are described, with special attention given to application of He II as a cryogen in several completed and planned space mission. Major applications

of He II include the completed Infrared Astronomical Satellite and the Spacelab 2 Infrared Telescope missions, and planned missions that include the NASA Cosmic Background Experiment, the Space IR Telescope, the Large Deployable Reflector, and the ESA's Infrared Space Observatory. Science experiments include the completed Superfluid Helium in Zero Gravity Experiment and the planned Superfluid Helium On-Orbit Transfer and Lambda Point experiments. I.S.

A92-13351* Martin Marietta Space Systems, Inc., Denver, CO.
SUPERFLUID HELIUM ON-ORBIT RESUPPLY
RALPH N. EBERHARDT and JOHN P. GILLE (Martin Marietta Space Systems, Inc., Denver, CO) IN: Advances in cryogenic engineering. Vol. 35A - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 10 p refs
(Contract NAS9-17854)
Copyright

The requirements for superfluid helium (SFHe) resupply were investigated, and the results were used to develop a conceptual design for a superfluid helium tanker (SFHT) which is designed to meet a 50-mission requirement. The SFHT design uses a conventional dewar approach with multiple vapor cooled shields, and a porous-plug phase separator for on-orbit temperature control. An open loop refrigeration approach is used for ground conversion of normal He to SFHe, allowing near-total fill of the supply tank. Design diagrams of the SFHT concept and of various SFHT subsystems are presented. I.S.

A92-13352* Ball Aerospace Systems Div., Boulder, CO.
A DESIGN AND CRITICAL TECHNOLOGY ISSUES FOR ON-ORBIT RESUPPLY OF SUPERFLUID HELIUM
RICHARD A. HOPKINS and ALLAN J. MORD (Ball Aerospace Systems Group, Boulder, CO) IN: Advances in cryogenic engineering. Vol. 35A - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 13 p refs
(Contract NAS9-17852)
Copyright

The issues of and the solutions to the critical design and technology areas of the Superfluid Helium On-Orbit Transfer (SHOOT) experiment, presently under development at the NASA Goddard Spaceflight Center, are discussed. Special attention is given to the SHOOT design requirements for the 10,000-liter superfluid He resupply tanker system, the concept details of the system, and the resupply operations and their analysis. A block diagram of the SHOOT system is included along with fluid management schematic and configuration diagrams of the system and its subsystems. A summary of the dewar performance is also presented. I.S.

A92-13353* Lockheed Missiles and Space Co., Palo Alto, CA.
EXPERIMENTAL VERIFICATION OF A TANK TO TANK HE II TRANSFER MODEL WITH TRADE STUDY RESULTS
S. W. K. YUAN (Lockheed Missiles and Space Co., Inc., Palo Alto, CA) and T. H. K. FREDERKING (California, University, Los Angeles) IN: Advances in cryogenic engineering. Vol. 35A - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 6 p refs
Copyright

A computer program has been developed to study the thermodynamics of tank to tank superfluid helium transfer. The model includes a supply and a receiver tank connected by a transfer line. The convey of He II from one tank to the other is controlled by a fountain effect pump (FEP). Phase separators are present in both the supply and receiver tank to regulate the bath temperature. Description of this model has been published elsewhere. In the present paper, data from a transfer experiment are used to verify the accuracy of this model. The experiment consisted of an FEP made of a 2-micron sintered stainless steel porous plug. Superfluid has been transferred from a liquid helium bath into a glass beaker. Bath temperatures, flowrate and heater power records are available. These results are compared to the predictions of the computer program and good agreement is found between the two. This model is very useful for the study and design of superfluid transfer systems, e.g., the Superfluid Helium Tanker (SFHT) and the Particle Astrophysics Magnet Facility (ASTROMAG). Author

A92-13354
A CONCEPTUAL STUDY FOR A SUPERFLUID HELIUM TANKER (SFHT)
JACK WOHL and TED NAST (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Advances in cryogenic engineering. Vol. 35A - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 10 p
Copyright

The baseline concept of the Superfluid Helium Tanker (SFHT), presently under development, for replenishing AXAF, SIRTF, Astromag, and other superfluid He users on orbit is described. Consideration is given to the SFHT requirements for servicing users from the Orbiter or the Space Station, to which the tanker will be transported by the Shuttle; the tank design; and the cryogenic subsystem. Special attention is given to the characteristics of the He II transfer operations, the fluid losses, the temperature variations, and the flow rates and vent rates. Diagrams are presented of the launch configuration concept, the EVA operation concept, the fluid subsystem general arrangement, and the He-II transfer and management. I.S.

A92-13355* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPARISON OF SIRTF DEWAR PERFORMANCE IN THE 900 KM AND 100,000 KM ORBITS
J. H. LEE, S. S. MAA (NASA, Ames Research Center, Moffett Field, CA), and Y. S. NG (Sterling Federal Systems, Inc., Palo Alto, CA) IN: Advances in cryogenic engineering. Vol. 35A - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 8 p refs
Copyright

Feasibility studies showed that the Space Infrared Telescope Facility (SIRTF) can be launched into a 100,000-km high earth orbit (HEO) using a Titan/Centaur launch vehicle. This paper compares the performance of an all-superfluid helium dewar system for SIRTF under conditions of the LEO (900-km) and the HEO missions. Results show that the SIRTF all-superfluid He dewar can achieve a 5-yr lifetime for the 100,000 km HEO mission, with 20 percent margin. Methods to achieve further enhancement of dewar lifetime for the HEO mission are suggested. I.S.

A92-13417* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
DISCRETE LIQUID/VAPOR DETECTORS FOR USE IN LIQUID HELIUM
M. J. DIPIRRO and A. T. SERLEMITSOS (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Advances in cryogenic engineering. Vol. 35B - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 7 p refs
Copyright

Simple devices have been constructed and tested which can discriminate between liquid helium and its vapor. The devices are 0.25-mm doped silicon cubes suspended from 0.05-mm-diameter stainless steel and manganin wires. A small current is passed through the device heating it and lowering its resistance. The degree of self-heating is dependent on whether the device is immersed in liquid or is surrounded by vapor. The voltage across the device then indicates the presence of liquid or vapor. The devices are meant to operate in the milligravity environment of space. Tests simulating thick superfluid films which would be present in this case indicate less than 0.3 milliwatt per detector is sufficient to boil away these thick films. The detector response time under these conditions is less than 50 milliseconds. Author

A92-13424* Martin Marietta Space Systems, Inc., Denver, CO.
THE COLD-SAT PROGRAM

WILLIAM J. BAILEY (Martin Marietta Space Systems, Inc., Denver, CO) IN: Advances in cryogenic engineering. Vol. 35B - Proceedings of the 1989 Cryogenic Engineering Conference, Los Angeles, CA, July 24-28, 1989 1990 12 p
(Contract NAS3-25063)
Copyright

The Cryogenic On-Orbit Liquid Depot Storage, Acquisition and Transfer (COLD-SAT) satellite is an experimental spacecraft launched from an expendable launch vehicle which is designed to investigate the systems and technologies required for efficient and reliable management of cryogenic fluid in the reduced-gravity space environment. Future applications such as Space Station, Space Transportation Vehicle (STV), external tank (ET), aft cargo carrier (ACC) propellant scavenging, storage depots, and lunar and interplanetary missions, among others, have provided the impetus to pursue this technology in a timely manner to support the design efforts. A refined conceptual approach has been developed and an overview of the COLD-SAT program is described which includes the following: (1) a definition of the technology needs and the accompanying experimental six-month baseline mission; (2) a description of the experiment subsystem, major features, and rationale for satisfaction of primary and secondary experiment requirements using LH2 as the test fluid; and (3) a presentation of the conceptual design of the COLD-SAT spacecraft subsystems which support the on-orbit experiment with emphasis on those areas which posed the greatest technical challenge. Author

A92-14704
REPLENISHING AN ORBITAL PROPELLANT DEPOT BY MEANS OF A COIL GUN
R. B. KENDRICK IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p refs
(IAF PAPER 91-206) Copyright

Construction of an orbital depot that is kept supplied with propellant by the celestial equivalent of a pipeline to provide orbital filling stations for spacecraft bound from low earth orbit to another destination is presented. Coil guns will accelerate small payloads to near orbital velocity, which acceleration will be intense, but acceptable as the payload will be a small amount of water. These payloads will be swept by decelerating into a tether hanging from the depot as it passes in a higher yet slower orbit. The water will be pumped from the tether to the depot where it will be separated and liquified into elemental oxygen and hydrogen for utilization as propellant. R.E.P.

A92-20645
THE TWO-SAIL PROPULSION CONCEPT
GIOVANNI VULPETTI (Telespazio S.p.A., Rome, Italy) and MAURO PECCHIOLI (ESA, European Space Operations Centre, Darmstadt, Federal Republic of Germany) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 43 p. Oct. 1991 43 p refs
(IAF PAPER 91-721) Copyright

In recent years a number of papers appeared by studying the feasibility of the field sail as a propulsive device for interplanetary and out-of-solar-system missions. This paper aims chiefly at studying the feasibility of major engineering problems in field-sail propulsion by superconductors: (1) to achieve very low temperatures in space by a passive control and stabilization, (2) to stabilize the magnetic sail against large fluctuations of the charged particles beam (solar wind), and (3) to get high payload fractions and short flight times. The present investigation is focused on several design aspects and shows that it is possible to target the above points by using current technology. A set of 15 spacecraft configurations are discussed. In addition, a preliminary spacecraft and flight design are presented for an extrasolar probe mission. Author

A92-22497
A PROPULSION STUDY ON WATER ELECTROLYSIS FOR THE COLUMBUS FREE FLYER
M. TANDARA and W. KOSCHEL (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. Oct. 1991 12 p refs
(IAF PAPER ST-91-018) Copyright

For orbital maneuvering, the Columbus Free Flyer and the International Space Station are planned to utilize mainly hydrazine based propellants. The relatively low performance and safety hazards associated with hydrazine encourages the search for alternatives. One such alternative is water electrolysis. This study shows some advantages and disadvantages of a water electrolysis-based orbital propulsion system for the Columbus Free Flyer. Author

A92-22877 National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
THE SHOOT CRYOGENIC COMPONENTS - TESTING AND APPLICABILITY TO OTHER FLIGHT PROGRAMS
MICHAEL J. DIPIRRO, MICHAEL E. SCHEIN, ROBERT F. BOYLE, ORLANDO FIGUEROA, DAVID A. LINDAUER, DANIEL C. MCHUGH, and P. J. SHIRRON (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Cryogenic optical systems and instruments IV; Proceedings of the Meeting, San Diego, CA, July 10-12, 1990 1990 12 p refs
Copyright

Cryogenic components and techniques for the superfluid helium on-orbit transfer (SHOOT) flight demonstration are described. Instrumentation for measuring liquid quantity, position, flow rate, temperature, and pressure has been developed using the data obtained from the IRAS, Cosmic Background Explorer, and Spacelab 2 helium dewars. Topics discussed include valves and burst disks, fluid management devices, structural/thermal components, instrumentation, and ground support equipment and performance test apparatus. O.G.

A92-23826* National Aeronautics and Space Administration, Washington, DC.
SPACE CRYOGENICS WORKSHOP, 10TH, CLEVELAND, OH, JUNE 18-20, 1991, PROCEEDINGS
Workshop sponsored by NASA. Cryogenics (ISSN 0011-2275), vol. 32, no. 2, 1992, 186 p. For individual items see A92-23827 to A92-23853. 1992 186 p
Copyright

The present workshop on cryogenics discusses the anomalous on-orbit behavior of the Cosmic Background Explorer Dewar, the SHOOT orbital operations, cooling options for Astromag, and space IR telescope facility mission and cryogenic design. Attention is given to the design of a spaceworthy adiabatic demagnetization refrigerator, the evaluation of metal hydride compressors for applications in Joule-Thomson cryocoolers, diaphragm Stirling cryocooler developments, and a computer simulation model for Stirling refrigerators. Topics addressed include low-gravity thermal stratification of liquid helium on SHOOT, a screening program to select a resin for gravity probe-B composites, a simplified generic cryostat thermal model for predicting cryogen mass and lifetime, and the effect of gas mass flux on cryogenic liquid jet breakup. Also discussed are damping criteria for thermal acoustic oscillations in slush and liquid hydrogen systems, an STS-based cryogenic fluid management experiment, and the design and testing of a cryogenic mixer pump. P.D.

A92-23828* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
THE SHOOT ORBITAL OPERATIONS
M. J. DIPIRRO and P. J. SHIRRON (NASA, Goddard Space Flight Center, Greenbelt, MD) (Space Cryogenics Workshop, 10th, Cleveland, OH, June 18-20, 1991, Proceedings. A92-23826 08-31) Cryogenics (ISSN 0011-2275), vol. 32, no. 2, 1992, p. 85-90. 1992 6 p refs
Copyright

The present study describes the SHOOT on orbit operations, the reasons for the methods used to obtain the experimental data, and the expected results. Attention is given to prelaunch operations, ascent and pumpdown, beneficial accelerations, transfer

operations, adverse accelerations, crew-controlled transfer, and warm Dewar cooldown. Transfer losses expected for SHOOT as a function of the flow rate are illustrated. P.D.

A92-23840* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
LOW GRAVITY THERMAL STRATIFICATION OF LIQUID HELIUM ON SHOOT
P. J. SHIRRON and M. J. DIPIRRO (NASA, Goddard Space Flight Center, Greenbelt, MD) (Space Cryogenics Workshop, 10th, Cleveland, OH, June 18-20, 1991, Proceedings. A92-23826 08-31) Cryogenics (ISSN 0011-2275), vol. 32, no. 2, 1992, p. 159-166. 1992 8 p refs
Copyright

Estimates of the extent and impact of thermal stratification are presented as well as predictions of the behavior of the Hel/Hell boundary. Although thermal stratification of cryogens can be problematic and lead to their inefficient use in low gravity, for SHOOT the occurrence is beneficial both during ground hold and in orbit and presents no hazards. On the ground the parasitic heat load is both reduced and more efficiently removed. In orbit the pumpdown proceeds at a much more rapid rate, allowing orbital operations to begin earlier. The thermal conductivity of the aluminum tank and the normal liquid plus cooling at the liquid/vapor interface as the vapor bubble grows are sufficient to prevent undesirably high vapor pressures in the tank. P.D.

A92-23847* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ON-ORBIT CRYOGENIC FLUID TRANSFER RESEARCH AT NASA LEWIS RESEARCH CENTER
W. J. TAYLOR, D. J. CHATO, M. M. MORAN, and T. W. NYLAND (NASA, Lewis Research Center, Cleveland, OH) (Space Cryogenics Workshop, 10th, Cleveland, OH, June 18-20, 1991, Proceedings. A92-23826 08-31) Cryogenics (ISSN 0011-2275), vol. 32, no. 2, 1992, p. 199-204. 1992 6 p refs

A summary of research into on-orbit cryogenic fluid transfer at the NASA Lewis Research Center (LRC) is presented. Variable test parameters and liquid injection configurations elucidated the conditions necessary for a successful transfer of liquid hydrogen by the no-vent fill method. The model is based on conservation of mass and a first-law energy balance for a control volume. The ullage, the bulk liquid, and the tank wall are each represented by a single node. The magnitude of the maximum receiver tank pressure was found to be dependent on the liquid inlet temperature, the inlet mass flow rate, and the initial temperature. A comparison of the test data and the analytical results for a no-vent fill test with a small receiver tank is presented. P.D.

A92-23853
THE DESIGN AND TESTING OF A CRYOGENIC MIXER PUMP
T. A. MARTIN, D. H. BEEKMAN, and J. E. DILLARD (Martin Marietta Corp., Denver, CO) (Space Cryogenics Workshop, 10th, Cleveland, OH, June 18-20, 1991, Proceedings. A92-23826 08-31) Cryogenics (ISSN 0011-2275), vol. 32, no. 2, 1992, p. 243-250. 1992 8 p refs
Copyright

Results are presented of a mixer pump development program for use in liquid nitrogen, liquid hydrogen or liquid helum, and the associated test program that is to be conducted with this component. The pump requirements, design, and operating parameters are presented along with a discussion of the full test program and expected test results. This component will allow the elimination of direct ullage venting via its incorporation into an active pressure control system. Graphs and tables are presented of a CONE active pressure control subsystem schemactic, mixer pump nozzle size selection analysis, mixer pump flow rate requirements, design requirements for the cryogenic mixer pump, design head curve for the mixer pump, predicted pump performance, predicted pump power levels at four operating points, and the ground-based mixing test facility. P.D.

A92-28127
ROTOR-PENDULUM MODEL FOR THE PERIGEE ASSIST MODULE NUTATION ANOMALY
A. C. OR (Hughes Aircraft Co., El Segundo, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 15, Mar.-Apr. 1992, p. 297-303. Apr. 1992 7 p refs
Copyright

A stability problem of a three-DOF rotor-pendulum spacecraft model is studied in the parameter region of the flight anomaly of the Perigee Assist Module (PAM). Simulation results are reported which support the theory of resonance interactions as the cause of the PAM anomaly. Telemetric body angular rates can be matched satisfactorily by adjusting a few key parameters. Explanations are given for the discrepancy between the flight and model parameters in the instability region. In particular, it is suggested that liquid sloshing may have a quantitatively different force balance from mechanical pendulums, even though the qualitative effects of sloshing can be accounted for by pendulum motions. C.D.

A92-28512* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EVALUATION OF SUPERCRITICAL CRYOGEN STORAGE AND TRANSFER SYSTEMS FOR FUTURE NASA MISSIONS
HUGH ARIF, JOHN C. AYDELOTT, and DAVID J. CHATO (NASA, Lewis Research Center, Cleveland, OH) Apr. 1992 7 p refs
Copyright

A92-29641*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
FLUID STRESS DISTURBANCE ACTIVATED BY GRAVITY JITTERS INDUCED SLOSH WAVES IN MICROGRAVITY
R. J. HUNG, C. C. LEE (Alabama, University, Huntsville), and F. W. LESLIE (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 10 p. Jan. 1992 10 p refs
(Contract NAG8-129)
(AIAA PAPER 92-0880)

A full scale Gravity Probe-B (GP-B) Spacecraft propellant dewar tank subjected to various frequencies of gravity jitter have been investigated. Excitation of slosh waves induced by gravity jitter are simulated. Results show that fluid stress distribution exerted on the walls of the rotating dewar are closely related to the characteristics of slosh waves excited on the liquid-vapor interface in the rotating dewar tank. Slosh wave excitations shift the fluid mass distribution in the dewar tank which impose time dependent variations in GP-B Spacecraft moment of inertia, angular momentum, and torque produced by imbalance fluid stresses. This can provide a set of data leading toward the control of spacecraft imbalance caused by the uneven fluid stress distribution from slosh waves. Author

A92-31375* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
HYDRAULIC MODEL OF THE PROPOSED WATER RECOVERY AND MANAGEMENT SYSTEM FOR SPACE STATION FREEDOM
CHARLES E. MARTIN (McDonnell Douglas Space Systems Co., Huntsville, AL) and ALLEN S. BACSKAY (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Space Station ECLSS and thermal control; Proceedings of the 21st International Conference on Environmental Systems, San Francisco, CA, July 15-18, 1991 1991 21 p refs
(SAE PAPER 911472) Copyright

A model of the Water Recovery and Management (WRM) system utilizing SINDA '85/FLUINT to determine its hydraulic operation characteristics, and to verify the design flow and pressure drop parameters is presented. The FLUINT analysis package is employed in the model to determine the flow and pressure characteristics when each of the different loop components is operational and contributing to the overall flow pattern. The water is driven in each loop by storage tanks pressurized with cabin air,

and is routed through the system to the desired destination.
R.E.P.

N92-10197* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
MECHANIZED FLUID CONNECTOR AND ASSEMBLY TOOL SYSTEM WITH BALL DETENTS Patent
RONALD C. ZENTNER, inventor (to NASA) and STEVEN A. SMITH, inventor (to NASA) 22 Oct. 1991 10 p Filed 9 Nov. 1989 Supersedes N90-17138 (28 - 9, p 1230)
(NASA-CASE-MSC-21434-1; US-PATENT-5,058,929; US-PATENT-APPL-SN-433881; US-PATENT-CLASS-285-39; US-PATENT-CLASS-285-353; US-PATENT-CLASS-285-23; US-PATENT-CLASS-285-912; INT-PATENT-CLASS-F16L-15/00)
Avail: US Patent and Trademark Office

A fluid connector system is disclosed which includes a modified plumbing union having a rotatable member for drawing said union into a fluid tight condition. A drive tool is electric motor actuated and includes a reduction gear train providing an output gear engaging an integral peripheral spur gear on the rotatable member. Coaxial alignment means are attached to both the connector assembly and the drive tool. A hand lever actuated latching system includes a plurality of circumferentially spaced latching balls selectively wedged against the alignment means attached to the connector assembly or to secure the drive tool with its output gear in mesh with the integral peripheral spur gear. The drive motor is torque, speed, and direction controllable.
Official Gazette of the U.S. Patent and Trademark Office

N92-11129*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
IMPROVED THERMODYNAMIC MODELING OF THE NO-VENT FILL PROCESS AND CORRELATION WITH EXPERIMENTAL DATA
WILLIAM J. TAYLOR and DAVID J. CHATO 1991 18 p Presented at the 26th Thermophysics Conference, Honolulu, HI, 24-26 Jun. 1991; sponsored by AIAA Previously announced in IAA as A91-43444
(Contract RTOP 506-48-00)
(NASA-TM-104492; E-6350; NAS 1.15:104492; AIAA PAPER 91-1379) Avail: CASI HC A03/MF A01

The United States' plans to establish a permanent manned presence in space and to explore the Solar System created the need to efficiently handle large quantities of subcritical cryogenic fluids, particularly propellants such as liquid hydrogen and liquid oxygen, in low- to zero-gravity environments. One of the key technologies to be developed for fluid handling is the ability to transfer the cryogens between storage and spacecraft tanks. The no-vent fill method was identified as one way to perform this transfer. In order to understand how to apply this method, a model of the no-vent fill process is being developed and correlated with experimental data. The verified models then can be used to design and analyze configurations for tankage and subcritical fluid depots. The development of an improved macroscopic thermodynamic model is discussed of the no-vent fill process and the analytical results from the computer program implementation of the model are correlated with experimental results for two different test tanks. Author

N92-11132*# Rockwell International Corp., Canoga Park, CA. Rocketdyne Div.
DEFINITION, TECHNOLOGY READINESS, AND DEVELOPMENT COST OF THE ORBIT TRANSFER VEHICLE ENGINE INTEGRATED CONTROL AND HEALTH MONITORING SYSTEM ELEMENTS Final Report, Mar. - Oct. 1990
I. CANNON, S. BALCER, M. COCHRAN, J. KLOP, and S. PETERSON Oct. 1991 72 p
(Contract NAS3-23773)
(NASA-CR-187123; NAS 1.26:187123; RI/RD91-150; AD-B159505L) Avail: CASI HC A04/MF A01

An Integrated Control and Health Monitoring (ICHM) system was conceived for use on a 20 Klb thrust baseline Orbit Transfer Vehicle (OTV) engine. Considered for space used, the ICHM was defined for reusability requirements for an OTV engine service free life of 20 missions, with 100 starts and a total engine operational time of 4 hours. Functions were derived by flowing down requirements from NASA guidelines, previous OTV engine or ICHM documents, and related contracts. The elements of an ICHM were identified and listed, and these elements were described in sufficient detail to allow estimation of their technology readiness levels. These elements were assessed in terms of technology readiness level, and supporting rationale for these assessments presented. The remaining cost for development of a minimal ICHM system to technology readiness level 6 was estimated. The estimates are within an accuracy range of minus/plus 20 percent. The cost estimates cover what is needed to prepare an ICHM system for use on a focussed testbed for an expander cycle engine, excluding support to the actual test firings. Author

N92-11136*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TEST FACILITIES FOR HIGH POWER ELECTRIC PROPULSION
JAMES S. SOVEY (Sverdrup Technology, Inc., Brook Park, OH.), ROBERT H. VETRONE, STANLEY P. GRISNIK, ROGER M. MYERS, and JAMES E. PARKES (Sverdrup Technology, Inc., Brook Park, OH.) 1991 23 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 A91-52396
(Contract RTOP 506-42-31)
(NASA-TM-105247; E-6576; NAS 1.15:105247; AIAA PAPER 91-3499) Avail: CASI HC A03/MF A01

Electric propulsion has applications for orbit raising, maneuvering of large space systems, and interplanetary missions. These missions involve propulsion power levels from tenths to tens of megawatts, depending upon the application. General facility requirements for testing high power electric propulsion at the component and thrust systems level are defined. The characteristics and pumping capabilities of many large vacuum chambers in the United States are reviewed and compared with the requirements for high power electric propulsion testing.
Author

N92-12415 Colorado Univ., Boulder.
ULTRASONIC APPLICATIONS FOR SPACE-BASED LIFE SUPPORT SYSTEMS Ph.D. Thesis
AMOS STEVE JOHNSON 1990 218 p
Avail: Univ. Microfilms Order No. DA9122615

The reduction of gravitational acceleration forces in spaceborne environments allows the behavior of fluids to be dominated by forces normally masked by gravity. This behavior presents challenges and opportunities in the design of systems expected to operate in space. The dependence of life support systems on such fluid interactions to accomplish various processes can not be overlooked. For example, phase separation is one of the major fluid handling difficulties routinely faced in space technology, including life support systems. A vigorous manned space program demands the recycling of life support materials. Ultrasound is investigated as a potential technology to specifically address these problems. Earthbound applications for ultrasound are varied, which leads the investigation toward a multipurpose operational component of life support systems. Investigations have shown that the acoustic intensity gradients generated by ultrasound can be effectively used for multiphasic fluid pumping, fluid mixing, gas transfer across membranes, and cleaving complex biological compounds into smaller biologically digestible units. Investigations suggest that in addition to pumping fluids, acoustic gradients can further accelerate gas liquid phase separations. The physical arrangement, geometries, and limits of such uses are suggested by the tests done here. The critical parameters of sound frequencies and amplitudes are highlighted with regard to the noted applications. The capacity to perform many functions in microgravity is a particular asset further enhanced by the simplicity and compactness of such hardware. These characteristics will trade

favorably in terms of the mass and volume committed to an ultrasonic system compared to conventional technologies.
Dissert. Abstr.

N92-13276*# GenCorp Aerojet, Sacramento, CA.
ORBITAL TRANSFER VEHICLE ENGINE TECHNOLOGY: BAFFLED INJECTOR DESIGN, FABRICATION, AND VERIFICATION Final Report
J. A. SCHNEIDER Washington NASA Nov. 1991 234 p
(Contract NAS3-23772; RTOP 591-41-11)
(NASA-CR-4387; E-6413; NAS 1.26:4387; AD-A243733) Avail: CASI HC A11/MF A03

New technologies for space-based, reusable, throttleable, cryogenic orbit transfer propulsion are being evaluated. Supporting tasks for the design of a dual expander cycle engine thrust chamber design are documented. The purpose of the studies was to research the materials used in the thrust chamber design, the supporting fabrication methods necessary to complete the design, and the modification of the injector element for optimum injector/chamber compatibility. Author

N92-16319*# Creare, Inc., Hanover, NH.
HIGH EFFICIENCY PUMP FOR SPACE HELIUM TRANSFER Final Technical Report
ROBERT HASENBEIN, MICHAEL G. IZENSON, WALTER L. SWIFT, and HERBERT SIXSMITH Dec. 1991 96 p
(Contract NAS2-12950; SBIR-03.06-3800)
(NASA-CR-177595; A-92050; NAS 1.26:177595) Avail: CASI HC A05/MF A01

A centrifugal pump was developed for the efficient and reliable transfer of liquid helium in space. The pump can be used to refill cryostats on orbiting satellites which use liquid helium for refrigeration at extremely low temperatures. The pump meets the head and flow requirements of on-orbit helium transfer: a flow rate of 800 L/hr at a head of 128 J/kg. The overall pump efficiency at the design point is 0.45. The design head and flow requirements are met with zero net positive suction head, which is the condition in an orbiting helium supply Dewar. The mass transfer efficiency calculated for a space transfer operation is 0.99. Steel ball bearings are used with gas fiber-reinforced teflon retainers to provide solid lubrication. These bearings have demonstrated the longest life in liquid helium endurance tests under simulated pumping conditions. Technology developed in the project also has application for liquid helium circulation in terrestrial facilities and for transfer of cryogenic rocket propellants in space. Author

N92-20522*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HYDROGEN/OXYGEN AUXILIARY PROPULSION TECHNOLOGY
BRIAN D. REED and STEVEN J. SCHNEIDER 1991 23 p Presented at the Conference on Advanced Space Exploration Initiative Technologies, Cleveland, OH, 4-6 Sep. 1991; cosponsored by AIAA, NASA, and OAI
(Contract RTOP 506-42-31)
(NASA-TM-105249; E-6578; NAS 1.15:105249; AIAA PAPER 91-3440) Avail: CASI HC A03/MF A01

A survey is provided 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 (1500 lbf) to 440 mN (0.1 lbf) thrust. Ignition concepts for H/O thrusters and high temperature, oxidation resistant chamber materials are also reviewed. Author

18

COMMERCIALIZATION

Use of space stations for large scale commercial operations.

A92-10675* Auburn Univ., AL.
SPACE - A UNIQUE ENVIRONMENT FOR PROCESS MODELING R&D
TONY OVERFELT (Auburn University, AL) JOM (ISSN 1047-4838), vol. 43, Oct. 1991, p. 8-11. Research supported by GE Aircraft Engines, Lawrence Livermore National Laboratory, Boeing Co., et al. Oct. 1991 4 p refs
(Contract NAGW-810)
Copyright

Process modeling, the application of advanced computational techniques to simulate real processes as they occur in regular use, e.g., welding, casting and semiconductor crystal growth, is discussed. Using the low-gravity environment of space will accelerate the technical validation of the procedures and enable extremely accurate determinations of the many necessary thermophysical properties. Attention is given to NASA's centers for the commercial development of space; joint ventures of universities, industries, and goverment agencies to study the unique attributes of space that offer potential for applied R&D and eventual commercial exploitation. R.E.P.

A92-12902
AUTOMATIC EQUIPMENT FOR SEMICONDUCTOR PRODUCTION IN SPACE
IURII N. D'IAKOV, EVGENII V. MARKOV, ANATOLII I. LOOBUSHKIN, and SERGEI N. SULYGIN (NPO Nauchnyi Tsentr, Moscow, USSR) IN: AIAA/IKI Microgravity Science Symposium, 1st, Moscow, USSR, May 13-17, 1991, Proceedings 1991 6 p
Copyright

The equipment installed in the long-term orbit station (LOS) Mir is presented and described in terms of both construction and the ability to automatically fabricate semiconductrs in microgravitational conditions. The descriptions include two resistive automatic multifunctional furnaces (the Gallar and the Crator-B furnaces), the Onix control-system architecture and software structure, and an experimental light heater called Optizone-1. The Gallar furnace is designed to conduct a number of experiments and generate industrial semiconductor prototypes. The Onix control system permits the use of a multifunctional reconfigurable algorithm designed for use in the field of materials science. Crator-B is similar to Gallar except that it facilitates oriented solidification, and Optizone-1 provides a LOS environment for microgravitational crystal growth. C.C.S.

A92-20594* National Aeronautics and Space Administration, Washington, DC.
SPACE COMMERCE - PREPARING FOR THE NEXT CENTURY
BARBARA A. STONE (NASA, Office of Commercial Programs, Washington, DC) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p
(IAF PAPER 91-643) Copyright

The role of NASA in space commerce is discussed in terms of providing direct assistance to the private sector and in terms of the most suitable industrial areas for such support. The primary mechanism for such support is the program of Centers for the Commercial Development of Space (CCDS) which selects industrial high-technology projects to help make them viable. The research spans such fields as remote sensing, crop forecasting, and microgravity materials processing. The collaboration of NASA and private industry is discussed in terms of sounding-rocket projects, the Commercial Experiment Transporter, and academic/industrial programs designed to generate enthusiasm for commercial space research. The future of such research is expected to focus on CCDSs for microgravity-developed products, commercial

infrastructure, SEI, and commercial use of the Space Station Freedom. C.C.S.

A92-20602
COMMERCIAL SPACE ACTIVITIES - CASE STUDIES
V. NIJHAVAN (Payload Systems, Inc., Cambridge, MA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 4 p. Oct. 1991 4 p
(IAF PAPER 91-654) Copyright

Two microgravity case studies of commercial space activities which have resulted in industrial revenues are presented. They are protein crystal growth research performed on Mir and parabolic flights using payload systems. O.G.

A92-23697
ON-BOARD KNOWLEDGE-BASED ASSISTANT FOR ORBITAL RENDEZ-VOUS OPERATIONS
ARNAUD DE SAINT-VINCENT, FRANCOIS LECOUAT, PHILIPPE CALOUD (Matra Espace, Toulouse, France), and PHILIPPE MARCHAL (CNES, Toulouse, France) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 5 p refs

This paper describes a knowledge-based system that supports astronauts in their decision-making in orbit and especially during HERMES Rendez-Vous operations. A model-based failure diagnostic module and a mission replanning module have been implemented. They are being extended and integrated with a supervision module to form a real-time Rendez-Vous testbed. Author

A92-23698
COMPUTER AIDED DESIGN AND VERIFICATION OF AUTONOMOUS RVD FLIGHT MANAGEMENT SYSTEM
YASUFUMI WAKABAYASHI, ISAO KAWANO (NASDA, Tsukuba, Japan), NORIMASA YOSHIDA, MASANORI SATO, TATSUSHI KANBE (Mitsubishi Electric Corp., Kamakura Works, Japan), MUTSUO KITAMURA, and MASAKI ISHIKAWA (Mitsubishi Research Institute, Tokyo, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p refs

The Flight Management System (FMS) for future autonomous space vehicles with versatile capabilities such as Rendezvous and Docking will be a very complicated one. Since it must be extremely reliable as well due to safety requirement imposed on it, difficulties arise with its design and verification. An approach is proposed which utilizes prototyping at early stages of design with the aid of a specification description using object-oriented definitions of parts and a graphical representation of logics by flow chart, realized on a unified computer-aided environment. A computer program called the Flight Management Verification Program is developed which can accommodate top-level functional description of the FMS along with hardware and dynamic models of the vehicle and can execute the description with simulated errors. A series of test runs of the program demonstrate the validity of the approach. Author

A92-23722
DESIGN STUDY OF ROBOTIC SYSTEM FOR SPACE FACTORY
TAKEYA KAWAMURA, MICHIAKI MIZUOCHI, and YUKIO TANAKA (Mitsubishi Heavy Industries, Ltd., Kobe Shipyard and Machinery Works, Japan) IN: i-SAIRAS '90; Proceedings of the International Symposium on Artificial Intelligence, Robotics and Automation in Space, Kobe, Japan, Nov. 18-20, 1990 1990 4 p

A conceptual design is proposed for a space-based automated factory in a pressurized module dedicated to aerospace industrial activities. The robotic system is made up of a mobile system, both heavy-duty and dexterous dual-arm manipulators, and a camera arm for monitoring. The conceptual design is based on transfer tasks requiring a mobile system as well as tasks that involve objects of a large range of sizes. The final conceptual design incorporates five manipulator arms and the mobile system which allow dual-arm operations, operation inside equipment, collision avoidance, and transfer to the outside of the space module. Specific areas which require further investigation remain including the development of special tools, optimizing the manipulator-arm arrangement to permit the use of a shorter arm, and maximizing collision avoidance through the development of redundant-manipulator control theory. C.C.S.

N92-14963*# National Aeronautics and Space Administration, Washington, DC.
ACCESSING SPACE: A CATALOGUE OF PROCESS, EQUIPMENT AND RESOURCES FOR COMMERCIAL USERS, 1990
Dec. 1990 270 p
(NASA-NP-133; NAS 1.83:133) Avail: CASI HC A12/MF A03

A catalogue is presented which is intended for commercial developers who are considering, or who have in progress, a project involving the microgravity environment of space or remote sensing of the Earth. An orientation is given to commercial space activities along with a current inventory of equipment, apparatus, carriers, vehicles, resources, and services available from NASA, other government agencies and U.S. industry. The information describes the array of resources that commercial users should consider when planning ground or space based developments. Many items listed have flown in space or been tested in labs and aboard aircraft and can be reused, revitalized, or adapted to suit specific requirements. New commercial ventures are encouraged to exploit existing inventory and expertise to the greatest extent possible. Author

19

EXPERIMENTS

Design and description of experiments to be performed or managed from the space station.

A92-12426* National Aeronautics and Space Administration, Washington, DC.
NASA'S IN-SPACE TECHNOLOGY EXPERIMENTS PROGRAM - STATUS AND PLANS
LEONARD A. HARRIS, GREGORY M. RECK, JUDITH H. AMBRUS (NASA, Office of Aeronautics Exploration and Technology, Washington, DC), and RODNEY A. HEMMERLY (General Research Corp., Vienna, VA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. Oct. 1991 12 p refs
(IAF PAPER 91-001) Copyright

The Space Station Freedom constitutes a space facility uniquely suited to space technology-related R&D. Such test data as those involving fluids (power, thermal management, life support systems, and payload operations), space structures, and space materials, cannot be realistically obtained on the ground. The Space Station will also allow the validation of technologies that promise either higher performance or lower costs but which, if not validated in the necessary environment, could pose unacceptable program risks. O.C.

A92-12480 National Aeronautics and Space Administration, Washington, DC.
SPACE STATION FREEDOM CAPABILITIES FOR USERS
WILLIAM W. L. TAYLOR (NASA, Washington, DC), ROBERT S. SNYDER (NASA, Marshall Space Flight Center, Huntsville, AL), and HARVEY J. WILLENBERG (Boeing Co., Huntsville, AL) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 11 p. Oct. 1991 11 p
(IAF PAPER 91-069) Copyright

Space Station Freedom's major objectives are to prepare for human space exploration by providing a long-duration, continuously habitable spacecraft in low earth orbit for physiology studies and for development of systems to support human presence in space

and to enable laboratory and observational research in space. As a result of restructuring and the preliminary design review, designs of Space Station Freedom architecture and systems have progressed to the point where the accommodations for users can be well described. These capabilities are enumerated, covering such important resources as power and cooling, rack volume and external accommodations, crew time, data and command rates, and acceleration environment. Related items such as total energy, data management systems, and interfaces, station attitude, payload transportation, and on board and ground facilities are considered. Author

A92-12504* National Aeronautics and Space Administration, Washington, DC.
SCIENTIFIC USE OF SPACE STATION FREEDOM
ROBERT C. RHOME and MARY E. KICZA (NASA, Office of Space Science and Applications, Washington, DC) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. Oct. 1991 12 p
(IAF PAPER 91-100) Copyright

The overall strategic science planning of the Office of Space Science and Applications (OSSA) is presented. The science opportunities inherent to the restructured Space Station are discussed and a synopsis of the OSSA implementation plan for Space Station Freedom utilization is offered. Attention is given to the microgravity science and applications facilities, the advanced protein crystal growth facility, the biotechnology facility, the modular combustion facility, and the life sciences facility. R.E.P.

A92-12509* BDM Corp., Columbia, MD.
A SURVEY OF RAPID SAMPLE RETURN NEEDS FROM SPACE STATION FREEDOM AND POTENTIAL RETURN SYSTEMS
RONALD S. MCCANDLESS (BDM International, Inc., Columbia, MD), BETTE SIEGEL (NASA, Washington, DC), and KEVIN CHARLTON (BDM International, Inc., Washington, DC) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p refs
(IAF PAPER 91-106) Copyright

Results are presented of a survey conducted among potential users of the life sciences and material sciences facilities at the Space Station Freedom (SSF) to determine the need for a special rapid sample return (RSR) mission to bring the experimental samples from the Space Station Freedom (SSF) to earth between the Space Shuttle visits. The results of the survey show that, while some experimental objectives would benefit from the RSR capability, other available cost- and mission-effective means could be used instead of the RSR proposed. Potential vehicles for transporting samples from the SSF to earth are examined in the context of the survey results. I.S.

A92-12511
EUROPEAN OPPORTUNITIES FOR ASTRONOMICAL, SOLAR-TERRESTRIAL AND EARTH OBSERVATION RESEARCH ABOARD THE SPACE STATION FREEDOM
MANFRED GAIDA, HORST T. BLUME (DLR, Cologne, Federal Republic of Germany), and IAN L. THOMAS (Royal Aerospace Establishment, Farnborough, England) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 7 p. Oct. 1991 7 p refs
(IAF PAPER 91-108) Copyright

The model instruments considered for use in the Space Station Freedom (SSF) program are evaluated in terms of effectiveness and availability, and an instrument-traffic model is described. The model payloads are based current technologies that cost-effectively meet the goals of the SSF program in terms of investigation and physical limitations. An observational program is presented generically with attention to payload capabilities and to various scientific disciplines in terms of both cyclical and continuous modes. The preliminary European Instrument Traffic Model is defined for the first four years of Columbus operation. The model demonstrates that the requirements for stowage and well defined up/download transportation capabilities are critical and that mission timelining is essential to optimize resource utilization. C.C.S.

A92-12851*
AIAA/IKI MICROGRAVITY SCIENCE SYMPOSIUM, 1ST, MOSCOW, USSR, MAY 13-17, 1991, PROCEEDINGS
Symposium supported by IKI, NASA, and LSA. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, 392 p. For individual items see A92-12852 to A92-12909. 1991 392 p
Copyright

The state of the art of microgravity science is examined in reviews and reports. Consideration is given to fluid physics; modeling and numerical analysis; crystal growth of electronic materials, proteins, metals, alloys, glasses, and ceramics; biotechnology, combustion science, microgravity hardware, and fundamental phenomena; and education. Particular attention is given to containerless science and technology, a low-gravity two-phase flow with heat transfer, numerical investigation on Benard instability in a finite liquid layer, synthesis and crystallization of refractory compounds from solutions in metallic melts under microgravitation conditions, the long duration protein crystallization experiment aboard the Mir Space Station, directional solidification in immiscible systems, formation of periodic layer structure in oxide melts under different gravity values, opposed flow flame spread in normal, enhanced, and reduced gravity, automatic equipment for semiconductor production in space, and consort and joust sounding rocket missions. O.G.

A92-12852* National Aeronautics and Space Administration, Washington, DC.
MICROGRAVITY SCIENCE AND APPLICATIONS OVERVIEW - RESEARCH, FACILITY AND INSTRUMENTATION DEVELOPMENT, SPACE STATION FREEDOM OPERATIONS AND UTILIZATION PLANNING
ROGER K. CROUCH and M. E. KICZA (NASA, Office of Space Science and Applications, Washington, DC) IN: AIAA/IKI Microgravity Science Symposium, 1st, Moscow, USSR, May 13-17, 1991, Proceedings 1991 12 p refs
Copyright

The NASA microgravity science and applications program is reviewed. Particular attention is given to the planning for utilization of the Shuttle and plans leading to the utilization of Space Station Freedom. It is concluded that the potential rewards of the program include a better understanding of the physical processes in the space environment, which may lead to refined control strategies, and advances in technology, which may lead to important commercial applications. O.G.

A92-12869
GASB CRYSTAL GROWTH IN MICROGRAVITY CONDITIONS
O. V. SHUMAEV and L. L. REGEL' (AN SSSR, Institut Kosmicheskikh Issledovanii, Moscow, USSR) IN: AIAA/IKI Microgravity Science Symposium, 1st, Moscow, USSR, May 13-17, 1991, Proceedings 1991 5 p refs
Copyright

An experiment on GaSb crystallization through the Bridgman technique on board the Mir space station is described. The most stable phase of the melt was found to cause the shoulder formation at the beginning of growth. The specific balanced melt shape also affected heat transfer processes in the ampoule, thus leading to a more curvated initial solid-liquid interface and defects in the space crystal. It is concluded that microgravity conditions caused deterioration of the crystal structure. O.G.

A92-12882
LONG DURATION PROTEIN CRYSTALLIZATION EXPERIMENT ABOARD THE MIR SPACE STATION
A. P. ARROTT (Payload Systems, Inc., Cambridge, MA), G. K. FARBER (Pennsylvania State University, University Park), B. L. STODDARD (California, University, Berkeley), and R. K. STRONG (California Institute of Technology, Pasadena) IN: AIAA/IKI Microgravity Science Symposium, 1st, Moscow, USSR, May 13-17,

1991, Proceedings 1991 5 p refs
Copyright

Results are reported from the first of a six-mission program to develop and exploit long-duration space-based techniques to grow protein crystals of diffraction quality. An important objective of the first mission was to assess the quality of Mir as a protein crystal growth facility. The results were promising as protein crystals grown on Mir met or exceeded the quality of the best earth-grown crystals in size, morphology, internal perfection and mosaicity, and diffraction power. This suggests that the microgravity environment on Mir is conductive to crystal growth. The Mir space station was found to provide a stable environment for protein crystal growth, particularly in terms of temperature, vibration, and radiation exposure. Finally, recovery forces and shocks did not significantly affect crystal quality. The experiment results suggest that several changes in hardware and experiment design may yield further insight into the effect of microgravity on protein crystallization.
Author

A92-12884* *National Aeronautics and Space Administration.* Marshall Space Flight Center, Huntsville, AL.
ELECTROPHORESIS EXPERIMENTS IN MICROGRAVITY
ROBERT S. SNYDER and PERCY H. RHODES (NASA, Marshall Space Flight Center, Huntsville, AL) IN: AIAA/IKI Microgravity Science Symposium, 1st, Moscow, USSR, May 13-17, 1991, Proceedings 1991 4 p refs
Copyright

The use of the microgravity environment to separate and purify biological cells and proteins has been a major activity since the beginning of the NASA Microgravity Science and Applications program. Purified populations of cells are needed for research, transplantation and analysis of specific cell constituents. Protein purification is a necessary step in research areas such as genetic engineering where the new protein has to be separated from the variety of other proteins synthesized from the microorganism. Sufficient data are available from the results of past electrophoresis experiments in space to show that these experiments were designed with incomplete knowledge of the fluid dynamics of the process including electrohydrodynamics. However, electrophoresis is still an important separation tool in the laboratory and thermal convection does limit its performance. Thus, there is a justification for electrophoresis but the emphasis of future space experiments must be directed toward basic research with model experiments to understand the microgravity environment and fluid analysis to test the basic principles of the process. Author

A92-12886
NUMERICAL AND EXPERIMENTAL INVESTIGATION OF INCREASED CONCENTRATION SAMPLE SEPARATION BY CONTINUOUS FLOW ELECTROPHORESIS IN SPACE
A. A. AKSENOV, A. V. GOLOVINKIN, M. A. MESHKOV (Moskovskii Fiziko-Tekhnicheskii Institut, Dolgoprudny, USSR), A. V. GUDZOVSKII (Academy of Sciences, Institute for the Computer Aided Design, Moscow, USSR), and A. A. SEREBROV (NPO Energiia, Kaliningrad, USSR) IN: AIAA/IKI Microgravity Science Symposium, 1st, Moscow, USSR, May 13-17, 1991, Proceedings 1991 5 p refs
Copyright

A mathematical model is proposed which can be used to explain sample suspension properties following separation by continuous-flow electrophoresis (CFE) in space. Expressions for the sample are based on the electrohydrodynamic interactions of particles suspended in a buffer which depend on the value for the respective concentration. The concentration spreading in the CFE chamber is examined for a negligible ponderomotive force. The results are compared to the sample-jet instability in an electric field which occurs in some orbiting and ground-based CFE chambers by using the Mir orbital station as an example. The concentrational effects in Mir electrophoretic experiments can be explained by the dependence of sample suspension properties on the concentrations of fractions. The difference between the conductivity and capacitivity in the sample jet and the pure buffer causes sample-jet instability in the electric field. C.C.S.

A92-12899
SPACE STATION FREEDOM CAPABILITIES FOR MICROGRAVITY MATERIAL PROCESSING
HARVEY J. WILLENBERG (Boeing Defense and Space Group, Huntsville, AL) IN: AIAA/IKI Microgravity Science Symposium, 1st, Moscow, USSR, May 13-17, 1991, Proceedings 1991 7 p
Copyright

The present configuration planned for the Space Station Freedom is presented with specific attention given to the development of technologies and materials under conditions of microgravity. The resource capability of the entire station is defined and broken down for particular research areas including the United States Laboratory (USL). The modular interior of the USL is discussed including the layout, payload configuration, payload rack dimensions, and the implications of the facilities for conducting research. The replaceable logistics elements are important for exchanging materials, crewmembers, specimens, and samples as research directions change. Flexibility is further enhanced by the 55 racks which can be used to manifest payloads throughout the station, and the USL payloads provide power, thermal control, data, and video services. C.C.S.

A92-12901
SADKO PROJECT - NEW POSSIBILITIES FOR FUNDAMENTAL RESEARCH IN MATERIALS SCIENCE AND PHYSICS OF FLUIDS UNDER MICROGRAVITY
V. M. BALEBANOV, L. L. REGEL', V. P. SHALIMOV, A. M. TURCHANINOV, A. A. VEDERNIKOV, M. B. SHCHERBINA-SAMOILOVA (AN SSSR, Institut Kosmicheskikh Issledovanii, Moscow, USSR), V. M. KOVTUNENKO, R. S. KREMNEV, N. A. MOROZOV, B. D. IAKOVLEV (NPO Lavochkin, Moscow, USSR) et al. IN: AIAA/IKI Microgravity Science Symposium, 1st, Moscow, USSR, May 13-17, 1991, Proceedings 1991 7 p
Copyright

The development of an unmanned cargo platform for use with the Phobos spacecraft is reviewed with attention given to scientific instrumentation for studying materials and fluids under microgravity conditions. The technological hardware presented includes: (1) a multipurpose universal resistive furnace for specimen processing called the ChSK-3; (2) a second furnace with higher temperature and processing capabilities called the ABC; and (3) the RGA system for studying crystal growth in solutions with precision recording systems. The Sadko spacecraft is described and found to be capable of supporting the scientific instrumentation when built according to the specifications presented. Sadko is a revised version of the Mars-94 project with a Vega spacecraft lander which can support the technologies for fundamental research on materials and fluid physics. C.C.S.

A92-12904
EQUIPMENT SET 'BIRYUZA' AND 'ANALIZ' FOR ZERO-GRAVITY STATE STUDY
W. KH. GATAULLIN, SH. A. VAKHIDOV, V. I. SMYSHLIAEV, and N. V. ALEKSEENKO IN: AIAA/IKI Microgravity Science Symposium, 1st, Moscow, USSR, May 13-17, 1991, Proceedings 1991 2 p refs
Copyright

The equipment designed for investigating heat-mass exchange in microgravitational environments is described with attention given to results of specific experiments. The TB01 equipment is basically composed of a universal thermostat (Biryuza) and an automatic measuring device for electric currents (Analiz). The Biryuza provides the environment for investigating physical and chemical processes in solutions, gels, etc., and the Analiz can make direct measurements during the course of the space flight. Experiments conducted with the TB01 include temperature control and apparatus calibration as well as the study of chemical reactions in a zero-gravity environment. The TB01 is presently being revised by introducing a microcalculator and a disk-memory system into the device and providing compatibility with a common class of computers. C.C.S.

A92-12907* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
OPERATIONAL PERSPECTIVES FOR PERFORMING MICROGRAVITY SCIENCE IN ORBIT
BONNIE J. DUNBAR (NASA, Johnson Space Center, Houston, TX) IN: AIAA/IKI Microgravity Science Symposium, 1st, Moscow, USSR, May 13-17, 1991, Proceedings 1991 4 p
Copyright

The combination of automation and operator-based technologies is discussed with respect to orbital microgravity experiments in order to optimize the performance and results. A list of five design objectives is presented, and each item is examined in terms of on-orbit flight history to identify relevant examples. It is suggested that human factors be considered in hardware design and that in-flight maintenance operations be considered an integral part of a program. The operational design can produce more effective results when it is established for 'failures' and mission success operations. The design must also be approached in terms of both the limitations and advantages of microgravity. The overarching theme of the investigation is that the mix of automation and operator interaction should be optimized by automating routine tasks and using the operator for critical assessments. C.C.S.

A92-14229
RF TUBES FOR SPACE-BASED ACCELERATORS
A. S. GILMOUR, JR. (New York, State University, Buffalo), B. R. GRAY (USAF, Rome Laboratories, Griffiss AFB, NY), and G. K. FARNEY IEEE Transactions on Electron Devices (ISSN 0018-9383), vol. 38, Oct. 1991, p. 2190-2204. Research supported by Southeastern Center for Electrical Engineering Education and SDIO. Oct. 1991 15 p refs
Copyright

The authors analyze and classify high-power RF tubes for possible application to space-borne linear accelerators at frequencies of 425, 850, and 1700 MHz. Devices considered include relatively conventional tubes such as klystrons, klystrodes, magnetrons, and crossed-field amplifiers; various novel devices such as the trirotron, timatron, lasertron, and gigatron; Soviet accelerator tubes (the martotron, gyrocon, and magnicon); the peniotron; and the resnatron. Primary factors considered in analyzing the devices were accelerator compatibility, weight, and efficiency. In addition, problems of thermal management, regulation, pulsing, and operating voltage were addressed. Several suggestions, recommendations, and results generated during the study are included. I.E.

A92-14237
DYNAMIC INTERACTIONS BETWEEN RF SOURCES AND LINAC CAVITIES WITH BEAM LOADING
B. R. CHEO (Polytechnic Institute, Farmingdale, NY) and STEPHAN P. JACHIM (Los Alamos National Laboratory, NM) IEEE Transactions on Electron Devices (ISSN 0018-9383), vol. 38, Oct. 1991, p. 2264-2274. Research supported by DOE. Oct. 1991 11 p refs
(Contract DNA001-85-C-0182)
Copyright

The issues of space-based, high-average-power, high-energy linear accelerators (LINACs) are addressed in connection with the associated RF power interaction problems. The basic operating principles of three types of LINACs are reviewed. Models of the RF source/accelerator cavity interaction, including beam loading, are presented. A one-port, single-mode cavity model is shown. Sufficient theoretical background on the transient analysis is given. The authors describe a modeling effort for a multimode, multiport system, including the effects of the drive circuitry. The authors discuss the utility of the models developed. I.E.

A92-14735
HIGH PERFORMANCE POINTING CONTROL SYSTEM DEVELOPMENT AT BRITISH AEROSPACE FOR ASTRONOMY PLATFORMS IN SPACE
W. J. ALLDRIDGE (British Aerospace /Space Systems/, Ltd., Earth Observation and Science Div., Filton, England) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 8 p. Oct. 1991 8 p refs
(IAF PAPER 91-322) Copyright

The Very High Pointing Accuracy (VHPA) Technology Research Program (TRP) is reviewed. Particular attention is given to reaction wheel testing, gyro testing, improved star tracker design, controller design and parameter identification, thruster control/flexible interaction, thermal distortion effects on GNC, and performance verification. O.G.

A92-14765
PROGRESS IN THE DESIGN AND DEVELOPMENT OF A MICROGRAVITY ISOLATION MOUNT FOR COLUMBUS
R. G. OWEN, D. I. JONES, A. R. OWENS, G. ROBERTS, P. HADFIELD (North Wales, University College, Bangor, Wales), and A. A. ROBINSON (ESTEC, Noordwijk, Netherlands) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 10 p. Oct. 1991 10 p refs
(Contract ESTEC-7637/88)
(IAF PAPER 91-379) Copyright

The microgravity isolation mount (MGIM) is a facility which provides active vibration isolation for sensitive experiments and is designed to be accommodated in a standard Columbus rack. The experiment floats inside the rack and its position is controlled by magnetic actuators. Non-contact methods of transferring electrical power, heat and data between the rack and the experiment have been developed in order to avoid introducing compliant elements which might degrade the acceleration environment. Vibration testing of a full-scale laboratory mock-up of the MGIM has demonstrated that the present MGIM provides effective vibration isolation in the 0.001 to 3 Hz frequency range. Author

A92-14766
SOLIDIFICATION OF SILVER-GERMANIUM ALLOYS IN AN AMORPHOUS MATRIX ABOARD THE SPACE STATION MIR
A. BEWERSDORFF, G. P. GOERLER, G. OTTO, K. WITTMANN (DLR, Cologne, Federal Republic of Germany), L. L. REGEL', V. SHALIMOV (AN SSSR, Moscow, USSR), C. BARTA, F. FENDRYCH, and A. TRISKA (Czechoslovak Academy of Sciences, Prague, Czechoslovakia) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p refs
(IAF PAPER 91-383) Copyright

An initial experiment aimed at establishing the undercooling properties of eutectic alloys embedded in an inert matrix under microgravity conditions was conducted aboard the Mir orbital laboratory. Metallic samples of the Ag-Ge eutectic system were embedded in a boron-trioxide matrix and processed in the CSK-1 space furnace. The undercooled melt droplets solidified spontaneously without contact to container walls and without any indication of sedimentation. R.E.P.

A92-14776
SPACECRAFT MICRO-GEE VIBRATION ISOLATION WITH ENHANCED PERFORMANCE VIA FEEDBACK CONTROL
MATHIEU MERCADAL, CARL A. BLAUROCK, ANDREAS H. VON FLOTOW, and MORMAN M. WERELEY (MIT, Cambridge, MA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. Research supported by McDonnell Douglas Space Systems Co. Oct. 1991 12 p refs
(IAF PAPER 91-412) Copyright

A laboratory prototype of a six-axis microgravity isolation mount is presented, that isolates its payload from the vibrations of the spacecraft that carries it into space. The carrier envisioned for ferrying the payload is the NASA Space Shuttle, but the design is equally applicable to Space Station Freedom. The isolation mount is expected to reduce the milli-GEE (0.00981 m/sec per sec) vibration of the orbiter cabin to micro-GEE levels inside the isolated payload. The mount accommodates data, power, and cooling umbilicals of limited stiffness. Author

A92-14778
EXPRES - A EUROPEAN SYSTEM TO DISTRIBUTE INFORMATION ON MICROGRAVITY EXPERIMENTS
PH. WILLEKENS (ESA, Paris, France), CH. HOEHNE (ESA, European Space Research Institute, Frascati, Italy), L. CAROTENUTO, C. MIRRA, V. DE CHIARA, F. M. SACERDOTI, R. VICINANZA (Microgravity Advanced Research and Support Center, Naples, Italy), K. WITTMANN, D. PADEKEN, H. DUWE (Microgravity User Support Center, Federal Republic of Germany) et al. IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p
(IAF PAPER 91-416) Copyright

The development and dissemination strategy are delineated for a database that provides information on experiments related to microgravity including materials sciences and life sciences. A consortium of aerospace agencies including NASA and ESA are establishing a multidisciplinary technical database as an inventory with extended abstract characteristics. The project is based on an existing microgravity database that is integrated with the Columbus Utilisation Information System. The database includes relevant experimental information including the objectives, results, and carrier systems from specific projects. Results of information collection and data structuring indicate that the ExpRes system can provide a synthetic overview of significant microgravity experiments. Conceptual descriptions are given for the system architecture and the distribution of data. C.C.S.

A92-15267* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
SPACE STATION FURNACE FACILITY - A MULTIPURPOSE, HIGH TEMPERATURE MICROGRAVITY RESEARCH FACILITY
ARTHUR S. KIRKINDALL (NASA, Marshall Space Flight Center, Huntsville, AL) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p
(IAF PAPER 91-378) Copyright

This paper describes the Space Station Furnace Facility (SSFF) program. The SSFF is a new development intended to provide an advanced facility for materials research in the microgravity environment of the Space Station. The SSFF will be designed for research in metals, oxides, glasses, and alloy solidification and crystal growth of electronic and electrooptical materials. The facility will be designed to process multiple samples in one or more furnaces in an automated mode. The SSFF will be built around a general facility core which will provide common support functions not provided by the Space Station, subsystems which could best be centralized, and common subsystems which could be distributed with each experiment module. The SSFF will be capable of operation in both the manned and unmanned mode and is scheduled for early deployment aboard the Space Station.
Author

A92-17351
MODERN RADIO SCIENCE 1990
J. B. ANDERSEN, ED. (Aalborg, University, Denmark) Oxford, England and New York, Oxford University Press, 1990, 217 p. For individual items see A92-17352 to A92-17357. 1990 217 p
Copyright

This book discusses electromagnetic fields and the essence of living systems; scientific and technological research from manned space platforms; electromagnetic quantities, units, and standards in a changing International System of Units (SI); solution techniques for electromagnetic field problems; and the theory of electromagnetic interference control. Other topics discussed include satellite measurements of moisture variables and global change, the ionosphere from space, simulation methods for plasma wave research, new bioinformation from ultraweak photon emission in life and biological activities (biophoton), nonlinear networks and chaos, and polarization. I.S.

A92-17352
SCIENTIFIC AND TECHNOLOGICAL RESEARCH FROM MANNED SPACE PLATFORMS
OWEN K. GARRIOTT (Teledyne Brown Engineering, Huntsville, AL) IN: Modern radio science 1990 1990 7 p
Copyright

Based on experience gained from experiments conducted aboard Spacelab-1, -2, and -3, and D-1 Spacelab manned missions, five mission sequences were defined to more fully exploit the opportunity to conduct laboratory science in space. These include the International Microgravity Laboratory, the U.S. Microgravity Laboratory, the Spacelab Life Sciences, the Atmospheric Laboratory for Applications and Science, and the United States Microgravity Payloads. Each of these missions will focus on a major discipline but will also incorporate compatible science in other areas. Thus, fundamental issues related to the adaptation of man to weightlessness will be studied in experiments in which crew members of every mission will be used as subjects. I.S.

A92-19062* Virginia Univ., Charlottesville.
CONTROL ISSUES OF MICROGRAVITY VIBRATION ISOLATION
C. R. KNOSPE, R. D. HAMPTON, and P. E. ALLAIRE (Virginia, University, Charlottesville) Acta Astronautica (ISSN 0094-5765), vol. 25, Nov. 1991, p. 687-697. Research supported by NASA. Nov. 1991 11 p refs
Copyright

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 designs. For example, it is shown that a focus on equivalent stiffness in isolation system design leads to a controller that sacrifices robustness for performance. Control theory as applied to vibration isolation is reviewed and passive analogies are discussed. The loop shaping trade-off is introduced and used to design a single-degree-of-freedom fedback controller. An algebraic control design methodology is contrasted to loop shaping and critiqued. Multi-axis vibration isolation and the problems of decoupled single loop control are introduced through a two-degree-of-freedom example problem. It is shown that center of mass uncertainty may result in instability when decoupled single loop control is used. This results from the ill-conditioned nature of the feedback control design. The use of the Linear Quadratic Regulator synthesis procedure for vibration isolation controller design is discussed.
Author

A92-20230
STUDY OF A HARD X-RAY CONCENTRATOR VIA CRYSTAL DIFFRACTION
F. FRONTERA (Ferrara, Universita; CNR, Istituto di Studio e Technologie sulle Radiazioni Extraterrestri, Bologna, Italy), P. DE CHIARA, and G. PASQUALINI (Ferrara, Universita, Italy) IN: EUV, X-ray, and Gamma-ray instrumentation for astronomy; Proceedings of the Meeting, San Diego, CA, July 11-13, 1990 1990 8 p refs
Copyright

The results of a Monte Carlo study of a hard X-ray concentrator for space astronomy are presented. This report is a part of a systematic study devoted to investigate the possibility of utilizing the Bragg diffraction technique to concentrate hard X-rays. In the Monte Carlo study a concentrator made of confocal mirrors with paraboloidal shape is considered. The mirror material is graphite (002) with mosaic structure. The main photon interactions of hard X-rays with the concentrator are simulated. Effective area and optical properties of a particular configuration of concentrator with shape that could be easily accommodate on the Space Station or aboard a free-flyer are given. Expected performances are discussed. Author

A92-20389* Alabama Univ., Huntsville.
ANALYSIS OF SPACELAB 3 RESIDUAL ACCELERATION DATA
MELISSA J. B. ROGERS and J. I. D. ALEXANDER (Alabama, University, Huntsville) Journal of Spacecraft and Rockets (ISSN

0022-4650), vol. 28, Nov.-Dec. 1991, p. 707-712. Dec. 1991 6 p refs
(Contract NAG8-759)
Copyright

A data reduction plan is being developed to efficiently process residual acceleration data, making such data more accessible to principal investigators of low-gravity experiments. Accelerometer data collected during the Spacelab 3 mission is being processed using a prototype version of this plan. The plan addresses various aspects of acceleration data analysis: the identification of disturbances that are intolerable to experiments, the investigation of acceleration orientations, the definition and characterization of the background acceleration corresponding to a given experiment time line, the isolation and examination of particular significant disturbances, and the identification of disturbance sources. Acceleration magnitude, frequency, and orientation are discussed: transient accelerations can have magnitudes as large as 0.01 g with frequency components no greater than 0.001 g. These accelerations fluctuate rapidly in orientation. The occurrence of disturbance sources in an orbiter is tentatively identified as a random process, whereas the response of the orbiter to given accelerations is considered deterministic. The need to continue monitoring of residual accelerations in orbiting space laboratories is stressed. Author

A92-20470
SOVIET FACILITIES FOR MATERIALS PROCESSING
P. SICKINGER (Kayser-Threde GmbH, Munich, Federal Republic of Germany), P. HOFMANN, K. KEMMERLE, R. KLETT, J. WINTER, E. WULF, I. V. BARMIN, I. G. FILATOV, A. V. EGOROV, A. S. SENCHENKOV et al. Microgravity Science and Technology (ISSN 0938-0108), vol. 4, Dec. 1991, p. 273-280. Dec. 1991 8 p refs
Copyright

Flight opportunities that can support the experimentation and processing of materials in a microgravity environment are listed which include the Foton, Nika-T, and MIR unmanned spacecraft. Also noted are the Splav experiment facilities which boast zone melting facilities, a gradient furnace, and an isothermal furnace. Lastly the upgrading of the Zona-4 temperature control is mentioned which is intended to prohibit changes in the width of the melting zone and thereby improve crystal-growth experiments. C.C.S.

A92-20534
HEAVY NUCLEUS COLLECTOR FOR SPACE STATION
P. B. PRICE (California, University, Berkeley) IN: Particle astrophysics - The NASA cosmic ray program for the 1990s and beyond 1990 4 p refs
Copyright

The planned Heavy Nucleus (HNC) experiment aboard the Space Station is discussed. The experiment will involve exposing an array of track-recording phosphate glass plates about 16 sq m in area for five yrs at an orbital inclination of 28.5 deg in order to measure the charge distribution of ultraheavy cosmic rays. The astrophysical goals of the experiment and the expected number of recorded events are discussed. C.D.

A92-20535
THE ASTROMAG FACILITY
GEORGE F. SMOOT (California, University, Berkeley) IN: Particle astrophysics - The NASA cosmic ray program for the 1990s and beyond 1990 9 p refs
Copyright

The Astromag, a large superconducting magnetic facility planned for the Space Station Freedom in the late 1990s, is discussed. The scientific objectives, magnet design, and safety issues of Astromag are addressed. The first-phase Astromag experiments are surveyed. C.D.

A92-20536
WIZARD - AN EXPERIMENT TO MEASURE THE COSMIC RAYS INCLUDING ANTI-PROTONS, POSITRONS, NUCLEI AND TO CONDUCT A SEARCH FOR PRIMORDIAL ANTIMATTER
R. L. GOLDEN (New Mexico State University, Las Cruces) IN: Particle astrophysics - The NASA cosmic ray program for the 1990s and beyond 1990 7 p refs
Copyright

The WiZard experiment will utilize the Astromag magnet facility onboard Space Station Freedom to explore the composition and energy spectra of low-Z cosmic rays. Particular emphasis will be placed on a search for primordial antimatter and measurement of antiproton and positron fluxes at energies up to 400 GeV. This paper presents the scientific goals and rationale; the experimental method is described and the present status of the WiZard project is summarized. Author

A92-20543* Minnesota Univ., Minneapolis.
THE C SHELL, AN ACTIVE DETECTOR OF UH NUCLEI
C. J. WADDINGTON and ROBERT R. CLINTON (Minnesota, University, Minneapolis) IN: Particle astrophysics - The NASA cosmic ray program for the 1990s and beyond 1990 5 p refs
(Contract NGR-24-005-050)
Copyright

This paper gives a brief description of the current status of the present program to develop a modular array of large electronic particle detectors. These modules were designed to study the UH nuclei in the cosmic radiation with eventual deployment on the Space Station or at a lunar base. This array would determine the abundances of elements from iron to the actinides and directly measure the energies of the lower energy nuclei. If the array was deployed on the Space Station, it would use the geomagnetic threshold to place limits on the higher energy nuclei, thus studying the energy spectrum up to about 10 GeV/n. Deployed at a lunar base, it would detect nuclei with energies down to the instrumental limit. Smaller versions could be flown on balloons to test and refine the modules. Author

A92-20840
PECULIARITIES OF THE SUBMICROSCOPIC ORGANIZATION OF CHLORELLA CELLS CULTIVATED ON A SOLID MEDIUM IN MICROGRAVITY
K. M. SITNIK, A. F. POPOVA (AN USSR, Institut Botaniki, Kiev, Ukrainian SSR), G. S. NECHITAILO (NPO Energiia, Moscow, USSR), and A. L. MASHINSKII (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) (Life sciences and space research XXIV/1/ - Gravitational biology; Proceedings of the Symposia 10 and 13 of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F1 and F2/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20827 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 1, 1992, p. 103-107. 1992 5 p refs
Copyright

A study was conducted of the submicroscopic organization of Chlorella vulgaris cells grown over 30 days on a solid agarized medium aboard the Mir orbital station. Comparative cytological analysis shows general regularities of rearrangements of the submicroscopic organization in Chlorella cells cultivated on both semiliquid and solid agarized nutrient media. R.E.P.

A92-20861* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ANIMAL RESEARCH FACILITY FOR SPACE STATION FREEDOM
SJOERD L. BONTING (NASA, Ames Research Center; SETI Institute, Moffett Field, CA) (Life sciences and space research XXIV/1/ - Gravitational biology; Proceedings of the Symposia 10 and 13 of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F1 and F2/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20827 07-51) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 1, 1992, p. 253-257. 1992 5 p refs
Copyright

An integrated animal research facility is planned by NASA for Space Station Freedom which will permit long-term, man-tended experiments on the effects of space conditions on vertebrates. The key element in this facility is a standard type animal habitat

which supports and maintains the animals under full bioisolation during transport and during the experiment. A holding unit accommodates the habitats with animals to be maintained at zero gravity; and a centrifuge, those to be maintained at artificial gravity for control purposes or for gravity threshold studies. A glovebox permits handling of the animals for experimental purposes and for transfer to a clean habitat. These facilities are described, and the aspects of environmental control, monitoring, and bioisolation are discussed. Author

A92-20990
C.E.B.A.S., A CLOSED EQUILIBRATED BIOLOGICAL AQUATIC SYSTEM AS A POSSIBLE PRECURSOR FOR A LONG-TERM LIFE SUPPORT SYSTEM?
V. BLUEM (Bochum, Ruhr-Universitaet, Federal Republic of Germany) (Life sciences and space research XXIV/4/ - Natural and artificial ecosystems; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission F /Meetings F10, F11, F1 and F12/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-20969 07-54) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 5, 1992, p. 193-204. 1992 12 p refs
(Contract BMFT-01-QV-85474; BMFT-01-QV-87180; BMFT-01-QV-88466)
Copyright

CEBAS-Aquarack is a long-term multigeneration experimental device for aquatic organisms which is disposed for utilization in a Space Station. It results from the basic idea of a space aquarium for maintaining aquatic animals for longer periods integrated in an Aquarack which consists of a modular animal-holding tank, a semibiological/physical water-recycling system and an electronic control unit. The basic idea to replace a part of the water-recycling system by a continuous culture of unicellular algae primarily leads to a second system for experiments with algae, a botanical Aquarack consisting of an algal reactor, a water recycling and the electronic control unit. The combination of the zoological part, and the botanical part with a common control system in the Aquarack, however, results in a Closed Equilibrated Biological Aquatic System' (CEBAS) representing a closed artificial ecosystem. Although this is disposed primarily as an experimental device for basic zoological, botanical, and interdisciplinary research, it opens the theoretical possibility to adapt it for combined production of animal and plant biomass on ground or in space. The basic conception of the hardware construction of the zoological part of the system is explained, with the corresponding scientific frame program including the choice of the experimental animals, and gives some selected examples of the hardware-related research. It further discusses the practical and economical relevance of the system in the development of a controlled aquatic life-support system in general. Author

A92-21795* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CONCEPTS OF BIOISOLATION FOR LIFE SCIENCES RESEARCH ON SPACE STATION FREEDOM
GLENN A. FUNK (NASA, Ames Research Center; GE Government Services, Moffett Field, CA) and CATHERINE C. JOHNSON (NASA, Ames Research Center, Moffett Field, CA) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 12 p. Jul. 1991 12 p refs
(SAE PAPER 911475) Copyright

The risk concepts related to biological research in space are defined with attention given to the design and operation of experimental hardware for NASA's Biological Flight Research Laboratory (BFRL). The definitions are set forth to describe safety measures for the use of nonhuman specimens in microgravity environments and the direct application of the risk-control concepts. Bioisolation is the process by which biological systems can coexist productively by means of physical, chemical, or biological methods; bioisolation requirements are given for mammals, plants, and microspecimens. The BRFL provides two levels of containment based on the complete sealing of all joints and interfaces in the Modular Habitat and an airflow system designed to provide net negative pressure of at least 0.13 kPa. The requirements are designed to assure a safe working environment for conducting nonhuman life-sciences research in the Space Station Freedom. C.C.S.

A92-21897* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TECHNOLOGY DEVELOPMENT ACTIVITIES FOR HOUSING RESEARCH ANIMALS ON SPACE STATION FREEDOM
JEFFREY W. JENNER, VLADIMIR M. GARIN, and FRANK D. NGUYEN (NASA, Ames Research Center, Moffett Field, CA) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 9 p. Jul. 1991 9 p refs
(SAE PAPER 911596) Copyright

The development and design of animal facilities are described in terms of the technological needs for NASA's Biological Flight Research Laboratory. Animal habitats are presented with illustrations which encompass waste-collection techniques for microgravity conditions that reduce the need for crew participation. The technology is intended to be highly compatible with animal morphology, and airflow is employed as the primary mechanism of waste control. The airflow can be utilized in the form of localized high-speed directed flow that simultaneously provides a clean animal habitat and low airflow rates. The design of an animal-habitat testbed is presented which capitalizes on contamination-control mechanisms and suitable materials for microgravity conditions. The developments in materials and technologies represent significant contributions for the design of the centrifuge facilities for the Space Station Freedom. C.C.S.

A92-21898* California Polytechnic State Univ., San Luis Obispo.
TRADE STUDY COMPARING SPECIMEN CHAMBER SERVICING METHODS FOR THE SPACE STATION CENTRIFUGE FACILITY
MICHAEL L. CALVISI (California Polytechnic State University, San Luis Obispo) and SIDNEY C. SUN (NASA, Ames Research Center, Moffett Field, CA) SAE, International Conference on Environmental Systems, 21st, San Francisco, CA, July 15-18, 1991. 14 p. Jul. 1991 14 p refs
(SAE PAPER 911597) Copyright

The Specimen Chamber Service Unit, a component of the Space Station Centrifuge Facility, must provide a clean enclosure on a continuing basis for the facility's plant, rodent and primate specimens. The specimen chambers can become soiled and can require periodic servicing to maintain a clean environment for the specimens. Two methods of servicing the specimen chambers are discussed: washing the chambers with an on-board washer, or disposing of the soiled chambers and replacing them with clean ones. Many of these issues are addressed by developing several servicing options, using either cleaning or replacement as the method of providing clean specimen chambers, and then evaluating each option according to a set of established quantitative and qualitative criteria. Disposing and replacing the Specimen Chambers is preferable to washing them. Author

A92-24305
HUBE - THE HOPKINS ULTRAVIOLET BACKGROUND EXPERIMENT
RANDY A. KIMBLE, RICHARD C. HENRY (Johns Hopkins University, Baltimore, MD), and FRANCESCO PARESCE (Johns Hopkins University; Space Telescope Science Institute, Baltimore, MD) IN: The galactic and extragalactic background radiation 1990 7 p refs
Copyright

The far-ultraviolet wavelength region between 1216 and 2000 A offers unusually favorable conditions for observing a variety of known or predicted diffuse emissions of both interstellar and extragalactic origin. A proposed instrument for studying those emissions, the Hopkins Ultraviolet Background Experiment (HUBE) is described. HUBE consists of two compact, fast components: a broadband camera (1350-2000 A) with 2 arcmin resolution and an imaging spectrograph (1230-1800 A) with 5 A resolution. These complementary components will be utilized for both a sky survey

and for sensitive deep pointings. As either a free-flying Scout-class satellite or as an attached payload on the Space Station, HUBE will make possible an investigation of unprecedented scope into the sources of the far ultraviolet background. Author

A92-25522
POLAR VISION
TIM FURNISS Flight International (ISSN 0015-3710), vol. 141, Feb. 12, 1992, p. 33-35. 12 Feb. 1992 3 p
Copyright

A review is presented of ESA's commitment to develop the Polar Orbit Earth Observation Mission (POEM) to be flown aboard the Polar Platform. Attention is given to the objectives of POEM 1, including extension of the range of observational parameters in line with environmental requirements, flying SAR, and providing demonstration flight opportunities for operational meteorological payloads. R.E.P.

A92-26310*# National Aeronautics and Space Administration, Washington, DC.
A MICROGRAVITY SCIENCE AND APPLICATIONS PROGRAM OVERVIEW
M. E. KICZA (NASA, Microgravity Science and Applications Div., Washington, DC) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 7 p. Jan. 1992 7 p
(AIAA PAPER 92-0472) Copyright

The Microgravity Science and Space Applications Program (MSSAP) is described in terms of the research it supports in fields related to physical processes and materials. Three primary fields are reviewed which include fundamental sciences such as transport phenomena, materials science, and biotechnology issues such as macromolecular crystal growth. The program strategy is to begin with MSSAP studies in ground-based facilities such as drop towers and to evolve to flight experiments as the research achieves technical maturity. Ground-based experiments in progress include the Acceleration Characterization and Analysis Project and the Solid Surface Combustion Experiment (SSCE). Several furnace experiments for materials studies are described including flight tests for the SSCE, and reference is given to a flight for the Protein-Crystal Growth Experiment. C.C.S.

A92-26379
MIRAS - OBSERVATION OF TRACE CONSTITUENTS OF THE STRATOSPHERE ON THE BASIS OF THE MIR STATION [MIRAS - UNE OBSERVATION DES CONSTITUANTS MINORITAIRES DE LA STRATOSPHERE A PARTIR DE LA STATION MIR]
G. GAUFFRE (ONERA, Chatillon, France), C. CAMY-PEYRET (Paris VI, Universite, France), and C. LIPPENS (Institut d'Aeronomie Spatiale de Belgique, Brussels, Belgium) (ICSO '91 - Conference Internationale d'Optique Spatiale, Toulouse, France, Sept. 25-27, 1991) ONERA, TP no. 1991-227, 1991, 12 p. In French. 1991 12 p In FRENCH refs
(ONERA, TP NO. 1991-227)

The MIRAS experiment, a collaboration between France, Belgium, and the former Soviet Union, is scheduled to be flown in 1995. Twelve molecules of the atmosphere which play a fundamental role in the thermal and chemical equilibria will be studied in their temporal, vertical, and horizontal distributions. Consideration is given here to the measurement methodology, the instrument used (a grid spectrometer), and the scientific program. L.M.

A92-26760
ATMOSPHERIC INSTRUMENTS ON ATLAS 1 AND EURECA 1 [INSTRUMENTS ATMOSPHERIQUES SUR ATLAS 1 ET EURECA 1]
C. MULLER (Institut d'Aeronomie Spatiale de Belgique, Brussels, Belgium) IN: The middle atmosphere and space observations; International Summer School on Space Physics, Marseille, France, Aug. 1990, Proceedings 1991 6 p In FRENCH refs
Copyright

The operation of the infrared grid spectrometer onboard Spacelab 1 and ATLAS 1 is described. Attention is also given to a project that involves flying an instrument of the same type on the manned station Mir 2. Orbital considerations are presented, and a description of the instrument is given. L.M.

A92-26761
THE USE OF THE EUROPEAN POLAR PLATFORM FOR MIDDLE ATMOSPHERE RESEARCH
C. J. READINGS (ESA, Paris, France) IN: The middle atmosphere and space observations; International Summer School on Space Physics, Marseille, France, Aug. 1990, Proceedings 1991 20 p
Copyright

Instruments which have been proposed for flight on the European Polar Platform for studying atmospheric chemistry and dynamics are examined. Emphasis is given to the GOME, SCIAMACHY, GOMOS, MIPAS, and DWS instruments, discussing the instrumental concepts, target species, and experimental significance. C.D.

A92-27001#
LIQUID PHASE EPITAXY - MODELLING AND SPACE EXPERIMENTS
V. I. POLEZHAEV and N. A. VEREZUB (AN SSSR, Institut Problem Mekhaniki, Moscow, USSR) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 10 p. Jan. 1992 10 p refs
(AIAA PAPER 92-0601) Copyright

The gravitational sensitivity for the geometrical uniformity of A3B5 semiconductor epitaxial layers is described for cases of microgravity (the Splav furnace on Salyut and Cosmos space stations), terrestrial environment, and mathematical modelling. The epilayer growth was carried out in a graphite container of the furnace high-temperature isothermal zone for the GaAs and GaP systems. A mathematical model for the layer growth from the saturated solution in the melt was developed using the unsteady Navier-Stokes equations. Results of space experiments and calculations show that there is possibility to eliminate liquid phase epitaxy (LPE) nonuniformities. A slow rotation of the LPE cell which realizes a special type of convection is proposed as one of alternatives to microgravity for controlling the geometrical nonuniformity of epilayers. O.G.

A92-28384
ULTRASTRUCTURAL ORGANIZATION OF CHLORELLA CELLS CULTIVATED ON A SOLID MEDIUM IN MICROGRAVITY [UL'TRASTRUKTURNA ORGANIZATSIIA KLITIN KHLORELI, VIROSHCHENIKH NA TVERDOMU POZHIVNOMU SEREDOVISHCHI V UMOVAKH MIKROGRAVITATSII]
A. F. POPOVA, K. M. SITNIK, E. L. KORDIUM, G. S. NECHITAILO, and O. L. MASHINS'KII (AN URSR, Institut Botaniki, Kiev, Ukrainian SSR) Akademiia Nauk Ukrains'koi RSR, Dopovidi, Matematika, Prirodoznavstvo, Tekhnichni Nauki (ISSN 0868-8052), Aug. 1991, p. 154-157. In Ukrainian. Aug. 1991 4 p In UKRAINIAN refs
Copyright

Chlorella cells grown for 30 days on board the Mir space station are found to differ from the control cells in their ultrastucture and relative volumes of the organelles and cell inclusions. Some of these changes are observed only in the chlorella cells cultivated on a solid medium. The observed changes in the submicroscopic organization of the chlorella cells grown on a solid medium in microgravity must be taken into account in developing techniques for plant growth in space. V.L.

A92-32451
COLUMBUS VII - SYMPOSIUM ON SPACE STATION UTILIZATION, 7TH, ANACAPRI, ITALY, JULY 1-6, 1991, PROCEEDINGS
Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, 155 p. For individual items see A92-32452 to A92-32470. Apr. 1992 155 p
Copyright

Topics presented include an overview of the Columbus program, a synthesis of the different aspects of Columbus utilization, Space Station program status, an overview of human physiology in microgravity, and requirements and needs in the field of materials science in space. Also presented are the Columbus Attached Laboratory capabilities, the status and prospects of the microgravity laboratories for Columbus, automation and robotics for Columbus utilization, and European external payloads on Columbus and SSF. R.E.P.

A92-32454
FLUID SCIENCE REQUIREMENTS FOR COLUMBUS
I. MARTINEZ (Madrid, Universidad Politecnica, Spain) (Columbus VII - Symposium on Space Station Utilization, 7th, Anacapri, Italy, July 1-6, 1991, Proceedings. A92-32451 12-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, p. 135-144. Apr. 1992 10 p refs
Copyright
The features of fluid science (FS) experimentation in microgravity are presented, pointing to a synthesis of general needs and requirements from the investigators for a space laboratory. Special attention is given to the characterization of fluid science in microgravity. The characteristics of FS experiments are considered in detail, and the geometry of the configuration (that best identifies an experiment) is categorized. R.E.P.

A92-32456
EVALUATION OF COLUMBUS ATTACHED LABORATORY (APM) CAPABILITIES AGAINST TWO FACILITY/EXPERIMENT SCENARIOS
D. HEYLAND and H. M. KAPPLER (DLR, Cologne, Federal Republic of Germany) (Columbus VII - Symposium on Space Station Utilization, 7th, Anacapri, Italy, July 1-6, 1991, Proceedings. A92-32451 12-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, p. 149-154. Apr. 1992 6 p refs
Copyright
A first draft version of a payload scenario that will serve for studies on the utilization of ground infrastructure covering four years of Columbus operation is discussed. The resources timelined for the APM include orbit (coverage/noncoverage periods computed and taken into account for w.r.t. data transmission), outfitting (taken into account for facility composition), power/energy, and data rate. As Columbus laboratory layouts and experiment processing are only weakly defined in certain areas, knowledge from facilities/experiments to be flown on the Spacelab D2 mission has been introduced for a more realistic facility/experiment scenario. R.E.P.

A92-32457
THE COLUMBUS ATTACHED LABORATORY CAPABILITIES
ERNESTO VALLERANI, SAVERIO LIOY, and LUIGI D'EMILIANO (Alenia Spazio S.p.A., Turin, Italy) (Columbus VII - Symposium on Space Station Utilization, 7th, Anacapri, Italy, July 1-6, 1991, Proceedings. A92-32451 12-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, p. 155-165. Apr. 1992 11 p
Copyright
The principal technical and architectural features of the current Columbus Attached Laboratory, as derived from external and internal system requirements, in connection with achieving overall performance capability and compatibility with the SSF are presented. Relevant aspects and design solutions are described in the field of required resources, payload, and crew accommodation. The interoperability regime that regulates Columbus Attached Laboratory on-orbit life in its integrated role within the SSF is addressed in some of its principal features. R.E.P.

A92-32458
THE MICROGRAVITY LABORATORIES FOR COLUMBUS - STATUS AND PROSPECTS
PAUL CLANCY (ESA, Microgravity and Columbus Utilisation Dept., Paris, France) (Columbus VII - Symposium on Space Station Utilization, 7th, Anacapri, Italy, July 1-6, 1991, Proceedings. A92-32451 12-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, p. 167, 168. Apr. 1992 2 p
Copyright
This paper describes the planning for the Columbus Attached Laboratory of the International Space Station Freedom. These facilities will allow research in the areas of basic biology, materials science, fluid sciences and human physiology to be carried out in the ESA Attached Laboratory. A short description of the status of study activities for these four main laboratories Biolab, High Temperature Materials Processing Lab (HTMPL), Fluid Science Lab (FSL), and Anthrolab is given. The impact of important aspects such as automation and robotics, telescience and other operational aspects are discussed. In addition, some preliminary studies for facilities for the Free Flying Laboratory are described. Author

A92-32459
FLUID SCIENCE LABORATORY
R. MONTI (Napoli, Universita, Naples, Italy) (Columbus VII - Symposium on Space Station Utilization, 7th, Anacapri, Italy, July 1-6, 1991, Proceedings. A92-32451 12-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, p. 169-173. Apr. 1992 5 p
Copyright
A technical evaluation of the Fluid Science Laboratory (FSL) is presented, giving the scientific objectives and the means of meeting the users requirements. The basic facilities and the major diagnostic equipment to meet these requirements are described. The information acquired from this evaluation underlines the importance for the rational and best design of the FSL, to keep up with the evolution of the boundary conditions related to SSF and to the Columbus scenarios. R.E.P.

A92-32460
SPACE SCIENCE USING COLUMBUS (5) EXTERNAL PAYLOADS
HENK OLTHOF (ESTEC, Noordwijk, Netherlands) and EBERHARD SCHULZ-LUEPERTZ (MBB GmbH, Ottobrunn, Federal Republic of Germany) (Columbus VII - Symposium on Space Station Utilization, 7th, Anacapri, Italy, July 1-6, 1991, Proceedings. A92-32451 12-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, p. 175-179. Apr. 1992 5 p refs
Copyright
Recently the capability for mounting attached payloads to the main structure of the International Space Station 'Freedom' has been substantially reduced. The Columbus project is considering the possibility of exchanging the scientific airlock for a more versatile external mounting structure at the end cone of the Columbus Attached Laboratory. This paper addresses the accommodation of a few space science (Astronomy and Solar Physics) experiments on such an external mounting platform and assesses their observing capability. Author

A92-32461
UTILIZATION SUPPORT ACTIVITIES - TELESCIENCE
R. MONTI (Napoli, Universita, Naples, Italy), G. NAJA (ESA, Paris, France), and R. FORTEZZA (Microgravity Advanced Research and Support Center, Naples, Italy) (Columbus VII - Symposium on Space Station Utilization, 7th, Anacapri, Italy, July 1-6, 1991, Proceedings. A92-32451 12-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, p. 181-188. Apr. 1992 8 p refs
Copyright
'Telescience' is a novel operative mode which allows a principal investigator to interactively control scientific experiments performed aboard a space platform from a ground station; the execution of an experiment can in this way be modified on the basis of emerging information. Communications links that are entirely transparent to the scientist are required, in conjunction with a verification capability for remote payload-controls. Both physical simulations and true

microgravity experiments are to be used in hardware and software evaluation. ESA envisions the use of telescience aboard the Columbus. The Columbus-related telescience projects thus far envisioned are discussed with a view to their remote-control integration. O.C.

A92-32462
MARS-MEC - INTEGRATION OF MARS MICROGRAVITY DATABANK IN CUIS
PH. WILLEKENS (ESA, Microgravity and Columbus Utilisation Dept., Paris, France), C. HOEHNE (ESA, European Space Research Institute, Frascati, Italy), L. CAROTENUTO, V. DE CHIARA, C. MIRRA, F. M. SACERDOTI, and R. VICINANZA (Microgravity Advanced Research and Support Center, Naples, Italy) (Columbus VII - Symposium on Space Station Utilization, 7th, Anacapri, Italy, July 1-6, 1991, Proceedings. A92-32451 12-12) Space Technology - Industrial and Commercial Applications (ISSN 0892-9270), vol. 12, April 1992, p. 197-200. Apr. 1992 4 p refs
Copyright

An overview is presented of the ESA Columbus Utilization Information System (CUIS) with emphasis on the microgravity data bank (MDB) for collecting scientific and technical information related to microgravity experiments. The conception and development of MARS-MEC, considered to be the first prototype of the catalog element of the MDB, are discussed. The principal elements of MDB are a bibliographic database and a catalog of the microgravity experiments, plus a directory of the microgravity users and a database of technical documentation. R.E.P.

N92-10031*# Research Inst. for Advanced Computer Science, Moffett Field, CA.
TELESCIENCE TESTBED PILOT PROGRAM, VOLUME 1: EXECUTIVE SUMMARY Final Report
BARRY M. LEINER Feb. 1989 45 p
(Contract NASW-4234)
(NASA-CR-188833; NAS 1.26:188833; RIACS-TR-89-7) Avail: CASI HC A03/MF A01

Space Station Freedom and its associated labs, coupled with the availability of new computing and communications technologies, have the potential for significantly enhancing scientific research. A Telescience Testbed Pilot Program (TTPP), aimed at developing the experience base to deal with issues in the design of the future information system of the Space Station era. The testbeds represented four scientific disciplines (astronomy and astrophysics, earth sciences, life sciences, and microgravity sciences) and studied issues in payload design, operation, and data analysis. This volume, of a 3 volume set, which all contain the results of the TTPP, is the executive summary. Author

N92-10112*# Alabama Univ., Huntsville. Center for Microgravity and Materials Research.
PROCESS MODELLING FOR SPACE STATION EXPERIMENTS Final Report
J. IWAN D. ALEXANDER, FRANZ ROSENBERGER, ARUNAN NADARAJAH, JALIL OUAZZANI, and SAKIR AMIROUDINE 17 Oct. 1990 141 p
(Contract NAS8-36955)
(NASA-CR-184227; NAS 1.26:184227) Avail: CASI HC A07/MF A02

Examined here is the sensitivity of a variety of space experiments to residual accelerations. In all the cases discussed the sensitivity is related to the dynamic response of a fluid. In some cases the sensitivity can be defined by the magnitude of the response of the velocity field. This response may involve motion of the fluid associated with internal density gradients, or the motion of a free liquid surface. For fluids with internal density gradients, the type of acceleration to which the experiment is sensitive will depend on whether buoyancy driven convection must be small in comparison to other types of fluid motion, or fluid motion must be suppressed or eliminated. In the latter case, the experiments are sensitive to steady and low frequency accelerations. For experiments such as the directional solidification of melts with two or more components, determination of the velocity response alone is insufficient to assess the sensitivity. The effect of the velocity on the composition and temperature field must be considered, particularly in the vicinity of the melt-crystal interface. As far as the response to transient disturbances is concerned, the sensitivity is determined by both the magnitude and frequency of the acceleration and the characteristic momentum and solute diffusion times. The microgravity environment, a numerical analysis of low gravity tolerance of the Bridgman-Stockbarger technique, and modeling crystal growth by physical vapor transport in closed ampoules are discussed. Author

N92-11217*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MICROGRAVITY VIBRATION ISOLATION: AN OPTIMAL CONTROL LAW FOR THE ONE-DIMENSIONAL CASE
R. D. HAMPTON (Virginia Univ., Charlottesville.), C. M. GRODSINSKY (Virginia Univ., Charlottesville.), P. E. ALLAIRE (Virginia Univ., Charlottesville.), D. W. LEWIS, and C. R. KNOSPE (Virginia Univ., Charlottesville.) Oct. 1991 23 p
(Contract RTOP 694-03-0C)
(NASA-TM-105146; E-6422; NAS 1.15:105146) Avail: CASI HC A03/MF A01

Certain experiments contemplated for space platforms must be isolated from the accelerations of the platforms. 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 (preview) 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 (less than 50 Hz) 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

N92-11918*# Research Inst. for Advanced Computer Science, Moffett Field, CA.
AN APPLICATION FOR MULTI-PERSON TASK SYNCHRONIZATION
ROBERT L. BROWN and DEE DOYLE Jul. 1990 14 p
(Contract NCC2-387)
(NASA-CR-187712; NAS 1.26:187712; RIACS-TR-90-24) Avail: CASI HC A03/MF A01

Computer applications are studied that will enable a group of people to synchronize their actions when following a predefined task sequence. It is assumed that the people involved only have computer workstations available to them for communication. Hence, the approach is to study how the computer can be used to help a group remain synchronized. A series of applications were designed and developed that can be used as vehicles for experimentation. An example of how this technique can be used for a remote coaching capability is explained in a report describing an experiment that simulated a Life Sciences experiment on-board Space Station Freedom, with a ground based principal investigator providing the expertise by coaching the on-orbit mission specialist. Author

N92-12430*# Analex Corp., Cleveland, OH.
MICROGRAVITY SCIENCE REQUIREMENTS AND THE NEED FOR DATA COMPRESSION
WILLIAM G. HARTZ *In* NASA. Goddard Space Flight Center, Space and Earth Science Data Compression Workshop p 51-56 Nov. 1991
Avail: CASI HC A02/MF A01

The Microgravity Science and Applications Div. (MSAD) of the NASA Office of Space Science and Applications (OSSA) is responsible for encouraging and directing the research of a wide range of physical phenomena in reduced gravity. Under MSAD's

direction, NASA-Lewis is presently developing the concept of a multiuser facility which will perform combustion science experiments in space. This facility, the Combustion Experiment Module (CEM), will be located in either the Shuttle Spacelab or the Space Station Freedom lab and will be operational by mid-1997. In addition to standard instrumentation to measure temperature, pressure, and acceleration, CEM shall use a variety of imaging and optical diagnostic techniques. Images shall be the primary source of experimental data. These images create an enormous amount of data which must be archived on orbit for later analysis. Also, ground based investigators will require enough data from the orbiting facility to determine if the experimental parameters need to be changed before proceeding with the next run. The storage and transmission of this data present a major challenge to the CEM design. Data compression will play a major role in the design of the CEM diagnostics system. Author

N92-13083# Joint Publications Research Service, Arlington, VA.
RESULTS FROM PLANT GROWTH EXPERIMENTS ABOARD ORBITAL STATIONS
A. VOLKOV, S. KRIKALEV, and G. NECHITAYLO *In its* JPRS Report: Science and Technology. USSR: Space p 28-29 30 Jul. 1990 Transl. into ENGLISH from Pravda, Moscow (USSR), 22 Oct. 1989 p 3
Avail: CASI HC A01/MF A01

A general description of research involving plant growth experiments aboard U.S.S.R. orbital space stations is given. Weightlessness effects, gravitational effects, and the plant development cycle in relation to life support systems are briefly discussed. The development of a new polymer material, polyacrylamide gel, is described. Other experiments with animal and plant tissues are described. Author

N92-13151*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SPACE ACCELERATION MEASUREMENT SYSTEM DESCRIPTION AND OPERATIONS ON THE FIRST SPACELAB LIFE SCIENCES MISSION
RICHARD DELOMBARD and BRIAN D. FINLEY (Sverdrup Technology, Inc., Brook Park, OH.) Nov. 1991 28 p
(Contract NAS3-25266; RTOP 694-03-OH)
(NASA-TM-105301; E-6648; NAS 1.15:105301) Avail: CASI HC A03/MF A01

The Space Acceleration Measurement System (SAMS) project and flight units are briefly described. The SAMS operations during the STS-40 mission are summarized, and a preliminary look at some of the acceleration data from that mission are provided. The background and rationale for the SAMS project is described to better illustrate its goals. The functions and capabilities of each SAMS flight unit are first explained, then the STS-40 mission, the SAMS's function for that mission, and the preparation of the SAMS are described. Observations about the SAMS operations during the first SAMS mission are then discussed. Some sample data are presented illustrating several aspects of the mission's microgravity environment. Author

N92-13984# Toronto Univ., Downsview (Ontario). Inst. for Aerospace Studies.
MATERIALS PROCESSING IN SPACE
R. C. TENNYSON, N. SALANSKY, W. D. MORISON, G. FISHBEIN et al. *In its* Activities of the University of Toronto Institute for Aerospace Studies p 90-91 1989
Avail: CASI HC A01/MF A02

Several programs are currently underway at the University of Toronto Institute for Aerospace Studies (UTIAS) in the area of materials processing in space, including: (1) the design and development of some hardware components for a NASA space-based molecular beam epitaxy facility for growing thin films; (2) a continued evolution of a multipurpose test bed, capable of supporting a range of demonstration experiments on NASA's KC-135 microgravity aircraft, designed to prepare a television program on microgravity science; (3) the development and testing of atomic oxygen, temperature, vacuum, and ultraviolet resistant thermal control materials and coatings for spacecraft applications; and (4) evaluation of material degradation of composite samples recovered from the Long Duration Exposure Facility. CISTI

N92-17411*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
FACING PAGE TEST FOR THE ASTRONAUT SCIENCE ADVISOR PRESENTATION
MICHAEL M. COMPTON *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Statin Evolution Symposium. Volume 1: Space Station Freedom, Part 2 p 367-391 Sep. 1991
Avail: CASI HC A03/MF A03

The goal of the Astronaut Science Advisor (ASA) project is to improve the scientific return of experiments performed in space by providing astronaut experimenters with an 'intelligent assistant' that encapsulates much of the domain- and experiment-related knowledge commanded by the Principal Investigator (PI) on the ground. By using expert systems technology and the availability of flight-qualified personal computers, it is possible to encode the requisite knowledge and make it available to astronauts as they perform experiments in space. The system performs four major functions: diagnosis and troubleshooting of experiment apparatus, data collection, protocol management, and detection of interesting data. The experiment used for development of the system measures human adaptation to weightlessness in the context of the neurovestibular system. This so-called 'Rotating Dome' experiment was flown on the recent Spacelab Life Sciences One (SLS-1) Mission. This mission was used as an opportunity to test some of the system's functionality. Experiment data was downlinked from the orbiter, and the system then captured the data and analyzed it in real time. The system kept track of the time being used by the experiment, recognized occurrences of interesting data, summarized data statistically and generated potential new protocols that could be used to optimize the course of the experiment. Author

N92-17412*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE ASTRONAUT SCIENCE ADVISOR: GROUND TESTING DURING SLS-1
MICHAEL M. COMPTON *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 1: Space Station Freedom, Part 2 p 393-416 Sep. 1991
Avail: CASI HC A03/MF A03

The objective of the Astronaut Science Advisor (ASA) is the improvement of the scientific return of experiments performed in space. This is accomplished through the use of expert systems technology to encode the domain and experiment knowledge commanded by the principal investigator (PI) and make it available to the astronaut experimenters. The principal functions of the ASA include the following: capture, reduce, and archive experimental data; monitor data quality and help diagnose problems with equipment when experimental data is erratic or poor; identify and permit investigation of interesting data; and suggest protocol changes that would result in better utilization of remaining time. Author

N92-20353*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SPACE STATION CENTRIFUGE: A REQUIREMENT FOR LIFE SCIENCE RESEARCH
ARTHUR H. SMITH (California Univ., Davis.), CHARLES A. FULLER, CATHERINE C. JOHNSON, and CHARLES M. WINGET Feb. 1992 27 p Conference held in Davis, CA, Jan. 1986
(Contract RTOP 199-80-02)
(NASA-TM-102873; A-90309; NAS 1.15:102873) Avail: CASI HC A03/MF A01

A centrifuge with the largest diameter that can be accommodated on Space Station Freedom is required to conduct life science research in the microgravity environment of space. (This was one of the findings of a group of life scientists convened

at the University of California, Davis, by Ames Research Center.) The centrifuge will be used as a research tool to understand how gravity affects biological processes; to provide an on-orbit one-g control; and to assess the efficacy of using artificial gravity to counteract the deleterious biological effect of space flight. The rationale for the recommendation and examples of using ground-based centrifugation for animal and plant acceleration studies are presented. Included are four appendixes and an extensive bibliography of hypergravity studies. Author

N92-22091# National Space Development Agency, Tokyo (Japan). Space Experiment Group.
DEVELOPMENT OF FMPT (FUWATTO 1991)
NORIO SOICHI *In its* Preprints of NASDA's 5th Technical Symposium p 31-63 1 Jun. 1990 In JAPANESE; ENGLISH summary
Avail: CASI HC A03/MF A03

The First Material Processing Test (FMPT) is Japan's first experience in conducting manned space experiments. Twenty-two material science experiments and twelve life science experiments were selected and have been developed for the flight using the Space Shuttle/Spacelab module. Major instrument systems have been developed by the National Space Development Agency of Japan (NASDA) and will be installed in three double racks. The Shuttle, on which a Japanese Payload Specialist (PS) will conduct experiments for the first time with some American crew members, is scheduled to be launched on 17 Jun. 1991. Experiments and flight hardwares are fully developed, and FMPT seems to be a good example and precedent for future space environment utilization. Author (NASDA)

20

PLATFORMS & TETHERS

Descriptions and requirements of independent experimental platforms or missions using tethers aboard space stations.

A92-12437
THE SPOT MKII BUS - A KEY TO EARTH OBSERVATION IN THE 90'S
J. AUBERTIN, C. BILLARD, and P. RANZOLI (Matra Espace, Toulouse, France) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 6 p. Oct. 1991 6 p
(IAF PAPER 91-013) Copyright

The major technical characteristics of the second-generation multimission earth observation platform (MKII) are discussed. The MKII incorporates a number of improvements brought into most of the MKI subsystems to extend the mission capabilities, achieve better performance, and increase mission lifetime. The first two missions using the MKII platform will be SPOT 4, program and Helios reconnaissance program. In addition, an enhanced version of MKII was selected by ESA for the European Polar Platform. The paper describes the various potential missions that can be accommodated by MKII and suggests the programmatic issues for consideration by new programs. Diagrams of the MKII bus are included. I.S.

A92-12462
SMALL SPACEBORNE PLATFORMS TO MONITOR CANADA'S ENVIRONMENT AND RESOURCES
MARIE-JOSE MONTPETIT and IVOR C. BARNARD (Spar Aerospace, Ltd., Satellite and Communications Systems Div., Sainte-Anne-de-Bellevue, Canada) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 11 p. Oct. 1991 11 p refs
(IAF PAPER 91-044) Copyright

The paper discusses an approach to a remote-sensing small-satellite (smallsat) design for monitoring Canada's environment and natural resources. Special attention is given to the preliminary design issues of a smallsat system, the possible Canadian smallsat missions, the user's requirements, the sensor requirements and technologies, data handling, ground stations, and data distribution. Areas needing further development are identified. I.S.

A92-12522
THE EUROPEAN POLAR PLATFORM
R. A. BOWLER, P. TRUSS, and B. J. OKE (British Aerospace /Space Systems/, Ltd., Earth Observation and Science Div., Bristol, England) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 9 p. Oct. 1991 9 p
(IAF PAPER 91-127) Copyright

The ESA Polar Platform (PPF) missions will be coordinated with those of NASA's Earth Observation System, following scheduled launch in 1997. The PPF spacecraft is made up of two major assemblies: a service module containing utilities equipment, and a mission-specific payload module on which payload sensors and specific payload-support equipment are accommodated. This architecture allows separate and parallel development and integration of utilities and instruments; the interface decoupling between the two leads to a shortening of the final spacecraft-integration program phase. O.C.

A92-14748
HYPERBOLIC AEROCAPTURE AND ELLIPTIC ORBIT TRANSFER WITH TETHERS
JAMES M. LONGUSKI and JORDI PUIG-SUARI (Purdue University, West Lafayette, IN) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 10 p. Oct. 1991 10 p refs
(IAF PAPER 91-339) Copyright

After developing a realistic model for an orbiting tether in an atmosphere, it is demonstrated that such space tethers can be used for hyperbolic aerocapture and elliptic orbit transfer. The numerical results in the elliptic case indicate that orbital maneuvers can be performed with small tension forces in the tether. In the hyperbolic case the behavior is not so benign, because the forces are quite large, but the utilization of tethers for aerocapture appears to be physically feasible. Author

A92-15259
A PARAMETRIC STUDY OF THE TETHER-ELEVATOR DYNAMICS AND CONTROL IN THE PRESENCE OF ATTACHMENT POINT OFFSET
V. J. MODI, S. BACHMANN, and A. K. MISRA (British Columbia, University, Vancouver, Canada) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 19 p. Research supported by Centers of Excellence Program. Oct. 1991 19 p refs
(Contract NSERC-A-2181)
(IAF PAPER 91-355) Copyright

A mathematical model is proposed for studying planar dynamics of a space-station-based Tethered Elevator System (TES). The model accounts for finite dimensions of the station, offset of the tether-attachment point from the station's mass center, and crawling motion of the elevator to or from a platform supported by the fixed-length tether. The tether, assumed massless but elastic, is modeled as a double pendulum, while the elevator, end platform and moving-offset attachment are treated as point masses. The system center of mass is assumed to follow an arbitrary elliptic orbit. The governing equations of motion, obtained using the Lagrangian procedure, are coupled, nonlinear, and nonautonomous. Numerical results are given for the rigid tether model with the system mass center following a circular orbit. Simulation of the uncontrolled dynamics suggests that elevator maneuvers can excite unacceptably large amplitude station and tether pitch oscillations, which persist due to the absence of damping. An optimal Linear Quadratic Regulator (LQR) control strategy is applied in conjunction with two distinctly different types of actuators. The elevator thruster is required during rapid retrieval. Author

A92-15405
ATTITUDE DYNAMICS OF A SPINNING TETHERED SYSTEM IN LEO
M. B. QUADRELLI (Aeritalia S.p.A., Turin, Italy) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 26 p refs
Copyright
The attitude dynamics of a spinning tethered system in LEO has been investigated focusing on two problems: the attitude dynamics of the whole tethered system considered as an extensible dumbbell and the attitude dynamics of one of the end masses, acted upon by a restoring torque provided by the tethered linkage. The concept of a rigid body with time-varying moments of inertia was used to derive a standard Mathieu equation and a set of conditions for the moments of inertia ratios, the spin frequency, and the frequency of the tether stretch. It is concluded that a growth in the out-of-plane wobbling because of the tether stretching is to be expected whenever appropriate conditions on the moments of inertia are satisfied but the existence of such a motion is too small to represent a real problem. O.G.

A92-15406* Aeritalia S.p.A., Turin (Italy).
TETHERED SATELLITE SYSTEM DYNAMICS AND CONTROL
B. MUSETTI, B. CIBRARIO, L. BUSSOLINO (Aeritalia S.p.A., Turin, Italy), C. S. BODLEY, H. A. FLANDERS (Martin Marietta Corp., Astronautics Group, Denver, CO), D. K. MOWERY, and D. D. TOMLIN (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 24 p refs
Copyright
The first tethered satellite system, scheduled for launch in May 1991, is reviewed. The system dynamics, dynamics control, and dynamics simulations are discussed. Particular attention is given to in-plane and out-of-plane librations; tether oscillation modes; orbiter and sub-satellite dynamics; deployer control system; the sub-satellite attitude measurement and control system; the Aeritalia Dynamics Model; the Martin-Marietta and NASA-MSFC Dynamics Model; and simulation results. O.G.

A92-15407
TETHERED SATELLITE SYSTEM-SATELLITE ATTITUDE CONTROL
B. MUSETTI (Aeritalia S.p.A., Turin, Italy) and I. T. MITCHELL (Vega Space Systems Engineering, Ltd., Harpenden, England) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 16 p
Copyright
The attitude measurement and control system (AMCS) for the first tethered satellite system mission is described. The on-board gyro-compassing algorithm and yaw attitude control law are analyzed to supplement large-scale simulations. The analysis shows a good performance of the AMCS in establishing and maintaining the desired yaw datum. The gyro-compassing algorithm is shown to be globally stable within the convergent region. The algorithm is treated in isolation from the yaw attitude control law, since when embedded within the yaw attitude control loop the whole system has been shown to be stable. O.G.

A92-15408
ORBIT CIRCULARIZATION USING A TETHER OF VARYING LENGTH
M. MORANA and M. B. QUADRELLI (Aeritalia S.p.A., Turin, Italy) IN: Dynamics of flexible structures in space; Proceedings of the 1st International Conference, Cranfield, England, May 15-18, 1990 1990 13 p refs
Copyright
The purpose of the present work is to study the feasibility of circularizing an eccentric Space Station orbit by varying length of a tether attached to an end mass. The system is analyzed using the simple 'dumbbell' satellite model. Results are compared and discussed with respect to different length variation laws. It is concluded that a small eccentric orbit is circularized in a few days. The achievement of the minimum time for this operation is limited by a loss of tension at high vibration amplitudes and by the supplied/absorbed energy ratio for the reeling/unreeling operation. Author

A92-17777
COMMERCIAL PLATFORMS FROM THE EXTERNAL TANK
THOMAS C. TAYLOR, WILLIAM A. GOOD, DAVID NIXON, ART OVERMAN (Global Outpost, Inc., College Park, MD), and MICHAEL SIMON (MAN Technologie AG, Munich, Federal Republic of Germany) IN: Space manufacturing 8 - Energy and materials from space; Proceedings of the 10th Princeton/AIAA/SSI Conference, Princeton, NJ, May 15-18, 1991 1991 8 p refs
Copyright
Discarded Space Shuttle External Tanks (ETs) have two attractive uses in the context of orbiting platforms' commercial operations: first, as a source of metal that can be used as feedstock for containerless-processed products, and second, as internally pressurizable containers for microgravity processing tasks. Attention is presently given to a cost-effective, privately financed method for the recovery of ETs by means of a kit that will be carried aboard it. An entire man-visited orbiting platform can be derived from salvaged ETs at minimum cost. O.C.

A92-17797* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TETHER METHODS FOR REACTIONLESS ORBITAL PROPULSION
GEOFFREY A. LANDIS (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) IN: Space manufacturing 8 - Energy and materials from space; Proceedings of the 10th Princeton/AIAA/SSI Conference, Princeton, NJ, May 15-18, 1991 1991 5 p refs
Copyright
In space, limits on transportation effectiveness are set by requirements for reaction mass, since reaction mass must be carried on board and often comprises the majority of the launch mass of a space system. Thus, applications where a tether can be used for propulsion with no requirement of reaction mass are extremely attractive for space development. It is a remarkable fact that tethers can be used to increase orbital energy with no requirement for reaction mass. Author

A92-18404
PERFORMANCE ENHANCEMENT USING POWER BEAMING FOR ELECTRIC PROPULSION EARTH ORBITAL TRANSPORTERS
JEFFERY E. DAGLE (Pacific Northwest Laboratory, Richland, WA) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 6, Nov. 1991, p. 17-20. Nov. 1991 4 p refs (Contract DE-AC06-76RL-01830)
Copyright
Power requirements for an electric propulsion earth orbital transport vehicle (EOTV), which can effectively deliver large payloads using much less propellant than chemical transfer methods, are addressed. The power beaming concept is described. Arcjets, magnetoplasmadynamic (MPD) thrusters, and ion engines are covered. Power supply characteristics are discussed for nuclear, solar and power-beaming systems. Operational characteristics are given for each, as are the effects of the power supply alternative on the overall craft performance. Because of its modular nature, the power beaming can meet the power requirements of all three electric propulsion types. Commonality of approach allows, different electric propulsion approaches to be powered by means of a single power supply approach. Power beaming exhibits better flexibility and performance than onboard nuclear or solar power systems. I.E.

A92-18443
REAL-TIME ESTIMATOR FOR CONTROL OF AN ORBITING SINGLE TETHER SYSTEM

MICHAEL E. GREENE and THOMAS S. DENNEY, JR. (Auburn University, AL) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. 27, Nov. 1991, p. 880-883. Nov. 1991 4 p refs
Copyright

A real-time estimator is developed for the control of the Tether Dynamics Explorer (TDE) system. TDE is being used in a series of tethered satellite flight experiments whose purpose is to validate existing system models and test proposed control laws. Each experiment consists of an orbiting Delta II second stage which deploys toward the Earth a small box-shaped passive endbody at the end of a flexible tether. A discrete extended Kalman filter (DEKF) is presented which can operate in real time and in conjunction with control laws. This filter estimates the in-plane and out-of-plane tether libration angles and their rates from a proposed three-axis tether tension measurement device in the Delta second stage. The simulation results indicate that the DEKF can estimate the libration angle and their rates from a three-axis tension and length measurement with an acceptable error. In addition, the relatively simple computations required make this algorithm particularly well suited for real-time operation. I.E.

A92-18606
DYNAMICS OF A TETHERED SATELLITE SUBJECTED TO AERODYNAMIC FORCES
GUIDO DE MATTEIS and LUCIANO M. DE SOCIO (Roma I, Universita, Rome, Italy) Dec. 1991 7 p refs
Copyright

A92-18627
ORBITAL DYNAMICS OF THE HANGING TETHER INTERFEROMETER
ANTHONY B. DECOU (Northern Arizona University, Flagstaff, AZ) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Nov.-Dec. 1991, p. 1309-1311. Dec. 1991 3 p refs
Copyright

An examination is conducted of the consequences of Coriolis forces, analyzing a strategy for the cancellation of the Coriolis forces by means of ion thrusters. The thrust levels thus employed are found to be easily achievable by existing technology, for the case of a 10-km baseline interferometer that operated in GEO. The major remaining question regarding the scheme's practicality involves vibrations induced in the tether by the central station of its configuration. O.C.

A92-20520
OEDIPUS-A - SPACE RESEARCH WITH A NEW TETHER
H. J. JAMES (Department of Communications, Communications Research Centre, Ottawa, Canada) and B. A. WHALEN (National Research Council of Canada, Herzberg Institute of Astrohysics, Ottawa) EOS (ISSN 0096-3941), vol. 72, March 19, 1991, p. 137, 139, 140, 144. 19 Mar. 1991 5 p refs
Copyright

The OEDIPUS space-research tether system concept involves the use of a large double probe to measure weak magnetic field-aligned dc electric fields in the auroral topside ionosphere. The bistatic character of the payload has attracted the attention of plasma-wave experimenters, who have prevailed in the inclusion of a radio transmitter on one end of the payload and a synchronized receiver on the other. This instrument pair is capable of supporting novel experiments on plane-wave and sheath-wave propagation in plasmas. O.C.

A92-21153
NONLINEAR FEEDBACK DEPLOYMENT AND RETRIEVAL OF TETHERED SATELLITE SYSTEMS
SRINIVAS R. VADALI (Texas A & M University, College Station) and EUISOK KIM Feb. 1992 7 p refs
Copyright

A92-21185 National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
GROUND-BASED IMPLEMENTATION AND VERIFICATION OF CONTROL LAWS FOR TETHERED SATELLITES
DAVID A. GWALTNEY (NASA, Langley Research Center, Hampton, VA) and MICHAEL E. GREENE (Auburn University, AL) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 15, Jan.-Feb. 1992, p. 271-273. Research supported by NASA. Feb. 1992 3 p refs
Copyright

Davis and Banerjee (1990) have developed a tethered-spacecraft system model in which out-of-plane librations are damped, using a length-rate control after the tether has been deployed. Attention is presently given to the implementation of such control schemes to prototype hardware designed for space flight. A prototype reel mechanism has been constructed for use in the Getaway Tether Experiment; both the Davis and Banerjee control scheme and a converted tension-control law have been implemented with tether length and length rate available as feedback. O.C.

A92-25689#
OPTIMAL WING CONFIGURATION OF A TETHERED SATELLITE SYSTEM IN FREE MOLECULAR FLOW
ANDREW D. SANTANGELO and GLEN E. JOHNSON (Michigan, University, Ann Arbor) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 7 p. Jan. 1992 7 p refs
(AIAA PAPER 92-0218) Copyright

An analysis is presented of the Tethered Satellite/Wing System in free molecular flow (at altitude of 142 km) in planar motion subject to impulse moments. The focus of this mission is to demonstrate and validate deployment and retrieval operations of a Tethered System, conduct hypersonic aerothermodynamic research, and validate Tethered Satellite System, or TSS, operations in the earth's upper atmosphere. The analysis indicates that a wing system could provide stable flight over a wide range of conditions. Author

A92-26821
LOGICA IN POLAR PLATFORM
British Interplanetary Society, Journal (ISSN 0007-094X), vol. 45, March 1992, p. 127, 128. Mar. 1992 2 p refs
Copyright

Specific developments by Logica for the ESA ERS-1 polar platform satellite are described in terms of the space-, ground-, and related-segment activities. The present contributions include computer modeling of the platform to support mission planning and standardizing communications specifications for software and some hardware. Also included are managing the technical and programmatic options of the ground-segment concept, the development of image-processing systems and archiving support, and the definition of the Data-Relay Satellite system. C.C.S.

A92-26981#
PREDICTED POTENTIALS AND CURRENTS FOR TSS-1
V. A. DAVIS, I. KATZ, T. T. LUU (Maxwell Laboratories, Inc., La Jolla, CA), and M. R. OBERHARDT (USAF, Phillips Laboratory, Hanscom AFB, MA) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 8 p. Research supported by USAF. Jan. 1992 8 p refs
(AIAA PAPER 92-0574) Copyright

The distribution of voltages is calculated as predicted for the elements of the Tethered Satellite System 1 (TSS-1) and the tether currents for the range of predicted conditions. Orbiter-ion collection is calculated with the 3D NASCAP/LEO code with attention given to orientation, potential, and plasma conditions. The resulting data is integrated into the EPSAT mission-analysis code to determine the results in terms of spacecraft-environment interactions. The subsatellite surface and the orbiter are shown to support potentials of more than 2 kV and about 1 kV under conditions of low ionospheric plasma density. During periods of the maximum ambient density the expected currents can reach 250 mA, and a

range of 10-100 kiloohm is given for the orbiter ion-collecting sheath impedance. It is concluded that the sheath ionization can potentially damage the subsatellite equipment. C.C.S.

A92-32187* National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, FL.
TETHERED ELEVATOR DESIGN FOR SPACE STATION
LOREN A. ANDERSON (Central Florida, University, Orlando, FL) and MICHAEL H. HADDOCK (NASA, Kennedy Space Center, Cocoa Beach, FL) Apr. 1992 6 p refs
Copyright

N92-11071*# Vanderbilt Univ., Nashville, TN. School of Engineering.
AERODYNAMIC CALCULATIONS RELATED TO TETHERED SUB-SATELLITE EXPERIMENTS Final Report, 1 Jun. 1988 - 31 Jul. 1991
J. LEITH POTTER and J. KENT ROCKAWAY 1 Aug. 1991 35 p
(Contract NAG1-878)
(NASA-CR-188964; NAS 1.26:188964) Avail: CASI HC A03/MF A01

The results are presented of four aerodynamic studies that were in support of a broader, preliminary inquiry concerning the potential use of downward-deployed tethered sub-satellites for in-flight aerothermodynamic research. There are a multitude of questions regarding the general tethered satellite concept and the present report addresses only a few of these. A method for estimating drag and local surface pressure and shear on orbiting or re-entereing bodies is described, and examples based on the planned TSS-2 (Tethered Satellite System) are given. The problem of pressure measurement are explored, taking into account thermal transpiration, lag time, and the disturbed flow field created by the satellite body. The performance of an aerodynamic stabilizer, a ring-tail design, is calculated and its influence on satellite motion is illustrated. A method for optimizing future satellite shapes for desired aerodynamic properties is transitional rarefied flow with given geometric constraints is proposed and examples are shown. Author

N92-13126*# Tokyo Univ. (Japan). Inst. of Space and Astronautical Science.
SPACE FLYER UNIT (SFU)
T. NINOMIYA and K. KURIKI *In* JPL, California Inst. of Tech., Deep Space Network: Mission Support Requirements 4 p Oct. 1991
Avail: CASI HC A01/MF A03

The DSN (Deep Space Network) mission support requirements for the Space Flyer Unit (SFU) are summarized. The SFU is an unmanned, reusable, and retrievable free-flying platform for multipurpose use. The SFU spacecraft will carry seven individual experiments to be completed during its mission period. The mission objectives are outlined and the DSN support requirements are defined through the presentation of tables and narratives describing the spacecraft flight profile; DSN support coverage; frequency assignments; support parameters for telemetry, command and support systems; and tracking support responsibility. M.G.

N92-13141*# Logicon Control Dynamics Co., Huntsville, AL.
TETHERED SATELLITE SYSTEM DYNAMICS AND CONTROL REVIEW PANEL AND RELATED ACTIVITIES, PHASE 3 Final Report, Dec. 1989 - Nov. 1990
Aug. 1991 139 p
(Contract NAS8-35835)
(NASA-CR-184254; NAS 1.26:184254) Avail: CASI HC A07/MF A02

Two major tests of the Tethered Satellite System (TSS) engineering and flight units were conducted to demonstrate the functionality of the hardware and software. Deficiencies in the hardware/software integration tests (HSIT) led to a recommendation for more testing to be performed. Selected problem areas of tether dynamics were analyzed, including verification of the severity of skip rope oscillations, verification or comparison runs to explore dynamic phenomena observed in other simulations, and data generation runs to explore the performance of the time domain and frequency domain skip rope observers. Author

N92-19188# Applied Technology Associates, Inc., Albuquerque, NM.
STABILIZED SENSOR PLATFORM FOR MANNED SPACE OBSERVATION Final Report
HENRY R. SEBESTA 31 Oct. 1991 21 p
(Contract F04701-90-C-0071)
(AD-A244132) Avail: CASI HC A03/MF A01

This report documents system-level requirements in all applicable areas which need to be considered in the development and design of a stabilized sensor platform. The objective of the platform is to enhance man's ability to use optical instruments and perform observations of ground scenes from orbiting space vehicles. This report is intended to serve several purposes within the overall plan, namely: (1) Establishes, documents, and provides rationale for technical and operational requirements which the platform design must fulfill; (2) Provides a consolidated source of information, inputs, and reference materials which influence the design approach and technology selections; (3) Allows broad and early exposure of our development baselines for the stabilized sensor platform so that reviewers can identify and feedback any issues or concerns. GRA

N92-19248*# Spectra Research Systems, Inc., Arlington, VA. Operations Div.
TETHERS IN SPACE HANDBOOK, SECOND EDITION
PAUL A. PENZO, ed. (Jet Propulsion Lab., California Inst. of Tech., Pasadena.) and PAUL W. AMMANN, ed. May 1989 259 p
Original contains color illustrations
(Contract NASW-4341)
(NASA-CR-188756; NAS 1.26:188756) Avail: CASI HC A12/MF A03; 1 functional color page

The Tethers in Space Handbook, Second Edition represents an update to the initial volume issued in September 1986. As originally intended, this handbook is designed to serve as a reference manual for policy makers, program managers, educators, engineers, and scientists alike. It contains information for the uninitiated, providing insight into the fundamental behavior of tethers in space. For those familiar with space tethers, it includes a summary of past and ongoing studies and programs, a complete bibliography of tether publications, and names, addresses, and phone numbers of workers in the field. Perhaps its most valuable asset is the brief description of nearly 50 tether applications which have been proposed and analyzed over the past 10 years. The great variety of these applications, from energy generation to boosting satellites to gravity wave detection is an indication that tethers will play a significant part in the future of space development. This edition of the handbook preserves the major characteristics of the original; however, some significant rearrangements and additions have been made. The first section on Tether Programs has been brought up to date, and now includes a description of TSS-2, the aerodynamic NASA/Italian Space Agency (ASI) mission. Tether Applications follows, and this section has been substantially rearranged. First, the index and cross-reference for the applications have been simplified. Also, the categories have changed slightly, with Technology and Test changed to Aerodynamics, and the Constellations category removed. In reality, tether constellations may be applicable to many of the other categories, since it is simply a different way of using tethers. Finally, to separate out those applications which are obviously in the future, a Concepts category has been added. A new section included here on Conference Summaries recognizes the fact that the tether community is growing internationally, and that meetings provide a means of rapid communication and interaction. Finally, the Bibliography section has been considerably updated to include all known references. These are listed by author and by subject and include the papers to be presented at the Third International Conference in May 1989. Author

21

TRANSPORTATION NODE

Use of the space station as a node for the launching, assembly or support of lunar or other exploratory missions.

A92-12450* Advanced Decision Systems, Mountain View, CA.
VHP - AN ENVIRONMENT FOR THE REMOTE VISUALIZATION OF HEURISTIC PROCESSES
STUART L. CRAWFORD and BARRY M. LEINER (Advanced Decision Systems, Mountain View, CA) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 6 p. Research supported by U.S. Army. Oct. 1991 6 p refs
(Contract NAS2-13282)
(IAF PAPER 91-029) Copyright

A software system called VHP is introduced which permits the visualization of heuristic algorithms on both resident and remote hardware platforms. The VHP is based on the DCF tool for interprocess communication and is applicable to remote algorithms which can be on different types of hardware and in languages other than VHP. The VHP system is of particular interest to systems in which the visualization of remote processes is required such as robotics for telescience applications. C.C.S.

A92-12458
AEROBRAKE ON-ORBIT ASSEMBLY NEUTRAL BUOYANCY TESTING - A MODEL FOR COOPERATIVE SEI RESEARCH
JOHN M. GARVEY, DAVID E. ANDERSON (McDonnell Douglas Space Systems Co., Huntington Beach, CA), and GORDON K. LEE (North Carolina State University, Raleigh) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. Oct. 1991 12 p refs
(IAF PAPER 91-039) Copyright

Results of tests conducted on a mock-up of the aerobrake on-orbit assembly for Space Station Freedom are presented, and the assembly's design, fabrication, and test approach are described. It is shown that the results of tests provide verificaton that on-orbit assembly is a feasible approach for achieving the large aerobrake dimensions that are required for a manned Mars mission. Issues that should be attended to in future investigations are discussed. Diagrams of the airobrake assembly are included. I.S.

A92-14984
STARPORT CYCLER EXPEDITION CONCEPTS
BUZZ ALDRIN (Starcraft Enterprises, Laguna Beach, CA) IN: Leaving the cradle: Human exploration of space in the 21st century; Proceedings of the 28th Goddard Memorial Symposium, Washington, DC, Mar. 14-16, 1990 1991 15 p
(AAS PAPER 90-119) Copyright

The various options for highly economical expansion of space exploration activities in earth orbit are discussed, with a view to the support of Mars exploration activities. The various manned and unmanned system components considered are elements of a 'Space Taxi and Return' system which employs NASA's Space Station Freedom as a basis for further growth. Spacecraft configurational concepts are illustrated. O.C.

A92-16200
MACHINE-MADE GRAVITY-PROPELLED INTERPLANETARY SPACE STATIONS AND THE EXPLORATION OF MARS
MICHAEL A. MINOVITCH (Phaser Telepropulsion, Inc., Los Angeles, CA) British Interplanetary Society, Journal (ISSN 0007-094X), vol. 44, Dec. 1991, p. 598-610. Dec. 1991 13 p refs
Copyright

A long-range plan is presented for the initial exploration and colonization of Mars, based upon using economical machine-made toroidal structures, initially to establish permanent orbiting Space Stations at both earth and Mars and using the construction technique to establish a permanent interplanetary transportation system between the two Space Stations using interplanetary Space Stations moving on nonstop gravity-propelled trajectories of the form earth-Mars-earth-Mars that can be maintained indefinitely at relatively low cost. After initial injection from earth, the interplanetary Space Stations will require no further onboard rocket propulsion beyond that required for guidance. Initial injection is accomplished by two high specific impulse multimegawatt ECR plasma accelerators mounted in each column cylinder energized by a circular self-supporting thin-film solar array attached to the rotating torus. Relatively small transfer vehicles carried inside the column cylinders provide the transportation between the interplanetary Space Stations and the orbiting Space Stations. A separate terminal transportation system is established at Mars that operates between the orbiting Space Station and the surface, using reusable vehicles. The automated construction technique is also utilized for constructing pressurized toroidal habitats and high-capacity cryogenic fuel storage tanks on the Martian surface. Author

A92-17770
EXTENDING THE OPERATIONAL ALTITUDE OF SOLAR SAILS DOWN TO SPACE STATION ALTITUDES WITH AN ELECTRODYNAMIC TETHER
RICHARD MOSS and MANUEL MARTINEZ-SANCHEZ (MIT, Cambridge, MA) IN: Space manufacturing 8 - Energy and materials from space; Proceedings of the 10th Princeton/AIAA/SSI Conference, Princeton, NJ, May 15-18, 1991 1991 16 p refs
Copyright

A propulsion system featuring the integration of an electrodynamic tether with a solar sail vehicle is presently studied, with a view to the design of a spacecraft capable of flight from Space Station LEO altitudes to a deep space destination and return, without refueling. Three different solar sail/electrodynamic tether vehicle configurations are studied: their features encompass the square solar sail and heliogyro, as well as both fixed and deployable electrodynamic tethers. Orbital debris impacts are identified as a major concern, especially for deployable tether-incorporating confugurations. O.C.

A92-17773
A CONCEPTUAL DESIGN FOR A MODULAR, HIGH-VOLUME, ARTIFICIAL-GRAVITY CREW COMPARTMENT IN A MANNED MARS SPACECRAFT
HOWARD KLEINBERG (Spar Aerospace, Ltd., Advanced Technology Systems Div., Weston, Canada) IN: Space manufacturing 8 - Energy and materials from space; Proceedings of the 10th Princeton/AIAA/SSI Conference, Princeton, NJ, May 15-18, 1991 1991 14 p refs
Copyright

A concept is proposed for the crew compartment of the manned mission to Mars. Other assumptions regarding the configuration are stated, in order to accommodate those of the Life-Section (LS), as appropriate. Among the concept requirements are large internal volume, artificial-gravity spin capability, crew protection from space radiation, and enough volume to carry and operate a closed ecological life support system (CELSS) to support the crew during a journey to and from Mars that may take a year or more. This design will provide a large internal volume, while still being modular enough to be assembled in LEO. It will house the crew's living and working quarters, the CELSS, and the interface between the LS and the rest of the spacecraft. Author

A92-18485
FUTURE EARTH-MOON TRANSPORTATION SYSTEM FOR MANNED LUNAR BASE PROJECT - STUDY OF LOW COST CONFIGURATION
TORU TANABE and SHINICHI NAKASUKA (Tokyo, University, Japan) IAF, International Astronautical Congress, 42nd, Montreal, Canada, Oct. 5-11, 1991. 12 p. Research supported by Institute for Future Technology of Japan. Oct. 1991 12 p refs
(IAF PAPER 91-441) Copyright

Los-cost configuration of earth-moon space transportation system for a specific lunar base project is studied. The transportation system consists of launchers, OTVs, moon landers, and other infrastructures, and the combination of the variety, type,

size and number of these elements is searched for which yields the most cost-effective transportation service for the several assumed mission models. Since the search space for the least cost combination will be quite huge because of the large number of design parameters and their mutual interactions, a systematic approach is employed to reduce the search space. Space fuel stations on LLO or LEO are also studied in terms of its effect on total system cost, and it is indicated that LEO fuel station will sufficiently reduce the total system cost under large mission size. As a result of these studies, a new space transportation scheme is proposed which employs LEO fuel station and reusable OTVs. Several technical issues for the realization of this scheme are discussed as well. Author

A92-24347#
USING SIMULATION AS A TOOL FOR EVALUATING ON-ORBIT ASSEMBLY SUPPORT EQUIPMENT
MARK L. D'AMARA and GEORGE W. MORGENTHALER (Colorado, University, Boulder) IN: AIAA/SOLE Space Logistics *Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical* Papers 1991 11 p refs
(AIAA PAPER 91-4086) Copyright

The problem of assembling a lunar or Mars transfer vehicle utilizing a coorbiting transportation node as a 'drydock' and the Space Station Freedom (SSF) as a base of operations is examined using simulation, statistical estimation, and decision theory. The results show that simulation models can help to provide insights into decisions regarding orbital assembly operations. Complementary support equipment and the performance of such equipment can be evaluated by simulating rough orders of magnitude of the effects of changes in the system architecture. C.D.

A92-24374#
THE SUPPORT OF LUNAR BASE OPERATIONS - FUTURE SPACE TRANSPORTATION SYSTEM REQUIREMENTS
GENNARO J. AVVENTO (USAF, Washington, DC) IN: AIAA/SOLE Space Logistics Symposium, 4th, Cocoa Beach, FL, Nov. 4-6, 1991, Technical Papers 1991 6 p refs
(AIAA PAPER 91-4124) Copyright

A blueprint is presented for a transportation system supporting colonial activity on the moon. The elements of such a system, including earth-to-orbit vehicles, LEO staging platforms, orbital maneuvering vehicles, orbital transfer vehicles, lunar landers, and earth return ballistic capsules, are described. An implementation strategy using the vehicles is examined. C.D.

A92-27006*# National Aeronautics and Space Administration, Washington, DC.
UNIVERSE EXPLORATION VISION
D. O'HANDLEY (NASA, Washington, DC), P. SWAN (Motorola, Inc., McLean, VA), and W. SADEH (Colorado State University, Fort Collins) AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 5 p. Jan. 1992 5 p
(AIAA PAPER 92-0623) Copyright

U.S. space policy is discussed in terms of present and planned activities in the solar system and beyond to develop a concept for expanding space travel. The history of space exploration is briefly reviewed with references to the Mariner II, Apollo, and Discoverer programs. Attention is given to the issues related to return trips to the moon, sprint vs repetitive missions to Mars, and the implications of propulsion needs. The concept of terraforming other bodies within the solar system so that they can support human activity is identified as the next major phase of exploration. The following phase is considered to be the use of robotic or manned missions that extend beyond the solar system. Reference is given to a proposed Thousand Astronomical Units mission as a precursor to exploratory expansion into the universe, and current robotic mission activities are mentioned. C.C.S.

N92-17362*# McDonnell-Douglas Space Systems Co., Huntington Beach, CA.
MARS AEROBRAKE ASSEMBLY DEMONSTRATION
JOHN M. GARVEY *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 2: Space Station Freedom, Part 2 p 1433-1470 Sep. 1991
Avail: CASI HC A03/MF A04

NASA has identified aerobraking as a potentially critical technology for the Space Exploration Initiative (SEI). The size of Mars aerobrakes may be beyond the capabilities of future launch vehicles to place them into orbit in one launch. On-orbit assembly using facilities and operations developed under the Space Station Freedom (SSF) Program represent one approach for realizing such large structures. the results of early testing in this subject can help influence the future evolution of the SSF. The objectives are to: (1) generate empirical data on operational procedures for on-orbit assembly of a large Mars aerobrake; (2) develop aerobrake design concepts; (3) identify critical issues and requirements associated with SSF utilization; and (4) to stimulate student participation in the SEI. Author

N92-17414*# *National Aeronautics and Space Administration.* Langley Research Center, Hampton, VA.
SSF GROWTH CONCEPTS AND CONFIGURATIONS
WILLIAM M. CIRILLO *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 1: Space Station Freedom, Part 2 p 449-488 Sep. 1991
Avail: CASI HC A03/MF A03

There are three primary objectives for the Space Station Freedom (SSF) Growth concepts and configuration study task. The first objective is the development of evolutionary SSF concept consistent with user requirements and program constraints. The second primary objective is to ensure the feasibility of the proposed SSF evolution concepts as the systems level. This includes an assessment of SSF evolution flight control analysis, logistics assessment, maintainability, and operational considerations. The final objective is to ensure compatibility of the baseline SSF design with the derived evolution requirements at both the system and element (habitat modules, power generation equipment, etc.) levels. Author

N92-17415*# McDonnell-Douglas Space Systems Co., Washington, DC.
STV FUELING OPTIONS
KEN FLEMMING *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 1: Space Station Freedom, Part 2 p 489-531 Sep. 1991
Avail: CASI HC A03/MF A03

Lunar vehicles that will be space based and reusable will require resupply of propellants in orbit. Approximately 75 pct. of the total mass delivered to low earth orbit will be propellants. Consequently, the propellant management techniques selected for Space Exploration Initiative (SEI) orbital operations will have a major influence on the overall SEI architecture. Five proposed propellant management facility (PMF) concepts were analyzed and compared in order to determine the best method of resupplying reusable, space based Lunar Transfer Vehicles (LTVs). The processing time needed at the Space Station to prepare LTV for its next lunar mission was estimated for each of the PMF concepts. The estimated times required to assemble and maintain the different PMF concepts were also compared. The results of the maintenance analysis were similar, with co-orbiting depots needing 100 to 350 pct. more annual maintenance. The first few external tanks mating operations at KSC encountered many problems that could cause serious lunar mission schedule delays. The use of drop tanks on lunar vehicles increases by a factor of four the number of critical propellant interface disturbances. Author

N92-17416*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SPACE STATION FREEDOM/LUNAR TRANSFER VEHICLE PROPELLANT OPERATION HAZARD ANALYSIS
SAM DOMINICK (Martin Marietta Corp., Vandenberg AFB, CA.), STEVEN M. STEVENSON, and HARVEY FEINGOLD (Science Applications International Corp., Schaumburg, IL.) *In* NASA,

Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 1: Space Station Freedom, Part 2 p 533-564 Sep. 1991
Avail: CASI HC A03/MF A03

Space Station Freedom (SSF), as a transportation node for Space Exploration Initiative missions, would involve the assembly and refurbishing of lunar and Mars transfer vehicles. This includes operations involving cryogenic propellants (LH2 7 LO2) such as storing and handling of loaded propellant tanks, assembly onto the vehicle, and propellant transfer. Cryogenic propellants dictate rigorous safety precautions and impose unique requirements to ensure flight safety to both personnel and SSF elements. The objective of this study is to identify potential hazards and risks associated with cryogenic propellants. This involves identification of pertinent system design features and operational procedures. Criticality of identified risks/hazards shall be assessed and those that fall in the catastrophic and critical categories shall include mitigating solutions. *Author*

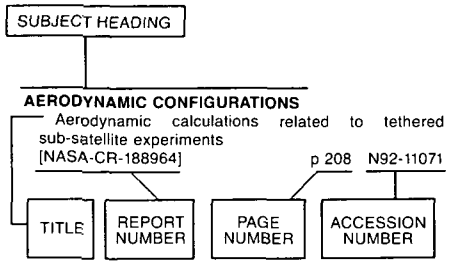
N92-17422*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, FL.
COMPUTER SYSTEM EVOLUTION REQUIREMENTS FOR AUTONOMOUS CHECKOUT OF EXPLORATION VEHICLES
TOM DAVIS and MIKE SKLAR *In* NASA, Washington, Beyond the Baseline 1991: Proceedings of the Space Station Evolution Symposium. Volume 1: Space Station Freedom, Part 2 p 697-727 Sep. 1991
Avail: CASI HC A03/MF A03

This study, now in its third year, has had the overall objective and challenge of determining the needed hooks and scars in the initial Space Station Freedom (SSF) system to assure that on-orbit assembly and refurbishment of lunar and Mars spacecraft can be accomplished with the maximum use of automation. In this study automation is all encompassing and includes physical tasks such as parts mating, tool operation, and human visual inspection, as well as non-physical tasks such as monitoring and diagnosis, planning and scheduling, and autonomous visual inspection. Potential tasks for automation include both extravehicular activity (EVA) and intravehicular activity (IVA) events. A number of specific techniques and tools have been developed to determine the ideal tasks to be automated, and the resulting timelines, changes in labor requirements and resources required. The Mars/Phobos exploratory mission developed in FY89, and the Lunar Assembly/Refurbishment mission developed in FY90 and depicted in the 90 Day Study as Option 5, have been analyzed in detailed in recent years. The complete methodology and results are presented in FY89 and FY90 final reports. *Author*

LARGE SPACE STRUCTURES AND SYSTEMS IN THE SPACE STATION ERA / *A Bibliography (Supplement 05)*

MARCH 1993

Typical Subject Index Listing



The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of document content, a title extension is added, separated from the title by three hyphens. The accession number and the page number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document. Under *any one subject heading, the accession numbers* are arranged in sequence.

A

B

C

D

E

F

H

J

K

L

M

N

O

P

Q

R

S

Page Intentionally Left Blank

U

V

W

X

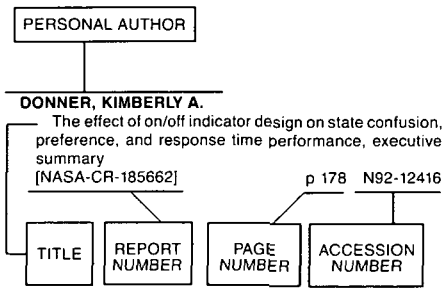
Y

Z

LARGE SPACE STRUCTURES AND SYSTEMS IN THE SPACE STATION ERA / *A Bibliography (Supplement 05)*

MARCH 1993

Typical Personal Author Index Listing



Listings in this index are arranged alphabetically by personal author. The title of the document provides the user with a brief description of the subject matter. The report number helps to indicate the type of document listed (e.g., NASA report, translation, NASA contractor report). The page and accession numbers are located beneath and to the right of the title. Under any one author's name the accession numbers are arranged in sequence.

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

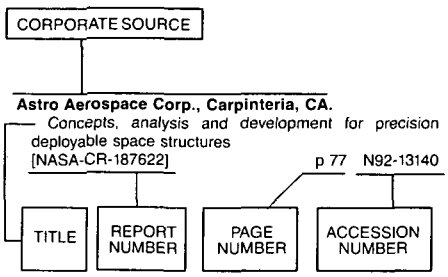
W

X

Y

Z

Typical Corporate Source Index Listing



Listings in this index are arranged alphabetically by corporate source. The title of the document is used to provide a brief description of the subject matter. The page number and the accession number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document.

A

Acurex Corp., Mountain View, CA.
Conceptual design of a self-deployable, high performance parabolic concentrator for advanced solar-dynamic power systems
[NASA-CR-187061] p 53 N92-16480

Advanced Decision Systems, Mountain View, CA.
VHP - An environment for the remote visualization of heuristic processes
[IAF PAPER 91-029] p 209 A92-12450

Aeritalia S.p.A., Turin (Italy).
Tethered satellite system dynamics and control p 206 A92-15406
Software integration, verification, and qualification for manned space laboratories: Strategies and techniques p 150 N92-20591
Software management strategies and practices for space systems development p 151 N92-20610
Columbus software: Transition from software development to system operations p 151 N92-20623

Aerospace Corp., El Segundo, CA.
Assessment of the tribiological requirements of advanced spacecraft mechanisms
[AD-A241674] p 106 N92-13148
Modeling performance degradation in nickel hydrogen cells p 125 N92-13194

Aerospatiale, Cannes (France).
LOCSTAR solar array p 131 N92-13249
SPOT 4 solar array p 131 N92-13250
The AMADEUS experiment: In-flight test results evaluation p 89 N92-13260
Effect of an in-flight pollution by thrusters on a solar array p 133 N92-13261
Solar array management guide p 16 N92-13269

Aerospatiale, Les Mureaux (France).
Ground control for the Hermes-MTFF: Application of the mission analysis methods developed at Aerospatiale p 18 N92-20772

Aerospatiale, Paris (France).
Structures and fracture mechanic of brittle matrix composites
[REPT-911-430-131] p 42 N92-12064

Air Force Inst. of Tech., Wright-Patterson AFB, OH.
Control of a large flexible space structure using multiple model adaptive algorithms
[AD-A243759] p 80 N92-17602
An analytic method of propagating a covariance matrix to a maneuver condition for linear covariance analysis during rendezvous
[AD-A243354] p 187 N92-17732
A comparison of fractional order time derivative models of the viscoelastic stress relations in thermorheologically complex materials
[AD-A243971] p 44 N92-19369

Air Force Systems Command, Kirtland AFB, NM.
Effects of space environment on structural materials - A preliminary study and development of materials characterization protocols p 33 A92-10527

Aix-Marseilles Univ. (France).
Dynamical analysis by infrared thermography of breakdown phenomena in BSFR type reverse biased solar cells mounted on a GSR3 coupon in simulated spatial conditions p 131 N92-13244

Alabama Cryogenic Engineering, Inc., Huntsville.
The minimum temperature of the 'vortex' cryocooler p 107 A92-13398

Alabama Univ., Huntsville.
Current collection by a long conducting cylinder in a flowing magnetized plasma p 116 A92-10467
Gravity Probe-B Spacecraft attitude control based on the dynamics of slosh wave-induced fluid stress distribution on rotating dewar container of cryogenic propellant
[IAF PAPER 91-256] p 188 A92-12592
Composite material debris shielding for long-term space structures
[IAF PAPER 91-282] p 34 A92-12604
Use of composite materials in multi-wall structures to prevent perforation by hypervelocity particle impact p 34 A92-14179
Spacecraft wall design for increased protection against penetration by orbital debris impacts p 48 A92-18378
Analysis of Spacelab 3 residual acceleration data p 198 A92-20389
Process modelling for Space Station experiments
[NASA-CR-184227] p 203 N92-10112
Contamination study
[NASA-CR-184225] p 41 N92-10639
Analysis of surfaces from the LDEF A0114, phase 4
[NASA-CR-188990] p 41 N92-11074
The interactions of atmospheric cosmogenic radionuclides with spacecraft surfaces p 41 N92-11075
Effects on LDEF exposed copper film and bulk p 41 N92-11076
Measurements of erosion characteristics for metal and polymer surfaces using profilometry p 41 N92-11077
Welding in Space Workshop
[NASA-CR-184234] p 51 N92-12269
A minimum propellant solution to an orbit-to-orbit transfer using a low thrust propulsion system p 187 N92-15858

Alabama Univ., Tuscaloosa.
MLITemp: A computer program to predict the thermal effects associated with hypervelocity impact damage to space station MLI
[NASA-CR-184245] p 50 N92-11079
Emergency egress requirements for Space Station Freedom p 180 N92-15886

Alcatel Espace, Toulouse (France).
Power distribution system for a synthetic aperture radar p 123 N92-13171
GEPOS: Global evaluation and optimisation of future power systems concepts p 127 N92-13210

Alcatel Kirk ASD A/S, Ballerup (Denmark).
Small size DC/DC converter for regulated power buses p 140 N92-13180

Alenia Spazio S.p.A., Naples (Italy).
Simulation of large power distribution system behavior under load switching conditions: The Columbus Attached Laboratory EPDS case p 124 N92-13189

Analex Corp., Cleveland, OH.
Microgravity science requirements and the need for data compression p 203 N92-12430

Applied Computing Enterprises, Nepean (Ontario).
Literature survey of active damping using piezoelectric devices
[ACE-R-CSA-91-3.0] p 82 N92-20840
Modelling of piezoelectric behaviour for actuator and sensor applications
[ACE-R-CSA-91-2-0] p 83 N92-20843

Applied Technology Associates, Inc., Albuquerque, NM.
Stabilized sensor platform for manned space observation
[AD-A244132] p 208 N92-19188

Arizona State Univ., Tempe.
Robust H(infinity) control design for the Space Station with structured parameter uncertainty p 66 A92-18604
Control synthesis for flexible space structures excited by persistent disturbances p 69 A92-21159

Arizona Univ., Tucson.
First spatio-temporal results from the LDEF Interplanetary Dust Experiment p 23 A92-18666
Autonomous space processor for orbital debris
[NASA-CR-189986] p 90 N92-19493

Artegie (France).
Watts Per Kilo (WPK): Solar array dimensioning tool version 2 enhancements p 130 N92-13242

Aston Univ., Birmingham (England).
The threat of parasitic electron emission in high-voltage power and communication systems operating under space conditions p 126 N92-13201

Astro Aerospace Corp., Carpinteria, CA.
Concepts, analysis and development for precision deployable space structures
[NASA-CR-187622] p 77 N92-13140

Auburn Univ., AL.
Space - A unique environment for process modeling R&D p 193 A92-10675
Ground-based implementation and verification of control laws for tethered satellites p 207 A92-21185
Active vibration control p 81 N92-19615

Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France).
The electronic copilot: A fruitful experience toward complex project management using artificial intelligence in the space domain p 151 N92-20627

Axiomatix, Los Angeles, CA.
Space station tracking requirements feasibility study, volume 2
[NASA-CR-185641-VOL-2] p 186 N92-11084
Space station tracking requirements feasibility study, volume 1
[NASA-CR-185641-VOL-1] p 186 N92-11085

B

Ball Aerospace Systems Div., Boulder, CO.
A design and critical technology issues for on-orbit resupply of superfluid helium p 189 A92-13352

BDM Corp., Columbia, MD.
A survey of rapid sample return needs from Space Station Freedom and potential return systems
[IAF PAPER 91-106] p 195 A92-12509

BDM International, Inc., Washington, DC.
A survey of rapid sample return needs from Space Station Freedom and potential return systems
[IAF PAPER 91-106] p 195 A92-12509

Bendix Field Engineering Corp., Columbia, MD.
Using C to build a satellite scheduling expert system: Examples from the Explorer Platform planning system
[NASA-CR-189247] p 17 N92-14700

Bionetics Corp., Moffett Field, CA.
The CELSS Test Facility Project - An example of a CELSS flight experiment system p 159 A92-20979
Ion exchange - Simulation and experiment
[SAE PAPER 911508] p 162 A92-21813

C

D

E

F

G

H

I

J

O

P

R

S

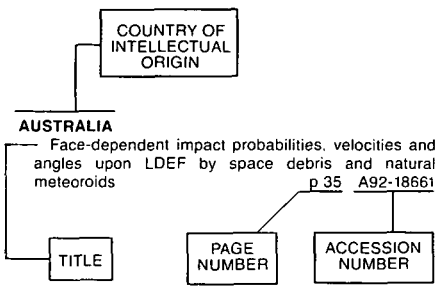
T

U

V

W

Typical Foreign Technology Index Listing



Listings in this index are arranged alphabetically by country of intellectual origin. The title of the document is used to provide a brief description of the subject matter. The page number and the accession number are included in each entry to assist the user in locating the citation in the abstract section. If applicable, a report number is also included as an aid in identifying the document.

A

ARGENTINA
Finite element modeling of flexible tracks
p 47 A92-15399
Modelling of superelements in mechanism analysis
p 67 A92-19454

AUSTRALIA
Face-dependent impact probabilities, velocities and angles upon LDEF by space debris and natural meteoroids p 35 A92-18661

B

BAHRAIN
Optimum design of geometrically nonlinear space trusses p 66 A92-18587

BELGIUM
Active damping of a truss structure using piezoelectric actuators p 47 A92-15396
Atmospheric instruments on ATLAS 1 and Eureca 1
p 201 A92-26760
Active damping by a local force feedback with piezoelectric actuators p 72 A92-28138
USO concept in the member states - Belgium
p 8 A92-32466
Development study of improved models of the Earth's radiation environment
[AERONOMICA-ACTA-A-360-1991] p 31 N92-16491

BRAZIL
A family of half-bridge PWN zero-voltage switching converters, employing switched capacitor snubber
p 140 N92-13183
Orbit transfer: Dynamic analysis
[INPE-5352-TDI/461] p 187 N92-19438

BULGARIA
The first 'space' vegetables have been grown up in the 'Svet' greenhouse by means of controlled environmental conditions
[IAF PAPER 91-575] p 154 A92-18565
'Mir' radiation dosimetry results during the solar proton events in September-October 1989 p 158 A92-20912
Investigation of an automatic attitude control system for orbital stations p 70 A92-23431
A method for determining the potential of a spacecraft
p 24 A92-23433
Analysis of a redundant free-flying spacecraft/manipulator system p 103 A92-29704

C

CANADA
Robust failure detection for linear distributed parameter systems p 56 A92-11125
Controller design for Msat - A third generation spacecraft p 58 A92-11443
Supervised space robotic system - Operator interface design
[IAF PAPER 91-027] p 92 A92-12448
Small spaceborne platforms to monitor Canada's environment and resources
[IAF PAPER 91-044] p 205 A92-12462
Control system architecture of the Mobile Servicing System
[IAF PAPER 91-055] p 92 A92-12469
Robotic vision technology for Space Station and satellite applications
[IAF PAPER 91-061] p 92 A92-12475
The Space Station Freedom Mobile Servicing System - The challenge of managing in changing times
[IAF PAPER 91-065] p 5 A92-12477
On the design and development of the Space Station Remote Manipulator System (SSRMS)
[IAF PAPER 91-074] p 92 A92-12483
The Space Station remote manipulator system, human computer interface considerations
[IAF PAPER 91-075] p 92 A92-12484
Integrating the Space Station Remote Manipulator System into the Space Station assembly process - The challenges and techniques
[IAF PAPER 91-084] p 117 A92-12491
Time-delayed remote operation and maintenance of Space Station Freedom
[IAF PAPER 91-092] p 10 A92-12498
SPDM robot/astronaut comparisons with respect to Space Station Freedom operations
[IAF PAPER 91-093] p 92 A92-12499
Space Station utilization planning in Canada
[IAF PAPER 91-102] p 10 A92-12506
A case-based planning system for spacecraft electrical power system control
[IAF PAPER 91-226] p 117 A92-12582
An approach to dynamics of flexible orbiting systems with application to the proposed Space Station
[IAF PAPER 91-293] p 60 A92-12609
Microgravity science activities in Canada
p 7 A92-12853
Orbital debris shielding design of the Radarsat spacecraft
[IAF PAPER 91-283] p 46 A92-14712
Dynamics analysis of complex space structures using natural orthogonal complement
[IAF PAPER 91-295] p 60 A92-14715
On the control of a class of flexible manipulators using feedback linearization approach
[IAF PAPER 91-324] p 92 A92-14737
A parametric study of the tether-elevator dynamics and control in the presence of attachment point offset
[IAF PAPER 91-355] p 205 A92-15259
Dynamics and control of flexible interconnected bodies - A formulation with application p 61 A92-15379
Controller order reduction for flexible spacecraft using closed-loop balancing methods p 62 A92-15382
Dynamics of systems with interconnected flexible members in the presence of thermal deformations
p 62 A92-15386
The use of Kane's equation to write a continuous model of a flexible robot as a step toward a discrete model
p 93 A92-15392
Material property measurements for viscoelastic space structures p 47 A92-15402
System modes and dynamics of the proposed space station type configurations p 64 A92-15411
Atomic oxygen effects on polymer-based materials
p 35 A92-17560
High resolution spectroscopic measurements from the Space Shuttle - Orbiter glow and atmospheric emissions
p 20 A92-17561
A conceptual design for a modular, high-volume, artificial-gravity crew compartment in a manned Mars spacecraft p 209 A92-17773
An approach to dynamics and control of orbiting flexible structures p 67 A92-19460
Plasma-deposited protective coatings for spacecraft applications p 35 A92-20381
OEDIPUS-A - Space research with a new tether
p 207 A92-20520
A formulation and transient dynamics of the evolving Space Station p 68 A92-21020
Research and development program in automation and robotics in support of Canada's mobile servicing system for the Space Station Freedom p 95 A92-23655
Automation of Mobile Servicing System operations
p 95 A92-23661
Speech recognition for robots - A probabilistic approach p 98 A92-23687
On the nature of control algorithms for free-floating space manipulators p 100 A92-24090
Applications of space logistics engineering in quantitative risks assessment and management of Space Station Freedom
[AIAA PAPER 91-4054] p 12 A92-24330
Applications of smartly designed radiation hardened gate arrays in space maintenance and logistics support of Space Station Freedom
[AIAA PAPER 91-4104] p 137 A92-24359
Long Duration Exposure Facility surface temperatures
p 112 A92-24662
Shape determination for large flexible satellites via stereo vision p 70 A92-24664
Nonlinear modeling and dynamic feedback control of the flexible remote manipulator system
p 102 A92-29258
Evaluation of plasma-deposited protective coatings for spacecraft applications
[AIAA PAPER 92-2152] p 39 A92-31287
Optimal control of large space structures using distributed gyricity: A continuum approach
[UTIAS-341] p 77 N92-12042
Ergonomics applied to operational systems in space stations
[NRC-28710] p 179 N92-12418
LDEF temperature histories: A simple theory
[UTIAS-340] p 114 N92-13142
Materials processing in space p 204 N92-13984
Spacecraft dynamics and control p 78 N92-13988
Structural mechanics and materials science
p 43 N92-13989
Canadian Space Station software product assurance program p 150 N92-18626
Literature survey of active damping using piezoelectric devices
[ACE-R-CSA-91-3.0] p 82 N92-20840
Modelling of piezoelectric behaviour for actuator and sensor applications
[ACE-R-CSA-91-2-0] p 83 N92-20843

CHINA
Application of TO film for controlling charging on satellite surface
[IAF PAPER 91-309] p 34 A92-14726
Nonlinear dynamic response of frame-type structures with hysteretic damping at the joints p 68 A92-20755
Docking dynamics of a spacecraft
p 185 A92-24813
Hybrid adaptive control of space station
p 70 A92-24815

D

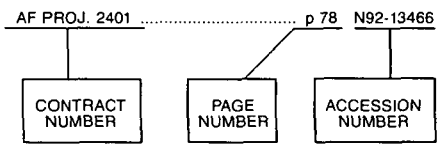
F

G

I

J

Typical Contract Number Index Listing

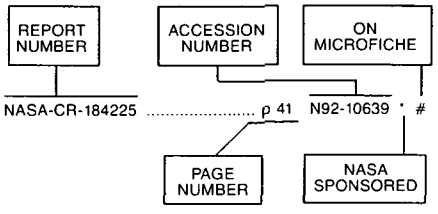


Listings in this index are arranged alphanumerically by contract number. Under each contract number, the accession numbers denoting documents that have been produced as a result of research done under the contract are shown. The accession number denotes the number by which the citation is identified in the abstract section. Preceding the accession number is the page number on which the citation may be found.

LARGE SPACE STRUCTURES AND SYSTEMS IN THE SPACE STATION ERA / *A Bibliography (Supplement 05)*

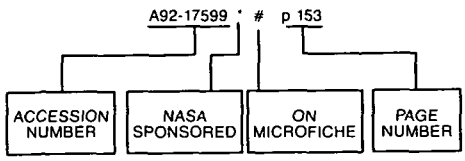
MARCH 1993

Typical Report Number Index Listing



Listings in this index are arranged alphanumerically by report number. The page number indicates the page on which the citation is located. The accession number denotes the number by which the citation is identified. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

Typical Accession Number Index Listing



Listings in this index are arranged alphanumerically by accession number. The page number listed to the right indicates the page on which the citation is located. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

AVAILABILITY OF CITED PUBLICATIONS

IAA ENTRIES (A92-10000 Series)

Publications announced in *IAA* are available from the AIAA Technical Information Service as follows: Paper copies of accessions are available at $10.00 per document (up to 50 pages), additional pages $0.25 each. Standing order microfiche are available at the rate of $1.45 per microfiche for *IAA* source documents and $1.75 per microfiche for AIAA meeting papers.

Minimum air-mail postage to foreign countries is $2.50. All foreign orders are shipped on payment of pro-forma invoices.

All inquiries and requests should be addressed to: Technical Information Service, American Institute of Aeronautics and Astronautics, 555 West 57th Street, New York, NY 10019. Please refer to the accession number when requesting publications.

STAR ENTRIES (N92-10000 Series)

One or more sources from which a document announced in *STAR* is available to the public is ordinarily given on the last line of the citation. The most commonly indicated sources and their acronyms or abbreviations are listed below, and their addresses are listed on page APP-4. If the publication is available from a source other than those listed, the publisher and his address will be displayed on the availability line or in combination with the corporate source line.

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

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

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

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

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

Avail: ESDU. Pricing information on specific data, computer programs, and details on Engineering Sciences Data Unit (ESDU) topic categories can be obtained from ESDU International Ltd. Requesters in North America should use the Virginia address while all other requesters should use the London address, both of which are on page APP-4.

Avail: Fachinformationszentrum, Karlsruhe: Gesellschaft fur wissenschaftlich-technische Information mbH 7514 Eggenstein-Leopoldshafen 2, Germany.

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

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

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

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

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

Avail: US Patent and Trademark Office. Sold by Commissioner of Patents and Trademarks, U.S. Patent and Trademark Office, at the standard price of $1.50 each, postage free. (See discussion of NASA patents and patent applications below.)

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

Avail: USGS. Originals of many reports from the U.S. Geological Survey, which may contain color illustrations, or otherwise may not have the quality of illustrations preserved in the microfiche or facsimile reproduction, may be examined by the public at the libraries of the USGS field offices whose addresses are listed on page APP-4. The libraries may be queried concerning the availability of specific documents and the possible utilization of local copying services, such as color reproduction.

FEDERAL DEPOSITORY LIBRARY PROGRAM

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

PUBLIC COLLECTION OF NASA DOCUMENTS

An extensive collection of NASA and NASA-sponsored publications is maintained by the British Library Lending Division, Boston Spa, Wetherby, Yorkshire, England for public access. The British Library Lending Division also has available many of the non-NASA publications cited in *STAR*. European requesters may purchase facsimile copy or microfiche of NASA and NASA-sponsored documents, those identified by both the symbols # and * from ESA – Information Retrieval Service European Space Agency, 8-10 rue Mario-Nikis, 75738 CEDEX 15, France.

ADDRESSES OF ORGANIZATIONS

American Institute of Aeronautics and Astronautics
Technical Information Service
555 West 57th Street, 12th Floor
New York, New York 10019

British Library Lending Division,
Boston Spa, Wetherby, Yorkshire,
England

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

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

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

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

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

Fachinformationszentrum Karlsruhe
Gesellschaft fur wissenschaftlich-technische
Information mbH
7514 Eggenstein-Leopoldshafen 2, Germany

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

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

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

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

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

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

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

University Microfilms, Ltd.
Tylers Green
London, England

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

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

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

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

CASI PRICE TABLES

(Effective October 1, 1992)

STANDARD PRICE DOCUMENTS

PRICE CODE	NORTH AMERICAN PRICE	FOREIGN PRICE
A01	$ 9.00	$ 18.00
A02	12.50	25.00
A03	17.00	34.00
A04-A05	19.00	38.00
A06-A09	26.00	52.00
A10-A13	35.00	70.00
A14-A17	43.00	86.00
A18-A21	50.00	100.00
A22-A25	59.00	118.00
A99	69.00	138.00

MICROFICHE

PRICE CODE	NORTH AMERICAN PRICE	FOREIGN PRICE
A01	$ 9.00	$ 18.00
A02	12.50	25.00
A03	17.00	34.00
A04	19.00	38.00
A06	26.00	52.00
A10	35.00	70.00

IMPORTANT NOTICE

CASI Shipping and Handling Charges
U.S. — ADD $3.00 per TOTAL ORDER
Canada and Mexico — ADD $3.50 per TOTAL ORDER
All Other Countries — ADD $7.50 per TOTAL ORDER
Does NOT apply to orders
requesting CASI RUSH HANDLING.
Contact CASI for charge.

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA SP-7085 (05)		

4. Title and Subtitle	5. Report Date
Large Space Structures & Systems in the Space Station Era A Bibliography with Indexes	March 1993
	6. Performing Organization Code JTT
7. Author(s)	8. Performing Organization Report No.
	10. Work Unit No.
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 1363 reports, articles and other documents introduced into the NASA scientific and technical information system between January 1, 1992 and July 31, 1992. 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))	18. Distribution Statement
Large Space Antenna Large Space Structures Large Space Systems Space Stations	Unclassified - Unlimited Subject Category - 18

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price *
Unclassified	Unclassified	364	A16

*For sale by the NASA Center for AeroSpace Information, 800 Elkridge Landing Road, Linthicum Heights, MD 21090-2934

FEDERAL REGIONAL DEPOSITORY LIBRARIES

ALABAMA

AUBURN UNIV. AT MONTGOMERY LIBRARY
Documents Dept.
7300 University Drive
Montgomery, AL 36117-3596
(205) 244-3650 FAX: (205) 244-0678

UNIV. OF ALABAMA
Amelia Gayle Gorgas Library
Govt. Documents
Box 870266
Tuscaloosa, AL 35487-0266
(205) 348-6046 FAX: (205) 348-8833

ARIZONA

DEPT. OF LIBRARY, ARCHIVES, AND PUBLIC RECORDS
Federal Documents
Third Floor State Capitol
1700 West Washington
Phoenix, AZ 85007
(602) 542-4121 FAX: (602) 542-4400; 542-4500

ARKANSAS

ARKANSAS STATE LIBRARY
State Library Services
One Capitol Mall
Little Rock, AR 72201
(501) 682-2869

CALIFORNIA

CALIFORNIA STATE LIBRARY
Govt. Publications Section
914 Capitol Mall - P.O. Box 942837
Sacramento, CA 94237-0001
(916) 322-4572 FAX: (916) 324-8120

COLORADO

UNIV. OF COLORADO - BOULDER
Norlin Library
Govt. Publications
Campus Box 184
Boulder, CO 80309-0184
(303) 492-8834 FAX: (303) 492-2185

DENVER PUBLIC LIBRARY
Govt. Publications Dept. BS/GPD
1357 Broadway
Denver, CO 80203
(303) 571-2135

CONNECTICUT

CONNECTICUT STATE LIBRARY
231 Capitol Avenue
Hartford, CT 06106
(203) 566-4971 FAX: (203) 566-3322

FLORIDA

UNIV. OF FLORIDA LIBRARIES
Documents Dept.
Library West
Gainesville, FL 32611-2048
(904) 392-0366 FAX: (904) 392-7251

GEORGIA

UNIV. OF GEORGIA LIBRARIES
Govt. Documents Dept.
Jackson Street
Athens, GA 30602
(404) 542-8949 FAX: (404) 542-6522

HAWAII

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

IDAHO

UNIV. OF IDAHO LIBRARY
Documents Section
Moscow, ID 83843
(208) 885-6344 FAX: (208) 885-6817

ILLINOIS

ILLINOIS STATE LIBRARY
Reference Dept.
300 South Second
Springfield, IL 62701-1796
(217) 782-7596 FAX: (217) 524-0041

INDIANA

INDIANA STATE LIBRARY
Serials/Documents Section
140 North Senate Avenue
Indianapolis, IN 46204
(317) 232-3678 FAX: (317) 232-3728

IOWA

UNIV. OF IOWA LIBRARIES
Govt. Publications Dept.
Washington & Madison Streets
Iowa City, IA 52242
(319) 335-5926 FAX: (319) 335-5830

KANSAS

UNIV. OF KANSAS
Govt. Documents & Map Library
6001 Malatt Hall
Lawrence, KS 66045-2800
(913) 864-4660 FAX: (913) 864-5380

KENTUCKY

UNIV. OF KENTUCKY LIBRARIES
Govt. Publications/Maps Dept.
Lexington, KY 40506-0039
(606) 257-3139 FAX: (606) 257-1563; 257-8379

LOUISIANA

LOUISIANA STATE UNIV.
Middleton Library
Govt. Documents Dept.
Baton Rouge, LA 70803
(504) 388-2570 FAX: (504) 388-6992

LOUISIANA TECHNICAL UNIV.
Prescott Memorial Library
Govt. Documents Dept.
305 Wisteria Street
Ruston, LA 71270-9985
(318) 257-4962 FAX: (318) 257-2447

MAINE

TRI-STATE DOCUMENTS DEPOSITORY
Raymond H. Fogler Library
Govt. Documents & Microforms Dept.
Univ. of Maine
Orono, ME 04469
(207) 581-1680

MARYLAND

UNIV. OF MARYLAND
Hornbake Library
Govt. Documents/Maps Unit
College Park, MD 20742
(301) 454-3034 FAX: (301) 454-4985

MASSACHUSETTS

BOSTON PUBLIC LIBRARY
Govt. Documents Dept.
666 Boylston Street
Boston, MA 02117
(617) 536-5400 ext. 226
FAX: (617) 267-8273; 267-8248

MICHIGAN

DETROIT PUBLIC LIBRARY
5201 Woodward Avenue
Detroit, MI 48202-4093
(313) 833-1440; 833-1409
FAX: (313) 833-5039

LIBRARY OF MICHIGAN
Govt. Documents Unit
P.O. Box 30007
Lansing, MI 48909
(517) 373-0640 FAX: (517) 373-3381

MINNESOTA

UNIV. OF MINNESOTA
Wilson Library
Govt. Publications Library
309 19th Avenue South
Minneapolis, MN 55455
(612) 624-5073 FAX: (612) 626-9353

MISSISSIPPI

UNIV. OF MISSISSIPPI
J.D. Williams Library
Federal Documents Dept.
106 Old Gym Bldg.
University, MS 38677
(601) 232-5857 FAX: (601) 232-5453

MISSOURI

UNIV. OF MISSOURI - COLUMBIA
Ellis Library
Govt. Documents
Columbia, MO 65201
(314) 882-6733 FAX: (314) 882-8044

MONTANA

UNIV. OF MONTANA
Maureen & Mike Mansfield Library
Documents Div.
Missoula, MT 59812-1195
(406) 243-6700 FAX: (406) 243-2060

NEBRASKA

UNIV. OF NEBRASKA - LINCOLN
D.L. Love Memorial Library
Documents Dept.
Lincoln, NE 68588
(402) 472-2562

NEVADA

UNIV. OF NEVADA
Reno Library
Govt. Publications Dept.
Reno, NV 89557
(702) 784-6579 FAX: (702) 784-1751

NEW JERSEY

NEWARK PUBLIC LIBRARY
U.S. Documents Div.
5 Washington Street - P.O. Box 630
Newark, NJ 07101-0630
(201) 733-7812 FAX: (201) 733-5648

NEW MEXICO

UNIV. OF NEW MEXICO
General Library
Govt. Publications Dept.
Albuquerque, NM 87131-1466
(505) 277-5441 FAX: (505) 277-6019

NEW MEXICO STATE LIBRARY
325 Don Gaspar Avenue
Santa Fe, NM 87503
(505) 827-3826 FAX: (505) 827-3820

NEW YORK

NEW YORK STATE LIBRARY
Documents/Gift & Exchange Section
Federal Depository Program
Cultural Education Center
Albany, NY 12230
(518) 474-5563 FAX: (518) 474-5786

NORTH CAROLINA

UNIV. OF NORTH CAROLINA - CHAPEL HILL
CB#3912, Davis Library
BA/SS Dept.—Documents
Chapel Hill, NC 27599
(919) 962-1151 FAX: (919) 962-0484

NORTH DAKOTA

NORTH DAKOTA STATE UNIV. LIBRARY
Documents Office
Fargo, ND 58105
(701) 237-8886 FAX: (701) 237-7138
In cooperation with Univ. of North Dakota, Chester Fritz Library
Grand Forks

OHIO

STATE LIBRARY OF OHIO
Documents Dept.
65 South Front Street
Columbus, OH 43266
(614) 644-7051 FAX: (614) 752-9178

OKLAHOMA

OKLAHOMA DEPT. OF LIBRARIES
U.S. Govt. Information Div.
200 NE 18th Street
Oklahoma City, OK 73105-3298
(405) 521-2502, ext. 252, 253
FAX: (405) 525-7804

OKLAHOMA STATE UNIV.
Edmon Low Library
Documents Dept.
Stillwater, OK 74078
(405) 744-6546 FAX: (405) 744-5183

OREGON

PORTLAND STATE UNIV.
Millar Library
934 SW Harrison - P.O. Box 1151
Portland, OR 97207
(503) 725-3673 FAX: (503) 725-4527

PENNSYLVANIA

STATE LIBRARY OF PENN.
Govt. Publications Section
Walnut St. & Commonwealth Ave.
P.O. Box 1601
Harrisburg, PA 17105
(717) 787-3752

SOUTH CAROLINA

CLEMSON UNIV.
Cooper Library
Public Documents Unit
Clemson, SC 29634-3001
(803) 656-5174 FAX: (803) 656-3025
In cooperation with Univ. of South Carolina, Thomas Cooper Library, Columbia

TENNESSEE

MEMPHIS STATE UNIV. LIBRARIES
Govt. Documents
Memphis, TN 38152
(901) 678-2586 FAX: (901) 678-2511

TEXAS

TEXAS STATE LIBRARY
United States Documents
P.O. Box 12927 - 1201 Brazos
Austin, TX 78711
(512) 463-5455 FAX: (512) 463-5436

TEXAS TECH. UNIV. LIBRARY
Documents Dept.
Lubbock, TX 79409
(806) 742-2268 FAX: (806) 742-1920

UTAH

UTAH STATE UNIV.
Merrill Library & Learning Resources Center, UMC-3000
Documents Dept.
Logan, UT 84322-3000
(801) 750-2684 FAX: (801) 750-2677

VIRGINIA

UNIV. OF VIRGINIA
Alderman Library
Govt. Documents
Charlottesville, VA 22903-2498
(804) 924-3133 FAX: (804) 924-4337

WASHINGTON

WASHINGTON STATE LIBRARY
Document Section
MS AJ-11
Olympia, WA 98504-0111
(206) 753-4027 FAX: (206) 753-3546

WEST VIRGINIA

WEST VIRGINIA UNIV. LIBRARY
Govt. Documents Section
P.O. Box 6069
Morgantown, WV 26506
(304) 293-3640

WISCONSIN

ST. HIST. SOC. OF WISCONSIN LIBRARY
Govt. Publications Section
816 State Street
Madison, WI 53706
(608) 262-2781 FAX: (608) 262-4711
In cooperation with Univ. of Wisconsin-Madison, Memorial Library

MILWAUKEE PUBLIC LIBRARY
Documents Div.
814 West Wisconsin Avenue
Milwaukee, WI 53233
(414) 278-2167 FAX: (414) 278-2137

National Aeronautics and
Space Administration
Code JTT
Washington, D.C.
20546-0001

Official Business

Penalty for Private Use, $300

SPECIAL FOURTH-CLASS RATE
POSTAGE & FEES PAID
NASA
PERMIT No. G27

NASA

POSTMASTER: If Undeliverable (Section 158 Postal Manual) Do Not Return

Please circulate this publication to other colleagues within your organization.